

Down-scaling SRES-scenarios for use of ecological and economic modelling of the Vechtstreek

NWO-Economic-ecological analysis of biodiversity in wetlands - internal report

Jan Vermaat, Florian Eppink, Aat Barendregt, Jasper van Belle, Martin Wassen & Jeroen van den Bergh

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IVM

Institute for Environmental Studies

Vrije Universiteit

De Boelelaan 1087

1081 HV Amsterdam

The Netherlands

Tel. ++31-20-5989 555

Fax. ++31-20-5989 553

E-mail: info@ivm.falw.vu.nl

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Abstract

This report carries out a down-scaling exercise of SRES/Foresight-similar scenarios to capture important possible future alternative socio-political settings for the Vechtstreek wetlands area. These scenarios will be used in an ecological-economical analysis of wetland biodiversity for this area. The report introduces the need for scenarios and briefly reviews existing approaches in The Netherlands and abroad. It highlights the requirements identified in a project workshop and then sets out to specify down-scaled features of four SRES-based scenarios in an extensive tabulation. Features addressed are agricultural land use, type and intensity of recreation, water management, carbon sequestration and biodiversity potential. Finally, these are translated into ranges of input parameters for the spatially explicit ecological and economic models.

1. Introduction

Within this NWO-programme, two PhD projects attempt to model spatio-temporal patterns of biodiversity development for the wetlands complex of the larger Vechtplassen area, but each from a widely different perspective. Florian Eppink will evaluate the benefits (and direct costs) of biodiversity conservation, will develop a model that achieves biodiversity conservation and economic goals at minimum cost (by spatially optimising the allocation of various land use types), and will apply the optimisation framework to scenarios for the Vechtstreek. Eppink develops a biodiversity module for the Land Use Scanner (REF). Jasper van Belle constructs a series of hydro-ecological models that generate spatially dynamic landscapes for the Vechtplassen area, and translates these to biodiversity predictions. Van Belle develops the spatially explicit succession model Fenscape. Overall, the programme will combine modelling outcomes from both projects in a joint 'overlay'-exercise, where differences and similarities will improve our understanding of the spatially-explicit feedback patterns between economic land use and biodiversity enhancement. In addition, the two PhD projects are complementary in the sense that Eppink's project employs a relatively coarse resolution, at a relatively large extent, compared with van Belle's project.

In order to maximise mutual consistency of the two projects, a joint delineation of scenarios to be applied in their modelling exercises is aimed for. The present report outlines such a set of scenarios for our work in The Vechtstreek area and presents a detailed downscaling effort. It is based on two internal project brainstorm workshops. The first, held in November of 2003 outlined criteria for scenarios required for a useful application in the area under study (cf section 3 below). The second, of February 2005, discussed the down-scaled implementation proposal translated into input parameters for both Fenscape and the Land use Scanner.

Scenarios are taken here as coherent, internally, consistent and plausible descriptions of a possible future state of the world (Parry & Carter, 1998; Lejour 2003; Turner, 2005). Scenarios portray images of how society and its supporting environment could look like given different sets of assumptions and consequent, rationalized conditions. Scenarios may combine contrasting ideologies and perspectives on societal structure as well as economic development at a number of scales. Scenarios are used to aid policy makers and managers in decision making in the light of future uncertainty. They also assist modellers to outline the relevant questions to address in modelling exercises. Scenarios have been applied at a range of scales. Overviews are provided by e.g. Rienstra (1998), Lorenzoni *et al.* (2000), Carter *et al.* (2001) and Turner (2005).

