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Project acronym: ENSEMBLES

Project title: ENSEMBLE-based Predictions of Climate Changes and their Impacts

Instrument: Integrated Project

Thematic Priority: Global Change and Ecosystems

### **D7.3 Scenarios of adaptive capacity**

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Duration: 60 Months

Organisation name of lead contractor for this deliverable: Uni-HH

Revision [draft, 1, 2, ..]

| <b>Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)</b> |   |   |
|--|---|---|
| <b>Dissemination Level</b>   |   |   |
| <b>PU</b>  | Public  | ✓ |
| <b>PP</b>  | Restricted to other programme participants (including the Commission Services)        |   |
| <b>RE</b>  | Restricted to a group specified by the consortium (including the Commission Services) |   |
| <b>CO</b>  | Confidential, only for members of the Consortium (including the Commission Services)  |   |

At the start of ENSEMBLES, scenarios of adaptive capacity were ready. They have since been applied. Complete documentation is finished (<http://www.uni-hamburg.de/Wiss/FB/15/Sustainability/fund.html>). An improved methodology was developed, and is currently being tested.

#### Related publications

Tol, R.S.J. (2005), *The Benefits of Greenhouse Gas Emission Reduction: An Application of FUND*, Research Unit Sustainability and Global Change FNU-64, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.

Tol, R.S.J. and G.W. Yohe (2006), *The Weakest Link Hypothesis for Adaptive Capacity: An Empirical Test*, Research unit Sustainability and Global Change FNU-97, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.

## Research Unit Sustainability and Global Change, Hamburg University and Centre for Marine and Atmospheric Science

### FUND: The Climate Framework for Uncertainty, Negotiation and Distribution

#### The Model

The *Climate Framework for Uncertainty, Negotiation and Distribution (FUND)* is a so-called integrated assessment model of climate change. *FUND* was originally set-up to study the role of international capital transfers in climate policy, but it soon evolved into a test-bed for studying impacts of climate change in a dynamic context, and it is now often used to perform cost-benefit and cost-effectiveness analyses of greenhouse gas emission reduction policies and to support game-theoretic investigations into international environmental agreements.

*FUND* links scenarios and simple models of population, technology, economics, emissions, atmospheric chemistry, climate, sea level, and impacts. Together, these elements describe not-implausible futures. The model runs in time-steps of one year from 1950 to 2200, and distinguishes nine major world regions. *FUND* further includes the option to reduce emissions of industrial carbon dioxide. Reductions can be set by the user, or calculated so as to meet certain criteria set by the user.

An integrated assessment model, *FUND* is used to advice policy makers about proper and not-so-proper strategies. The model, however, always reflects its developer's world views. It is therefore regularly contrary to the rhetoric of politicians, and occasionally politically incorrect.

It is the developer's firm belief that most researchers should be locked away in an ivory tower. Models are often quite useless in unexperienced hands, and sometimes misleading. No one is smart enough to master in half a day what took some one else over five years to develop. Not-understood models are irrelevant, half-understood models treacherous, and mis-understood models dangerous.

Therefore, *FUND* does not have a pretty interface, and you will have to make to real effort to let it do something, let alone to let it do something new. If you want to give it a try, you can download selected versions of the model. You will need [TurboPascal 7.0 for DOS](#) to operate it. This programme is no longer on the market, but you can purchase [Delphi by Borland](#) instead. Descriptions and applications of the model can be found in the [publications](#) listed below.

Table 1. Various versions of the *FUND* model, their application, and their availability.

| Version | Description  | Download                | Documentation            |
|---------|--|-------------------------|--------------------------|
| 1.0-1.5 | Experimental versions  | No                      |                          |
| 1.6     | Cost-benefit analysis; cost-effectiveness analysis                               | <a href="#">FUND1.6</a> |                          |
| 1.7     | As 1.6, with methane emission reduction  | <a href="#">Exp</a>     |                          |
| 1.8     | As 1.6, with alternative forms of discounting                                    | <a href="#">Exp</a>     |                          |
| 1.9     | As 1.6, with alternative social welfare functions                                | <a href="#">Exp</a>     |                          |
| 2.0     | Updated impact module; coalition formation                                       | <a href="#">FUND2.0</a> |                          |
| 2.1     | Limited international trade and investment, alternative social welfare functions | <a href="#">FUND2.1</a> |                          |
| 2.2     | Extended time horizon; thermohaline circulation                                  | <a href="#">Dev</a>     |                          |
| 2.3     | Endogenous technological change  | <a href="#">Dev</a>     |                          |
| 2.4     | Extended impact module, development aid  | <a href="#">Dev</a>     |                          |
| 2.5     | 16 instead of 9 regions, coalition formation                                     | <a href="#">Dev</a>     |                          |
| 2.6     | Health-wealth feedbacks  | <a href="#">FUND2.6</a> |                          |
| 2.7     | Methane and nitrous oxide emission reduction                                     | <a href="#">FUND2.7</a> |                          |
| 2.8     | Diarrhoea, extension to 2300   | <a href="#">FUND2.8</a> | <a href="#">download</a> |

Exp: These are experimental versions of the model, not to be used by non-expert users. You can obtain the source code by sending me an [email](#).

