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ExternE
Externalities of Energy

[redacted]

Contents

EXECUTIVE SUMMARY

Methodology

This paper reports the results of the Global Warming Sub-Task of the ExternE Project, which

present results at a number of discount rates - 0%, 1%, 3% and 10% - but do not recommend the use of the extremes of this set.

The future damages imposed by climate change due to current emissions will depend on the socio-economic conditions in future generations, in particular the capacity of those societies to

malaria will expand and impacts could be large. Other direct impacts, such as effects on air

may fall considerably. The Open Framework uses subjective assessments to test the sensitivity

to each of the major hazards. FUND concentrates on hurricanes, storms and floods

Results and Conclusions

Results of FUND and the Open Framework are presented separately and then compared to the

1. INTRODUCTION

The damages of climate change have not previously been addressed systematically within the

benefit analysis will identify an optimum strategy around which the international community

The functional unit used in the assessment is unit mass of a greenhouse gas rather than a unit

of power generated at a fixed point. The damages per unit of emission are independent of

The problem of how to address ecological impacts has been reviewed in collaboration with the

most problematic where large scale issues of ecological stability are concerned. In the

2.2.1 Comparison of FUND and the Open Framework

The two models used in this assessment have distinct features, although they share a number of common features. Both models calculate damages over time: from 1950 to 2200 for FUND and 1990 to 2100 for the Open Framework. Both share origins in the sectoral damage

2.2.3 Climate Modelling

Greenhouse concentrations are used to calculate the radiative forcing, which is then used to assess global average temperature and sea level rise. The Open Framework uses MAGICC

2xCO2-equivalent global mean temperature change).

In the latest version of FUND, the radiative forcing of each gas is modelled according to

than mortality. The share of

lthough some excess

disasters,

Given the different purposes and structures, it is difficult to compare the sectoral coverage of

equity weightings to observed (income dependent) WTP values, the social welfare function

which is constructed is sensitive to equity concerns

"Equity weighting" is not an optional extra, but an essential part of cost-benefit analysis

where ITP is the individual rate of pure time preference due to impatience, W is the growth

consumption.

The elasticity U is frequently assumed to be unity and the long term sustainable growth rate.

economic change. Clearly this is uncertain and the uncertainty grows over time. If the

This effect has been obscured by the dominant methodology for evaluation of climate change

Climate change may increase the numbers of people at risk of food shortage by many millions.

- the value of ecological stability and biodiversity, as well as
- the likelihood of serious socially contingent impacts described in the previous section

Neither weak nor strong sustainability provides a wholly satisfactory framework. And

Global Warming Damages

different timescales: both to daily weather and to climatic variability. Especially in regions of moisture stress, changes in the number of rain days and drought would have major effects.

Most impact assessments have assumed that changes in potential crop yield (or area suitable for cultivation) will map directly onto changes in actual production. This neglects the fact that actual productivity can lag behind the potential. Crops that perform close to their potential may be more sensitive to climate change than crops where the gap is large. In the latter case,

Valuing the secondary effects of agricultural impacts is more difficult. Land degradation and

migration can be valued - via land markets, the social costs of displaced populations, and

4.3 Water Supply Impacts

The effect of climate change on water has received less attention at the global level, although

which climate change can be mitigated by developing new resources (e.g. a reservoir) or altering demand (e.g. through pricing) is not clear. In much of the world, water use is not metered and prices do not reflect the volume of use (nor in some cases the actual market cost of water).

The only global estimate of water resources is the study by Darwin *et al.* (1995) as noted above. Changes in water resources were assessed in the context of their impact on irrigated agriculture. Water resources for four climate scenarios were found to increase for the world as a whole (by 6-12%). However, shortages would occur in some regions. For example, in Japan water supplies might increase or decrease by 10% and prices would increase by more than 75%. In contrast, the EC, Australia, New Zealand and SE Asia use less water for

The wetland losses are very variable between models and very uncertain as they depend on

Obviously the damage pathway approach of ExternE and the corresponding monetary valuation needs state indicators as a basic information. But data is only available for two important state indicators (Walz, 1996):

- threatened or extinct species as a share of total species known, and
- threatened habitats.

Furthermore, for a damage pathway approach, like ExternE, causal relationships between pressure and response indicators of biodiversity cannot be quantified on the basis of present

- Coast and small island - Climate change has the potential to affect coastal biodiversity. It may lead to a change in population sizes and distribution of species, alter the species composition and geographical extent of habitats and ecosystems, and increase the rate of species extinction (Bijlsma et al, 1996).

4.5.2 Monetary Valuation of Biodiversity and Ecosystem Impacts

For biodiversity in general, an extensive economic literature with monetary valuation studies already exists. Many contingent valuation surveys have assessed willingness to pay for the protection of endangered species (for a survey see Loomis and White, 1996; Pearce and Moran, 1994; Perrings et al, 1996). In most cases, values have been derived for single species and for the recreational use of certain areas. Additionally, some estimates are available for the value of plant species for medicinal purposes (Pearce et al, 1996). Monetary estimates of

readily accomplished for disasters. Calculating the future costs of weather hazards is constrained by the lack of knowledge in three essential spheres:

- Scenarios of climate change do not yet present a consensus on the likely effects on many weather hazards.
- The present distribution of extreme events is uncertain and may not be stationary on the time scale of decades to centuries, and
- Exposure and vulnerability to weather hazards are changing rapidly in many parts of the world. The maximum potential loss is unknown except for a few developed regions.

In addition, the imposition of incremental trends in climate (e.g. global warming and sea level

have a measurable benefit on lives lost, and some economic benefit through, for example,

reductions in frozen pipes (generally insured), reduced need for road de-icing agents and fewer agricultural losses (not insured).

2. Heat waves - The converse of cold spells. Heat stress is strongly related to temperature

7. Other severe weather – Other hazards, e.g. lightning, hail, and tornadoes, have received less

becoming common in areas that rarely experience them at present. If so, the number of lives

have a measurable benefit on lives lost and some economic benefit through for example

reductions in frozen pipes (generally insured), reduced need for road de-icing agents and fewer

agricultural losses (not insured).

2. Heat waves - The converse of cold spells. Heat stress is strongly related to temperature. The health damages of heat stress may be comparable in total to the benefits from reduced

7. Other severe weather – Other hazards, e.g. lightning, hail, and tornadoes, have received less attention. A shift from cyclonic to convective precipitation could result in these hazards

Table 5.1.1
Damages at Benchmark Warming (in billion US$/year)

The damages are dominated by mortality effects. These are concentrated in the regions of the

mortality in OECD countries is due to cold stress reduction.

Global agricultural damages estimated are negative (i.e. climate change benefits agriculture).

Species loss impacts estimated are relatively small. However, it should be noted that these are based on unreliable estimates of habitat and species value only (see Section 4.5), and therefore it cannot be assumed that all impacts on the natural world are insignificant.

