

European Network for the Asia-Pacific

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INTEGRATED ASSESSMENT MODELLING: FROM CLIMATE CHANGE ASSESSMENT TO GLOBAL CHANGE ASSESSMENT AT INTERLINKED SCALES.

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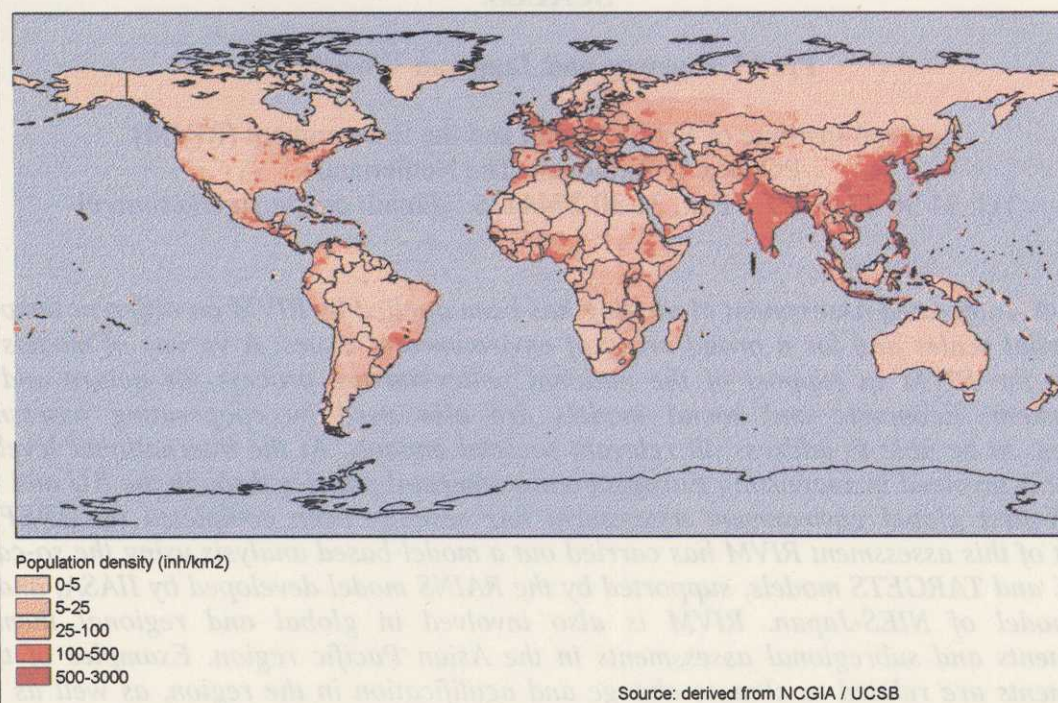
Abstract: *Integrated Assessment Modelling has been applied by RIVM on different temporal and spatial scales and for a broad array of environmental issues. A variety of models are used by the RIVM in support of the national policy-making process for nature and the environment. Economic and social models are also used by cooperating assessment institutes, to be able to address all relevant societal impacts. At the international level the institute is involved in supporting European environmental policies through the EU and UN-ECE. A first global environment assessment has recently been completed by UNEP. In support of this assessment RIVM has carried out a model-based analysis using the so-called IMAGE and TARGETS models, supported by the RAINS model developed by IIASA, and the AIM model of NIES-Japan. RIVM is also involved in global and regional thematic assessments and subregional assessments in the Asian Pacific region. Examples of these assessments are related to climate change and acidification in the region, as well as to a Chinese sustainable development programme organized by the China Council. Backed by the experience built up by RIVM in integrated assessment, the following recommendations for putting them to practical use have emerged:*

- *scientific consensus on methods and information to be used as a critical factor for success;*
- *a well-organized interaction with the policy-makers: a requirement for getting the results of the assessment accepted as a policy-making basis;*
- *a recommendation that UN bodies provide a general framework for assessment on different scales, to guarantee consistency.*

1. Introduction

The RIVM in the Netherlands has gained substantial experience in the field of integrated environment assessment. A comprehensive policy approach to environmental issues requires a similar scientific analysis of the problems at hand. The interactions between ecology and economy were recognized from the start of the assessment activities in the Netherlands. Recently, social issues have come to be considered as important as the economic ones, and are therefore going to be added to the assessments. Economic and demographic forces are major drivers of environmental problems.

Global Population Density 1994



Global Carbon Dioxide Emission Density 1990.