Dev: Currently under development. The model code will be made available after peer review.

*FUND* would not have existed without the generous financial support by the [Netherlands National Research Programme on Global Air Pollution and Climate Change](#), various research programmes of the [European Commission, Directorate-General XII](#), the National Science Foundation through its support for the [Center for Integrated Study of the Human Dimensions of Global Change](#), and the [Michael Otto Foundation](#).

## Publications

### FUND 2.8

Link, P.M. and R.S.J. Tol (2004), '[Possible Economic Impacts of a Shutdown of the Thermohaline Circulation: An Application of FUND](#)', *Portuguese Economic Journal*, **3**, 99-114.

### FUND 2.7

Tol, R.S.J. (2004), *Exchange Rates and Climate Change: An Application of FUND*, Research Unit Sustainability and Global Change **FNU-45**, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg. (*Climatic Change*, forthcoming) [download](#)

Tol, R.S.J. (2004), *Multi-Gas Emission Reduction for Climate Change Policy: An Application of FUND*, Research Unit Sustainability and Global Change **FNU-46**, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg. (*Energy Journal*, forthcoming) [download](#)

### FUND 2.6

Tol, R.S.J. (2002), *Climate, Development, and Malaria: An Application of FUND*, Research Unit Sustainability and Global Change **FNU-16**, Centre for Marine and Climate Research, Hamburg University, Hamburg. (*Climatic Change*, forthcoming) [download](#)

### FUND 2.5

Lise, W. and R.S.J. Tol (in preparation), Climate Coalitions in an Integrated Assessment Model.

#### FUND 2.4

Tol, R.S.J. (2002), *Emission Abatement Versus Development As Strategies To Reduce Vulnerability To Climate Change: An Application Of FUND*, Research Unit Sustainability and Global Change **FNU-12**, Centre for Marine and Climate Research, Hamburg University, Hamburg. (*Environment and Development Economics*, forthcoming) [download](#)

Tol, R.S.J. and G.W. Yohe (in preparation), Uncertainty, Cost-Benefit Analysis and Development Aid.

#### FUND 2.3

Tol, R.S.J. (2002), *Technology Protocols for Climate Change: An Application Of FUND*, Research Unit Sustainability and Global Change **FNU-14**, Centre for Marine and Climate Research, Hamburg University, Hamburg. (*Climate Policy*, forthcoming) [download](#)

#### FUND 2.2

Tol, R.S.J. (2001), *A Collapse of the Thermohaline Circulation and its Impacts on Africa*, National Academy of Sciences Committee on Abrupt Climate Change and the Yale/NBER Program on International Environmental Economic Workshop on Economic and Ecological Impacts of Abrupt Climate Change, Washington, D.C., March 22-23.

Tol, R.S.J. (2001), *Economic Implications of a Collapse of the Thermohaline Circulation*, Integration project meeting, Postdam, September 19-20.

#### FUND 2.1

Kemfert, C. and R.S.J. Tol (2001), 'Equity, International Trade and Climate Policy', in D. Heinen, S. Hoch, T. Krafft, C. Moss, P. Scheidt and A. Welschhoff (eds.), *Contributions of Global Change Research*, pp. 105-121, German National Committee on Global Change Research, Bonn. This paper applies FUND2.1.

Kemfert, C. and R.S.J. Tol (2002), '[Equity, International Trade and Climate Policy](#)', *International Environmental Agreements*, **2**, 23-48. This paper applies FUND2.1.

#### FUND 2.0

Darwin, R.F. and R.S.J. Tol (2001), '[Estimates of the Economic Effects of Sea Level Rise](#)', *Environmental and Resource Economics*, **19** (2), 113-129. This paper applies the impact module of FUND2.0.

Tol, R.S.J. (2002), '[New Estimates of the Damage Costs of Climate Change, Part I: Benchmark Estimates](#)', *Environmental and Resource Economics*, **21** (1), 47-73. This paper describes the impact module of FUND2.0.

Tol, R.S.J. (2002), '[New Estimates of the Damage Costs of Climate Change, Part II: Dynamic Estimates](#)', *Environmental and Resource Economics*, **21** (2), 135-160. This paper describes the impact module of FUND2.0.

