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CLIMATE CHANGE AND DEVELOPING COUNTRIES:
PRIORITIES FOR POLICY RESEARCH IN THE NETHERLANDS

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ABSTRACT

In this programming study priorities are identified for policy research in the Netherlands dealing with climate change in relation to developing countries. Three criteria are applied for the selection of appropriate research themes. The research should be policy-oriented and relevant for Dutch policy makers, it should deal with options with a large contribution to the abatement of global warming, and there has to be at least a minimum level of international cooperation. The proposed research themes are in the area of technology development and transfer, economic and financial measures, and legal and institutional measures.

To facilitate the evaluation of policy research, the study starts with an overview of anthropogenic greenhouse gas emissions with an emphasis on the quantitative distinction between developing and industrialized countries. Emission data are taken from the Intergovernmental Panel on Climate Change (IPCC). Further, a description is given of response strategies to achieve greenhouse gas emission reduction and to adapt to climate change.

PREFACE

Funding for this programming study was provided through the National Research Programme on Global Air Pollution and Climate Change (NOP-MLK), monitored by RIVM (National Institute of Public Health and Environmental Protection). The study was executed by F.D.J. Nieuwenhout (project leader) and J.H.A. van den Akker (research assistant) from the Global Issues group of ESC-Energy Studies. From outside ESC, three resource persons were involved as experts in specific fields of energy and development expertise; Mr. K. Blok of the University of Utrecht (RUU) in the field of energy conservation, Mr. E.H. Lysen from Lysen Consulting Engineer in the field of renewables research and energy policy in developing countries and Mrs. C. de Pater of the Ministry of Agriculture, Nature Conservation and Fisheries (LN&V) in the field of forestry in developing countries.

KEYWORDS

DEVELOPED COUNTRIES
DEVELOPING COUNTRIES
  ENERGY CONSUMPTION
  INDUSTRY
  AGRICULTURE
  FORESTRY
    AIR POLLUTION
      COMPARATIVE EVALUATIONS
POLLUTANTS
  CARBON DIOXIDE
  CARBON MONOXIDE
  METHANE
  NITROUS OXIDE
  HALOGENATED ALIPHATIC HYDROCARBONS
AIR POLLUTION ABATEMENT
  RESEARCH PROGRAMS
    RECOMMENDATIONS
NETHERLANDS
  GOVERNMENT POLICIES
  INTERNATIONAL COOPERATION
GREENHOUSE EFFECT

SYMBOLS AND ABBREVIATIONS

1 PgC = 1 petagram carbon = 10^{15} gram carbon = 1000 TgC
1 GtC = 1 gigatonne carbon = 10^{9} tonne = 1 PgC
1 tC = 1 tonne carbon
1 TgC = 1 teragram carbon = 10^{12} gram carbon

Mha: million of hectares

CO_2 carbon dioxide
CO carbon monoxide
CH_4 methane
N_2O nitrous oxide

The major group of halocarbons are CFCs (chlorofluorocarbons), that are fully halogenated halocarbons. Besides CFCs there are non-fully halogenated halocarbons as hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Present contribution of these gases is small compared to CFCs, but these are being considered as substitutes for CFCs.

BOS	Foundation for Dutch Forestry Development Cooperation
DGIS	Directorate-General for International Cooperation
EC	European Community
ECN	Netherlands Energy Research Foundation
ESC	Energy Studies
EZ	Ministry of Economic Affairs
FAO	Food and Agriculture Organization
GATT	General Agreement on Trade and Tariffs
IPCC	Intergovernmental Panel on Climate Change
ITTO	International Tropical Timber Organization
KNMI	Royal Dutch Meteorological Institute
LBL	Lawrence Berkeley Laboratory
LN&V	Ministry of Agriculture, Nature Conservation and Fisheries
NCO	National Commission on Information and Public Awareness on Development Cooperation
NGO	non-governmental organization
NOP-MLK	National Research Programme on Global Air Pollution and Climate Change
OECD	Organization of Economic Cooperation and Development
RAWOO	Advisory Council for Scientific Research on Development Cooperation
RIVM	National Institute of Public Health and Environmental Protection
SEI	Stockholm Environment Institute
TFAP	Tropical Forestry Action Plan
TNC	transnational corporation
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Science and Culture Organization
USAID	United States Agency for International Development
US EPA	United States Environment Protection Agency
V&W	Ministry of Public Works
VDO	Information Service Development Cooperation
VROM	Ministry of Housing, Physical Planning and Environment
WMO	World Meteorological Organization

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1. INTRODUCTION

1.1 Background

The unit Energy Studies (ESC) of the Netherlands Energy Research Foundation (ECN) has been commissioned by Programme Committee E of the National Research Programme on Global Air Pollution and Climate Change (NOP-MLK) to conduct a programming study to identify research priorities for greenhouse gas emission prevention in developing countries, and to evaluate the potential contribution which can be made by research in The Netherlands, being funded by NOP-MLK. Programme Committee E is directing its funding towards research on implementing sustainable solutions to prevent as far as possible changes in the climate system and to limit their consequences.

This study aims to support the Programme Committee, on the one hand by supplying concrete criteria which can be used to evaluate research proposals and on the other hand by suggesting directions for new research which can be stimulated through NOP-MLK. This research should be policy-oriented resulting in outcomes which a.o. could be made useful for providing a firm foundation for The Netherlands' position in international organizations and panels. Although the results of this study are primarily meant to be used within NOP-MLK they are expected to be relevant also for other Dutch funding agencies active in this field, after taking into account that their perspectives might differ from those of NOP-MLK.

1.2 Scope of the study

Because this programming study is meant for Programme Committee E, all the research topics which are dealt with by the other programme committees of the NOP-MLK are excluded. These are: functioning, modelling and monitoring of the global climate system (A), causes of changes in the climate system (B), impacts of changes in the climate system (C) and, integral models (a.o. meant for defining norms) (D).

This study focuses on prevention policy because adaptation is generally found to have a lower priority. The stronger the impact of prevention activities, the smaller the need for adaptation. Most adaptation measures are foreseen to be needed only in the medium or far future. Current global interest in adaptation strategies is important mainly because it shows the high cost of a rapidly changing climate. In particular, for low-lying countries the predicted impact of sea-level rise may be severe. The Netherlands has declared its solidarity with other low-lying countries. This justifies that some limited attention will be given to those adaptation measures for which the Netherlands has a comparative advantage in research capabilities. These advantages are e.g. in the field of coastal zone management, but perhaps also in the fields of research on tropical agriculture.

Greenhouse gases discussed in this report concentrate on those with the highest contribution to global warming. These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and halocarbons.

In this report countries will be aggregated into two groups:

- the North, the industrialized countries, comprising 1) North America (Canada and USA), 2) Rest OECD (Western Europe, Australia, New Zealand and Japan), and 3) Eastern Europe (including the USSR);
- the South, the developing countries, comprising 1) Africa, 2) China, 3) India, 4) Rest Asia (including Oceania) and 4) Latin America.

Box 1.1 Definition of groups of activities and related emissions.

ENERGY:

energy consumption (combustion of fossil fuels): CO_2, CO, CH_4 and N_2O
energy production (coal mining, production and distribution of natural gas): CH_4

INDUSTRY (only emissions from manufacturing processes; energy consumption in industry falls under 'energy'):

calcination process in cement production: CO_2
anaerobic fermentation in landfills and open dumps: CH_4
production of halocarbons (CFCs, HCFCs)

AGRICULTURE:

use of nitrogenous fertilizer: N_2O
cultivation of rice on flooded fields: CH_4
enteric fermentation in domesticated animals: CH_4

FORESTRY:

loss of carbon sink (in vegetation and soil) due to deforestation: CO_2
forested land brought under cultivation: N_2O
biomass (wood, charcoal, crop residues and dung) burning in confined spaces for energy extraction, as well as in unconfined conditions (shifting cultivation, prescribed burns in forests and pastures, burning of residues in fields after harvesting): CO, CH_4 and N_2O. The gas CO_2 is also emitted in burning but will contribute only to the extent that a net vegetation loss occurs and is already addressed to under 'deforestation'

This division is made for practical purposes only. One should always bear in mind the enormous differences among countries within both groups, in terms of income (per capita), of energy consumption (per capita), and of sources of greenhouse gas emissions.

Most aspects of global warming are still characterized by a considerable amount of uncertainty. Furthermore calculation results sometimes depend on more or less arbitrary assumptions such as for example the choice of a time horizon in case of evaluating the global warming potential of a greenhouse gas compared to that of carbon dioxide. In these cases, as far as possible, the numerical values of the reports of the Intergovernmental Panel on Climate Change (IPCC) are used. A list of global warming potentials of greenhouse gases can be found in annex C.

1.3 Overview

Chapter 2 presents the results and conclusions of completed studies in the area of climate change and developing countries. Data on the contribution of developing countries to greenhouse gas emissions are supplied.

In chapter 3 the response strategies are discussed in more detail. The measures are examined which could be taken to achieve reduction in emission of greenhouse gases (prevention strategies). Furthermore, some attention is given to measures concerning adaptation to climate change.

Chapter 4 discusses the approach for the evaluation of research proposals. Three criteria are applied to limit the number of eligible research themes to those which have a high priority and are optimally suited for being financed through NOP-MLK. A number of these research themes are discussed in more detail.

Chapter 5 contains the conclusions of this study.

Annex A gives some background information on the data presented in this report.

In annex B seven major international programmes are discussed in more detail. These are; a) the reported results of Intergovernmental Panel on Climate Change (IPCC); b) Country studies with long-term energy scenarios for developing countries by Lawrence Berkeley Laboratories (LBL); c) Greenhouse Gas Scenario Studies (G2S2) by Stockholm Environment Institute (SEI-Boston); d) World Bank environmental policy; e) the energy and environment programme of US Agency for International Development (USAID); f) the environment programme of the Directorate-General for International Cooperation of the Dutch Ministry of Foreign Affairs; and g) the Tropical Forestry Action Plan.

Annex C describes per greenhouse gas which global warming potential (GWP) relative to carbon dioxide has been used. As basic unit in this report the 'carbon equivalent' is taken and annex C gives conversion factors of other units (e.g. CO_2 equivalent, N_2O equivalent) to carbon equivalents.

Annex D contains a list of institutes in The Netherlands that operate, or could possibly operate, in the field of climate change and developing countries.

2. THE CONTRIBUTION OF DEVELOPING COUNTRIES TO GLOBAL EMISSIONS

2.1 Annual greenhouse gas emissions in the eighties

2.1.1 Main structural differences between North and South

At present the industrialized countries (the North) with 23% of the world's population contribute 57% of global annual emissions, while the developing countries (the South) are responsible for 43%. Per capita emission in the North is 5.6 tC per year, in the South only 1.4 tC per year (see figures 2.1 and 2.3).

There are also significant differences between the North and the South in composition of sources of annual emissions per sector (figure 2.1 and 2.2). While the energy sector accounts for 70% of all emissions from the North, its share in emissions from the South is no more than 36%. Instead, the forestry sector contributes 38% of all emissions from the South, while the figure for the North is only 3%.

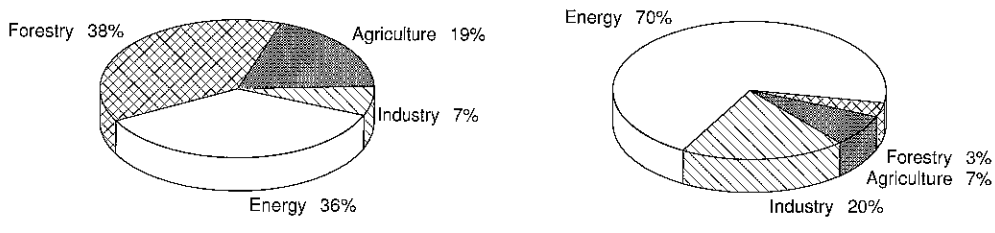
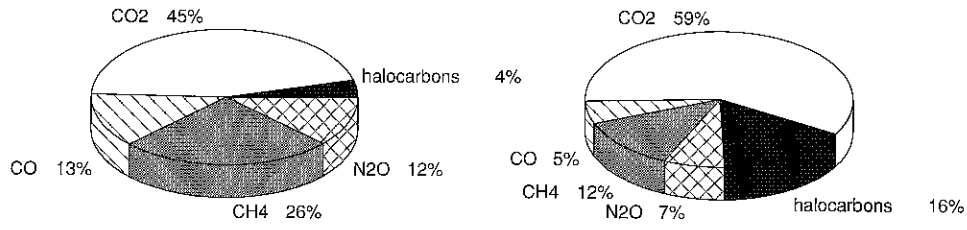


Figure 2.1. Annual greenhouse emissions in the eighties per sector.

With respect to composition of gases, the differences are less striking, but still significant. In the South emissions of CH_4 and CO are relatively larger than in industrialized countries, while emissions of CFCs are much smaller. This difference can be attributed to the emissions of methane from flooded rice fields in Asia, the emissions from biomass combustion (CO) and the much lower use of chlorofluorocarbons (CFCs) in developing countries (due to the lower standard of living). The relative importance of other gases (CO_2, and N_2O) is roughly the same in both parts of the world, for example CO_2 is the major greenhouse gas in both North and South. But the sources of these gases differ: in the North the energy sector is the main contributor to emissions, while in the South emissions from biomass burning and deforestation are at least as important as emissions from the energy sector. Emissions from halocarbons have only a minor contribution to emissions from the South, but are substantial in the North.