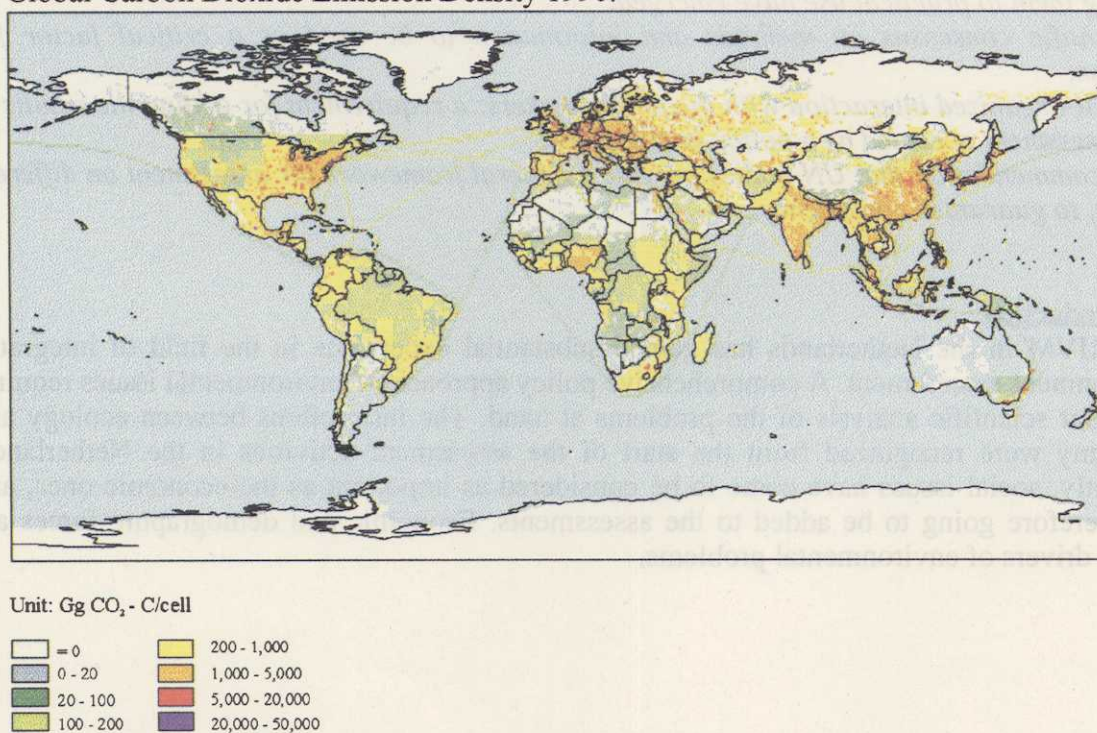


Figure 1: Current population density and CO₂ emission density as indicators of the main driving forces (NCGIA/USCB, 1995 and RIVM/TNO, 1996)

The knowledge available in the Netherlands on ecological, economic and social assessments has also been made available to international organizations and several individual countries like China, India, Benin, Bhutan and Costa Rica. The European Union's Environmental

Action Programme, the European Convention on Long Range Transboundary Air Pollution (UN-ECE), the Climate Convention (IPCC and COP), the United Nations Environmental Programme (UNEP) and the implementation of Agenda 21 (DPCSD), are all actively supported by means of assessment activities.

Adequate assessment requires the interlinked use of information on the existing situation, and models to analyze future developments. Assessments must be driven by different visions on future developments. Visions on the possible futures for the world at large have been developed by international organizations like IPCC and UNEP, by international companies like Shell and by assessment institutes like SEI, WRI, IIASA and CPB. Three visions have been recently developed in support of UNEP's Global Environment Outlook: Conventional Worlds, Barbarization and Great Transitions (Gallopín et al. 1995). In the conventional world vision current trends will prevail for the coming decades. However, a stronger will to implement policy reform, strengthen management systems and ensure the use of better technology, could form a part of this vision. The Barbarization vision unfolds a world of survival of the fittest which may even lead to collapse of the total social system. The Great Transition vision sketches a world of equity and efficiency which may be implemented by means of a green revolution.

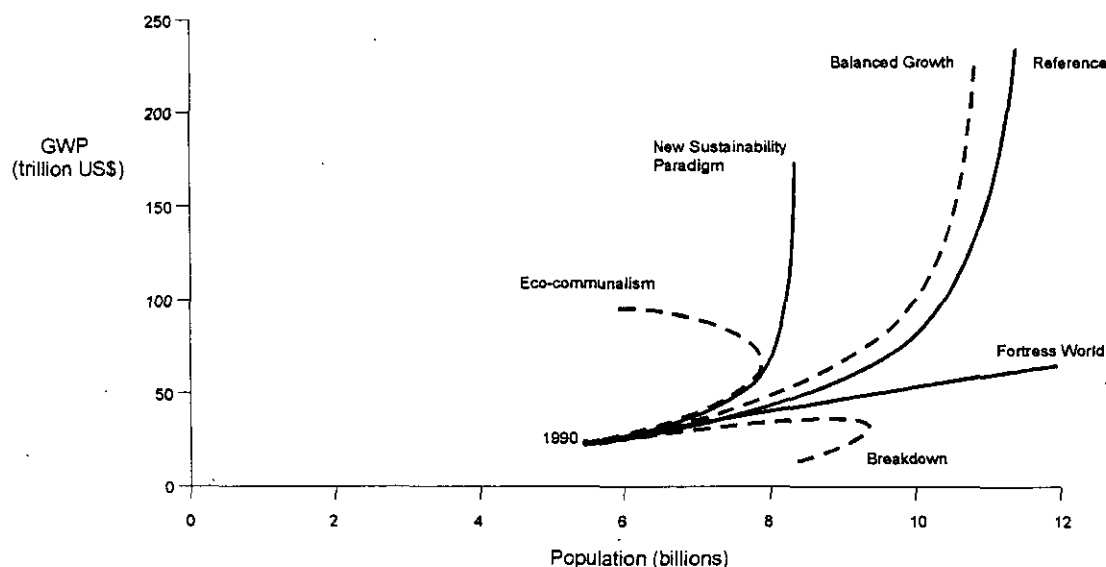


Figure 2: Population and economic growth from 1990-2050 under different development scenarios (Gallopín et al. 1997).

Because policy will have to be implemented on various spatial scales, the scenarios should be analyzed on different scales. UNEP did this for a single Conventional Worlds' reference scenario for six world regions in the first Global Environment Outlook. The RIVM and CPB carried out additional analyses for the other world visions. The results of these exercises will be reported in the next section. Further analysis at the regional level has been done by the European Environment Agency for the European region and by the Japanese NIES for the Asian region. RIVM is also involved in an Asian thematic assessment for acidification. The results of the Asian acidification assessment will be reported in section 3. The China Council is promoting an in-depth analysis of sustainable development several provinces. A comprehensive assessment of the developments in some specific regions will be used as an example of a (sub)national assessment.

2. Global assessment of a region-specific nature

RIVM and CPB have carried out several economic analyses of the world visions using an eight-sector and four-region economic model called Worldscan (Bollen and Gielen 1997). Openness of the economy (imports and exports) and regional market shares are examples of the issues investigated. Openness is defined as the ratio between the average of imports and exports, and the total GDP. On the world scale, trade in the Great Transition scenarios intensifies considerably compared to the other scenarios. This effect is caused by the optimistic assumptions for the growth of economic output in the non-OECD countries. Non-OECD countries show a deteriorating trade balance in the Barbarization scenario, mainly caused by interest payments to foreign investors as debt accumulates. The Conventional World Reference scenario shows a similar development, only to a lesser extent.