Table 5.1.2 presents the results using FUND for the base case scenario adopted in this work - the IPCC IS92a scenario, with damages evaluated over the period 1900-2100 and using equity

Table 5.1.5
FUND Sensitivity Analysis of Marginal Damages

Table 5.1.6
Uncertainty Analysis of Marginal Damages

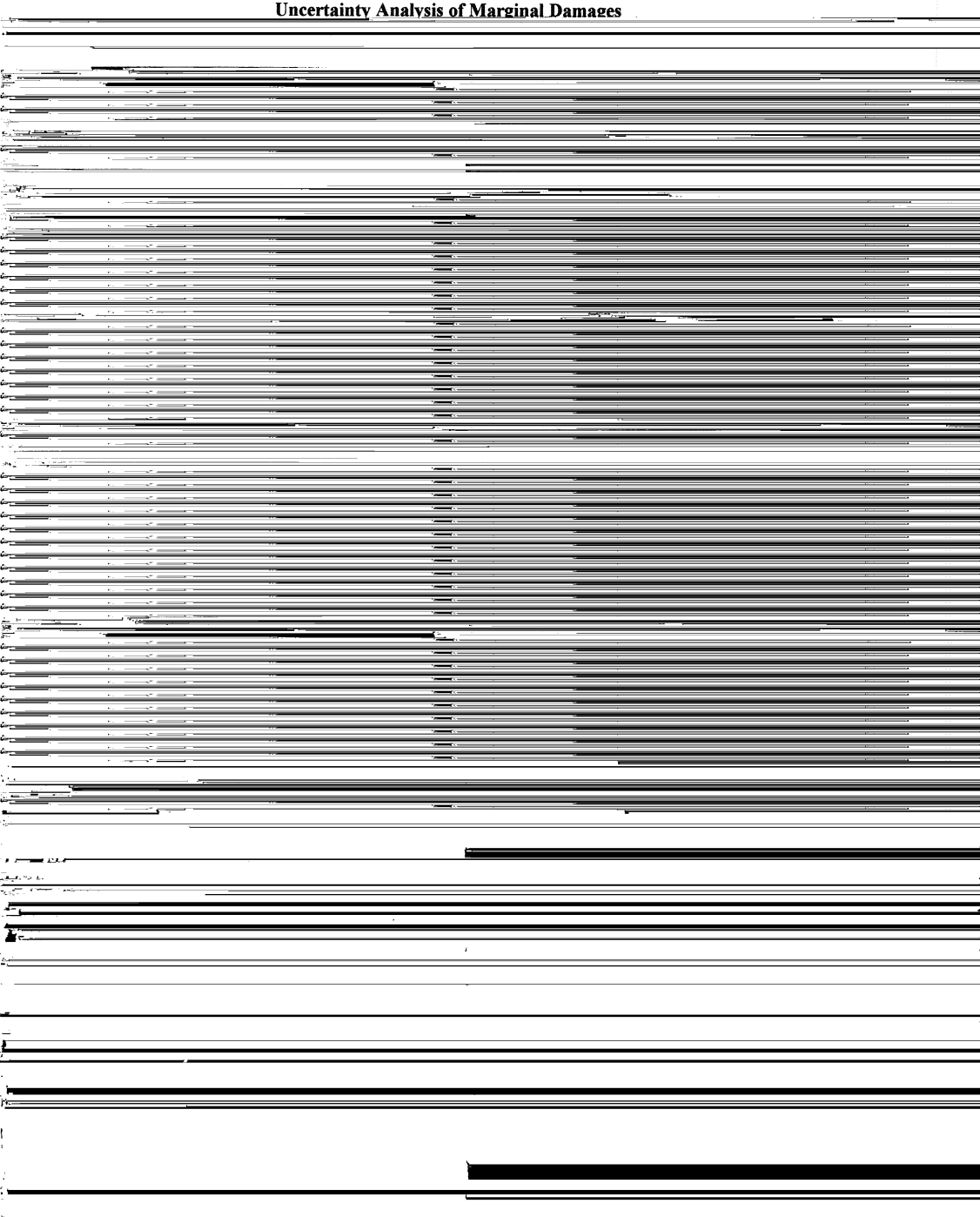

Table 5.2.1

The energy sector for heating and cooling shows a very varied distribution of gains and losses

Africa, under this baseline warming scenario experiences the greatest cooling damages while

Table 5.2.2
Base Case Damages

[redacted]

Table 5.2.3
Marginal Damages for CO_2, CH_4 and N_2O Emissions

Table 5.2.5
Uncertainty in Marginal Damages of CO_2

- The Open Framework uses more realistic climate change scenarios, including spatial

FUND and the Open Framework show a small net cost to agriculture in the equity weighted

Table 5.3.2
Comparison of Regional Damages from FUND and Open Framework

implying that the damages are, in general, somewhat later in time. However, for discount

rate and $15-235/tC at a 3.5 discount rate. The equivalent low and high estimates for the

6. CONCLUSIONS

The literature on climate change damages shows a very wide range estimates of the marginal

there are a number of reasons for this. The impacts of climate change are far reaching in space

Table 6.2
Marginal Damages (ECU) of Greenhouse Gas Emissions

Greenhouse Gas	Damage Unit	Marginal Damage from Model

The valuation of ecosystem and biodiversity impacts of climate change has proved difficult.

estimates of values of marginal ecosystem effects which are available are very unreliable. In

common with the rest of the ExternE Project no values for ecosystem damages are

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Appendix 1

The Climate Framework for Uncertainty, Negotiation and Distribution

Richard S.J. Tol
Institute for Environmental Studies
Vrije Universiteit Amsterdam

Table A1.1. Regions of the *Climate Framework for Uncertainty, Negotiation and*

Region (acronym)	Description

is not varied between the scenarios.

The scenarios of economic and population growth are perturbed by the impact of climate change. Population falls with climate change deaths, resulting from changes in heat stress, cold stress, malaria, and tropical cyclones. Heat and cold stress are assumed to affect only

Radiative forcing for carbon dioxide, methane and nitrous oxide are based on Shine *et al.*

$$IC_{j,t} = \frac{Y^a_{j,t}/P^a_{j,t}}{1+Y^a_{j,t}/P^a_{j,t}/20000} \frac{1+Y^a_{j,0}/P^a_{j,0}/20000}{Y^a_{j,0}/P^a_{j,0}} \quad (4)$$

where Y/P denotes income per capita, DC, the factor with which damage largely related to

The costs C^{HC} follow from

$$C^{HC} = H \quad C \qquad (8)$$

where

$$VHL_{j,t} = 250{,}000 + 175 Y^{a}_{j,t} / P^{a}_{j,t} \qquad (9)$$

The number of additional malaria deaths D^{M} follows from

$$D^{M}_{j,t} = M_j DC_{j,t} P^{a}_{j,t} \frac{T_t}{2.5} \qquad (10)$$

that is, malaria is assumed to be linear in the level of global mean temperature change, no

$$\sigma_{Hr,t} = 1_{t-1} \cdot HA_t \qquad (12b)$$

with HA denoting hurricane activity; 0.25 is the base increase, and

$$\left\{ 5_{Hr,\ldots} \cdot 1 \left(|\Delta HA_{\tau}| \left(\Delta HA_{\ldots} \right)^2 \right) \right.$$

where u_{ij} is the fraction of people (in region i) that leaves region i and enters region j. The

$$C_{j,t}^{DL,R} = \rho_{DL} C_{j,t-1}^{DL,R} + \begin{cases} \frac{1}{4}\frac{DL_j}{60} Y_{j,t}^{a} \frac{1}{2}\left(\frac{|\Delta S_T|}{0.008} + \left(\frac{\Delta S_t}{0.008}\right)^2\right) & \text{if } \Delta S_t > 0 \\ \frac{1}{4}\frac{DL_j}{60} Y_{j,t}^{a} \left(1 - \frac{1}{2}\left(\frac{|\Delta S_T|}{0.008} + \left(\frac{\Delta S_t}{0.008}\right)^2\right)\right) & \text{if } \Delta S_t \leq 0 \end{cases} \qquad (19c)$$

The tangible costs of wetland loss $C^{WL,T}$ are

$$\begin{cases} \frac{1}{4}\frac{WL_j}{60} Y_{j,t}^{a} \frac{1}{2}\left(\frac{|\Delta S_T|}{0.008} + \left(\frac{\Delta S_t}{0.008}\right)^2\right) & \text{if } \Delta S_t > 0 \\ \frac{1}{4}\frac{WL_j}{60} Y_{j,t}^{a} \left(1 - \frac{1}{2}\left(\frac{|\Delta S_T|}{0.008} + \left(\frac{\Delta S_t}{0.008}\right)^2\right)\right) & \text{if } \Delta S_t \leq 0 \end{cases}$$

range between 238.3 and 2.7 trillion dollar, depending on the discount rate chosen.