Based on IPCC reports

ɜ gas emissions in the eighties per gas.

ːharacteristics in the South[1]

e largest contributor to the man-caused greenhouse effect ɱing commitment). The main gas released in *fossil fuel* is CO_2, with relatively minor contributions from CO, N_2O s from the energy sector in the eighties were 19.1 (17.7- ɪm the South[2]. Here, the 'energy sector' includes data on ɪss combustion, are presented under the heading 'forestry ɪor share in energy consumption in the North, but biomass ɔuth's energy consumption. Biofuel only contributes to CO_2 ɪss of vegetation (deforestation, see further).

ng, gas production and distribution) CH_4 is released. The part (32%) to methane emissions from energy production,

ities associated with greenhouse gases (see figure 2.5): ste disposal in landfills (CH_4) and production and use of

In *cement manufacture* CO_2 is released when limestone $CaCO_3$ is converted to lime CaO. Global emissions from cement manufacture are estimated at 477 (450-550) $TgCO_2$, of which 43% from developing countries.

Global production of *halocarbons* (mostly chlorofluorocarbons, CFCs) at the end of the eighties was 1.31 (1.2-1.7) TgCFC (expressed in CFC-11 equivalents). CFCs account for about 10% of global warming commitment of current human-caused emissions. Use of CFCs has become widespread in the industrialized world, and are used in refrigerators, as propellants in foams, blowing agents for foams, or as solvents. The share of developing countries in CFC emissions is very small (about 16%), but may have been underestimated because of lack of production data.

1 The source of data on emissions and activities is described in more detail in annex A. Values and uncertainty ranges mentioned in this paragraph correspond to those depicted in figure 2.5.

2 Emissions from the other gases: CO 425 (400-1000) TgCO, CH_4 2 Tg(1.4-2.6) $TgCH_4$, N_2O 1.1 (0.1-2.5) TgN.

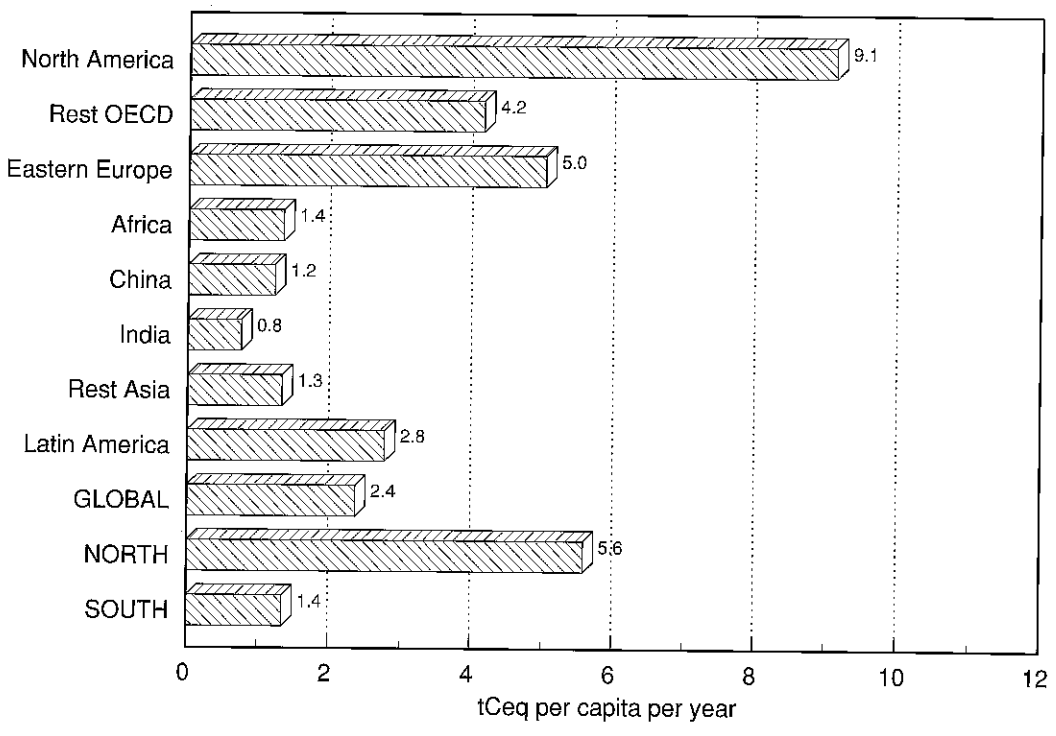


Figure 2.3. Annual per capita greenhouse gas emissions in the eighties.

On a global scale emissions from *landfills* are 40 (20-70) $TgCH_4$, of which some 35% from the South. The urban population produces high and concentrated volumes of waste. Some 70-85% of municipal solid waste collected in industrialized countries is deposited in landfills. Some 50-70% of urban waste is collected in developing countries, where is it is deposited in landfills or, more common, open dumps. Both landfills and open dumps develop anaerobic conditions, releasing methane. Currently, waste production in industrialized countries is much larger than in developing countries, due to high urbanization and high per capita waste production.

Three **agricultural activities** contribute to greenhouse gas emissions: domestic animals (CH_4), rice cultivation (CH_4) and use of fertilizer (N_2O).

Global emissions from *livestock husbandry* are 75 (50-110) $TgCH_4$, of which some 43% from the South. Especially ruminants produce much methane in their digestive system. Domesticated animals (bovines, buffaloes, sheep, goat, pigs, camels, horses, donkeys and caribous) contribute 85-95% of total methane production from animals. Wild animals and humans account for the rest.

Anaerobic decomposition in *flooded rice fields* produces CH_4. Seventy-three percent of the world paddy area is in five Asian countries: China, India, Indonesia, Thailand and Bangladesh. The South has about 95% of world's paddy rice area. The global methane release is 110 (25-170) $TgCH_4$.

Part of the nitrogen in fertilizer applied is released as N_2O. Of the global emission of 1.5 TgN, the South accounts for 43%. Estimates of emissions from fertilizer use vary widely from 0.06-2.4 TgN per year.

The **forestry sector** contributes by deforestation (CO_2) and biomass burning. CO_2 emissions from *deforestation* are quite uncertain, figures ranging from 500-2500 TgC are given in literature. Here, the IPCC global estimate of 728 TgC is assumed. This figure is based

on estimates of deforested area by the FAO [1]. Some 11.3 Mha are deforested annually in the tropics (7.5 Mha of closed forest, 3.8 Mha open forest). Reforestation in developing countries (some 1 Mha per year, excl. China) is totally overshadowed by the large deforestation.

Land conversion of forested area for cultivation enhances the (natural) emissions of N_2O from soils. Its impact remains largely uncertain. Global contribution is 0.4 (0.1-0.9) TgN.

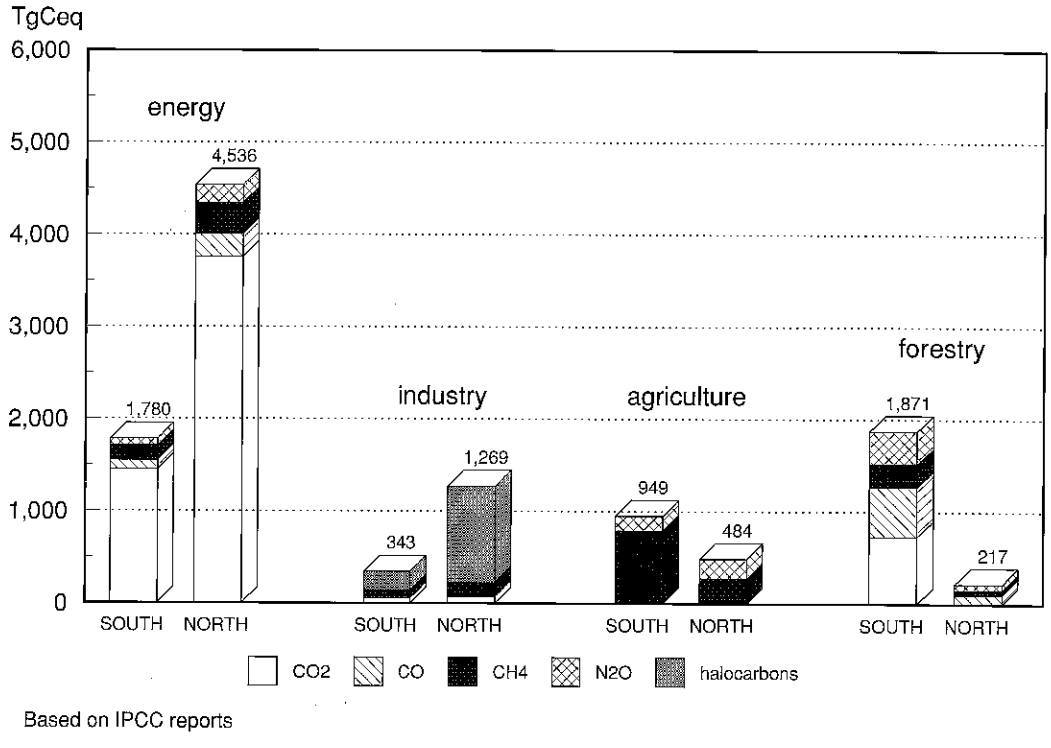


Figure 2.4. Annual emissions per gas end per sector in the eighties.

Combustion of biomass includes here CH_4, CO and N_2O[3]. As is the case with fossil fuels, the main gas released in combustion is actually CO_2. But CO_2 contributes only to the extent that net loss of vegetation occurs, and this contribution is already included in 'deforestation'. Activities contributing to biomass burning are 1) combustion as fuel (wood, charcoal, dung and crop residues) and 2) agricultural burning (burning of residues after harvesting, clearing of land, prescribed burns in forests and savannas). Emissions from biomass burning have so far been given less attention in literature, but the share in global emissions from the South is 17% (which is quite substantial). Of these emissions roughly 1/3 is due to biofuel combustion (woodfuels and residues), 1/3 due to burning of wastes, and fires for clearing, and 1/3 due to shifting cultivation [2].

3 CO: 789 (320-1350) TgCO, CH_4: 51 (20-110) TgCH_4, N_2O:1.3 (0.02-2) TgN.

2.1.3 Major uncertainties

The scientific facts concerning climate change are subject to considerable uncertainties. How large these uncertainties are, can be inferred from figure 2.5, in which low and high estimates of the contributions of different sources of greenhouse gases are presented [3]. In the perspective of this report, it is worth stressing that the uncertainties in establishing the contribution from developing countries are much higher than the uncertainties in establishing the contribution from industrialized countries. This conclusion results primarily from the fact, that the CO_2-related uncertainties from fossil fuel burning are much less than those from deforestation.

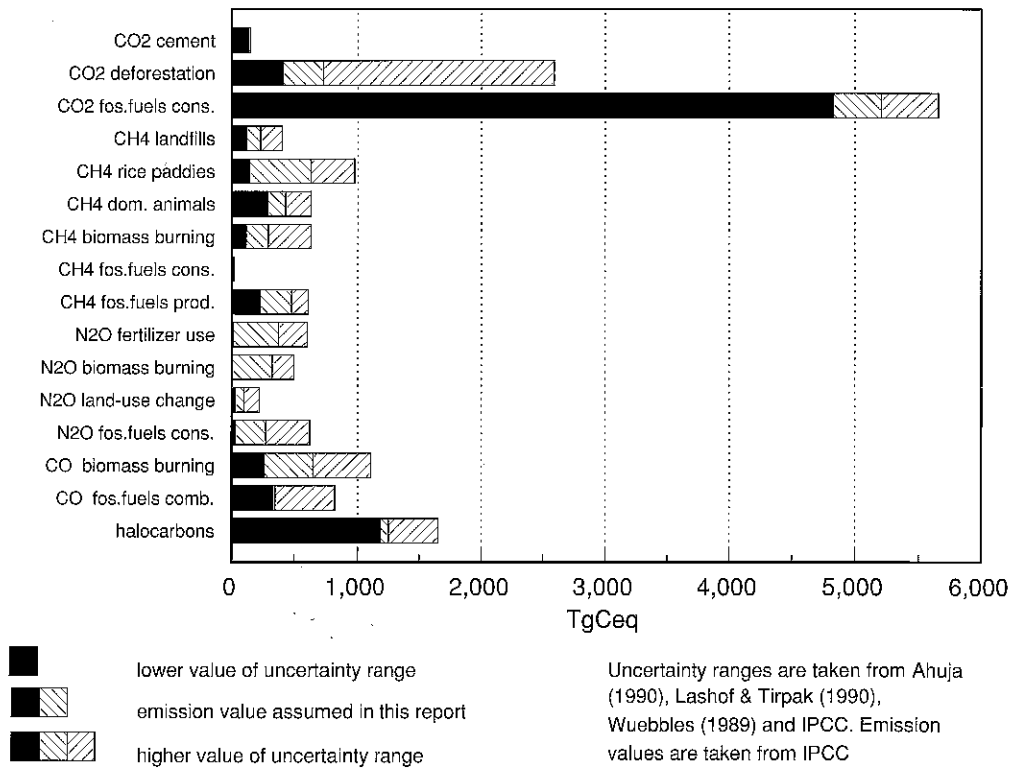


Figure 2.5. Uncertainties in global greenhouse gas emissions (in the eighties).