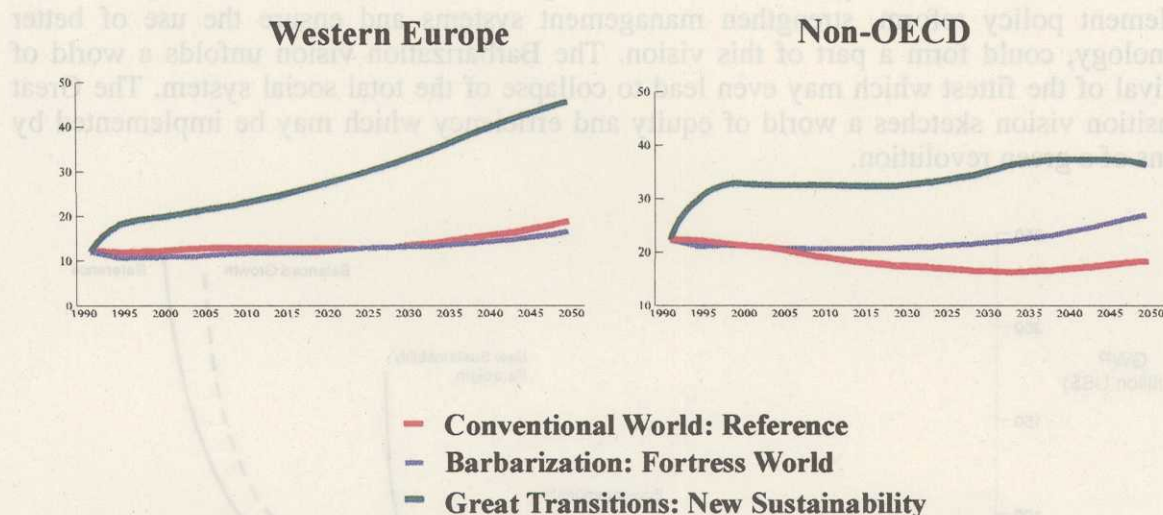


Figure 3: Openness of the economies in three world visions: import + export as percentage of GDP (Bollen and Gielen, 1997).

In the non-OECD regions the sectoral structure is dominated by agriculture and food (20 to 30%) and services (35 to 40%). In the OECD countries the service sector is by far the most important one. It accounts for 60 to 65 % of the total economic output in Western Europe. In this region the share of agriculture and food in the Great Transition scenarios, as an extreme case, decreases from about 9% to about 1%. The regional shares of these sectors in the world market change accordingly. The same is happening with the consumer goods market, although to a lesser extent.

These examples indicate that huge shifts in the regional sectoral structure may occur, depending on the scenario context. As a result, the environmental impacts may change enormously from region to region. A decline of agriculture in Western Europe may have favorable environmental effects in the region, either by ecologizing agriculture in large areas or by intensifying it in less or non-vulnerable areas.

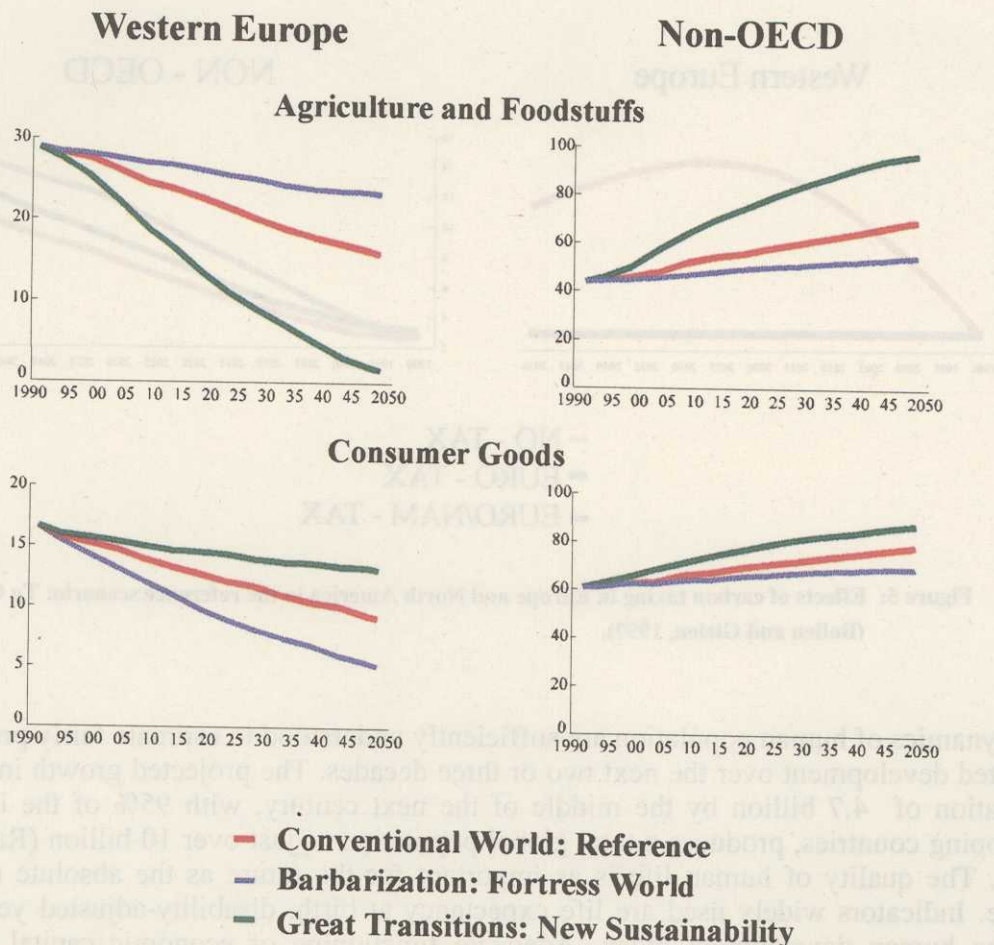


Figure 4: Regional shares on the global market in three world visions: percentage of global output (Bollen and Gielen, 1997).