Independent of that, South and Southeast Asia contribute most to world damage, followed

by Latin America and Africa. China's contribution does depend on the discount rate (it

Table A1.4. Duration of damage memory per category.[a]

category	years	category	years
agriculture	10	emigration	5
coastal protection	50	wetland (tangible)	10
life loss	15	wetland (intangible)	50
tropical cyclones	5	dryland	50

[a] Damage is assumed to decline geometrically at a rate of 1-1/lifetime.

Source: After Tol (1996).

Table A1.5. Regional damages of climate change; percentage of the net present value of

Table A1.8 repeats Table A1.7, this time equity-weighted. The importance of species loss

Table A1.8. Sectoral damages of climate change: percentage of the net present value of total damage over the period 1990-2100.[a]

Sea level rise[b]	57.8	61.1	68.6	75.1	82.1
Agriculture	2.7	2.4	1.5	0.7	-0.6
Extreme weather[c]	33.5	30.1	22.7	16.3	9.5
Species	0.9	0.8	0.6	0.4	0.2

marginal costs of carbon dioxide emissions are comparable to those that can be found in

the literature. Table A1.10 also presents marginal damage estimates for methane and

nitrous oxide. Usually, greenhouse gases are converted from one to another using their

emissions.

Table A1.12. Marginal damages for CO_2, CH_4 and N_2O emissions: damages discounted

Table A1.13 Sensitivity analysis marginal damage of carbon dioxide emissions (in $/tC):

Table A1.15 presents the marginal damages, and their breakdown over the impact

balance of heat and cold stress, comes second, and increases in importance over time

A1.3 Results under Uncertainty

Uncertainty prevails in all aspects of climate change. The chemistry of radiative active

Table A1.17. Description of parameter uncertainty.

Table A1.18 presents the results of a Monte Carlo analysis with 2500 runs applying the uncertainty assumptions described in Table A1.17 to marginal impact estimates of *FUND*.

Table A1.18. Characteristics of the uncertainty about the marginal costs of carbon

Figure 2. Uncertainty about the marginal costs of carbon dioxide emissions. Damages

time horizon: 2100; equity-weighted; no higher order effects.

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Appendix 2

The Open Framework Model

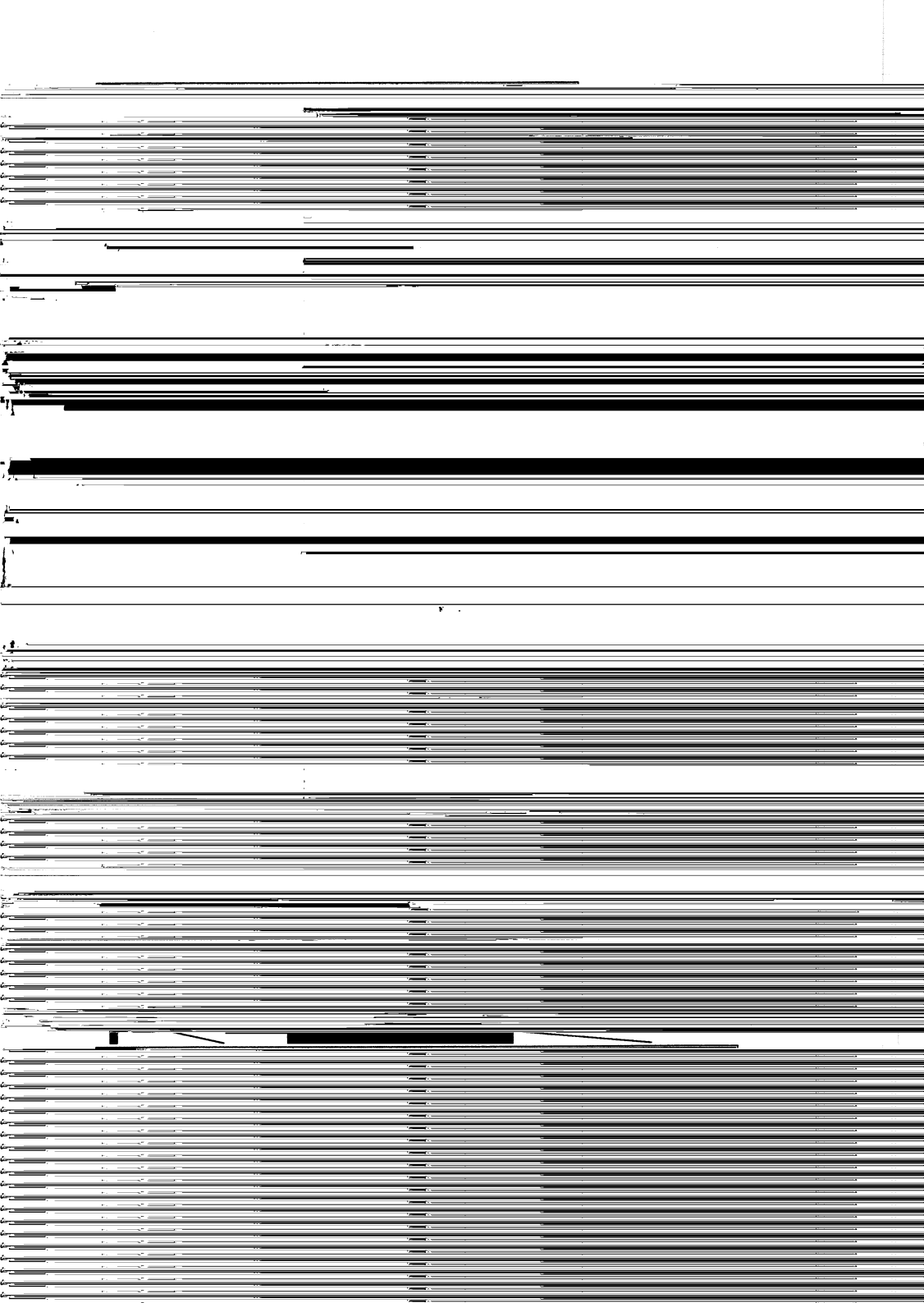
Evaluation of Climate Damages: Sensitivity of the Open Framework to Emissions of Carbon Dioxide, Methane and Nitrous Oxide