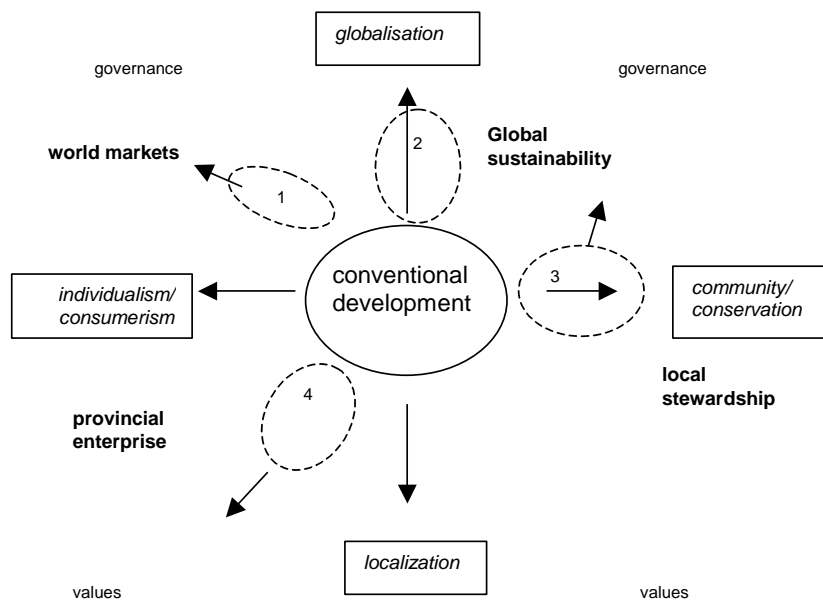
In The Netherlands and abroad, various sets of scenarios have been designed recently to explore future developments in societal structure, economic activities, land use requirements and consequences for responses to foreseen global and climate change. In the Netherlands, more particularly, such scenario – sets have been derived for:

- a) Water management, as laid down in various regional river basin plans ('deelstroomgebiedplannen', see for example Projectteam WB21, 2002; Brouwer *et al.*, 2003);
- b) Perspectives for nature, biodiversity and environmental impacts ('Natuur- en Milieuverkenningen', e.g. Luttik, 2002; Van der Hamsvoort, 2002);
- c) Longer-term international economic developments and the challenges these form for national Dutch and EC policy have been the goal of scenario exercises carried out by the CPB that recently published a new set of scenarios (see, e.g. Lajour, 2003).

Internationally, IPCC (Carter *et al.*, 2001; Houghton *et al.*, 2001) and also the so-called 'Foresight-Exercise' in the UK (see fig 1, from Turner, 2005) provide a relevant context. IPCC SRES (=Special Report on Emission Scenarios) scenarios have been developed to encompass possible future pathways for the world, i.e. at a global scale, whereas the Foresight exercise was done for the UK, hence at a smaller scale. Both share a broad-brushed approach to identify contrasting patterns of societal and political development in 'narrative' storylines, followed by a deduction of consequent economic and environmental patterns. . The latter will be briefly included here.

This report will first compare several sets of scenarios available in the literature, and then discuss criteria for the scenarios needed here, and finally, a number of scenarios is proposed and brought into perspective.

Figure 1.1 Four 'Environmental Futures Scenarios' from Turner (2005).



NOTE: the scenarios are indicated in bold text, and four 'orthogonal' directions of societal development are separated by 'zones of transition' not distinct boundaries. Source: OST/DTI, Environment Futures, Foresight, OST London <http://www.foresight.gov.uk/> - 'World Markets' is similar to SRES scenario A1, 'Provincial Enterprise' to A2, 'Local Stewardship' to B2 and 'Global Sustainability' to B1.

2. Comparison of existing sets of scenarios

Recent sets of scenarios show a striking similarity in the major dimensions across which they contrast the possible future developments of societies. Most (Carter, 2001; Luttik, 2002; Lajour, 2003; Turner, 2005) display a similar graphic interpretation of these two dimensions 'local-versus global' governance and 'community sense versus individualism' as societal coherence (cf Figure 2.1). Turner (in press) describes them as a frame of 'two orthogonal axes, representing characteristics grouped around concepts of societal values and forms of governance'.