Estimating greenhouse gas emissions from forest use is extremely difficult, because the magnitude of anthropogenic changes in natural carbon flows is very small compared to the magnitude of sources and sinks. The numbers in this report concerning deforestation should be interpreted cautiously. There is a large discrepancy between estimates of releases of CO_2 caused by deforestation (due to lack of precise data on deforestation area, and on the amount of carbon released after land-use change).

Emission estimates from the agricultural sector are also hampered by large uncertainties. Methane emissions from rice fields seem to depend on area rather than on yield, but are also a function of rice species, number and duration of harvests, temperature, irrigation practices and fertilizer use. Only a few measurements of wet rice field emissions are performed and only one in Asia [4], and moreover they give divergent results (28-120 gCH_4 per m^2). Some of the nitrogen in fertilizer applied is converted to N_2O and released to the atmosphere. N_2O emissions vary widely per type of nitrogenous fertilizer however.

In the North the largest sources of emissions are the energy sector and halocarbons, which are estimated relatively well. In the South the main emissions sources besides energy are

deforestation and agriculture. Because emissions from agriculture and forestry are hampered by large uncertainties, this implicates that the uncertainty range of total current emissions from the South is larger than uncertainty in the North's contribution. Combining emission data from North and South with the uncertainty ranges presented in figure 5, we find the following emission values and uncertainty ranges: South, 4.9 (2.7-8.2) TgC; North, 6.5 (5.4-9.0) PgC.

With respect to future emissions these relatively high uncertainties regarding the contribution from the South are even further enhanced, because the development paths open to the South are also characterized by relatively larger uncertainties in comparison to industrialized nations. Apart from issues concerning the relative cost effectiveness of prevention strategies between North and South, these larger uncertainties form an additional reason to pay a thorough attention to the South.

Some major uncertainties are in predicting the response of the earth system to greenhouse forcing. Climate change can be thought of in two parts:

1) the emission and radiative forcing of gases, and

2) the response within the atmosphere: feedbacks within the atmosphere-clouds-ocean-biosphere system are non-linear, they sometimes act negative (decrease global warming), and sometimes are responsible for large amplifications.

In this report most attention is given to the first: anthropogenic emissions, resulting in a rising equivalent CO_2 level in the atmosphere. To go into the details of climate change effects (temperature increase, together with changing precipitation patterns and sea-level rise) would be outside the scope of this report. The magnitude and timing of climate change is surrounded by uncertainty yet. Climate change, depends on the rate of change in forcing determined by feedbacks in the earth system. An example of a positive feedback is the release of CH_4 enhanced by global warming (a higher temperature stimulates a more rapid fermentation and an increased CH_4 release from e.g. northern peatbogs, permafrost, rice paddies). An example of a negative feedback is the so-called CO_2 fertilization effect (a CO_2 concentration enhanced by global warming, leads to an increased photosynthesis and thus an increased CO_2 uptake from the atmosphere). Currently, the strength of many of such feedbacks is not known, and the integration of oceans, clouds, atmosphere and biosphere in one climate model is in its infant stage. Furthermore the oceans play a very important, but not yet very well understood, role in the dynamics of the global warming. They act a thermal sponge, causing realized warming to lag behind the eventual equilibrium warming (i.e. the warming corresponding to a certain equivalent CO_2 level in the atmosphere.

Further uncertainty concerns the magnitude and timing of the impacts of climate change on agriculture, natural ecosystems, water resources and coastal zones, as well as the socio-economic consequences thereof.

2.2 Future trends in greenhouse gas emissions

2.2.1 The IPCC scenarios

The basis for examining future contributions of developing countries to greenhouse gas emissions are the scenarios used by IPCC [5]. The scenarios specify targets of atmospheric greenhouse gas concentration.

- A **"Business-as-Usual" scenario** assumes that no major emission control policies are implemented and a low compliance of countries with the Montreal Protocol on reduction of CFC emissions. As a consequence greenhouse gas level in the atmosphere (CO_2 equivalents) will be double that of pre-industrial level by the year 2030. In the IPCC reports this scenario is called the *'2030 doubling scenario'*, or *'scenario A'*.

- The **"Policy" scenario** assumes a major phase-in of non-fossil fuels, a major switch from carbon-intensive fossil fuel to natural gas, a high degree of energy efficiency, emission control regulations, halting deforestation, reforestation and a total phase-out of chlorofluorocarbons (CFCs). It goes towards greenhouse gas emission reductions goals of the Toronto Conference (although these are not completely achieved). As a result of various policy actions taken by governments the equivalent CO_2 level in the atmosphere stabilizes at about 50% above pre-industrial level. The scenario is the *'accelerated policies scenario' (scenario D)* of the IPCC reports.

Although the IPCC scenarios are taken as a base, they were modified slightly in this report to fill gaps in the data available on the regional level to the authors of this report. For more details on the source of the data presented here one is referred to annex A. Emission data on current (1985) and future (2025) emissions (Business-as-Usual, resp. Policy) are summarized per region and per sector in figures 2.6 and 2.7.

2.2.2 The energy sector

The share of the South in total energy-related emissions rises to about 43% in both scenarios. The global emissions in the energy sector change from 6.9 PgC (1985) to resp. 7.1 (Business-as-Usual) and 4.8 PgC (Policy). In the Business-as-Usual scenario no policy actions are assumed: fossil fuels continue to be the dominant energy source, energy consumption follows recent patterns along with economic and population growth. The share of fossil fuels in world energy supply remains at the current level: 80%. The Policy scenario assumes that a combination of measures is taken: improvements in efficiency in energy generation and end use, switching from carbon-intensive fossil fuels to natural gas, and substitution by non-fossil fuels (hydro, nuclear, renewables). The percentage share of fossil fuels in world energy supply drops to 50%.

2.2.3 The industrial sector

In the IPCC scenario presented here a doubling of CO_2 emissions from cement manufacture by 2025 is assumed in both Business-as-Usual and Policy scenarios, for both the North and the South.

International negotiations resulted in the Montreal Protocol (1987) on reduction of ozone-depleting chemicals as chlorofluorocarbons. Thirty-one (industrialized) countries, together responsible for 90% of world CFC production, have agreed to reduce their production by 1998 with 50%. The Business-as-Usual scenario assumes a low compliance of countries with the Montreal protocol. Under the Montreal Protocol the developing countries are entitled to increase their CFC usage. The share of developing countries in global halocarbon emissions is expected to change from 16% to 41% (Business-as-Usual), resp. 7% (Policy scenario). The Policy scenario assumes complete phase-out of major CFCs (partly by substitution by less harmful HCFCs). Global CFC emissions are reduced to about 7% of 1985 levels, while HCFC emissions rise 18-fold. In terms of warming commitment this means a reduction of total halocarbon emissions (CFCs and HCFCs) with 40%, compared to 1985 emissions.

With the rapid growth of urban population in the South the share of developing countries in methane emissions from landfills will rise from 36% in 1985 to 56% in 2025 in both scenarios. In the Policy scenario a 25% reduction (in both North and South) compared to the Business-as-Usual case is assumed due to some policy actions taken.

Conclusion is that the industrialized world has been contributing far more than its 'fair' share of emissions. The North can act upon its responsibility for the greenhouse problem. First, by accepting proportionally larger emission reductions. Second, by supporting the South to protect the environment by transfer of more efficient technology, of finance and of human resources, together with changes in trade systems and aid structures. Thus, the approach of the North may be directed towards 'precautionary' measures, while the approach of the South will follow a 'no-regrets' principle.

Also on the **energy supply side** important measures can be taken in the near term. Improvements are:

- to reduce losses in distribution of fuels and electricity, as well as increased recovery of methane what is now flared or vented in production;
- to refurbish power plants to introduce advanced gas-fired combustion technologies, cogeneration (the production of both steam for on-site heating and electricity) and to use more efficient coal technologies;
- fuel substitution (less coal, more natural gas).

In the medium term some renewable sources of energy could make a large contribution to eliminating emissions and reducing dependency of developing countries on fossil fuel imports. Renewable energy sources include hydropower, liquid and gaseous biofuels, geothermal energy, wind energy, solar thermal energy and photovoltaics. For example, in the transport sector ethanol or methanol produced from biomass has great potential in some developing countries. So far, nuclear energy has been an option for industrialized countries, but due to high capital cost and concern about safety, waste and nuclear weapon proliferation expansion of nuclear power is stagnating. Only if such issues are resolved the scope for expansion could increase, but especially in the South high capital cost, as well as aspects of safety and proliferation, will remain a constraint.

A third option, **reduction of emissions** by *CO_2 removal and storage* seems to be most relevant only in the longer term, because of the costs involved.

3.1.2 Industrial activities

In the Business-as-Usual scenario the share of **halocarbons** from the South in total global emissions is expected to increase from 3 to 11%. In principle a complete phase-out of CFCs could be attained. Three measures are important:

- substitution of CFCs by HCFCs. HCFCs are also greenhouse gases but with a much smaller warming potential than CFCs;
- recycling of CFCs and penetration of technologies that use CFCs more efficiently;
- switching from CFC-using products to other products.

CO_2 emission is inherent to the **cement manufacturing** process. The only way to reduce emissions therefore is to limit the amount of cement produced. In the South much basic infrastructure still needs to be built, and demand for cement is expected to grow rapidly, even faster than GNP growth.

Landfill gas production can be reduced by recycling and waste recovery, so that less refuse goes into the landfill, which also benefits the environment. Second, methane can be partly recovered from existing landfills and then be burned or used for energy supply. Third, separate collection of organic waste (waste paper, garden and food waste) and subsequent *aerobic* digestion could contribute significantly to methane emission reduction.

3.1.3 The agricultural sector

Magnitudes of the agricultural sources of greenhouse gas emissions and the potential effects of actions are difficult to quantify. In the Business-as-Usual scenario all three categories of agricultural activities are expected to increase. In the Policy scenario some reduction is assumed.

Methane emissions from **flooded rice fields** cannot be inhibited. But cultivation practices and plant variety influence the amount of methane produced. Before a strategy can be

be about 2°C by 2100 (above pre-industrial level). Some temperature increase and some climate change impacts seem inevitable, and this implies that in future some adaptation to impacts of climate change will have to be necessary.

A temperature increase as mentioned above could lead to a *sea-level rise* (above 1985 level) of 0.17-0.2 m by 2050 (Policy, Business-as-Usual scenario) and of 0.3-0.65 m by 2100 (Policy, Business-as-Usual). Such a rise would threaten coastal zones (e.g. the river deltas in Egypt and Bangladesh) and low islands. Some island states might disappear in the waves, productive land will flood, millions of people will be displaced, fresh water supplies will be contaminated by salt intrusion, droughts and storms might become more severe and exacerbate all of these impacts.

Besides temperature increase and sea-level rise, other features of climate change are: 1) an unequal global distribution of temperature increase (smaller in the tropics, larger going towards the polar regions), and 2) changes in regional precipitation patterns. All these climate change effects have *impacts on agriculture, forestry, fisheries and human settlements.* Impacts are e.g. a polarward shift of agroclimatic zones, a changing water supply (wetter in some areas, drier in others), occurrence of more and more intense weather extremes, changes in the location and extent of deserts.

Adaptive responses to sea-level rise are:

- abandonment of land and structures in vulnerable areas;
- changes in land-use in coastal systems;
- protective coast structures against inundations and salt water intrusions.

Adaptive responses in the area of natural resources are:

- changes in the agricultural and forestry production environment (building in resistance or tolerance of species to insects, soil salinity, temperature changes and to dryness);
- changes in the agricultural support system (relief strategies, marketing and trade, input supply system);
- changes in land-use in drought-struck areas;
- water resources management (water supply and flood control).

3.3 'Tie-in' options

Climate change and impacts thereof are surrounded by large uncertainties. One does not have to wait until these uncertainties are resolved. The longer one waits the more difficult it will become to halt global warming. To 'buy time', measures should be taken that reduce emissions irrespective of the reality of climate change, but that have other environmental, economic and social benefits (so-called *'tie-in' or 'no-regret' strategies*). Three **prevention** 'tie-in strategies' will also give the largest potential contribution to halting global warming from the South (see figure 3.1):

1) *slowing the growth in fossil fuel use* will contribute to tackling of environmental problems (smog, acid precipitation) as well as reducing energy import bills of many countries in the South;
2) *stopping deforestation,* will help to halt erosion processes, and to preserve genetic diversity. *Re- and afforestation* can help to upgrade degraded land, with positive effects on agriculture (agroforestry) and will contribute to future energy supply;
3) *phasing out CFCs,* which contributes to halting the depletion of the ozone layer.

3.4.4 Economic (market) measures

An international system of tradeable emission permits and/or charges could serve as an instrument to achieve a cost-efficient (from a global viewpoint) reduction of greenhouse gas emissions. This raises questions on the comparative cost effectiveness of measures. Other issues are 'equity and responsibility' (the 'right to pollute'), identification of emission sources and measurements, criteria used to allocate emission entitlement, and the scope and size of a market in which to trade permits.
Subsidies and financial incentives imply government interventions in the energy, transport, industry and agriculture sectors that often distort the economy in an adverse way (and encourage greenhouse gas emissions by inefficient use of resources). This applies not only to the national level, but to the global level as well. Trade barriers built by European Community's agricultural policy is one example. On the other hand subsidies can be used to promote environmentally sound goods and actions, but if not carefully designed, these can cause economic distortions too and fail to be effective.