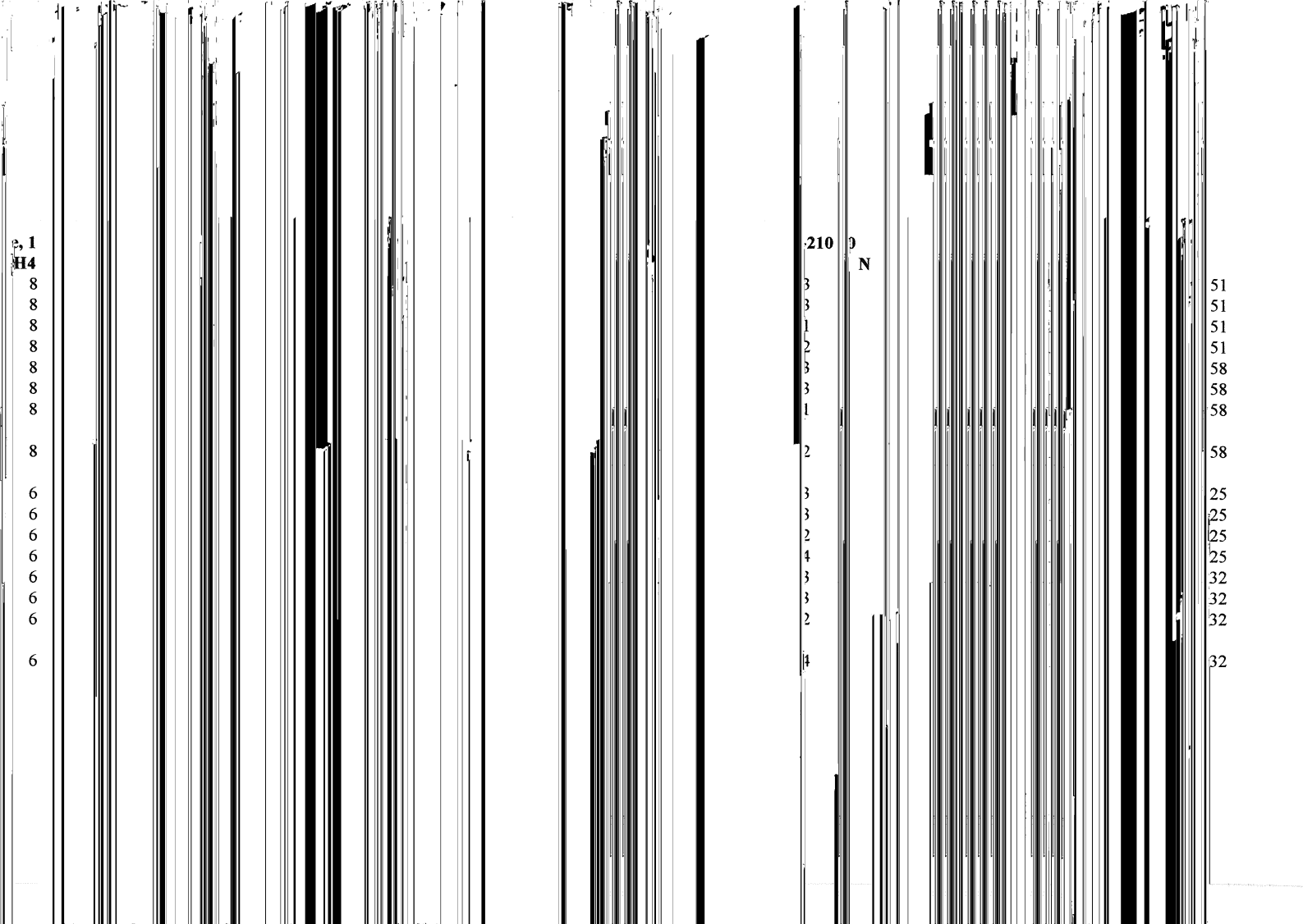
Rutger Hoekstra
Nick Eyre
David Blackwell
Robert Greener

The Open Framework provides a consistent platform for spatial analysis of climate change

For this project, a single year, 2100, was used, assuming a linear projection from the present climate (i.e. 1990).

6. Calculate first-order impact models for the current climate and for the scenario of climate change. The baseline climate is based on the 0.5 degree latitude by longitude climatology of Cramer and Leemans (1994). Climate parameters for the baseline are mean monthly





Economic Growth

Economic growth in the IS92a scenario – 2.9% to 2025 and 2.0% thereafter – is significantly

population growth, per capita incomes differ in the two scenarios. Average world per capita output rises to $21,500 in the IS92a scenario compared to $28,200 in the IS92d scenario, and

compared to $3,800 at present. The higher wealth in both scenarios implies greater resources

structure and the volume of data generated, it is not feasible to undertake a formal,

quantitative analysis of uncertainty or parameter sensitivity. On the other hand, the Open

economic or technological driving forces. Similarly, 17 of the 26 variables are linked to

assumptions of economic growth, per capita wealth, etc. Indices such as the value of wetlands,

value of drylands and price elasticity of water supply are logically linked – increases in wealth imply increases in each of these values.

Only a few of the variables are directly correlated with each other in the sense that one

Table 3. Relationship between parameters

		Climate	Economy	Technology	
	Coastal resources	√			
1	Wetlands lost, %		√		
2	Cost of wetlands lost		√		5
3	Underdeveloped low lying coast, %	√			4
4	Area of drylands lost per 1m sea rise	√			3
5	Cost of dryland lost		√		2
6	Migrant population, %		√		
7	Cost per migrant		√		

Annex: Equations for Estimating the Costs of Climate Change

The Open Framework estimates the costs of climate change for the IPCC's IS92a and IS92d scenarios using the output from the MAGICC and GISS models as well as economic inputs. Country level cumulative costs for all sectors (except the heating and cooling sectors which report annual costs) are calculated for the years 1990, 2000, 2010, 2025, 2050, 2075 and 2100. The net present value is found by interpolating (using a polynomial equation) between these points and discounting them at 0, 1, 3, 5 and 10%.

Coastal Impacts

Protection cost

To calculate the cumulative protection costs, the country level cost estimates for a 1m sea level rise have been scaled using a polynomial constant (1.28):

$$\left(\frac{\Delta s(t)}{}\right)^{c}$$

cWL = Cost of wetlands lost i.e. capital value 1990 (M$/km^2) (based on Fankhauser (1992)

and other valuation studies)

aGDP(t) = Global Agricultural GDP in year t (M$)

Drylands costs:

cMG = Annual cost of climate migrants, 1990 ($/person/year) (Ayers and Walters (1991) and

Cline(1992))

GNPpc(t) = Global GNP per capita in year t ($/Person)

$\Delta s(t)$ = Sea level rise in year t (cm)

Heating and Cooling Demand

Unlike the other sector costs, the benefits to the heating sector as well as the costs to the

$\left(cDD_x(2100) - cDD_x(1990)\right)$

R_{C_x} = Ratio indicating the change in the number of cooling degree days per year in country x

cDD (t)= Number of cooling degree days (base 20 °C) in country x in year t

The annual costs of cooling are found using the same method for the heating sector. Due to

$\Delta t(t)$ = Temperature change in year t (°C)

Water resources

$Ws_x(t)$ = Water surplus in country x in year t (sum of all the months which experience a water surplus)

Using this index the cumulative costs may be calculated. The water deficit elasticity is a

factor is used to calculate cumulative costs:

$$WRC_x(t) = c_x(1990) \times w_x(1990) \times \alpha_{wd} \times W_x \times \frac{\Delta t(t)}{\Delta t(2100)} \times \frac{(t-1990)}{2} \times 1000$$

$WRC_x(t)$ = Cumulative water resource costs in country x at time t

low, medium and high estimate of the cost and number of lives lost per disaster per year. 17

Parameters used in the OF

[redacted]

o.

[redacted]

			low	med	high	low	med	high	
1	pWL	%	50	75	100	50	75	100	2
2	cWL	M$/km^2	0.50	1.25	5.00	0.50	1.25	5.00	10
	Drylands								
3	pLLC	%	50	80	100	50	80	100	2
4	aLLC	km^2/km	0.60	0.90	1.20	0.60	0.90	1.20	2

Symbols (in the order that they appear in the table):

[redacted]

nWL = Estimation of actual percentage of potential wetlands that would be lost (%)

[redacted]

and other valuation studies)

[redacted] lost per kilometre of coast for a 1 m rise in sea level in

[redacted]

Appendix 3

Linking Weak and Strong Sustainability Indicators: The Case of Global Warming

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1. INTRODUCTION

The philosophy of a sustainable management of natural resources has been derived from the

theory of environmental and resource economics. Originally, the

Against this background, the aim of this paper is to explain the weak and strong sustainability

An early proposal for considering sustainability constraints in cost-benefit analysis has been

made by Barbier, Markandya and Pearce (1990, pp. 1260 - 1261). They formulate a

sustainability criterion requesting that the sum of damages done by a certain amount of

The axioms are:

- no dictatorship of the present (no finite set of generations should be dictatorial), and

The axioms can easily be related to the strong and weak sustainability paradigms. While the

alternative outcomes in a weighting scheme. Faucheux and Froger (1994, p. 62) suggest the

2.2.3 Scale Issues and Ecological Carrying Capacity

and quality of essential natural resources and functions. Secondly, they should reflect how far the actual use of natural resources is away from a sustainable scale.

Although the process of specifying and quantifying critical elements and thresholds evokes

theory and

- there is no consensus about these fundamental ethical questions.

Similar conclusions have been drawn by the Intergovernmental Panel of Climate Change

assumptions have to be made transparent, and a representative range of assumptions should be used in the form of an ethical sensitivity analysis.