Scenarios may be spelled out across various societal dimensions. An earlier set of CPB scenarios (CPB, 1992; Brouwer *et al.*, 2003) was specific with respect to the international geopolitical setting, the state of technology and knowledge; socio-cultural values adhered to in society, demographic predictions, and economic development (Table 2.1). The newer CPB-scenarios are largely conform those of SRES and the UK Foresight Exercise, but focus on demography, labour, trade, capital markets and economic growth and are implemented in a CPB-based equilibrium model of the world's economy (Lejour, 2003).

Turner (2005) extrapolates the four Foresight scenarios to the European coastal zone. He concludes that pressure on the coastal zone will increase under all scenario conditions, either through increased direct exploitation and use or through changes in land use in upstream catchment. Furthermore, the impact of climate change probably does not vary across scenarios until around 2030-2050. The same may well be valid for our restricted region, the Vechtstreek, as it shares many features with a coastal zone. The difference among scenarios is in the details, and the reader is referred to Turner (2005).

The exploratory study on future developments of the Dutch agricultural sector (Van der Hamsvoort, 2002) is quite different in structure and spatial detail from the previous ones discussed above. For sectoral detail on local agriculture in the Vechtplassen area this study was cross-checked. Furthermore, the overall scenario study of Luttik (2002) does include predictions on the agricultural sector. It identifies the same four SRES and Foresight scenario dimensions, acronym them, respectively:

- Sea Eagle (an individualistic world, similar to SRES A1, top left in fig 1);
- Dolphin (a cooperative world, B1, top right);
- Lynx (individualistic region, A2, bottom left; and
- Beaver (a cooperative region, B2, bottom right).

The document lacks a justification for these acronyms, presumably the team felt the need for selecting charismatic animal species that have an intuitively appropriate scale? Scenarios in Luttik (2002) address changes in governance style and scale, regional hydrology and water management, agriculture and fisheries, urbanization, mobility, recreative needs, nature conservation, management and its societal acceptance.

It has been downscaled to two smaller Dutch regions in an exemplary study by Vonk *et al.* (2002): i.e. the areas of the ‘Kromme Rijn’ and ‘Brabantse Wal’, both approximately 400 km², and located on geologically similar pleistocene-holocene transitions

Table 2.1 Summary description of three CPB scenario’s for longer term societal development in The Netherlands (adopted from Brouwer et al, 2003) [translated from Dutch].

	Global competition	European coordination	Divided Europe
1. Geo-political	Free, liberal markets, Policy-competition among states Europe à la carte	Mondial geopolitical blocks Europe: coordinates, development in different gears	Ineffective coordination: incoherent EU Free market perspective under-represented
2. Technology, knowledge	Rapid diffusion; market-oriented technology	Moderate diffusion of technology, the latter a strong societal orientation	Slow growth and diffusion of knowledge and technology
3. Socio-cultural	Strongly individualistic and material life style	Cohesion, solidarity Less material life style	Conflicts among stakeholders and nations paramount, Intolerance
4. Demography	Moderate migration matig NL population 2020: 16.9 mln	Migration substantial NL population 2020: 17.7 mln	Low migration NL population 2020: 16.2 mln
5. Economics	Worldwide strong and dynamic growth, strong exploitation of advantages GDP growth NL 3.25% Oil price2020: ca. \$ 25	Northern America lags behind, GDP growth NL: 2.75% Stronger international environmental policy Oil prices low	Strong growth in N-America and Asia GDP growth NL: 1.5% Consumption / production patterns change little

3. Criteria to be applied in the present project

Several broadly sketched criteria prevail:

1. Developed scenarios should lead to specific, spatial differences in forcing drivers or pressures or input variables of the models, and be relevant to the wetland area under study. Hence consequences for land use, agriculture, surface and groundwater quantities and quality should be deducible;
2. Developed scenarios are as much as possible consistent with, or based on, existing scenarios for agriculture, recreation, housing, trade and transport, economic activity in general, and national and EU policy (biodiversity);
3. Developed scenarios are preferably contrasting extremes across different relevant societal dimensions (as in SRES and Foresight).