The global emissions of carbon dioxide may increase by about 50% for the balanced growth variant, or even triple for the reference variant of the conventional world scenarios up to 2050. The other scenarios show developments in between these extremes. As an example of a policy analysis, the effects of a unilateral European and a bilateral European-American energy tax was investigated for the conventional world scenarios. Both policy options show a substantial carbon leakage to the developing world. Energy-intensive industries move to non-OECD regions where the energy efficiency is considerably lower. As a result, global emissions increase and stabilize in the regions imposing the tax. The latter regions also suffer from a tax-induced sectoral shift and a lowering of wages.

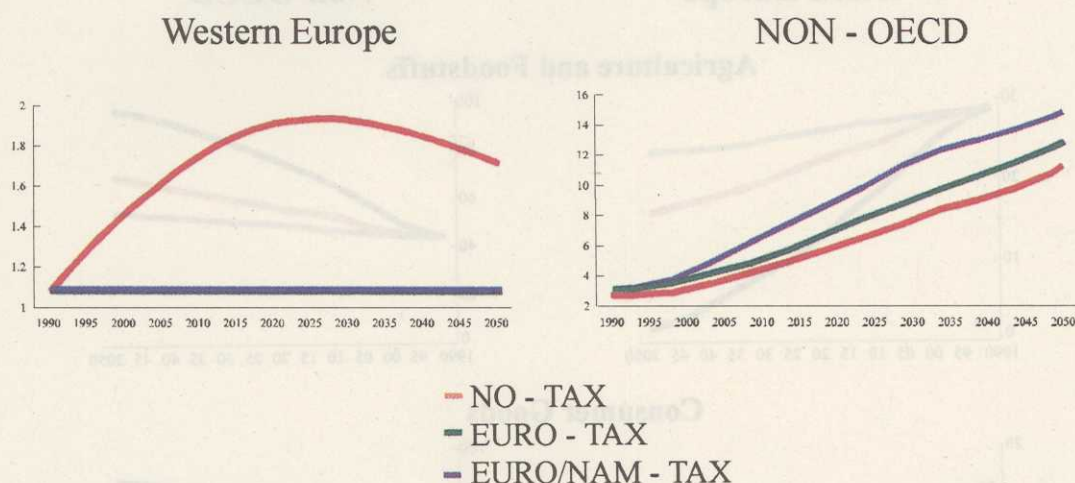


Figure 5: Effects of carbon taxing in Europe and North America in the reference scenario: Tg C (Bollen and Gielen, 1997).

The dynamics of human population are sufficiently understood to estimate fairly precisely the expected development over the next two or three decades. The projected growth in the world population of 4.7 billion by the middle of the next century, with 95% of the increase in developing countries, produces a total global population of just over 10 billion (Raskin et al. 1996). The quality of human life is as important for the future as the absolute number of people. Indicators widely used are life expectancy at birth, disability-adjusted years of life and the human development index. Adequate functioning of economic capital has to be accompanied by other, less tangible, forms of human and social capital (World Bank 1995). The growth of the economy as such is generally expressed in terms of GDP. The world's gross product is estimated to increase from about US\$20,000 billion to about US\$100,000 billion. Non-OECD regions are assumed to follow patterns similar to the OECD regions. Per capita incomes in Latin America and East Asia are projected to exceed current levels in OECD Europe in the second half of the next century. Per capita income in Asia and the Pacific are assumed to rise faster than in the industrialized countries during the 1990-2050 period. In spite of these projected growth rates, the income gap between developing and industrial countries is likely to increase in the near future.

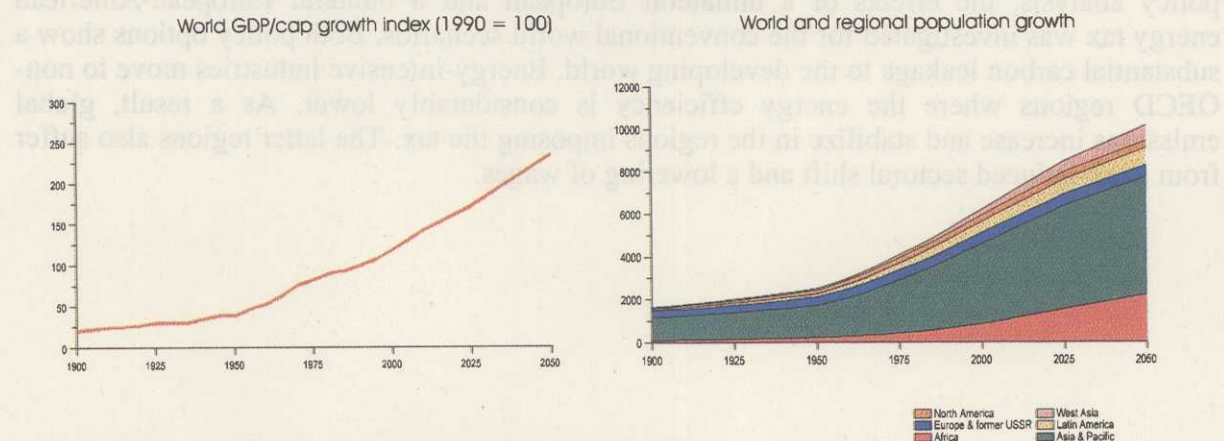


Figure 6: Economic and population growth in the reference scenario from 1900-2050 (population in millions; RIVM/UNEP, 1997).

The reference scenario for developments of population and economic growth can be translated to future demands on water, food and land (RIVM/UNEP1997). The CW reference scenario postulates a decrease in aggregate water intensity because of increasing water efficiency and gradual shifts to less water-intensive economic activities. The historical growth in total withdrawals in the industrialized regions slows down considerably and withdrawals in North America eventually decrease. Regionally, large increases in water demand are expected up to 2050 in Africa, Latin America, China, and South and Southeast Asia. At present, irrigation accounts for around 70% of total water withdrawals, industrial use for about 22%, and domestic use for the rest. Future domestic and industrial demands show a slight increase in industrialized regions and a marked increase (3 to 5 times) in developing regions. Agricultural demands show a slower increase of about 20% in total and about 35% for irrigation purposes.