Tol, R.S.J. (2003), '[Is the Uncertainty about Climate Change Too Large for Expected Cost-Benefit Analysis?](#)', *Climatic Change*, **56** (3), 265-289. This paper applies FUND2.0.

Tol, R.S.J. and H. Dowlatabadi (2001), '[Vector-borne Diseases, Climate Change, and Economic Growth](#)', *Integrated Assessment*, **2**, 173-181. This paper applies FUND2.0.

#### FUND 1.9

Tol, R.S.J. (2000), 'Equitable Cost-Benefit Analysis of Climate Change Policy' in: C. Carraro (ed.) *Efficiency and Equity of Climate Change Policy*, Kluwer Academic Publishers, Dordrecht, pp. 273-290. This paper applies FUND1.9.

Tol, R.S.J. (2001), '[Equitable Cost-Benefit Analysis of Climate Change](#)', *Ecological Economics*, **36** (1), 71-85. This paper applies FUND1.9.

Tol, R.S.J. (2002), '[Welfare Specification and Optimal Control of Climate Change: An Application of FUND](#)', *Energy Economics*, **24** (2), 367-376. This paper applies FUND1.9.

#### FUND 1.8

Tol, R.S.J. (1999), '[Time Discounting and Optimal Control of Climate Change: An Application of FUND](#)', *Climatic Change*, **41** (3-4), 351-362. This paper applies FUND1.8.

#### FUND 1.7

Tol, R.S.J., R.J. Heintz and P.E.M. Lammers (2003), '[Methane Emission Reduction: An Application of FUND](#)', *Climatic Change*, **57** (1-2), 71-98. This paper applies FUND1.7.

#### FUND 1.6

Hourcade, J.-C., M. Haduong, A. Gruebler and R.S.J. Tol (2001), '[INASUD Project Findings on Integrated Assessment of Climate Policies](#)', *Integrated Assessment*, **2** (1), 31-35. This paper applies FUND1.6.

Tol, R.S.J. (1995), 'The Damage Costs of Climate Change -- Towards More Comprehensive Calculations', *Environmental and Resource Economics*, **5**, 353-374. This paper describes the impact module of FUND1.6.

Tol, R.S.J. (1996), '[The Damage Costs of Climate Change: Towards a Dynamic Representation](#)', *Ecological Economics*, **19**, 67-90. This paper describes the impact module of FUND1.6.

Tol, R.S.J. (1997), 'The Climate Framework for Uncertainty, Negotiation and Distribution' in: O.K. Cameron, K. Fukuwatari and T. Morita (eds.), *Climate Change and Integrated Assessment Models: Bridging the Gaps -- Proceedings of the IPCC Asia-Pacific Workshop on Integrated Assessment Models*, Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, 591-593. This paper describes FUND1.6.

Tol, R.S.J. (1998), '[On the Difference in Impact between Two Almost Identical Climate Scenarios](#)', *Energy Policy*, **26** (1), 13-20. This paper applies FUND1.6.

Tol, R.S.J. (1999), 'The Marginal Costs of Greenhouse Gas Emissions', *The Energy Journal*, **20** (1), 61-81. This paper applies FUND1.6.

Tol, R.S.J. (1999), 'Kyoto, Efficiency, and Cost-Effectiveness: Applications of FUND', *Energy Journal Special Issue on the Costs of the Kyoto Protocol: A Multi-Model Evaluation*, 130-156. This paper applies FUND1.6.

Tol, R.S.J. (1999), '[Spatial and Temporal Efficiency in Climate Policy: Applications of FUND](#)', *Environmental and Resource Economics*, **14** (1), 33-49. This paper applies FUND1.6.

Tol, R.S.J. (1999), '[Safe Policies in an Uncertain Climate: An Application of FUND](#)', *Global Environmental Change*, **9**, 221-232. This paper applies FUND1.6.

FUND 1.5

Tol, R.S.J. (1997), '[On the Optimal Control of Carbon Dioxide Emissions -- An Application of FUND](#)', *Environmental Modelling and Assessment*, **2**, 151-163. This paper applies and describes FUND1.5.

Tol, R.S.J. (1996), 'The Climate Framework for Uncertainty, Negotiation and Distribution' in: K.A. Miller and R.K. Parkin (eds.), *An Institute on the Economics of the Climate Resource*, University Corporation for Atmospheric Research, Boulder, p 471-496. The paper describes FUND1.5.

Tol, R.S.J. (2001), '[Climate Coalitions in an Integrated Assessment Model](#)', *Computational Economics*, **18**, 159-172. This paper applies FUND1.5.