In addition, the literature suggests that scenarios should allow the distinction between autonomous development and policy consequences, and that these should have a high validity (i.e. in the sense of credibility, so be plausible and well supported, e.g. Luttik, 2002). Credibility is difficult to verify, where autonomous development and policy consequences may well strongly interact over the time-spans that these scenarios would cover.

Since we want to incorporate major societal and economic pressures operating on the Vechtstreek, we will include major economic centres into consideration, i.e. our spatial setting is confined by the polygon formed by the cities Amsterdam, Almere, Hilversum and Utrecht.

4. Proposed components and contours of the possible scenarios

The workshop of November 20, 2003, identified a number of issues that should be encompassed by the set of scenarios developed within the present project. We identified important policy issues and discussed contrasting, ‘orthogonal’ (sensu Turner, 2005), dichotomies that may reflect different avenues of societal development over the coming decades. We made the following observations:

1. The dichotomy individualistic/consumerism versus communal/conservation of SRES/Foresight was felt to be interesting and important as it may strongly affect the way in which urban concentrations of people around the Vechtplassen area would want to make use of the area. We adopted the connotations ‘hedonistic’ versus ‘beavergreen’ for the extremes. ‘Beavergreen’ would also have the highest degree of self-supporting sustainability at a local scale. This dichotomy appears similar to the horizontal axis of Figure 1.1;
2. The second dichotomy of Figure 1.1, that of decreasing versus increasing, local or global scales of societal engagement and governance, was not discussed. Still, as Turner (in press) points out, these have profound influence on environmental legislation of the EU and its implementation success;
3. A separate set of scenario elements would be formed by global change components: climate change and sea level rise would urge for increased adaptation or mitigation measures such as water retention and discharge facilities. The policy issue of carbon dioxide would urge for a maximisation of peat formation to sequester carbon. It was felt that these aspects need be included in our scenarios as well;
4. Similar to Van den Bergh *et al.* (2001), a set of different scenarios could be developed to optimize separate sectoral goals. Enhancement of recreative services to the surrounding towns, maximizing biodiversity potential for this wetland area, or optimizing agricultural productivity could be seen as such sectoral scenarios;
5. Predictions on developments in economy and demography may also result in highly divergent scenarios.

These points would preferably be reflected in the scenarios to be applied. Points 1-3 and 5 are easily covered when our chosen scenarios remain close to those of SRES/Foresight. Issue 4, involving a more strictly sectoral breakdown of scenarios, appears to be at odds with these. However, this may well be reconciled as the downscaling is effectuated.

It was decided to adhere to the four ‘Foresight’ or SRES scenarios and develop a regional down-scaling towards our Vechtstreek. For each of these scenarios, the perceived consequences are deduced for water management, carbon sequestration, type and intensity of recreation, agricultural land use and biodiversity potential of the Vechtstreek. First a summary follows of the scenario descriptors from the literature (using Carter *et al.*, 2001;

Vonk *et al.*, 2002; Lajour, 2003; Turner, 2005), which is subsequently extrapolated to the Vechtstreek.

This is all brought together in table 2, which inevitably has acquired substantial length. The table shows that downscaling of these four scenarios to the regional extent of the Vechtstreek leads to a distinct separation over most of the seven dimensions applied, i.e. agricultural land use, intensity of recreation, urban settlement and spatial planning policy, water management, carbon sequestration for climate change mitigation and biodiversity effects. We therefore confirm the approach and findings of Vonk *et al.* (2002) and conclude that scenario downscaling is quite well possible as its outcome remains within the reach of rational deductions and combines sufficient resolution with overview.