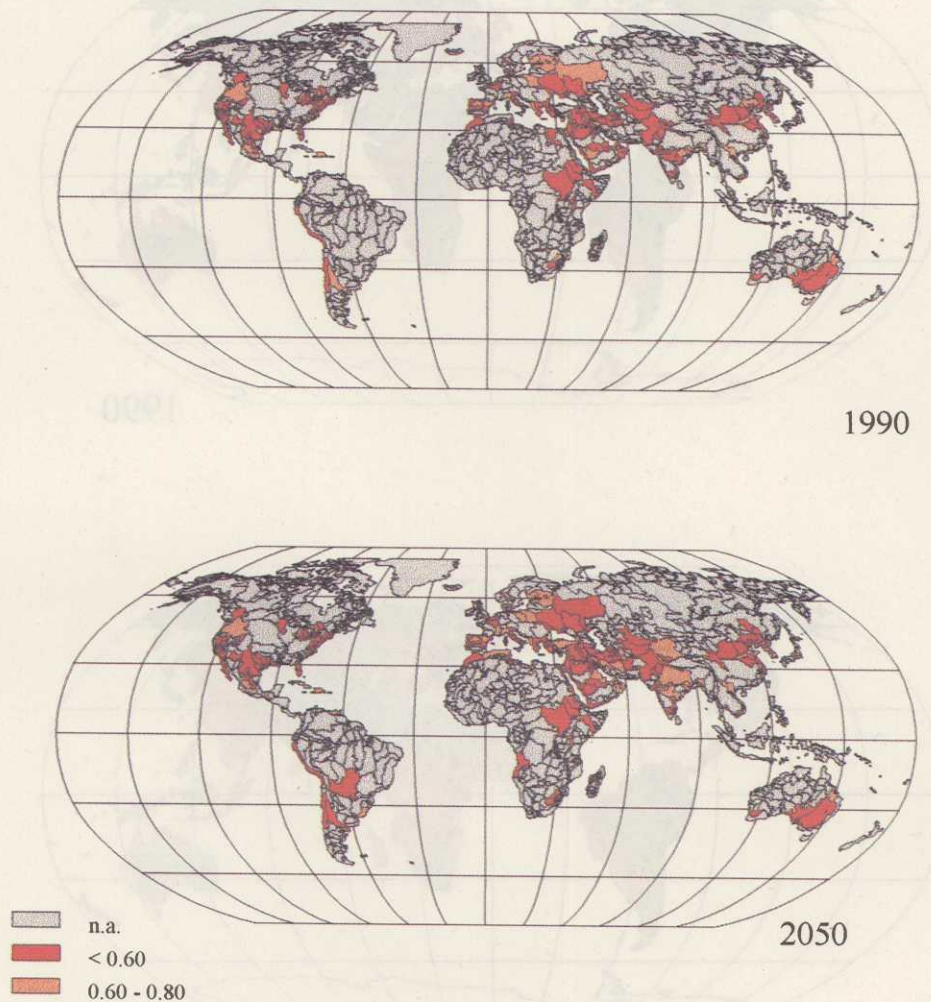


Figure 7: Water availability in the reference scenario from 1990-2050 (RIVM/UNEP, 1997).

Note: shown is the water demand satisfaction ratio (ranging between 0 and 1). Ratio 1 means full satisfaction, while ratio 0 means no satisfaction. Problem areas are shown in red and orange. Areas with very low population densities are left out of the calculations, and are shown in gray.

Irrigation intensity decreases only slightly. A model-based assessment was made of water satisfaction rates per catchment area, based on monthly averages of yearly averaged climate conditions (UNEP,1997). The number of catchment areas not facing water problems

decreases from 22 to 15%. The percentage of people not having water problems decreases from about 25 to 20%. The number of people having relatively severe water problems will increase from 1500 billion to 2800 billion in 2050. The areas most affected are parts of Africa, western Asia, southern India and China.

The global food demand is expected to increase by 50% by 2015 and 110% by 2050. The combination of the increase in agricultural demand, changes in consumption patterns, and ongoing technological development, will lead to a 27% increase of the total agricultural area by 2015 and about a 42% increase by 2050. This conversion from natural to domesticated land will mainly take place in Africa and Asia.