3.3 Improvements of Damage Cost Valuation

3.3.1 Intragenerational Equity

Responding to the IPCC criticism, Fankhauser and Tol (1995) and Tol (1996b) have derived a

discount rate and climate change is very ambiguous. Lowering the discount rate induces an

increasing level of economic activity and investment. This would probably lead to further

between the discount rate and environmental deterioration is known as the "conservationist's

STP = ITP + W x U for short term effects (< 30 to 40 years) (3)

and an

STP = W x U for long term effects (> 30 to 40 years) (4)

At first glance, the splitting concept and the time horizon for market transactions chosen by Rabl seem to be very arbitrary. At second glance, a special treatment of long term effects seems to be reasonable, because otherwise damages occurring a hundred or more years in the future will be totally ignored in monetary valuation studies. Understood as a first rule of

3.3.4 Zero discount rate

A more radical position is to set the discount rate equal to zero (Pearce, 1993, pp. 57 - 61). A zero discount rate follows the rule that consumption at one point of time does not count more than welfare at another point of time. However, it is feared that a zero discount rate would imply infinite social costs and total current sacrifice (Pearce, 1993, p. 58).

Nevertheless, there is some reason to use zero discount rates for certain natural resources (W_{NR}) whose market value are expected to rise proportionally to the Gross Global Product

Norgaard and Howarth remark: "With different distributions and efficient allocations, new

INDICATORS OF CLIMATE CHANGE

4.1 Indicators of environmental space

Important early contributions to the discussion of acceptable levels of greenhouse gas

- current energy consumption (status quo criterion),
- current population (equity current criterion; equal emission per capita),
- current and future population (equity cumulative criterion; equal emission per capita).

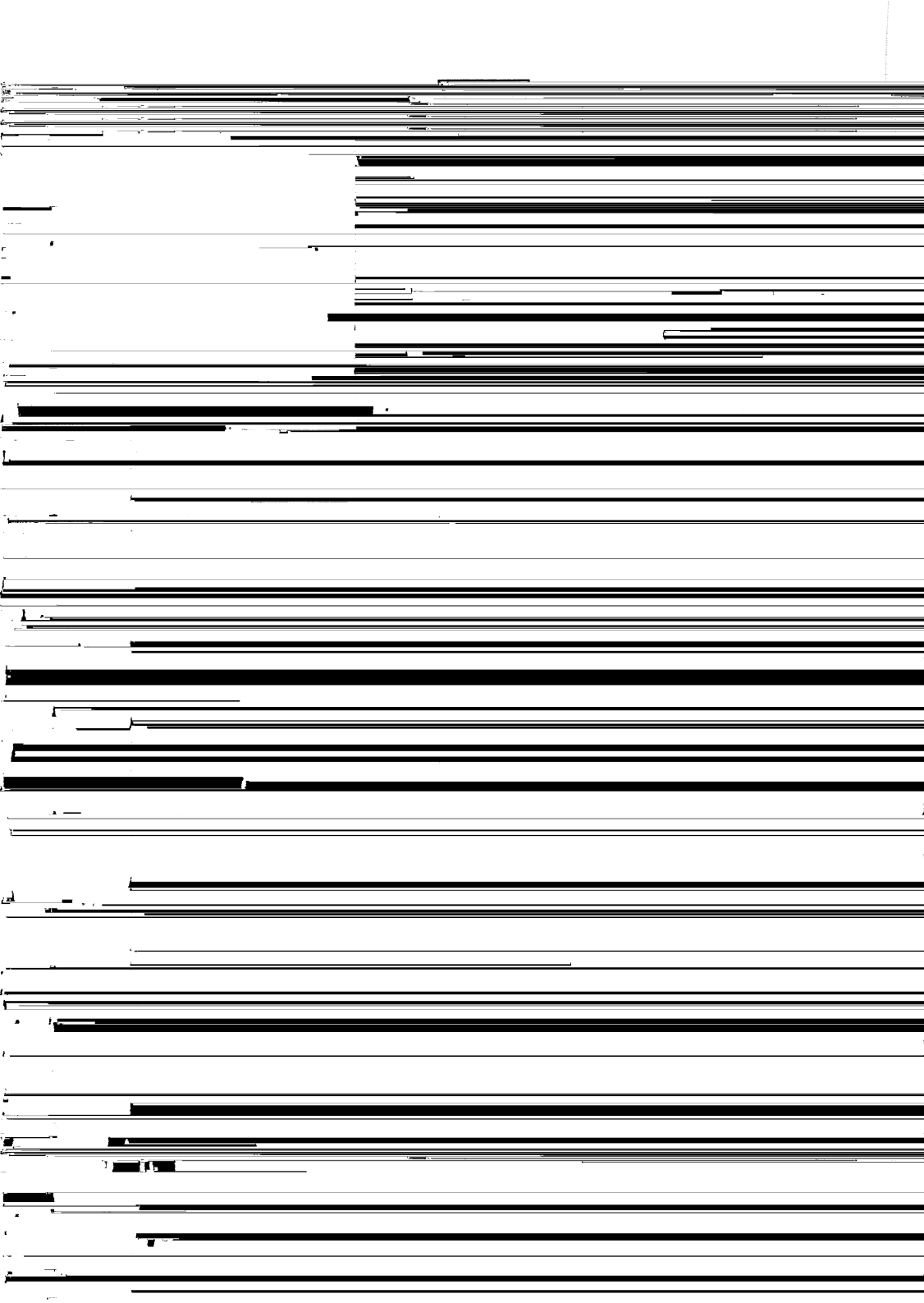
Following each of the five criteria, the global carbon-budget was distributed among nations and regions. The different sustainability indicators (according to different distribution criteria)

"and then, by proceeding backwards, the long-term global reduction target is derived which would ensure that these maximum stress levels are complied with" (WBGU, 1995b, pp. 3 - 4). Thus, the "backwards mode" of the scenario follows a strong sustainability approach being based on acceptable impacts or minimum standards of climate stability. Standard scenarios are carried out in a "forwards mode" estimating future, possibly non-sustainable emission and

The "backwards scenario" or "inverse scenario" contains six steps (see figure 1):

of these operational criteria, a two-dimensional climate window is defined that should not be exceeded.

It is important to mention that the missing link of "backwards" and "forwards" scenarios is the assessment of social and economic impacts. This assessment is located here between step 6 and 1. Pursuing a closed circle of integrated assessment, an economic analysis of different abatement and adaptation strategies would be desirable, including a valuation of remaining



5 DISCUSSION AND CONCLUSIONS

It has been shown that the outcomes of studies estimating economic and social impacts in monetary units are very uncertain. However, as the alternative approaches of strong sustainability have illustrated, uncertainties do not disappear when norms are used instead.

Schellnhuber (1995, p. 58), one of the developers of the "inverse scenario", states that norms

IPCC report (Munasinghe et al., 1996, p. 170). According to the IPCC report, cost benefit analysis encompasses a family of decision-analysis techniques like multicriteria analysis or decision analysis. Using such a broad interpretation, social and economic impacts do not necessarily have to be described in monetary units. A main disadvantage of cost benefit analysis is that in complex decision situations relevant multiple criteria (e.g. efficiency, equity, uniqueness of resources or health and safety) are mixed and reduced to one single criterion. Multicriteria analysis may be a better way to show trade-offs between these different policy goals (Munasinghe et al., 1996, p. 168).

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Appendix 4

Climate Change and Disasters: Economic Valuation of Altered Risk

Thomas E. Downing

Richard Tol

1. Introduction

A [redacted] of climate change impacts is the potential toll of weather-related disasters[1]

hazard. A shift in location and a change in land use policy could affect flood damages to a

Table 1 evaluates seven natural hazards that are likely to be affected by climate change (increased temperature, precipitation or wind). Direct impacts are commonly grouped as lives lost, insured property losses and economic losses (including uninsured losses, damage to

Mid-latitude windstorms can be exacerbated by driving rain. Insured and economic damages

3. Global Damage Estimates

The Open Framework (OF) includes a global assessment of the impacts of natural disasters.