Briefly, in this Vechtstreek area the A1 scenario is expected to lead to a minimal environmental impact although the pressure from recreation and urban expansion on nature reserves would increase, whereas those combining charismatic species with options for new nature would have a good chance to successfully expand. B1 would combine a minimal environmental impact with excellent water quality and expansion of natural areas. In this scenario, sustainability would be predominant as a guiding principle in policy implementations across society. B2 would maintain an environmental impact as in 2000 and stress would be on conservation of the overall status quo in existing landscapes. Finally, in A2 environmental impacts would remain similar or would continue to increase in the Vechtstreek, but natural areas would become more fragmented.

Table 4.1 Summary description of four SRES/Foresight scenario's and their perceived consequences in the Vechtstreek.

	World Markets (A1 / sea eagle)	Global sustainability (B1 / dolphin)	Local stewardship (B2 / beaver)	Provincial enterprise (A2 / lynx)
<i>Scenario descriptors</i>				
1. geo-political	Cosmopolitanism, individual freedom, large-scale politics, convergence among regions, increased cultural and societal interactions, substantial reduction differences in per capita income	European cooperation, larger scale, convergent world, global solutions to achieve economical, social and environmental sustainability, reformed EC decision making with strong international leadership from EC.	Regional or local solutions to economic, social and environmental problems, hence variably succesful. Focus is on environmental protection. World divides up into trade blocks and EC disintegrates. Lobbies of vested interests block reforms in various sectors and EC governments fail to modernise welfare state arrangements	Divergent, heterogeneous world: self reliance and preservation of local identities. Wealthy EU countrie turn to northern America for partnerships
2. Technology, knowledge	Rapid introduction of new, more efficient technologies	Rapid change toward service and information economy; reduced material intensity of this economy	Technological change is more diverse and less rapid than in A1, B1
3. Socio-cultural	Increased worldwide interactions	Improved equity, clean technologies. EC maintains social cohesion through strong and credible public institutions	Small communities, eco-farming	Cultural divergence
4. Demography	World population peaks around 2050, then declines EU growth rate 0.3	As in A1	World population increases, though less rapid than in A2; EU growth – 0.2%	World population increases continuously EU growth is 0.0%
5. Economics (including EC GDP and total flow of goods: 0.5x(imports+exports)x10 ⁹ , 2000 was 6000 x 10 ⁹ \$)	Rapid economic growth, economic integration GDP grows at 2.5%; flow = 27000	Stable economic growth due to selective refomrs in labor market eand social security. GDP grows at 1.6%; flow=22000	Intermediate economic development. Lack of modernisation and expanding public sector put a strain on EU economies. GDP Growth at 0.6%; flow = 10000	Overall global economic growth is slower than in other scenarios. Development is regionally oriented. GDP growth EC at 1.9%; flow = 15000

Table 4.1 Continued: downscaled effects.

	World Markets (A1 / sea eagle)	Global sustainability (B1 / dolphin)	Local stewardship (B2 / beaver)	Provincial enterprise (A2 / lynx)
<i>Downscaled effects in the Vechtstreek</i>				
1. Agricultural land use (sectoral share in NL GDP in 2040, 2000 = 6.5%)	Will decline strongly; efficient production technologies will have wide application (3.2%)	Land requirement will decrease slightly; increased use of ecological solutions; protection by EC regulations and an increased significance of the internal EC market (4.2%)	Slower technological improvement. An efficient minority will combine high tech agriculture with acceptable scenery; also ecological farming will gain importance. Traditional, present practice still common and land requirements will not decline (4.7%) EU regulations and market have limited effects. Man is seen as an important market with recreational needs (82%)	Traditional agriculture will be out-competed on Atlantic market. Regionally focused agriculture will survive in a mix of ecological farming and local products. (3.5%)
2. Type and intensity of recreation (share in NL GDP of 'other services' sector; 2000 = 73%)	No impeding regulations, exciting, sporty, mass recreation; increasing overseas holiday destinations reached by air (85%)	Demand for recreation is dampened by an effective mix of policy, social behavior and location of services. Focus on nature-related recreation and water sports (82%)		Water sports are the traditional strength of the region and will be enhanced (83%)
3. Urban settlement expansion	Liberal perspective: further suburbanisation of recreatively interesting zones. 'Service villas' for increased proportion of elderly rich in landscaped settings	Holiday destinations largely within safe and familiar EC. Substantial seasonal N-S migration of working population and pensionists. Urban development intensifies within existing borders; successful mix of green and social services within compact but greener cities	Cities and suburbs expand, but within regionally defined core areas: urban involution	Locally, in attractive scenery, villages will expand into centers for the wealthy with additional suburban services; decline in wealth will be felt clearly in towns.