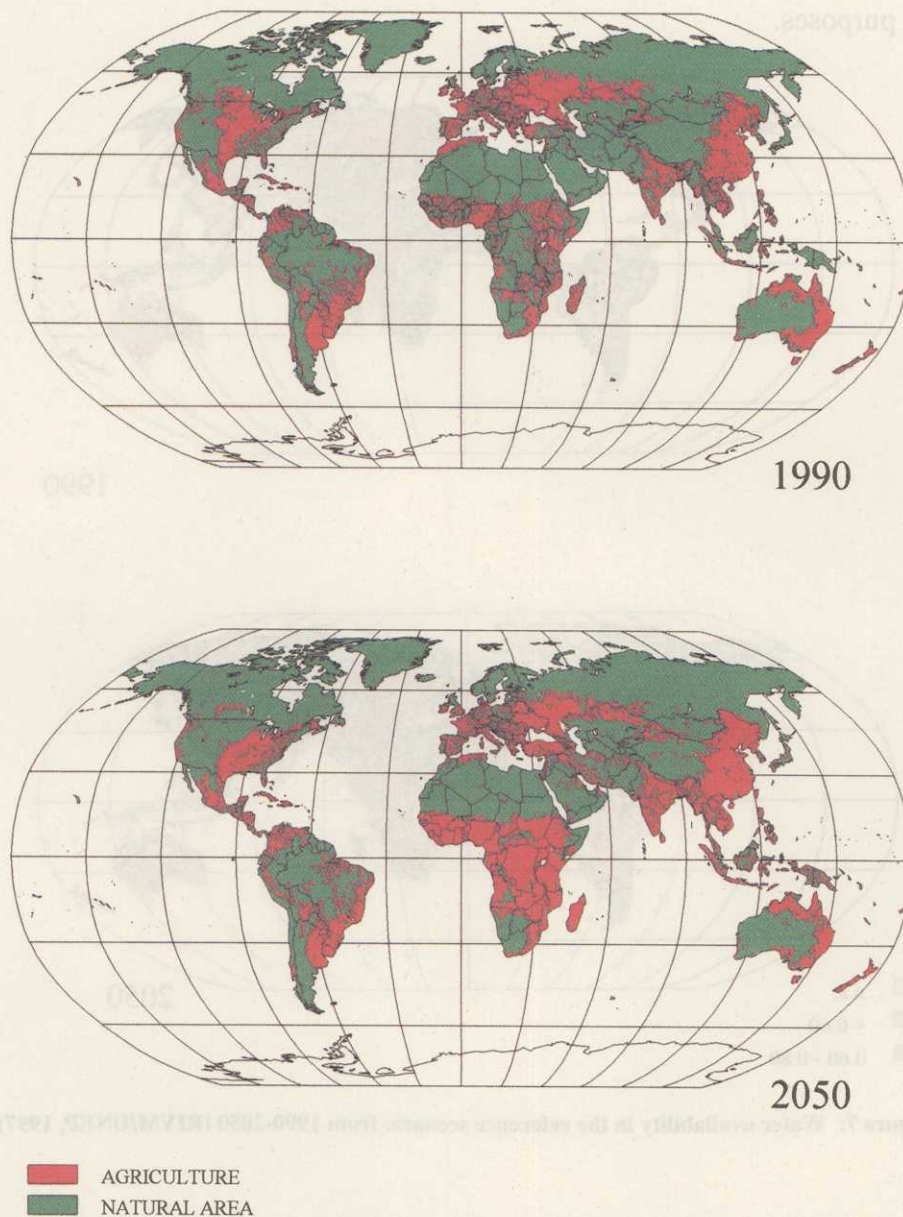


Figure 8: Land conversion from natural areas to domesticated land in the reference scenario from 1990-2050 (RIVM/UNEP, 1997)

Soil degradation has not yet been accounted for in these estimates. If no countermeasures are taken, an additional 30% of agricultural land may be needed to compensate for losses due to erosion. Optimistic views on the prospects of technology are often contradicted by pessimistic views on socio-economic capabilities of the agricultural sector. Because food security is one of the most basic human needs, much more international research and cooperation is required to establish achievable developments in agricultural production (UNEP 1997).

3. Regional assessment for Asia and the Pacific: the acidification example

Due to high economic growth, emissions of SO_2 in Asia rapidly increase from about 17 Tg S in 1990 to about 75 Tg S by 2050, if no control measures are taken.

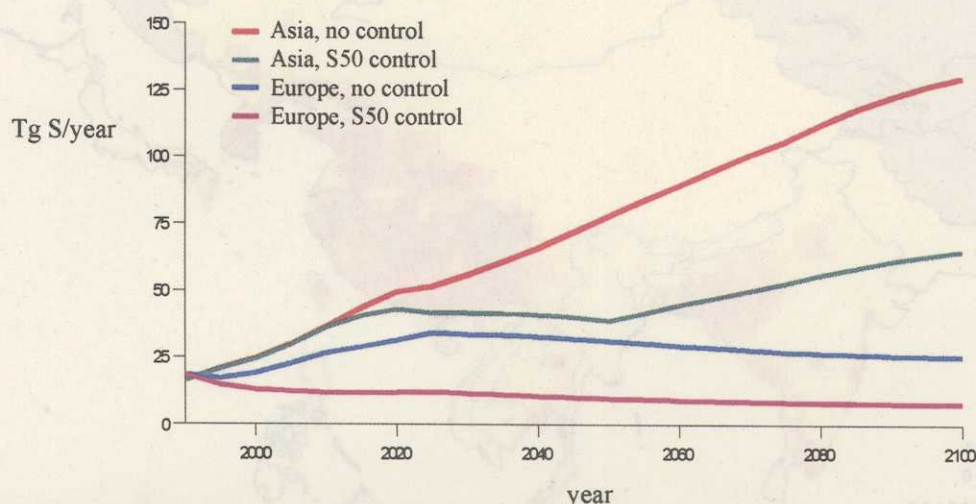


Figure 9: Projected sulfur dioxide emissions for Europe and Asia (Alcamo et al. 1996 and Posch et al. 1996).

Historical data in Europe provides evidence of the relationship between soil and surface-water acidification and increasing emissions, transport and deposition of sulfate. Urban exposure to sulfur dioxide and other air pollutants show a tendency to exceed WHO air quality guidelines in Asia. It seems to be just a matter of time before air pollution effects, such as sulfur-based acidification, become more widespread, also enveloping rural areas. Regional effects of acidification in Asia are becoming subject to increased investigation. For example, the Environmental Agency of Japan has started a major international effort to establish an Acid Deposition Monitoring Network in East Asia. Country participants involved in the establishment of this network have agreed on guidelines and the development of technical manuals; these will also include the use of numerical models to assess transport and impacts of acid deposition-related substances.

Another initiative to investigate the risk of damage due to acidification in Asia was taken in a project by the World Bank. This consisted of a first phase to establish an integrated air pollution assessment model. A result was the development of a Regional Air pollution, INformation and Simulation model for Asia (RAINS-Asia) to assess the relationship between the energy system, sulfur emissions, long-range dispersion and environmental impacts (Foell et al. 1995). The impact module of RAINS-Asia (Hettelingh et al. 1995a) is used to provide information on the probability of damage from acid deposition exceeding critical loads for emission reduction alternatives. RAINS-Asia enables the assessment of regional emissions in Asia subject to constraints related to energy use, emission abatement cost and environmental

sustainability. Environmental sustainability is quantified by means of critical loads, i.e. thresholds of acid deposition above which bio-geochemical balances are disrupted, leading to damage. Results of RAINS Asia assessments show that an average growth of the energy consumption of 4% per year up to 2020 will lead to increased risk of damage by acidification in China, Korea, Japan, the Philippines, Indo-China, Indonesia and the Indian subcontinent. Impacts due to multistress, i.e. the combined influence of ambient concentrations of sulfur dioxide, nitrogen oxides and tropospheric ozone, cannot be excluded, while amplification of the impacts due to climate change strengthen the case for an integrated approach to these threats.