3.4.5 Financial measures

To take measures without endangering their development the nations from the South need additional financial resources. The North should help the nations of the South by contributing financial resources.

Some institutional mechanisms should ensure the coordinated and effective *transfer* of resources. One way is to use existing institutions as the World Bank, development banks, bilateral agreements, and UN organizations. Another way is the parallel creation of a new international facility, such as a Climate Fund. To cope with damages of climate extremes such a Fund could contain an 'emergency facility'.

Financial resources for such a facility could be *generated* by:

- general taxes or other resources not directly related to climate change;
- specific taxes or levies related to greenhouse gas emissions ('carbon tax');
- undisbursed resources which result from savings on energy bills in the North and cuts in military expenditures;
- payments from countries unable to meet obligations allocated to them in a system of international emission permits and charges;
- debt relief and debt-for-nature swaps.

3.4.6 Legal and institutional measures

To capture and coordinate the worldwide multiple initiatives an international framework is needed. This framework could be established in the form of an *International Convention* on protecting the global atmosphere. Such a Convention should contain three elements: [14]

- *Overall targets* in terms of greenhouse gas emission reductions and corresponding time paths differentiate among countries, depending on their past and present contribution to emissions, as well as financial capability and stage of development.
- International commitments and implementation of funding mechanisms and management can be negotiated and formalized in the form of *protocols*. Existing protocols such as the one on CFCs and the Tropical Forestry Action Plan should be included.
- The foundation of a *body to coordinate* policy developments. One element of such a body is a Ministerial Forum that e.g. meets annually. Such a Forum would need support in the field of administration (from a permanent Bureau), policy preparation (e.g. by the IPCC) and an infrastructure for day-to-day operations. Such an infrastruc-

ture could rely on existing organizations (such as WMO, UNEP, FAO, IEA, World Bank). Its functions would be to run a data base on climate change emissions, monitoring of emissions, communication, and implementation of policies (project assessment, comparative cost-effectiveness, establishing equitable negotiation criteria, project assessment, management of financial flows).

4. RECOMMENDED RESEARCH THEMES

4.1 Evaluation approach

4.1.1 Evaluation criteria

The classification of implementation measures as introduced by the IPCC and described in paragraph 3.4 will be taken as the starting point for the evaluation of research proposals. These cover practically all possible implementation activities, hence a further selection is needed to limit the research themes to those which are optimally suited for funding through the National Research Programme on Global Air Pollution and Climate Change (NOP-MLK). In line with the aims of NOP-MLK the proposed research should be policy oriented.

Three criteria are formulated to evaluate if research proposals are eligible for funding through NOP-MLK. The first criterium has been helpful in selecting the broad research themes. The other two criteria can be used to evaluate research proposals when they are actually submitted within one of the themes. These three criteria are:

a) relevance for Dutch policy makers;

b) relative priority of the specific solution;

c) degree of international cooperation.

Recommended research themes which follow from the application of the criterium of relevance for Dutch policy makers are discussed in paragraph 4.2. It has been assumed that the classification of implementation categories by IPCC is complete in the sense that it covers all relevant implementation measures. After choosing some of the major broad themes within each of the categories and that comply to the criteria we are confident that at least the most important research topics are covered.

Although within each theme more detailed questions are given, which can form the base for more specific topics, the themes themselves remain of a more general nature. Not being specific, it is therefore not worthwhile to spend much attention to linking each of the themes to one of the Dutch research institutes. To find out if a specific topic falls within one of the existing research programmes in the Netherlands some of the overviews of the Dutch research capacity can be consulted. The RAWOO made an overview of character and size of development-oriented research activities in the Netherlands [15]. Furthermore, an inventory of climate research in the Netherlands has been made for the Netherlands Academy of Sciences in 1989 [16]. Current research activities falling under one of the recommended themes of paragraph 4.2 are mentioned in the same paragraph. Internationally, some of the major activities are outlined in Annex B.

Many uncertainties still remain in the field of implementation. Their crucial importance is illustrated by the title of the chapter ('Increased Risks') dealing with environmental issues in the policy document presented in September 1990 by the Minister of Development Cooperation [17]. These uncertainties cause endless discussions about the effectiveness of different measures and can seriously hamper a timely implementation. It is inherent to the limited amount of experience that has been gained until now in actual project execution, especially in case of large-scale activities. Many causal relations between human activities and changes in the natural environment and their effects on climate are not yet well understood. External effects limit the practical use of conventional cost-benefit or cost-effectiveness evaluations. There is still an enormous need for research in the future.

Highest efficacy in use of the limited funds available for research related to implementation aspects can be obtained if these funds are used in activities helping to overcome the most pressing needs of information. Active participation of policy makers in choosing the direction of the research aims will be beneficial.

4.1.2 Relevance for Dutch policy makers

Clearly, the NOP-MLK programme is not intended to address all research topics in the field of implementation of climate change abatement strategies and developing countries. Other organizations are placed in a better position to fund specific research topics. The Directorate-General for International Cooperation of the Ministry of Foreign Affairs (DGIS) is mainly active in country-specific programmes and projects in developing countries themselves. Research activities funded by DGIS have to be executed in close cooperation with local institutions and have to be directly beneficial for policy makers in developing countries. To make a clear distinction between activities which lie more in the domain of DGIS and other funding organizations which are interested in direct applications in developing countries, the following selection criterium is applied: Are the expected conclusions relevant for Dutch policy makers and not only for policy makers in the South? Results should be relevant for all the Dutch government departments of which the formulated policies have the potential of affecting the contribution of developing countries in global warming.

The choice to aim primarily at policy makers in the North results in the potential danger that the research themes reflect too much of a western perspective. To a certain extent this seems unavoidable. But one should bear in mind that the majority of the Dutch funding for research in and for developing countries flows through DGIS, where attention to interests of developing countries has the highest priority.

Policy makers in the Netherlands that can be aimed at in research through the NOP-MLK are mainly the departments of DGIS and VROM, but also EZ, V&W and LN&V (abbreviations are explained in the following paragraphs). It appears that practically all policy preparation research in the field of climate change is either done within the departments or within their departmental institutes (e.g. RIVM). This is partly confirmed by a report of IMEconsult [18], where it is mentioned that for the departments of LN&V and V&W it is not common to contract external advisors.

DGIS and to a certain extent also the other Directorates- General (DGs) of the Ministry of Foreign Affairs are the most directly involved in policy dealing with climate change and developing countries. Current environmental policy of DGIS is described in the above mentioned policy document on development cooperation, of which an outline is presented in Annex B.7.

The Ministry of Housing, Physical Planning and Environment (VROM) is responsible for environmental policy in the Netherlands. At the moment the Climate Change Division is preparing a 'climate document' in which attention will be paid to the relation between global strategies and national policies. VROM coordinates climate research through its departmental institute RIVM (National Institute of Public Health and Environmental Protection), and prepares for the Netherlands position in conferences and institutions such as IPCC. It is also involved in the preparation of a World Climate Treaty.

The Ministry of Economic Affairs (EZ) formulates energy policy and coordinates energy research. EZ also has to deal with international trade and domestic taxes and subsidies. Some of the topics of the DGIS spearhead programme 'Environment' which are mentioned under category 3 in Annex B.7 ('Environment in the (international) economic system') are also in the sphere of influence of EZ.

The Ministry of Public Works (V&W) is responsible for the meteorological institute KNMI and for coastal management through "Rijkswaterstaat" (Department of Public Works). Dutch coastal management policy is related to developing countries in two ways. First, a large scale effort made in the Netherlands will affect international availability of knowledge and techniques on adaptation measures against sea level rise. Second, massive and more or less successful support given to developing countries might well affect acceptability of adaptation measures in The Netherlands and other industrialized countries.

The Ministry of Agriculture, Nature Conservation and Fisheries (LN&V) has a link with climate change problems through its nature conservation policy. It can be involved through the international transfer of technology in the forestry sector.

Research could also be aimed at supporting the contribution of the Netherlands as a member of the European Community (EC).

The possible outcomes of research funded through NOP-MLK should have implications for policy decisions in the Netherlands and not exclusively for policy decisions in developing countries.

4.1.3 Relative priority of the solution

Some of the suggested greenhouse gas abatement strategies are expected to have a large impact on global warming. These are for example reforestation and combatting deforestation, energy conservation and the phasing out of the use of CFCs. Others have a lower potential or will almost certainly be very difficult to implement, such as the conversion of wet to dry rice cultivation and preventing the formation of N_2O caused by the use of fertilizer. Priority should be given to research dealing with the solutions with the largest expected contribution in the abatement of global warming. However, in case of comparative advantages of Dutch research capacity it should be allowed to focus on solutions which do not directly promise to have a large impact.

4.1.4 Degree of international cooperation

There is a strong preference to establish a minimum level of cooperation with institutions in developing countries to guarantee that their interests are well enough taken care for, that the right priorities are given to the different problems and that suitable information is obtained. Because the focus is not on direct implementation, candidate organizations for cooperation need not be limited to government departments and may include universities and other research organizations and even NGOs.

It is not required that all the proposed research should be adjusted to current international activities. There should be room for new topics in case the field of research is not yet taken up in other countries, which might be possible in those areas where the Netherlands has a comparative advantage. However, in practice most topics are of such a general nature that comparable activities in other countries exist already or will be initiated soon. In that case the proposed research should be brought in line with these activities.

4.1.5 Application of selection criteria

The selection criteria are meant to limit the large amount of possible research topics to a more manageable number of suitable policy-oriented research themes, supporting the preparation of those elements of Dutch policy which are related to greenhouse gas emissions and climate change in developing countries. An example of a research activity which has a low priority of being funded by NOP-MLK, is research accompanying implementation projects of energy-efficient or renewable energy technologies in a particular developing country. This is because it is too much focused at applications in the local situation in developing countries instead of being directed at policy preparation in the Netherlands, thereby making it more suitable for funding through DGIS. Also funding of applied research to improve energy efficiency of different technologies or to develop renewables is clearly outside the scope of NOP-MLK, because it is not policy-oriented. An example of what can be suitable of being funded by NOP-MLK in relation to energy efficiency and renewables is research into the barriers in transfer of energy-efficient technology and into the role of the Netherlands government in stimulating this transfer of

technology. In case of forestry, the research related to an individual reforestation project is not eligible for funding by NOP-MLK, but studying more in general the nature of barriers to reforestation or social forestry measures can be included.

In general, the choice to focus on the implementation measures related to Dutch policy implies the exclusion from this programme of all technical oriented research. But policy studies which are aimed at governments in developing countries need not be excluded always. That is because only a maximum of 50% of the funds needed for a proposed research activity can be covered by NOP-MLK. The rest must be obtained from other sources, who have their own restrictive criteria which will be different from the three mentioned above. This implies that the interpretation of the criteria should not be exclusive. For example the first criterium of relevance for Dutch policy makers should not imply that the research need not be important for policy makers in the South. It has to be advantageous also for the latter group to be able to secure finance from for instance DGIS. The larger the share of project funds contributed by NOP-MLK, the more important it becomes to comply with the criteria. The idea of having a special niche of research which can only be funded by NOP-MLK is irreconcilable with the condition that half of the funding should come from another agency.

There are two main advantages in financing only part of the required funds. The first is that the proposal is also evaluated by another institution, so that the chances increase that a competent research group obtains funding for a useful research activity. Secondly, the number of potential beneficiaries of the research outcomes becomes larger because of the involvement of another institution. However, there is the disadvantage that there might be useful research proposals which cannot be granted in this way because there is no obvious additional source of finance. It might be impossible to set up a research design in such a way that it satisfies the requirements of more than one funding agency. For those cases it is recommended that the current condition is relaxed that at most 50% of the funds needed can be covered by NOP-MLK.

4.2 Recommended research themes

The recognition of the importance for developing countries of undesired side effects of seemingly unrelated policy measures in industrialized countries is long overdue. A well known example is the distortive effects the European Community's Common Agricultural Policy has on food security in Africa. In the field of climate change, demand patterns in industrialized countries of some tropical products (e.g. the use of tropical hardwood) will affect land-use change in developing countries with negative consequences for global warming. The position taken by the Netherlands on topics directly and indirectly related to climate change and developing countries needs to be well-founded, in bilateral contacts as well as in the international fora. Besides preparation research for the IPCC, this relates to activities of the financing organizations such IMF and World Bank (Global Environmental Facility, debt-for-nature swaps and debt-for-development swaps), and e.g. the UNCTAD and GATT (trade and technology transfer).

Widespread support from developing countries for global warming abatement strategies cannot reasonably be expected except in a "no-regret" situation. In that case, even if climate change would turn out to be absent or much smaller than expected now, the costs incurred of greenhouse gas abatement would not be regretted. This could take place if the measures are more or less completely financed by the North or in case of a so-called "tie-in" strategy, where there are extra advantages besides the global warming aspects. An example of the latter is erosion prevention as an advantage of forest conservation with the aim of preventing the release of the stored carbon. Taking into account these "tie-in" effects is a step further in the direction of integrating environmental aspects as a generally accepted part of a cost-benefit analysis of human activities.