Table 4.1 Continued: downscaled effects.

	World Markets (A1 / sea eagle)	Global sustainability (B1 / dolphin)	Local stewardship (B2 / beaver)	Provincial enterprise (A2 / lynx)
4. Spatial planning	Limited regulation: suburbia will expand greatly	EU perspective prevails; water has prime priority in NL, both quality and quantity. Car transport is effectively reduced by altered societal behaviors and senescence of the population.	Only a wider contour-framework will be used for spatial planning. This will lead to similar suburbia as in A1.	All is negotiable: flexible planning rules will lead to urbanisation of the countryside
5. Water management	Water serves primarily for transport and recreation	Flooding and desiccation are combatted by carefully planned retention areas including wetlands; also reduction in net water consumption per capita	Flood risk problems are solved technically and cooperatively with downstream regions	Waterways have transport as primary function. Flooding will be dealt with technically and devolved to downstream regions
6. Carbon sequestration	Not an issue	Will be carefully approached from both source and sink side. EC has strong policy here and enforces it well, also outside EU	Not an issue	Not an issue
7. Biodiversity	Focus on makable but 'original' landscapes, with a focus on charismatic species; true biodiversity will be conserved only where NGOs succeed in their claim for land; fragmentation of the remaining nature areas will not increase further	Successful implementation of EC regulation. Reservation of sufficient land for biodiversity conservation: species loss curves will flatten out and recolonisation may increase	Focus is on existing (agricultural) landscapes and preservation of these with 'typical' biodiversity	Largely private conservation initiatives; policy is that nature is for people, i.e. esthetical and recreational needs prevail. Nature will become increasingly fragmented

5. Translation into quantifiable model input parameters

The Fenscape model required eight different input parameters, i.e. concentrations of chloride, iron, nitrogen, phosphorus and sulphate (rows 1-5 in Table 5.2), as well as wave exposure, management type, recreative accessibility and succession stage transition time. The latter parameter is not a function that can be influenced by scenarios, as it is inherent to the natural or man-induced change in vegetation in this landscape of fens and marshes. Economic land use models would require water level (i.e. water management strategies) and overall nutrient availability or degree of eutrophication, and thus can be covered by the above list. The first four water quality parameters predominantly affect the first types in the succession and the direction of succession from open water to the various types of fens, marshes, carr and other woodland present in the area. The regional water balances affect these water quality parameters, the origin of the ground and surface water and the coupled mass balances for nutrients. These have been studied comparatively well (e.g. Witmer, 1989; Wassen *et al.*, 1990; Schot & Molenaar, 1992; Verstraelen *et al.*, 1992; Barendregt *et al.*, 1995; Best & Jacobs, 2001; Van den Bergh *et al.*, 2001), allowing extrapolation and ‘what-if’ deductions. The consequences of the four different SRES scenarios for the values or possible ranges of input parameters in Fenscape have been laid out in Table 5.2. Their positions along four modelled dimensions have also been charted for a graphical impression (Figure 5.1): the scenarios clearly spread out.