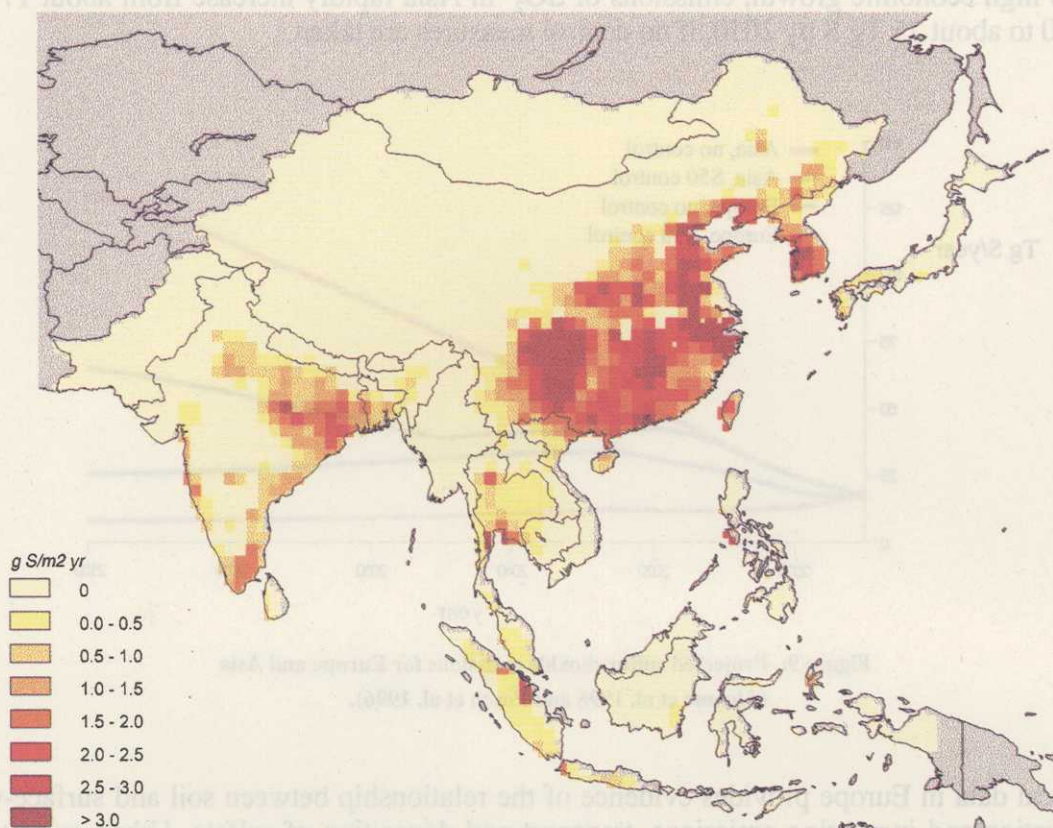


Figure 10: Asian areas where critical loads of sulfur are exceeded in 2050 assuming partial controls of emissions (Foell et al. 1995).

The critical load concept was used in a similar way, to identify the risk of damage in negotiations on the reduction of sulphur emissions in Europe (Hettelingh et al. 1995b), with the aim of decreasing the excess sulfur deposition over critical loads through cost-optimal emission abatement. Current negotiations on the reduction of nitrogen oxides involve the notions of multistress caused by acidification, eutrophication and tropospheric ozone. Close collaboration between scientists and policy-makers has been established in Europe through the Convention on Long Range Transboundary Air Pollution of the UN/ECE. In this framework integrated model assessments have become part of the yardsticks used in the negotiation of air pollution abatement protocols. In Asia, a similar exchange of information between scientists and policy may become operational through monitoring networks and other fora, including those of UNEP's GEO initiative.

4. Subregional assessment by the China Council

The China Council for International Cooperation on Environment and Development was established by the State Council of the Chinese Government in 1991, to facilitate cooperation between China and the international community for the environment and development. The Council is a high-level advisory body producing proposals for consideration by the Chinese government. Key issues for the next five-year programme are pollution control, energy strategies, environmental economics, trade and sustainable development, protection of biodiversity and monitoring.

The Council is developing policy plans for the major urban and industrial areas of the People's Republic of China, in particular for Suzhou, Chongqing and Guangzhou as pilot areas. Compared to a country like the Netherlands, the environmental conditions in these areas are rather poor (RIVM 1996).

	Suzhou	Chongqing	Guangzhou	Netherlands
Population density (pop. per sq km)	675	654	832	452
GDP per capita (10,000 yuan)	1.6	0.5	1.7	16.5
Energy use (tonne coal eq./10,000 yuan)	2.4	4.0	2.5	0.7
Vehicles per sq km	24	8	67	301
SO ₂ emissions (kg per ton coal)	6.8	23.5	6.9	1.4
SO ₂ concentrations (mg/m ³ urban)	0.07	0.35	0.10	0.02
TSP concentrations (mg/m ³ urban)	0.28	0.35	0.28	0.05
Environmental costs (% of GDP)	1.5	0.7	1.0	2.5