The steps are:

Table 2. Global incidence and impacts of natural disasters, 1967-1992

Average Number of Lives Lost per Disaster Event

Table 3. Baseline (1990) estimates of impacts of natural disasters, USSM

	Value of lives lost	Total cost of disasters

3.3 Reference scenarios for 2100

The baseline (1990) estimates are projected to 2100, without the influence of climate change.

3.4 Scenarios of climate change impacts

The same process as above is used to project the incidence and impacts of disasters in 2100

this time including a set of factors that reflect the changing risk due to climate change (Table

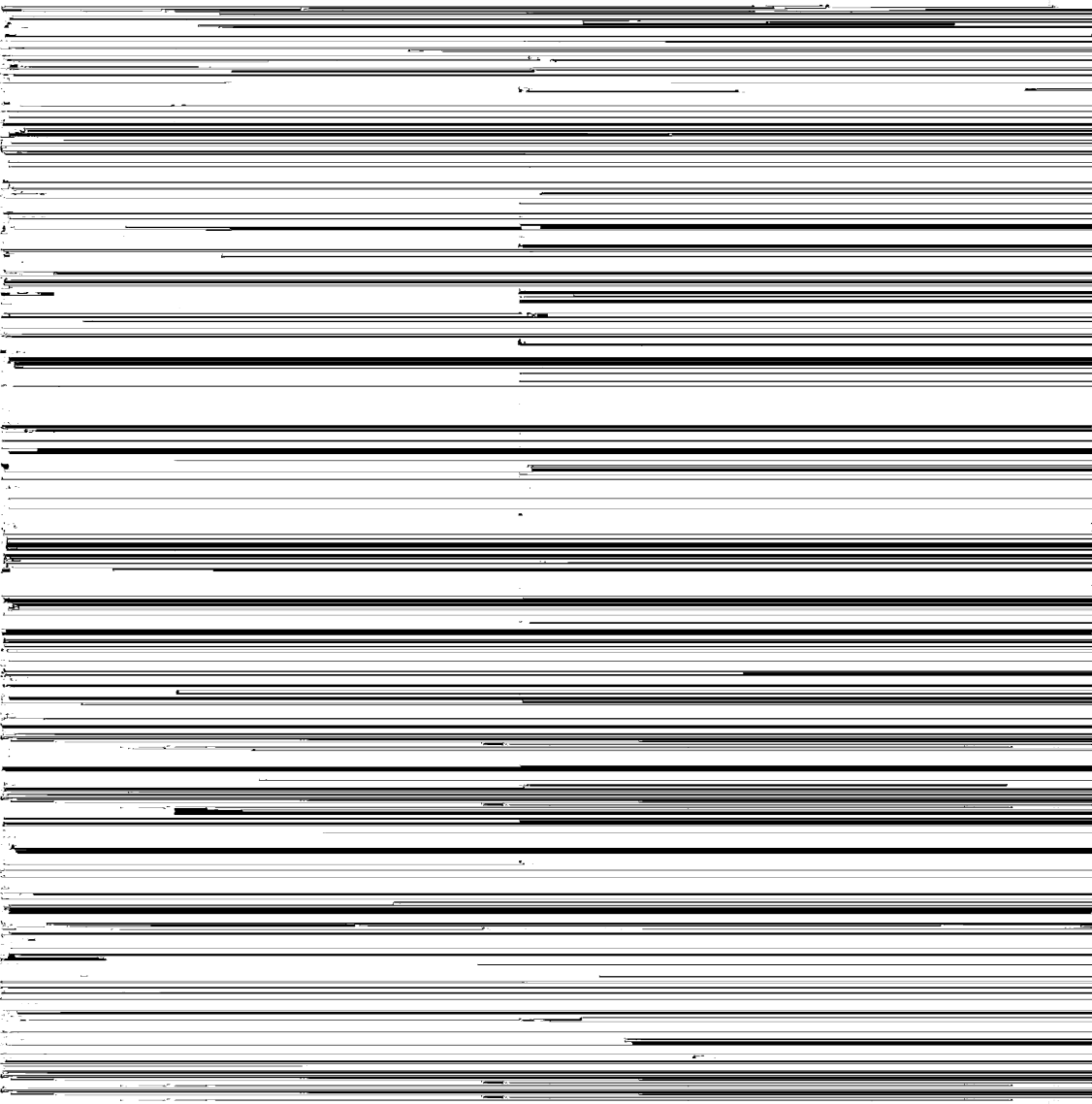
4). IN the absence of robust scenarios from global climate models, this approach provides a

- Incidence: Cold-related events decrease, while heat related events increase sharply. The

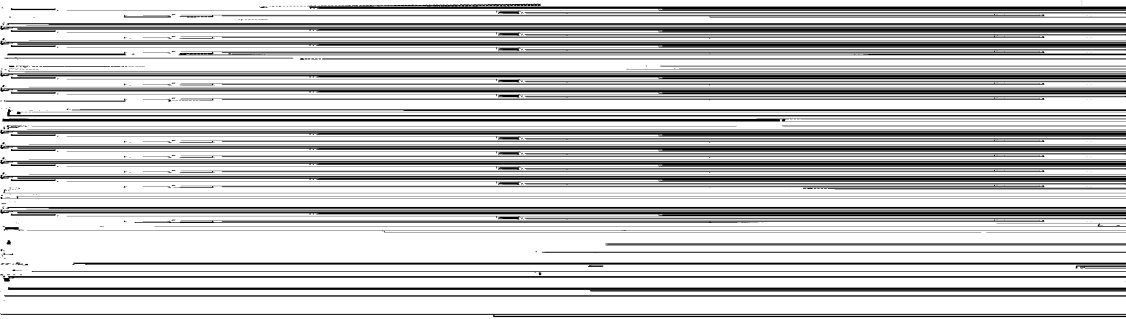
3.5 Comparison of reference and climate change scenarios

The difference between the reference projection of disaster impacts in 2100 and the climate change scenarios is shown in Table 6. The medium estimate is over $250 billion, with a range

Table 7. Net present value of cost of climate change, 1990-2100, US$M



change, US$M



5. Acknowledgements

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Appendix 5

Issues of Intragenerational Equity and Income Adjustment

Nick Eyre
Eyre Energy Environment

1. Introduction

The extension of ExternE analysis to climate change makes it impossible to avoid tackling

The Ministerial Declaration supported by the EU at the second Conference of Parties to the

FCCC endorsed the IPCC report as "the most comprehensive and authoritative assessment of

methodology which retains these - or at least produces a numerical output which is consistent

methodology for other impacts.

4. Consistency with Welfare Economics

The normal practice in the monetary valuation literature is to use WTP as a proxy for welfare.

and quite compatible with the framework of welfare economics that equity issues are considered explicitly.

5. Proposed Approach

The approach proposed here draws heavily on the equity adjusted approach to constructing a

debates about the IPCC report. This paper looks at equity adjustments within the framework

compensated for in the aggregation. The following discussion considers the VOSL, but

The effects of this approach are not only that the risk to life in different countries is valued

equally, but that the VOSL used is that relevant to average global per capita income. It is

- average global income (leading to a VOSL of approximately 1 MECU) and

Appendix 6

Economic Valuation of Regional and Temporal Impacts of Climate Change

Thomas E. Downing

Rutger Hoekstra

Nick Eyre
David Blackwell

1. Introduction

Why are space and time important in economic evaluations of the impacts of climate change?