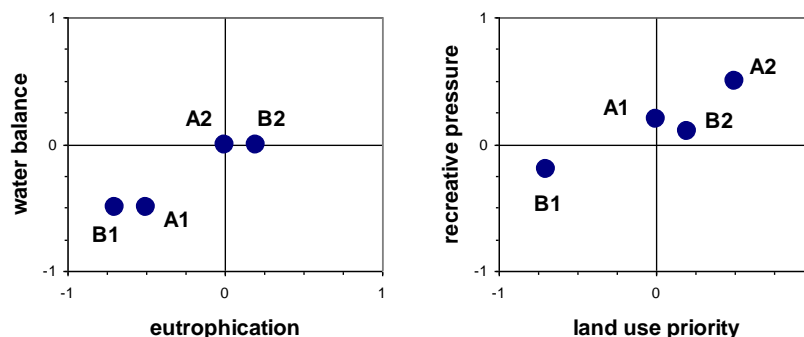


Figure 5.1 Position of the four SRES scenarios along four important dimensions for landscape development in the Vechtstreek.

Note: Derived qualitatively from Table 3 and scaled between -1 and $+1$, where 0 = present status quo. Positive values for water balance suggest a stronger disturbance of the natural water balance and positive land use priority is priority for agriculture and recreation over nature.

Table 5.1 Translation of downscaled scenarios to input parameters of Fenscape.

	Major determinants	To be measured from, range to be implemented in the model	World Markets (A1 / sea eagle)	Global sustainability (B1 / dolphin)	Local stewardship (B2 / beaver)	Provincial enterprise (A2 / lynx)
1. Chloride in surface water	Balance surface versus groundwater; seepage	Water balance, high chloride indicates surface water from Eemmeer, or deep brackish seepage	Technological improvements reduce overall environmental impacts: more natural regional water balances	As A1, but more stress on sustainability, hence also clean technology and sustainable water use	Status quo in regional water balance; no further reduction in groundwater extraction	Status quo in regional water balance
2. Iron in surface water	As above	As above, Iron indicates groundwater seepage	As above	As above	As above	As above
3. and 4. Nutrients, N and P in surface water	Sources: river Vecht, lake sediments, agriculture (via surface water and air), atmosphere (N), recreants	As above plus nutrient mass balances	Agriculture will decline, hence as nutrient loading, atmospheric deposition declines as well	nutrient loads from water and atmosphere decline strongly and are being controlled; surface water quality is improved with dredging and active biological management	Traditional farming practice still common, hence nutrient loading will decline only slightly	Although traditional farming practice is out competed on Atlantic market, regionally its production remains relevant, hence nutrient loading will not decline
5. Sulphate in surface water	Balance surface versus groundwater: IJmeer>Vecht and polderboezem>groundwater	As above	Effects diminished	Effects diminished	Mineralisation of sulphate will continue to cause internal eutrophication	As B2

Table 5.1 Continued.

	Major determinants	To be measured from, or to be implemented in the model through:	World Markets (A1 / sea eagle)	Global sustainability (B1 / dolphin)	Local stewardship (B2 / beaver)	Provincial enterprise (A2 / lynx)
6. Wave action	Position in lake relative to other open water and main wind direction (SW)	Manipulated via grid cell neighbors	Status quo	Larger areas of shallow water reserved for early succession stages	Status quo	Water sports are region-specific and will increase without being regulated: more water movement, hence probability early succession is less
7. Management	Mowing for hay, cutting of trees, dredging of new turbaries, creating sheltered zones in lake littorals	Via model decision rules, and adjustment of initial map used for model runs	Pressure on nature reserves increases for combination with dwellings for the wealthy; focus on charismatic species; fragmentation stops in only those focal areas where NGOs are successful, not everywhere.	Increased flow of resources to (re-)development of natural areas, larger areas, but also a stress on sustainable, self-guiding and inexpensive management strategies	Agriculture and recreation have priority over nature, hence less resources for nature conservation; traditional, semi-natural landscapes are preferentially preserved	As B2, nature is intended for people, increased fragmentation
8. Accessibility to and intensity of recreation	Recreative behavior, economic wealth, regulations	In open water: increased water movement will reduce establishment chance for <i>Stratiotes</i> -succession, elsewhere more nutrients	Holiday destinations worldwide, locally recreative pressure also increases because regulation is largely absent	Local recreative needs change and decline, hence pressure declines	Recreative pressure between B1 and A2	Local recreative pressure increases, notably water sports; more boats, marina's and leisure hours spent on the waterside