It is unlikely that developing countries will go further in the foreseeable future than adopting a "no-regret" strategy. In some of the industrialized countries there is a tendency to go beyond this, towards a "precautionary strategy", whereby options are included of taking measures only for the sake of preventing climate change. This can not be expected from most developing countries because their current and historical greenhouse gas contributions are generally low compared to the contributions of the North and also because of a lack of domestic funds and because of the higher priority given to development activities. This implies that solutions in developing countries should either have strong "tie-in" advantages or have to be financed for a considerable part by the North.

The global environmental problems as mentioned under category 1 in Annex B.7 suggest activities in developing countries which probably will not substantiate if they are not financed by the industrialized countries. In contrast with that, most activities in the field of sustainable development on national level (category 2, Annex B.7) are accompanied with important 'tie-in' effects.

Themes for research dealing with international relations and domestic policy which are recommended to be funded through NOP-MLK are given in the rest of this paragraph, using the classification of IPCC as discussed earlier. Wherever the research themes fit in with activities of the DGIS spearhead programme 'Environment' this has been mentioned explicitly. It should be stressed again that these themes are primarily directed at policy makers in the Netherlands, implying that research dealing with the diagnosis of the local situation, and the search for local solutions is important, but outside the scope of NOP-MLK.

4.2.1 Public information and education

Supplying information and providing education are activities which are crucial in obtaining sufficient wide-spread support for a substantive climate change abatement strategy. However, these are not in need of specific research activities, and are therefore excluded here. They have to be covered by the existing public information channels such as the National Commission on Information and Public Awareness on Developing Cooperation (Nationale Commissie voorlichting en bewustwording Ontwikkelingssamenwerking: NCO) and the Information Service Development Cooperation (Voorlichtingsdienst Ontwikkelingssamenwerking: VDO) of the Ministry of Foreign Affairs. Also research in setting up public information campaigns in developing countries is not included because its focus is primarily at the local situation.

4.2.2 Technology development and transfer

Guiding applied research

Most fundamental research is supported and funded by governments and most applied research takes place within private companies, and almost exclusively in industrialized countries. In the past the applied research related to climate change and with applications in developing countries has been mainly focused on non-conventional and renewable energy supply technologies such as biomass digesters, biomass gasifiers, windmills and solar energy techniques. Despite considerable efforts in basic research, technology development and implementation, only local and limited results have been attained, with the possible exception of the use of bio-ethanol (in Brazil) and the dissemination of some improved charcoal stove types. Their combined contribution in the abatement of global warming is small at the moment.

To obtain an accurate picture of the role of a particular biomass technology one should not only include fossil fuel savings and avoided carbon dioxide emissions but one should also include effects on emissions of the other greenhouse gases. For example in case of biomass digesters the avoided methane emissions are more important in the light of

greenhouse gas abatement than the avoided carbon dioxide emissions from the use of an equivalent amount of fossil fuels. Including these aspects can work out favourably for some of the biomass using technologies. It is still unclear what the effects on the emission of methane and carbon monoxide are of the more controlled combustion of biomass in a gasifier compared to direct burning.

Besides the above mentioned energy supply technologies, for which the need for government support was recognized from the start, there is the much wider field of energy consuming equipment. When applied in developing countries their use generally does not differ substantially from the use in industrialized countries. In that case, there is no need for special adaptations, requiring additional applied research. However, sometimes the circumstances of use in developing countries are different, resulting in the need for adjustments. For example many cars, especially public vehicles and trucks, have engines that are worn out or are tuned up in such a way that motor power is at its maximum, resulting in thick clouds of incompletely burned fuel leaving the exhaust. Through photochemical smog this can have disastrous effects on city air-pollution and contribute to global warming.

Another example where extra applied research will be useful is rural electrification. The high cost of system expansion, which is usually only for a small part covered by electricity bill receipts, forms a drain on government budgets and takes up a considerable share of international development funds. This is the main reason for the often low percentage of rural households having access to electricity. These costs can be limited by planning appropriate distribution systems, by using energy efficient electric appliances to slow down the rate of capacity expansion, and by including the option of decentralized use of renewables where they constitute a viable alternative to grid extension.

Research funded within the NOP-MLK programme could start with coping with the following questions: Do products and processes exist, for which there is a well-defined need for additional research, directly beneficial for developing countries? Should governments in industrialized countries stimulate such applied research, and if yes, in what way? What are the areas where private companies do not have enough incentives in improving technologies to become optimally suited for the use in developing countries? How can (rural) electrification take place with the lowest reasonably attainable emission level of greenhouse gases? This, while taking into account that the prime objective of both policy makers in developing countries as well as donor agencies supporting rural electrification will remain the strategy of least cost system expansion. Is there a need for additional research in the field of replacement of CFCs?

How does the choice of technology in industrialized countries affect its use in developing countries? It appears that part of the technological developments show up in the South with some time lag. Does that mean that e.g. an extra effort in industrialized countries to develop even more efficient electric appliances will eventually have the additional benefits of improved efficiency in developing countries through a sort of global 'trickle-down' process? Where are the decisions taken concerning the application of the different technologies?

Technology transfer

Within development processes technology transfer can play a crucial role. Inappropriate technologies can hamper development and cause excessive dependence on imports of spare parts and fossil fuels. Not only energy conversion technologies and end-use equipment are involved, but also processes in industry and the choice of transport equipment. It also includes transfer of techniques for sustainable agriculture and sustainable forest management.

Is the current process of technology transfer of energy efficient equipment and processes adequate and of a sufficient scale to guarantee timely implementation of greenhouse gas abatement options in developing countries? How can the barriers be eliminated, which currently limit technology transfer? Which technologies and in which countries give the

best opportunities for 'leap-frogging' (this implies skipping the successive stadia of the use of increasingly efficient technologies, by directly using the best practical means). What can be the future role of transnational corporations (multinationals or TNCs), individual governments of industrialized countries and the GATT? What are the effects of dumping obsolete technologies? In general, research in this field should not deal with the problems of the transfer of a certain technology to a specific developing country, but should be limited to the more general policy aspects of technology transfer.

Techniques for sustainable agricultural practices and sustainable tropical forest management are often practised already by indigenous peoples. Research into formalizing this knowledge is not within the scope of the NOP-MLK programme, but the consecutive step of dissemination of knowledge and techniques can be included. This will be mainly a process of transfer of knowledge from South to South.

Technology transfer can play an important role in case of the adaptation measures for which the Netherlands has a comparative advantage. This is especially the case for coastal management where past experiences can be used to support the low lying developing countries. Rijkswaterstaat (the departmental institute of the Ministry of Public Works) has contributed to the Coastal Zone Management Subgroup of the IPCC Response Strategies Working Group III. The work in this group focused on studying the impacts of climate change on coastal areas and assessing the options for adaptation to sea level rise.

4.2.3 Economic measures

Comparative cost-effectiveness assessments
A considerable number of solutions have been suggested already for the abatement of greenhouse gas emissions. The cost-effectiveness of these measures appear to span a whole range. Tie-in measures, having extra benefits besides the environmental aspects, sometimes have negative greenhouse gas abatement cost if these extra advantages are taken into account. This is the case with many energy conservation projects, and also for most reforestation and forest management activities. At the other end of the range are some costly renewable energy and end-of-pipe CO_2 removal projects, without any positive "tie-in" effects. For the spearhead programme 'Environment' of DGIS the outcomes of comparative cost-effectiveness studies will support the decision process of allocation of funds within the category of activities dealing with 'global environmental problems' (category 1, Annex B.7).

In the context of a suggested international system of tradable emission permits, studies are needed to assess the relative cost effectiveness of the different solutions. Special attention needs to be given to differences in cost effectiveness between application of the different measures in industrialized and developing countries and how this will affect the optimal global distribution of measures. Interrelations between the different suggested measures should be taken into account. Successful energy conservation measures might e.g. decrease the scale of fuel substitution. Besides the questions regarding equity and other resulting problems of large-scale transfer of funds, an analysis should include non-economic aspects such as population pressure and domestic customs and laws. Outcomes of comparative cost-effectiveness assessments will be supportive in the choice of measures in the field of taxes and subsidies and will also assist in directing financial assistance, from e.g. a Climate Fund, to the most cost effective measures.

Taxes and subsidies
One of the common policy instruments to influence human behaviour is the imposition of taxes and subsidies. These are often meant to stimulate a more rational behaviour leading to a more efficient allocation of means. Taxes and subsidies leave individual actors such as households and firms the freedom to decide if action should be undertaken and to what

What is a justifiable amount of funds as compensation for guarding a part of the 'global commons'? How can the interests of developing countries be looked after well enough in the position taken by the Netherlands, including its position as member of the EC?

Global structural change
Currently there is a tendency that energy-intensive basic industries gradually move to developing countries because of availability of resources (vertical integration), lower wages and less strict environmental standards. National laws restricting domestic production of CFCs might lead to moving production capacity of e.g. refrigerators to other countries. How does this affect optimal setting of national greenhouse gas emission ceilings in a climate treaty? Studies dealing with global structural change make up part of the research which needs to be done in the field of 'environment in the economic system' (category 3, Annex B.7).

Integration of greenhouse gases in Environmental Impact Assessments
Some developing countries already have the legal requirements for executing environmental impact assessments for large and potentially damaging activities. The number of these countries is likely to increase in the future. At the moment it is not yet common to include effects on global climate in an environmental impact assessment. Research will be needed to operationalize inclusion of greenhouse gas emissions in standard environmental impact assessments. This work is related to efforts which are being made to include social costs or externalities such as environmental effects in a standard project evaluation (environmental accounting). It falls under the activities of 'development of instruments' as part of the DGIS spearhead programme 'Environment' (category 4, Annex B.7).

5. SUMMARY AND CONCLUSIONS

Greenhouse gas emissions:

- The contribution to greenhouse gas emissions from the North and from the South are approximately at the same level.
- Largest contribution in the South comes from deforestation and other land-use changes, while in the North the energy sector provides by far the largest share.
- Uncertainties about the emissions of different greenhouse gases are considerable and are much larger for the contribution of the South than for the North. This is so, because largest uncertainties remain on carbon dioxide emission from deforestation as well as methane and nitrous oxide emissions, that have a relatively larger share in emissions from the South than in emissions from the North.

The response strategies which are generally thought to be the most effective in the abatement of global warming are:

- Efficiency improvements in the energy system and conservation in energy end-use.
- Improved management and conservation of existing forests and re- and afforestation.
- Substitution of CFCs by less harmful products such as e.g. HCFCs.

The following criteria are used to restrict research themes and proposals to those which are optimally suited for being funded by the NOP-MLK:

- The research should be policy-oriented and relevant for Dutch policy makers.
- Priority should be given to research dealing with options which could make a large contribution to the abatement of global warming.
- There has to be at least a minimum level of cooperation with institutions in developing countries.

The identified research themes after application of the selection criteria can be ordered according to the classification of implementation measures as used by IPCC:

- Technology development and transfer:
  - Role of the government in guiding applied research.
  - Aspects of technology transfer.
- Economic measures:
  - Comparative cost-effectiveness assessments of the different suggested solution strategies.
  - Taxes and subsidies as instruments to influence behaviour in a direction which is favourable to the abatement of global warming.
- Financial measures:
  - Research supporting foundation and operation of a climate fund.
  - Research related to other funding mechanisms.
- Legal and institutional measures:
  - Side effects of international trade restrictions meant to be beneficial for the abatement of greenhouse gas emissions.
  - Equitable negotiation criteria to be used in the preparation of a climate treaty.
  - Effects of global structural change of production on emissions of greenhouse gases and setting of national emission ceilings.
  - Integration of greenhouse gases in Environmental Impact Assessments.

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ANNEX A BACKGROUND DOCUMENTATION ON THE CONTRIBUTION OF DEVELOPING COUNTRIES TO GREENHOUSE GAS EMISSIONS

To compile the emission data presented in this report detailed estimates of emissions per activity (e.g. oil combustion) per gas (e.g. CO_2) per region (e.g. Africa) were made for the current (1985) situation and for the year 2025 (Business-as-Usual and Policy scenarios). The data are basically based on IPCC data, presented in the following reports: 1) the report of Working Group III (IPCC-III 1990); 2) the report of the IPCC US/Netherlands Expert Group (Task A 1990), 3) the report of the IPCC US/Japan Expert Group (US/Japan 1990), and 4) a recent USAID report (USAID 1990), in which a compilation of emission data from IPCC is presented.