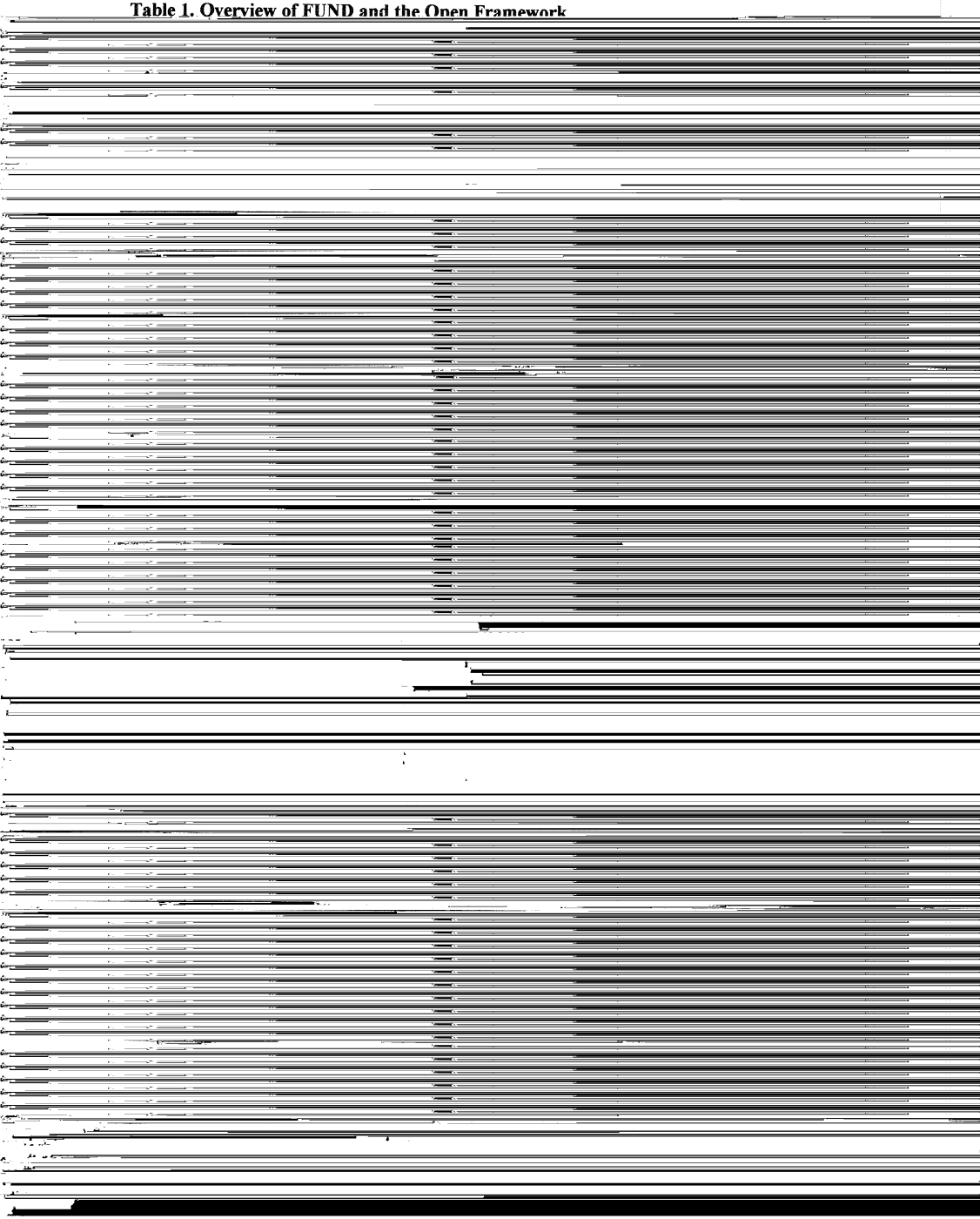
NPV may not adequately capture the importance of climate change

This paper presents new analyses of economic costs of climate change. We present the results

climatic variations and the climate forcing of global GHG emissions.

Global-average temperature change and sea level rise are calculated by the 1995 version of

Table 1. Overview of FUND and the Open Framework



Almost all of the adverse effects on agriculture are in Africa and South and East Asia. With the exception of the Middle East, the regional net benefits are small. Almost all of the water

there is very little heating benefit in Africa, where the largest cooling costs occur. In contrast, the Middle East and former Soviet Union have large heating benefits, with modest cooling

costs. In other regions the heating benefits and cooling costs are more equal.

Two features of the regional costs are striking. First, for each sector one or two regions, often

including Africa, dominate the total costs. Second, the OECD countries do not show large

[redacted]

4. Temporal Impacts of Climate Change in FUND

The temporal profiles of impacts are presented first for the world, comparing market and non-market impacts and with and without equity weighting for both *FUND* and the OF. *FUND* provides annual estimates of impacts, based on both the level and rate of climate change. A

linear profile.

Market impacts in non-Annex I regions show somewhat different profiles (Figure 3b)

Changes over time are less, except for Africa. Except for China (CPA), impacts first rise, then

outweighed by increasing urbanisation (and thus heat stress mortality) and the increasing

valuation of impacts.

In the non-Annex I regions the pattern is more involved than in the richer countries. A

Market and non-market damages are aggregated in Figure 5. In both regions, non-market

damages dominate the total damages. This results in an upward profile of damages in the

OECD countries. In developing countries the aggregated profile tends to show a marked

increase followed by substantial declines. China, however, is the reverse as non-market

5. Conclusions

Both space and time are essential aspects of economic valuations of climate change damages.

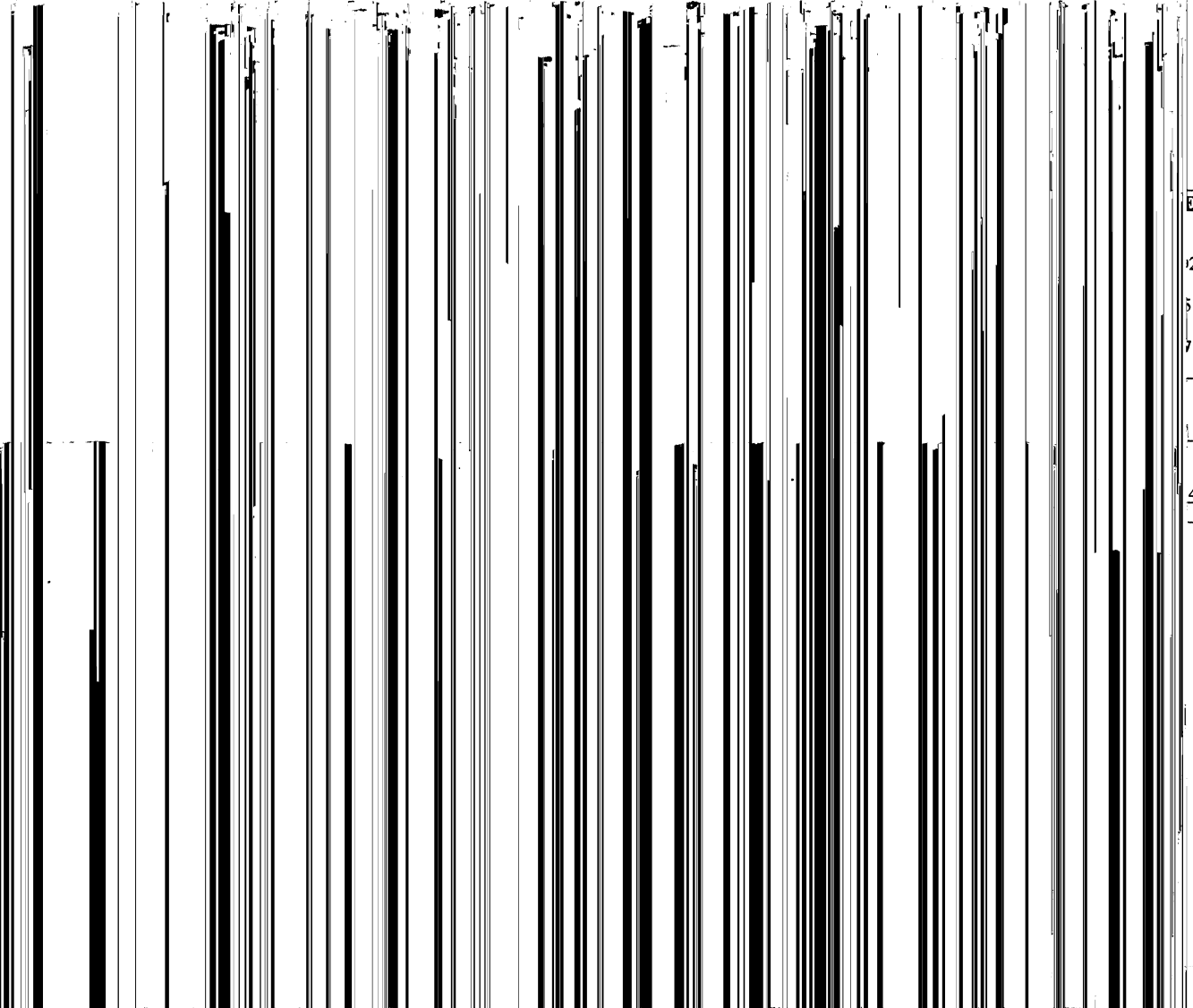
Realistic representation of regions is required to capture the spatial distribution of climate