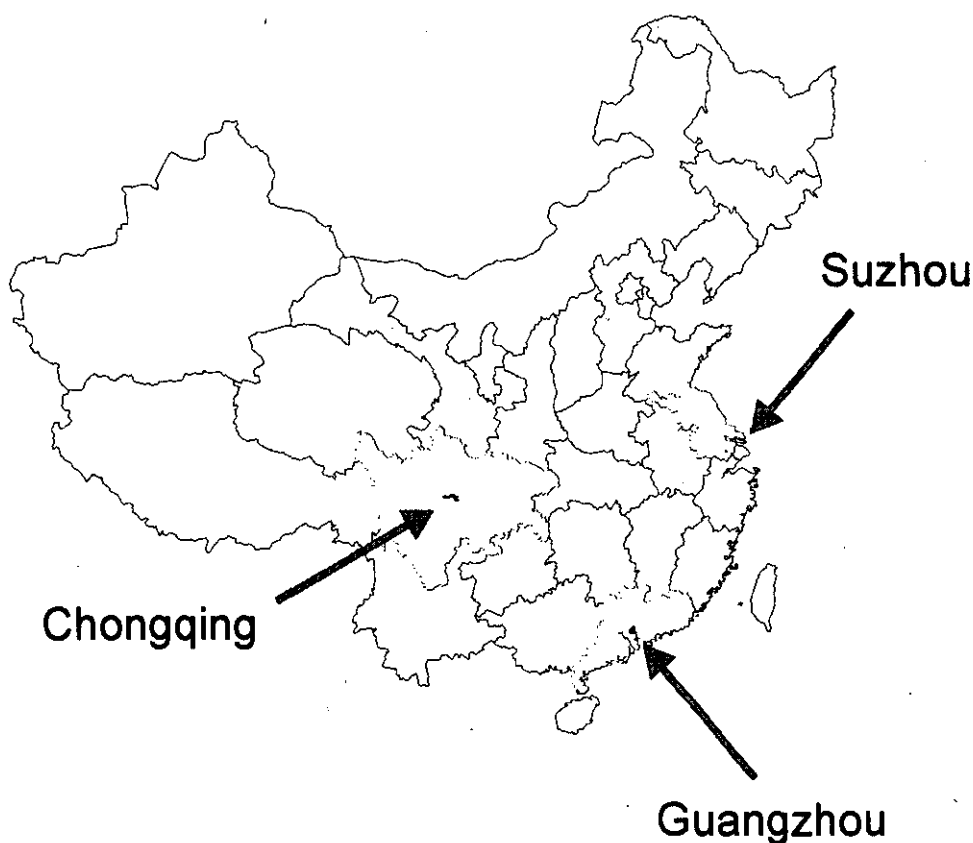


Figure 11: Location of the Suzhou, Chongqing and Guangzhou areas in the People's Republic of China.

A long-term environmental outlook has been prepared for each area, with the Chongqing outlook serving as an example. Air pollution in this area originates mainly from power plants, heavy industry, and domestic use of coal and vehicles. Water pollution poses risks for diseases and affects the productivity of fisheries. The economic output is assumed to triple between 1995 and 2010, transport is expected to double, and the population will grow by about 10% to 16.8 million.

Emission reductions of 65-80% will be needed to meet WHO air quality guidelines for human health and about 80% to avoid acidification. Current policies will not achieve these kinds of reductions. Current policy also aims at a comprehensive utilization of solid waste up to 60-80%. Water policies are aimed at increasing the percentage of surface waters meeting national standards, from 90 to 98 %. The current level of environmental investments does not prevent the exceedance of environmental targets for SO₂ (exceedance of 220%), dust and BOD (exceedance of 40%) and treatment of industrial waste (40% treated). Increasing the level of investments to 2% of GDP will improve the environmental performance considerably, although the targets for SO₂ and waste will not be fully met. A higher share of environmental investments in the total investments could lead to a lower economic growth rate, if external funding cannot be obtained.

The assessments at the specific region level can be derived from national assessments, highlighting specific priorities at the subnational level. Environmental investments, when compared to the Chinese average of 1% of GDP, vary considerably among the areas in China. At the subnational level the emphasis is mainly on water, air and waste problems, accounting for almost all the costs involved. The examples given also stress the need for subnational assessment and for information on larger countries.

5. Conclusions and recommendations

Integrated assessment is a powerful tool in supporting environmental policies, providing the information and methodologies used are not a subject of scientific debate. IPCC serves as a useful instrument to achieve scientific consensus on the issue of climate change. A close interaction between assessors and policy-makers is required to get the results accepted and implemented thereafter in the policy-making process. The climate case is an example of a well-organized interaction in the negotiating process.

However, climate as such is too narrow an issue for integrated assessment of all relevant economic, social and environmental factors. Limiting the assessment to climate alone may result in overemphasizing issues of a relatively minor importance in a broader framework or the other way around. For instance, the effects of climate change on human health in poor regions are probably less important compared to other environmental factors as the availability of food and water.

The World Bank advocates an integrated assessment of economic, social and environmental issues, and rightfully so. The well-being of the population should serve as an ultimate goal in which the importance of human, social, economic and natural capital can be expressed. UNEP's Global Environment Outlook and the related CSD Trends Report are moving in that direction. These global assessments will provide a framework for regional and thematic assessments. In turn, national assessments can build on the assessments at a higher level. The reverse bottom-up process is certainly as valuable as a source of detailed information for adequate (sub)regional as well as global assessments. UNEP, UNDP and DPCSD must intensify their existing cooperation so as to facilitate the different levels of assessments, at the very least by providing a general framework for analysis so as to guarantee consistency.

This framework should not be limited to environmental models. Economic and demographic models representing coherent regions in a socio-economic sense must be included as soon as possible. The CPB in the Netherlands is in the process of developing a multiregion and multisector equilibrium model for the world's economy. Combined with the UN-linked system of national economic models, this may serve as a useful tool for economic analysis. Demographic models are still under development; this is a process which needs speeding up. The Japanese AIM model, the RAINS model of IIASA, the POLESTAR model of SEI and the Dutch IMAGE model, could well serve as environmental models operating under the umbrella of the socio-economic models mentioned. Detailed models can be used to add detailed regional or issue-oriented analysis to the total framework.

The TARGETS framework developed by RIVM could be used to this end. The system in TARGETS offers a shell in which economic and population models can be employed interactively with models representing the use of land, water, minerals and energy (derived demands) and the changes in bio-geochemical cycles. The pressure, state, impact and response approach is also reflected in this shell. It could contain core data sets, simplified versions of the environmental models mentioned and the economic and demographic models to be developed (Rotmans and de Vries, in prep.).

The network of Collaborating Centers organized by UNEP can be used to promote the use of a common framework for integrated assessment. This framework should enable the Centers to add detailed analysis to the encompassing comprehensive analysis. The secretariats of regional and global conventions (air pollution, climate, desertification, biodiversity) should make use of the same framework by supplementing it with issue-oriented information. The secretariat of the Commission on Sustainable Development could use the framework to upgrade national reports on progress to comprehensive regional and global trend reports, and to analyze policy options. The World Bank and the United Nations Development Programme must take an interest in this framework as an instrument to evaluate investment programmes. Thus a UN-wide cooperation is required to promote full-scale integrated assessment for sustainable development.

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