The global total emissions per gas correspond to the IPCC values. The IPCC reports do not always provide the required regional details. To compile a regional breakdown per gas per activity, other literature had to be used in addition:

- energy consumption:
  - current (1985) CO_2 emission data for oil, gas and coal combustion per region from Wagner & Waldeck (1988), WRI (1988), tables 7.1, 20.1; Goldemberg *et.al.* (1988), notes 1.1-A, 2.1-A, 1.1-B;
  - the 2025 data are taken from USAID (1990), table 3.2/4.1, that are based on estimates given in Task A (1990);
  - global CO, CH_4 and N_2O emissions in 1985 and 2025 are based on estimates in Ahuja (1990) and IPCC (1990) and allocated per region according to the CO_2 emissions;
- energy production:
  - 1985 emissions from coal and gas production taken from US/Japan (1990), p.29-33 and WRI (1988), table 7.1; China and India data from ADB (1987) and WRI (1988);
  - the 2025 emissions are adapted from data given in US/Japan (1990) and IPCC-III (1990);
- cement manufacturing:
  - current emission data taken from USAID (1990), table A2.2 and Goldemberg *et.al.* (1988), note 2.5.3.4.-D;
  - for 2025 a doubling of emissions is assumed in both scenarios, corresponding to the assumptions in IPCC-III (1990);
- landfills:

  in both scenarios the global emission values (e.g. 40 $TgCH_4$ in 1985) is taken from IPCC-III (1990), and allocated per region according to estimates given in US/Japan (1990).
- halocarbons (CFCs/HCFCs):

  emission data are taken from USAID (1990), tables 2.2, 3.8 and 4.5, that are based on data given in Task A (1990);
- use of fertilizer / rice cultivation / livestock:

  emissions are taken from USAID (1990), tables 3.7/4.4, based on the Task A (1990) report; and from WRI (1988), tables 17.2 and 17.5;

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ANNEX B SELECTED INTERNATIONAL ACTIVITIES CONCERNING CLIMATE CHANGE AND DEVELOPING COUNTRIES

B.1 Introduction

Numerous research efforts have been made already in relation to climate change. Much of it is indirectly of interest for developing countries. Some of the outcomes were presented in chapter 2. To prevent the occurrence of too much double work and to guide the choice of themes for future research a discussion is presented here of some selected international activities concerning climate change and developing countries. These include:

- three large international research programmes (policy preparation for UN, sectoral energy studies in developing countries, and a model/database to assess greenhouse gas abatement strategies);
- environmental policy statements of a multilateral and two bilateral donors;
- an international plan on forestry.

The Intergovernmental Panel on Climate Change is the largest international effort dealing with climate change research and policy formulation and coordination. Most of the numerical information in this report is taken from IPCC reports.

A well-known programme on energy end-use is being executed by Lawrence Berkeley Laboratory. Comparative analysis of energy and CO_2 emission scenarios for the main developing countries are made.

The Boston Center of the Stockholm Environment Institute has developed a data base and model which can be used to make long-term projections of greenhouse gas emissions. It can be used as a tool in the assessment of greenhouse gas emission abatement strategies.

Currently, climate related policies are being formulated in a situation characterized by many remaining uncertainties. In some cases policy preparation is even preceding research outcomes. This situation stimulates a strong backward link towards research. For this reason, environmental policy of a large multilateral agency (the World Bank) and a large bilateral donor (USAID) are described here, as well as that of the Dutch Directorate-General for International Cooperation (DGIS).

Some activities are in the stage of execution, part of them having been started originally for other purposes than abating climate change. Many future forestry projects will be brought under the Tropical Forestry Action Plan (TFAP). The large amount of criticism which has accompanied the TFAP is an indication that much more research is needed.

B.2 Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change is a body set up by the UN General Assembly in 1988 to advise world leaders on global climate change. It is established under the auspices of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP).

The IPCC scientists have been working in three working groups. Working Group I [1] focuses on scientific issues: the nature of the greenhouse threat and the science of climate modelling and prediction. Working Group II [2] studies on the impacts of climate change on agriculture, ecosystems, coastal zones and water resources. Working Group III [3] deals with policy responses: prevention and adaptation options and their implementation. By August 1990 the integrated results of the three working groups were published in draft

reports [4], and presented at the IPCC conference in Sundsvall, Sweden. These IPCC reports served as a basis for policy agreements between governments that were negotiated at the World Climate Conference in Geneva, October 1990.

Main conclusion of Working Group I on scientific issues was that emissions of greenhouse gas from human activity *will enhance* the natural greenhouse effect resulting in an additional warming of the earth's surface. Based on computer simulations they predict an average rate of temperature increase of 0.3°C (0.2-0.5°C) per decade and a sea-level rise of about 6 cm (3-10 cm) per decade (if emissions continue at their present rates). There are however many uncertainties with regard to timing, magnitude and regional patterns of climate change.

In line with the climate change predictions of Working group I, Working Group II reports on impacts of such climate change:

- production of agricultural, livestock and forestry products can increase or decrease, and patterns of trade in these products can change;
- natural ecosystem zones shift towards the poles;
- large water resource problems can occur, especially in (semi-)arid zones;
- human settlements in coastal lowlands and islands are vulnerable to floods and severe storms, in (semi-)arid areas droughts could intensify.

The consideration of climate change response strategies has so far proven to be a very sensitive subject for policy makers. In view of the seriousness of impacts of climate change the IPCC scientists of Working Group III call for responses despite the uncertainties surrounding climate change. Responses that can be justified on other reasons besides greenhouse warming are: phasing out halocarbon emissions, efficiency improvements and conservation in energy demand and supply, use of energy sources with no or less emissions, more efficiency in the production of goods, sustainable forest management and review of agricultural practices. It is natural that developing countries give priority to economic growth to narrow the gap between North and South. Emissions from developing countries are expected to increase significantly. A rapid transfer of technologies that help to limit or adapt to climate change (together with financial assistance) is urgently needed. This asks for close international cooperation.

B.3 Country Studies by Lawrence Berkeley Laboratory

The Energy Analysis Program of the International Energy Studies Group of Lawrence Berkeley Laboratory (LBL) is a well known program of sectoral and end-use oriented studies of energy consumption in developing countries. In the course of a whole series of research activities, quantitative and qualitative energy demand information has been compiled for many developing countries. This places the group in a good position to conduct energy demand scenario studies related to greenhouse gas emissions [5].

Currently a collaboration study is going on with research groups in the following developing countries; China, India, Indonesia, South Korea, Argentina, Brazil, Mexico, Venezuela, Nigeria, Tanzania, Sierra Leone, Egypt, Taiwan and the six countries of the Gulf Cooperation Council (GCC). The study aims at a better understanding of changes in economic structure, energy efficiency and fuel mix. Long-term energy scenarios are being developed for each of these countries. In future studies will be conducted to evaluate costs and benefits of reducing carbon emissions from these countries [6].

The focussing year of the energy scenarios is 2025. Energy demand is disaggregated by its major end-uses, and where relevant by income class. Real GDP (Gross Domestic Product) is taken as an indicator of economic activity. International comparisons of activity

levels (production per capita and saturation of consumer goods) are made, comparing current levels achieved in more advanced economies with the expected future activity levels in the developing countries.

In the preliminary analysis, two scenarios were developed. In the High Emissions (HE) scenario, policies affecting economic growth are included, but no climate related considerations are made. The Low Emissions (LE) case evaluates the effect of explicit policy measures to curb carbon emissions. Both scenarios assume the same GDP growth figures.

The first results show that for the nine large energy-consuming developing countries, that are covered by the study [7], total annual carbon emissions in 2025 will reach a level of 3.27 billion ton according to the HE case and 2.57 billion according to the LE scenario, up from a level of 0.84 billion ton in 1985. The share of electricity in the South's fuel mix is expected to rise 6-fold. About 80% of the reduction in carbon emission in the LE case was attained because of energy efficiency improvements and the rest by fuel switching [8].

The identified future greenhouse gas emission trends per sector are as follows:

1) In the *residential* sector one first transition that will perpetuate is the shift from biofuels to (more efficient) fossil fuels, and a second one is the expanded use of electricity. The first transition contributes to slower increase in primary energy consumption (but an increase in CO_2 emissions); the second one contributes to both an increase in fuel consumption and CO_2 emission. In both scenarios carbon emissions will increase. Reduction possibilities exist primarily in more efficient use of electricity and the use of non-fossil sources of energy in electricity generation.
2) In the *transportation* sector fuel demand will increase, influenced by GNP growth (freight transport) or GNP per capita growth (passenger transport). Emissions will increase therefore. Emission reduction possibilities exist in improving fuel efficiency, use of mass transport and substitution by biomass-derived fuels (e.g. ethanol).
3) In both scenarios the *industry* sector contributes most to carbon emissions by 2025. The fuel mix becomes less carbon-intensive as the share of coal will decline.
4) The shares of the *commercial* and *agriculture* sectors in fuel demand are presently small, and will remain relatively small. Possibilities of efficiency improvements in the commercial sector are the same as in the residential sector.

B.4 Greenhouse Gas Scenario System of SEI-Boston

The Boston Center of the Stockholm Environment Institute (SEI-B) is housed at the Tellus Institute, formerly named the Energy Systems Research Group. Many years of experience in scenario analysis resulted in the development of the LEAP (Long-range Energy Alternatives Planning) system. LEAP has become a widely-used, user-friendly energy planning model. Recently, SEI-Boston developed a new program, called Greenhouse Gas Scenario System (G2S2). It is a database and policy assessment tool which assists in making projections of net anthropogenic emissions of all major greenhouse gases. LEAP can be used to provide inputs for G2S2. The G2S2 system is a computer-based tool for: [9]

- compiling and reporting current and historical greenhouse gas emissions,
- projecting greenhouse gas emissions under a range of economic and demographic assumptions, and
- assessing the feasibility and consequences of policy scenarios for reducing greenhouse gas emissions.

For the base year, data are used from 145 countries divided over nine regions. Historical emissions of the major greenhouse gases are used; methane over the period 1980 to present, carbon dioxide and nitrous oxide from energy use, land-use change and biomass

use over the period 1860 to present, nitrous oxide from fertilizer use from 1900 to present, and carbon monoxide from energy use, land-use change and biomass use over the period 1985 to present [10].

Eight major sources of greenhouse gases are included: energy consumption, cement production, CFC use, landfills, land-use change, livestock production, rice cultivation and fertilizer use. G2S2 reports at country, regional and global level [11].

A set of reference projections has been made for the period up to 2010, based on population data from the World Bank and GDP growth assumptions from US Environmental Protection Agency. These are being modified at the moment, including price and income effects, and "natural" efficiency changes [12].

B.5 Environmental policy of the World Bank

Following the universal acknowledgement that environmental management is intimately linked to sustainable development, the World Bank now recognizes the need for integrating environmental concerns in all its activities. Thereby special attention is required for the following five problem areas:

- destruction of natural habitats
- land degradation
- degradation and depletion of fresh water resources
- urban, industrial and agricultural pollution
- degradation of the "global commons" [13].

For all projects with significant environmental impacts an environmental assessment is required since October 1989. In the so-called Environmental Assessment Operational Directive, the process of evaluating projects is standardized and formalized. This makes it more likely that environmental consequences are recognized in an earlier stage of the project cycle, and can be taken into account in the project design. The borrower is responsible for the environmental assessment, which encourages the development of know-how and the strengthening of institutional capacity in the individual countries.

World Bank loans for environmental purposes consist on the one hand of free-standing environmental loans and on the other hand of projects with benefits to the environment as a by-product. Free-standing environmental loans increased in number from 2 in 1989 to 11 in fiscal year 1990. They are mainly concentrated in Africa and focus on conserving natural habitats and tropical forests. Examples of components of projects in 1990 which benefit the environment as a by-product were; the elimination or reduction of subsidies for pesticides, full cost recovery in pricing energy or water services, and improved land distribution policies and tenure arrangements.

The Global Environmental Facility is a new programme located in the World Bank in cooperation with UNEP and UNDP. It is meant to support measures to protect the "global commons", acting in situations where individual countries would have to bear the cost of environmental protection, but where the benefits accrue to the global community. The facility will fund programmes in the following areas: protection of the ozone layer, reduction in greenhouse gas emissions, protection of biodiversity, and protection of international water resources.

For future environmental strategy work it will be crucial to improve the understanding of consequences and underlying causes of environmental degradation. Increased effort will be needed to identify appropriate social, economic and other policy measures for sound environmental management. Also the relation between poverty and environmental degradation needs further attention. A key question concerns the feasibility of continued

economic growth on a global scale. Future economic development will increasingly depend on technical progress in using resources efficiently. This should be an international effort, also involving the industrialized countries.

B.6 USAID global climate policy

USAID is pursuing a strategy on global change that supports robust, sustainable development in the face of scientific uncertainty [14]. This is a consequence of the current USA's "no-regrets" policy whereby those measures are propagated which are worth implementing, independent of the reality of the greenhouse effect.

In the energy sector the on-going programmes focus on policy reform, including pricing, least-cost planning, private sector involvement, improved energy system and environmental management, and clean-energy technology commercialization. The technological innovation programme stresses energy efficiency, renewables and clean fossil options. One of USAID's newly proposed activities is the Global Energy Efficiency Initiative (GEEI) which is meant to become an international programme of energy efficiency. Together with the US Electric Power Research Institute (EPRI) and utilities in industrial and developing countries the possibilities of an international electric utility network are evaluated. This network would sponsor collaborative research and technology development related to climate change.