change, to understand sensitivity to climate change, and to document the distribution of

impacts. The above analysis clearly shows that by aggregating national impacts to a regional

level some impacts are averaged together and some extreme cases appear less so.

Downing, T. E., N. Eyre, et al. (1996). Full Fuel Cycle Study: Evaluation of the Global Warming Externality for Fossil fuel cycles with and without CO2 abatement and for two reference scenarios. Cheltenham, International Energy Agency (IEA) Greenhouse Gas R& D Programme.



E	World
	220
2	-11,684,002
	318,324
5	35,264,865
	2,747,543
7	70,031,298
	863%
	168
1	105,857,214
	51
4	-35,825,917
	0.3

Appendix 7

Human Health Damages of Climate Change

[redacted]

Eyre Energy Environment

1. Introduction

Impacts to human health are widely accepted as one of the most important categories of

[redacted]

sick people. Many of the effects are the exacerbation of already existing health problems in these groups by environmental stress. "Chronic" effects, on the other hand, are understood to

be "new illnesses" due to differences in the environment. It is mortality effects which are

important to distinguish between "acute mortality" and "chronic mortality".

The value of statistical life (VOSL), commonly used in valuing mortality effects is based on

will be small because of human adaptation. However, it seems unlikely that humans are

genetically equally well suited to all climates, and therefore chronic effects cannot be ruled

Table 2

Expected Acute Mortality Effects of Heat Stress in a Range of Cities

uncertainty in projecting damage as a function of income using data from a smaller number of cities in different countries is a factor of 2.5, implying that the restricted sample may well be unrepresentative. Additional uncertainty due to model structure (assumed functional form, dynamics etc.), valuation (use of YOLL and VLYL) and extrapolation to other climates must also be allowed for. The overall uncertainty in the value for acute heat stress is estimated to be a factor of about 5. Omission of chronic effects of heat stress is potentially very significant but unquantifiable.

2.2 Acute Cold Effects

The most widely quoted study in the climate change damage literature on the impacts of climate change on cold related deaths is based on US estimates (Kalkstein, 1989). It concludes that the death rate will be reduced by 9 per million at $2xCO_2$ or 4 per million if

Additional confidence that there is indeed a income effect comes from time series analyses

populations are outside tropical and sub-tropical climates, say above latitude 30 degrees.

It can be seen that malaria is the most widespread geographically, produces the largest number of infections and is judged by the IPCC (McMichael, 1996) to be the most sensitive to climate change. Although the fatality rate is significantly lower than some other diseases, like malaria (mortality and morbidity) is likely to be dominant amongst these diseases. Attention is

uncertain. At this level, morbidity has greater damages than mortality when the value of *f* falls

[redacted]

damages may be significant. If public health programmes improve over time, so that the value

[redacted]

alone a reliable approach as activity of the mosquito vector is strongly anti-correlated with

conditions. The simplest assumption would be that total impacts are weighted inversely

regions, but the climate is generally less favourable to ozone formation than in regions with

anthropogenic emissions in 2050 of approximately 200 Mt of both NOx and VOC (Pepper et

al. 1992), the expected annual global damages with current climate would be approximately

et al. 1992). The differences between the two ends of the range, and the underlying

inequalities between and within countries are unstated. Our ability to estimate the capacity of

therefore very poor.

The only study on food security referenced by the health assessment chapter of IPCC Working

MECU. The resulting damages are therefore in the range 140 to 10,000 billion ECU per year.

higher order damages resulting from public health

McMichael, A.J. (1996) "Human Population Health", in Climate Change 1995: Impacts,

Ecosystems and Biodiversity

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Zentrum für Europäische Wirtschaftsforschung (ZEW)

1. Introduction

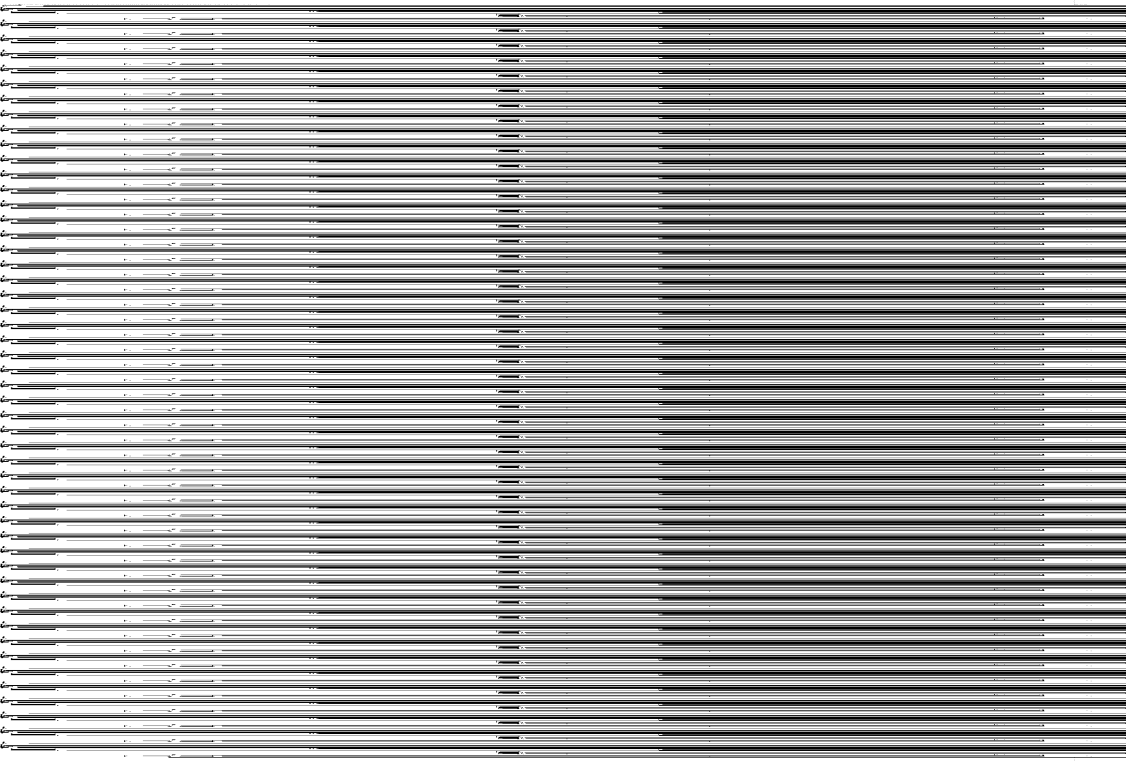
The IPCC Second Assessment Report, WG III describes the state of the art concerning

Table 1: Indicators of Biodiversity and Habitat Protection

Furthermore, it is important to mention for a damage pathway approach like ExternE that

biodiversity of soil microbial and faunal population by changing the soil moisture and the

With regard to biodiversity, an extensive empirical literature already exist. Many contingent



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