Current activities in the forestry sector involve debt-for-development swaps in the Philippines and Madagascar. USAID is providing finance for a reforestation project in Guatemala which is meant to offset the carbon dioxide emissions from a new coal-fired power plant in the USA. Furthermore, studies are conducted assessing sustainable agricultural systems. New climate related initiatives in the forestry sector are: strengthening international tropical forest research and expanding technical services in forest management, buffer zone development, conservation and nature tourism. Further research efforts are needed into root causes of tropical deforestation and degradation, including market failures and policy distortions. In the fiscal year 1991 starts the Sustainable Agricultural Systems Collaborative Research Support Program (CRSP) that will integrate agricultural, environmental and social sciences within USAID's agricultural portfolio.

Key countries for USAID support in the field of climate change are Brazil, India, Indonesia, Mexico, Pakistan, Philippines, Poland, Zaire and the Central American region. The selection of these countries was based on two criteria: a) the present and potential contribution to emission of greenhouse gases, and b) political considerations [15].

B.7 Environmental policy of DGIS

Recently, the Minister of Development Cooperation presented a policy document to Parliament, including the outline of an environmental policy for the coming years [16]. It is the intention that the environmental component will be integrated in all relevant development cooperation activities. To advance this goal a new spearhead programme has been established, extending the already existing 'Energy and Ecology' programme. In general the four new spearhead programmes are intended to direct, more or less temporarily, extra attention to a specific theme with the aim that eventually it will become an integral part of regular development cooperation activities. In the spearhead programme 'Environment' additional funds are available for small-scale measures and large-scale programmes and projects which are not yet funded under the regular programme.

Policy intentions formulated in the policy document [17] which are directly or indirectly related to climate change are the following for the different fields of activities:

UN organisations
The Netherlands shall pursue a policy of strengthening the UN organisations with authorities to enforce environmental measures, to bring about commodity agreements which promote sustainability and diversification (UNCTAD), to strengthen environmental considerations in trade and investment regulations (GATT) and to add the environmental component to structural adjustment programmes (World Bank) [18].

Regulations
Netherlands policy will aim at preventing 'double standards', implying that Dutch firms who want to invest abroad have to stick to the same environmental regulations as they are amenable to in the Netherlands. Therefore developing countries have to prepare adequate environmental laws, for which the Netherlands will supply technical support [19].

Forestry
In the field of tropical forestry the Netherlands will contribute through:

- strengthening of organisations of forest dwellers;
- an effective control system to prevent exhaustion of resources caused by over-exploitation of wood;
- international trade policy through ITTO;
- international nature conservation treaties;
- international treaties for forest management, reforestation, prevention of erosion and desertification;
- contribution to improved forest management through the Tropical Forestry Action Plan [20].

Energy planning
Developing countries will be assisted further in developing energy planning capacity, including mechanisms for examining energy efficiency, research and building of production capacity. Some research will continue to be executed in the Netherlands, which should be coordinated with the National Research programmes for renewable energy [21].

Urban areas
The Netherlands will assist with the introduction of efficient stoves, possibly in combination with substitution of kerosene and LPG for wood and charcoal. In the electricity sector, policy will be directed at end-uses such as lighting and household appliances. More attention shall be given to environmental pollution and energy saving activities in the assistance to firms in developing countries [22].

All four categories of activities in the spearhead programme 'Environment' are more or less related to climate change [23]:

1. Global environmental problems
   Measures which transcend boundaries are generally not directly relevant for the development of individual countries, implying that additional mechanisms are needed such as financial support and technology transfer. Main themes are: greenhouse effect, CFCs, biological diversity and conservation of tropical rainforests.
2. Sustainable development on (sub-) national level
   Emphasis is on direct relevant development policy with attention for themes such as Low External Input Sustainable Agriculture (LEISA), management of natural resources (incl. forestry), energy and urban environment.
3. Environment in the (international) economic system
   Relation between environment and trade, commodities, international flows of capital, trans national corporations, debts, structural adjustments and so on.

4. Development of instruments; knowledge improvement
   This consist of operationalizing ecological sustainability at all levels: from knowledge improvement of local management systems in their cultural environment to the systematic integration of environmental values in economic and other decision instruments.

B.8 Tropical Forestry Action Plan

In 1985 the Tropical Forestry Action Plan (TFAP) was started as an international framework for sustainable development and management of tropical forests. The Food and Agriculture Organization of the United Nations (FAO) is the lead agency, being supported by the World Bank, the United Nations Development Programme (UNDP) and the World Resources Institute.

> "The ultimate goal of the TFAP is to enhance the development and conservation of tropical forestry resources and their contribution to sustainable socioeconomic development. The specific objective is, that it wants to provide the conceptual and coordinating framework for immediate, accelerated and joint action at both international and national and local level in the field of tropical forestry.
>
> In this respect the TFAP has the following main functions:
>
> - to increase national and international political and public awareness on tropical forestry to achieve higher priority of forestry in national plans and in international cooperation,
> - to be a tool to review national policies and to identify strategic lines of action and investment priorities at national level,
> - to increase fund allocation for forestry,
> - to strengthen and harmonize national action and be an effective device for coordination of multilateral and bilateral development cooperation and investment in the field of forestry."

(This citation and most of the information presented in this section about the TFAP is from a report of the Foundation BOS,) [24].

There are five priority areas for action selected:

- forestry in land use.
- fuelwood and energy.
- conservation of forest ecosystems.
- forest-based industrial development.
- the institutional base for forestry development.

The TFAP is an international framework with a focus on activities at the level of the individual countries. Each country is responsible for the organization and implementation of the exercises at country level. In a preliminary stage, a group of participating agencies is formed consisting of some multilateral and bilateral donor organizations, with one of them acting as coordinating Lead Agency. The planning stage starts with carrying out a *forestry sector review* to determine the constraints, problems and potentials of the forestry sector's contribution to national development and its linkages with other sectors of the economy. This results in the formulation of a short-term national *action plan* and a longer-term *forestry strategy*. In the implementation stage the national TFAP Office and the Lead Agency coordinate and monitor the follow-up activities of the Action Plan. Implementation activities are action-oriented.

A total of 81 tropical countries are involved in the TFAP as of November 1990. Seventeen of them have finished the planning phase and are starting to implement their plans. Another fourteen countries are now in the stage of drafting or approving national Action Plans.

One of the aims of *development cooperation in the Netherlands* is structural poverty alleviation. Therefore, the Dutch contribution to the TFAP is basically focused on the action fields 'Forestry in Land Use', 'Fuelwood and Energy', 'Conservation of Forest Ecosystems' and also on 'Institutions', as far it is directly related to the other three action fields. The national aid volume for the forestry sector is still growing, and is now at the level of about 100 million guilders per year, and is expected to increase to 150 million guilders per year.

NOTES TO ANNEX B

[1] The countries involved in Working Group I are Australia, Austria, Belgium, Canada, China, Denmark, Egypt, Ethiopia, Federal Republic of Germany, Finland, German Democratic Republic, Italy, Japan, Netherlands, New Zealand, Saudi Arabia, Senegal, Soviet Union, Sweden, Switzerland, United Kingdom and United States of America.

[2] Countries involved in Working Group II are Union of Socialist Soviet Republics, Japan and Australia.

[3] Countries involved in Working Group III are Australia, Canada, PR China, Federal Republic of Germany, France, India, Japan, Malta, Netherlands, New Zealand, United Kingdom, United States and Zimbabwe.

[4] IPCC (1990)
- *Scientific Assessment of Climate Change*, Intergovernmental Panel on Climate Change Working Group I, WMO/UNEP, WMO Secretariat, Geneva, June 1990;
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[16] *Een Wereld van Verschil; Nieuwe Kaders voor ontwikkelingssamenwerking in de jaren negentig* (A World of Differences; A New Famework for Development Cooperation in the Nineties), Policy document presented to Parliament by the Minister of Development Cooperation (J.P. Pronk), September 1990.

[17] Ibid.

[18] ibid., p.90.

[19] Ibid., p.91.

[20] Ibid., p.97-98.

[21] Ibid., p.104.

[22] Ibid., p.106.

[23] Ibid., p.342.

[24] Savenije, H. (1990)
Tropical Forestry Action Plan, Recent Developments and Netherlands Involvement, Department of Forestry Development Cooperation (ABOS), Direction Forestry and Landscaping, Ministry of Agriculture, Nature Conservation and Fisheries; Foundation for Duch Forestry Development Cooperation (BOS), Wageningen, Netherlands, 1990.

ANNEX C THE GLOBAL WARMING POTENTIAL OF GREENHOUSE GASES

The potential of a gas for warming the atmosphere is determined by various factors: radiative forcing, atmospheric lifetime and indirect impacts on concentrations of other gases. To compare the emissions of various greenhouse gases these factors have to be taken in one single 'unit'. In this report the contribution of greenhouse gases is expressed relative to CO_2 in *equivalent C units* (PgCeq, TgCeq). One could also have taken *equivalent CO_2 units:* 1 mol of CO_2 is equivalent to 1 mol of C, in other words 1 TgC is equivalent to 3.667 $TgCO_2$.

The emission contribution of non-CO_2 greenhouse gases can be expressed too in equivalent carbon units by using a conversion factor, called the *global warming potential* (GWP). The GWP presents the cumulative radiative forcing caused by greenhouse gas emissions relative to CO_2. The GWP is The GWP expresses the radiative forcing due to an instantaneous injection of 1 kg of each gas relative to 1 kg of CO_2, integrated over time (including indirect impacts). The choice of a time horizon is crucial for the relative role of short-living versus long-living gases[6]. In this study a time horizon of 100 years is taken, corresponding to the IPCC assumption.

	Global warming Potential (GWP)	Assumed residence time in atmosphere (years)
CO_2 carbon dioxide	1	120 years
CO carbon monoxide	3	--
CH_4 methane	21	10
N_2O nitrous oxide	290	150
CFC-11	3500	60

Remarks:

1) GWP of CH_4 includes indirect effects on concentration of the greenhouse gases O_3, H_2O and CO_2;
2) CO is not a greenhouse gas itself, but has indirect effects on concentrations of O_3 and CO_2;
3) In this report the halocarbons (CFCs and other halocarbons as HCFCs) are expressed in CFC-11 equivalents (here shortly called CFC equivalent) and can then be converted into carbon equivalents analogous to the other non-CO_2 gases.

The GWPs used in this report are the same as used by the IPCC, assuming a time horizon of 100 years. There are large uncertainties in GWPs of gases. In a report by ECN, Netherlands [1] a summary of ranges of GWPs is given (calculated for a time horizon of 100 years and for a residence time of CO_2 of 150 years: CO_2 1; CO 2.4-7.5; CH_4 12.4-39.6; N_2O 153-259, CFC-11 1829-3106. These ranges are enlarged further when also the residence time of CO_2 is varied.

6 If the aim of reduction of greenhouse gases is to decrease the rate of warning a short time horizon is chosen. If the aim is to reduce total global temperature a long time horizon is taken.

To summarize, the following conversion factors are used:

	CO_2 equivalents	
	$TgCO_2$	$TgC_{(eq)}$
1 $TgCO_2$	1	0.2727
1 TgCO (= 0.4286 TgC, CO eqs.)	3	0.8181
1 $TgCH_4$	21	5.727
1 TgN_2O (= 0.3182 TgN)	290	79.084
1 TgCFC	3500	954.459

NOTE

[1] On Comparing the Emissions of Different Greenhouse Gases, J. Ybema, Energy Studies, Energy Research Foundation (ECN), Petten, Netherlands, ECN-RX--90-082, December 1990.

ANNEX D INVENTORY OF RELEVANT INSTITUTES IN THE NETHERLANDS

The list of addresses is an inventory of *universities* and *other research institutes*, as well as *consulting companies*, that are involved or could get involved in climate-change-related research in the area of (1) energy, (2) nature and environment, (3) North-South relations (financial-economical, juridical, trade) and (4) technology development, transfer, and assessment. For each institute or department a short description of research or policy topics related to above-mentioned research themes is given. We have tried to cover as much institutes and organizations as known to us, but we do not pretend that the list is complete.

The following information sources have been used:

(1) *Ontwikkelingsgerichtonderzoek in Nederland, Een Overzicht*, Advisory Council for Scientific Research on Development Cooperation (RAWOO, Raad van Advies voor het Wetenschappelijk Onderzoek in het Kader van Ontwikkelingssamenwerking), May 1989.

(2) *Adreslijst 1989, Nederland en de Derde Wereld*, Information Service Development Cooperation, Ministery of Foreign Affairs (VDO, Voorlichtingsdienst Ontwikkelingssamenwerking, Ministerie van Buitenlandse Zaken), 's-Gravenhage, March 1989.

(3) *Pyttersen's Nederlandse Almanak 1990-'91*, Bohn Stafleu van Loghum, 1990.

(4) P.Smits, RAWOO, *private communication*, 5-4-1991.

(5) CIMI (Centrale Ingang Milieu Informatie, Central Information Service on Environment, RIVM), *private communication*, 16-4-1991.

D.1 Universities

Agricultural University of Wageningen (LU, Landbouwuniversiteit)
PO Box 9101
6700 HB Wageningen
08370-89 111

(1) Department of Development Economics (Vakgroep Ontwikkelingseconomie)
Topics: international trade, low-income agriculture, regional planning, land use
Enquiries: 08370-84 360, prof.dr. A. Kuyvenhoven, ir. J.T. Sital

(2) Department of General Economics (Vakgroep Staathuishoudkunde)
Topics: international and environmental economics
Enquiries: 08370-84255, drs.ir. R.P.M. Schout

(3) Department of Forestry, Section of Forest Management (Vakgroep Bosbouw, Sectie Boshuishoudkunde)
Topics: tropical forestry, nature and environment, rural development
Enquiries: 08370-84 426, ir. K.F. Wiersum

(4) Department of Nature Conservation, Tropical Section (Vakgroep Natuurbeheer, Sectie natuurbeheer in de tropen)
Topics: nature conservation, climate change, ecology and development
Enquiries: 08370-83 174, drs. S. de Bie

(5) Department of Theoretical Production Ecology (Vakgroep Theoretische Productie-ecologie)
Topics: plant-breeding and ecology, biosphere and CO_2, climate change impacts on plant production, denitrification in soils
Enquiries: 08370-82 141, prof.dr.ir. R. Rabbinge, dr.ir. J. Goudriaan

Catholic University (KUB, Katholieke Universiteit Brabant)
PO Box 90153
5000 LE Tilburg
013-66 9111

(1) Development Issues Research Institute (Instituut voor Ontwikkelingsvraagstukken, IVO)
Topics: international socio-economic relations
Enquiries: 013-66 2264, drs. B. Evers

Catholic University of Nijmegen (KUN, Katholieke Universiteit Nijmegen)
PO Box 9102
6500 HC Nijmegen
080-61 6161

(1) Third World Centre (Derde Wereld Centrum)
PO Box 9108
6500 HK Nijmegen
Topics: North-South relations / multinationals / Netherlands development cooperation policy / transnational corporations
Enquiries: 080-51 3058 / 3059, prof.dr. G. Huizer, dr. D. Haude

Delft University of Technology (TUD, Technische Universiteit Delft)
PO Box 5048
2600 GA Delft
015-789111

(1) Centre for International Cooperation and Appropriate Technology (CICAT)
PO Box 5048
2600 GA Delft
Topics: technology transfer, technology assessment
Enquiries: 015-78 3612, drs. A. Wouters

Eindhoven University of Technology (TUE, Technische Universiteit Eindhoven)
Postbus 513
5600 MB Eindhoven
040-47 9111

(1) Centre for International Cooperation Activities (CICA)
Topics: technology transfer, technology assessment
Enquiries: 040-47 2246, P. Laperre M.Sc.

Erasmus University (EUR, Erasmus Universiteit Rotterdam)
PO Box 1738
3000 DR Rotterdam
010-408 1111

(1) Faculty of Economics (Faculteit Economische Wetenschappen)
(a)Section Micro Economics and Economic Order (Vakgroep Micro-economie en economische orden)
Topics: international economic relations
Enquiries: 010-408 1441, prof.dr. S.I. Cohen

(b)Section Development Programming (Vakgroep Ontwikkelingsprogrammering)
Topics: technology, development planning
Enquiries: 010-408 1451, dr. P.H.J.J. Terhel

Leyden University (RUL, Rijksuniversiteit Leiden)
PO Box 9606
2300 RC Leiden
071-27 2727

(1) Centre for Environmental Studies (Centrum voor Milieukunde)
PO Box 9518
2300 RA Leiden
Topics: development and environment
Enquiries: 071-27 7470, ir. C.A. Drijver (Section Environment and Development)

(2) Faculty of Law (Faculteit Rechtsgeleerdheid)
Department of Public International Law (Vakgroep Internationale Publiekrechtelijke Vakken)
Topics and enquiries: 071-27 7533, prof.mr. H.G. Schermers (international organizations), prof.dr. F. van Dam (international economic relations), dr. P.D. Cameron (energy law)

State University of Groningen (RUG, Rijksuniversiteit Groningen)
PO Box 72
9700 AB Groningen
050-63 9111

(1) Faculty of Law (Faculteit Rechtsgeleerdheid)
PO Box 716
9700 AS Groningen
Department of International Law and Sociology of International Relations (Vakgroep Volkenrecht en Sociologie van Internationale Betrekkingen)
Topics: North-South relations / juridical aspects
Enquiries: 050-63 5700 / 5705, prof.mr. P.J. Teunissen

(2) Faculty of Economic Sciences (Faculteit Economische Wetenschappen)
PO Box 800
9700 AV Groningen
Department of General Economics (Vakgroep Algemene Economie)
Topics: North-South relations / economic aspects
Enquiries: 050-63 3717, prof.dr. A. Maddison (Section Development Economics, Sectie Ontwikkelingseconomie)

(3) Centre for Energy and Environmental Studies (Interfacultaire Vakgroep Energie en Milieukunde, IVEM)
PO Box 72
9700 AB Groningen
Topics: energy and environment
Enquiries: 050-63 4611, dr.ir. W. Biesiot

State University of Limburg (RL, Rijksuniversiteit Limburg)
PO Box 616
6200 MD Maastricht
043-88 7777 / 8888 / 2222

(1) Maastricht Economic Research Institute on Innovation and Technology (MERIT)
Topics: technology transfer and assessment, international trade and economic relations
Enquiries: prof.dr. L. Soete

University of Amsterdam (UvA, Universiteit van Amsterdam)
PO Box 19268
1000 GG Amsterdam
020-27 2621

(1) Faculty for Political Science (Faculteit Politieke en Sociaal-Culturele Wetenschappen)
Department of International Law and International relations (Vakgroep Volkenrecht en Internationale Betrekkingen)
Topics: North-South relation
Enquiries: 020-525 2147, prof.dr. G.C.A. Junne

(2) Department of Environmental Science (Interfacultaire Vakgroep Milieukunde, IVAM)
Topics: energy conservation, recycling, renewable energy, environmental policy
Enquiries: prof.dr. E. Tellegen, prof.dr. L. Reijnders (020-525 6206)

University of Twente (UT, Universiteit van Twente)
PO Box 217
7500 AE Enschede
053-89 9111

(1) Faculty of Business and Management Sciences (Faculteit Bedrijfskunde)
Group Development Sciences (Vakgroep Ontwikkelingskunde)
Topics: technology transfer, rural energy, social forestry
Enquiries: 053-89 3520 (faculty), prof.dr. E.W. Hommes, prof.dr. W.S. Hulscher

Utrecht University (RUU, Rijksuniversiteit Utrecht)
PO Box 80125
3508 TC Utrecht
030-53 5198 / 53 9111 / 39 9111

(1) Faculty of Law (Faculteit Rechtsgeleerdheid)
Department of International Socioeconomic Public Law (Vakgroep Internationaal Sociaal en Economisch Publieksrecht)
Topics: North-South relations / juridical aspects
Enquiries: 030-39 3100, prof.mr. A.H.A. Soons

(2) Faculty of Geographical Sciences (Faculteit Ruimtelijke Wetenschappen)
Department of Geography of Developing Countries (Vakgroep Sociale Geografie Ontwikkelingslanden)
Topics: regional development
Enquiries: 030-53 2044, prof.dr. J.A. van Ginkel, prof.drs. J. Hamer

(3) Faculty of Chemistry (Faculteit Scheikunde)
Department of Science, Technology and Society (Vakgroep Natuurwetenschap & Samenleving)
Topics: energy and environment
Enquiries: 030-39 2377, prof.dr. W.C. Turkenburg

(4) Department of Environmental Studies
Topics: environmental issues
Enquiries: 030-53 2359, prof.dr. L.A. Clarenburg, prof.dr. P. Glasbergen

Vrije Universiteit (VU)
De Boelelaan 1105
1081 HV Amsterdam
020-548 9222

(1) Institute of Environmental Studies (Instituut voor Milieuvraagstukken, IVM)
Topics: environment and developing countries
Enquiries: 020-548 3827, drs. L. Braat, dr. J. Arntzen

(2) Faculty of Economics, Business Administration and Econometrics (Faculteit Economische Wetenschappen)
(a)Department of Development and Agrarian Sciences (Vakgroep Ontwikkelings- en Agrarische en Economie)
Topics: North-South relations
Enquiries: 020-548 7039, dr. H.J.W. Weijland
(b)Economic and Social Institute (Economisch en Sociaal Instituut, ESI)
Topics: North-South relations
Enquiries: 020-548 4610, dr. H.P. Smit (general economics)
(c)Department of Regional Economics (Vakgroep Regionale Economie)
Topic: environmental and regional economics
Enquiries: prof.dr. J.B. Opschoor, prof.dr. P. Nijkamp

D.2 Other institutes

ASC, African Studies Centre (Afrika Studie Centrum)
PO Box 9555
2300 RD Leiden
Topics: rural development, human resources development, development policy, North-South relations
Enquiries: 071-27 3372 / 73, dr.J.C. Hoorweg

BOS, Foundation for Dutch Forestry Development Cooperation (Stichting voor Nederlandse Bosbouw Ontwikkelingssamenwerking)
PO Box 23
6700 AA Wageningen
Topics: tropical forestry and development cooperation
Enquiries: 08370-95353, ing. W. Kloppenburg

CEDLA, Interuniversity Centre for Study and Documentation of Latin-America
Keizersgracht 395-397
1016 EK Amsterdam
Topics: plattelandsontwikkeling, ontwikkelingsbeleid en North-South relation
Enquiries: 020-525 3498, dr. C.W.M. den Boer

ECN, Netherlands Energy Research Foundation (Energie-onderzoek Centrum Nederland)
PO Box 1
1755 ZG Petten
02246-4949

(1) Energy Studies (ESC)
Topics: energy and environmental policy
Enquiries: 02246-4321, dr. J.J.C. Bruggink

(2) Renewable Energy (Duurzame Energie)
Topics: renewable energy technologies
Enquiries: 02246-4184, ir. H.J.M. Beurskens

IAC, International Agricultural Centre (Internationaal Agrarisch Centrum)
PO Box 88
6700 AB Wageningen
Topics: agriculture and forestry issues
Enquiries: 08370-90 111, prof.dr. F.P. Jansen

IHE, International Institute for Hydraulic and Environmental Engineering
PO Box 3015
2601 DA Delft

Topics: civil and environmental engineering
Enquiries: 015-78 3401, prof.dr.ir.G.J.F.R. Alaert (Environmental Engineering Department)

ITC, International Institute for Aerospace Survey and Earth Sciences
PO Box 6
7500 AA Enschede
Topics: remote sensing, forestry, land evaluation
Enquiries: 053-32 0330, dr.ir. K.J. Beek, ir. D.A. Stellingwerf

KIT, Royal Tropical Institute (Koninklijk Instituut voor de Tropen)
Mauritskade 63
1092 AD Amsterdam
020-568 8711
Topics: rural development
Enquiries: Rural Development (Plattelandsontwikkeling, 020-568 8486)

NEI, Netherlands Economical Institute (Stichting Nederlands Economisch Instituut)
PO Box 4175
3006 AD Rotterdam
Topics: economical development and planning
Enquiries: 010-408 1804, drs. M. van Pelt

RIVM, National Institute of Public Health and Environmental Protection (Rijksinstituut voor Volksgezondheid en Milieuhygiëne)
PO Box 1
3720 BA Bilthoven
Topics: environmental issues, climate change, rural development,
Enquiries: 030-74 9111, International Cooperation Office (Bureau Internationale Samenwerking), ir. A.R. Bergen (head), ir. A.G.N. Jansen

TNO, Netherlands Organization for Applied Scientific Research (Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek)
PO Box 6010
2600 JA Delft
Topics: technology development, energy and environment
Enquiries: 015-69 6900, TNO Environment and Energy (Milieu en Energie)

WL, Delft Hydraulics (Waterloopkundig Laboratorium, WL)
De Voorst
PO Box 152
8300 AD Emmeloord
Topics: coastal development, climate change and sea-level rise
Enquiries: 05274-2922, B. Peerbolte, K. Hulsbergen

D.3 Consultants

BTG, Biomass Technology Group,
PO Box 217
7500 AE Enschede
Topics: small-scale energy technologies, biomass
Enquiries: 053-89 2897, ir. H.E.M. Stassen

DHV Consultants B.V.
PO Box 1399
3800 BJ Amersfoort
Topics: environmental engineering, transport engineering, urban development, building architecture, structural engineering, port and road engineering, energy
Enquiries: 033-68 2500, Sector Water and Environment

EDP, Association for Energy Development and Planning
Kerkweg 88
2641 GG Pijnacker
Topics: energy devlopment and planning
Enquiries: 01736-95461, ir. T.H. Jansen

ETC, Consultants for Development Programmes
PO Box 64
3830 AB Leusden
Topics: socio-economic and socio-cultural development programmes
Enquiries: 033-94 3086, ir. C.Reijntjes (ILEA, Information Centre Low External Input Agriculture)

Euroconsult
PO Box 441
6800 AK Arnhem
Topics: rural development, agriculture and forestry, civil engineering, environmental engineering, energy planning and engineering, physical planning, land and water use
Enquiries: 085-57 7111, ir. P. de Wildt (INSUNAD, Institutional, Urban and Natural Resources Development)

Haskoning Consulting Engineers and Architects
PO Box 151
6500 AD Nijmegen
Topics: infrastructure, agricultural development, energy planning
Enquiries: 080-22 8015, drs. J.H. de Goede (Human Settlements and Development)

Lysen Consulting Engineer
PO Box 351
3830 AK Leusden
Topics: energy and environment
Enquiries: 033-95 1807, E.H. Lysen