The ultimate implications of these four scenarios on, for example, water quality, finally will have to be estimated using local water and nutrient balances. The well-established balances for Lake Naardermeer from Barendregt *et al.* (1995) have been worked out here as a case applying the two scenarios that are most distant in terms of nutrient and water balances (B1 and B2; fig 2 left). We only use the water and phosphorus balances here. We assume that under B1 the natural seepage conditions will be restored largely and the reserve is placed within a large buffer zone, and hence that no river water has to be used as additional supply during dry summers. Furthermore, atmospheric P inputs as well as those from the trains have been reduced drastically. For B2, groundwater extraction from adjacent higher grounds has probably increased, and a buffer zone could not be purchased by the NGO owning the reserve due to lack of finances. All this necessitates a combination of summer water inlet and water level declines, causing mineralization of sediment-stored P.

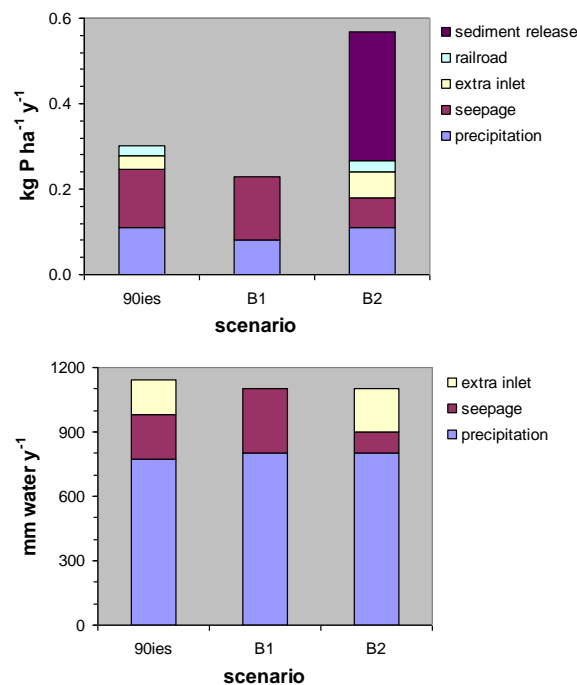


Figure 5.2 Foreseen impact of two SRES scenarios on the inputs balance of water and phosphorus in Lake Naardermeer.

Note: Outputs have not been shown here, but balance for water and suggest net storage for phosphorus in the nineties. Based on the balances published in Barendregt *et al.* (1997). Internal P sediment release is based on a 10% exposed area during one month and a release rate of $10 \text{ mg m}^{-2} \text{ d}^{-1}$ (Kalf, 2001).

The balances show a comparatively small change in water balance, but a rather drastic increase in P input, due to mineralization of P stored internally in the sediment of the lakes that is subsequently released. This must have profound consequences for the lake biota, as has been witnessed during the seventies, when lake level was allowed to drop (Barendregt *et al.*, 1997). These differences in loading can be used in determining the input levels for model scenario runs. The pattern in the scatter among the four scenarios in Figure 5.1 suggests that not all scenarios may be required.

6. Conclusions

This study has carried out a specific down-scaling exercise of four SRES scenarios to be applied in the wetland area of the Vechtstreek. We see that this downscaling is possible and leads to operational input parameters to be applied in further model runs beyond the scope of this report.

We have shown that largely narrative and qualitative descriptions of these scenarios can be specified in a quantitative way without too much order-of-magnitude estimations because detailed mass balances are available for the area.

Since these scenarios essentially are multidisciplinary and multidimensional, the use of rather lengthy tables is inevitable. Applications, however, again can be aggregated into comparatively straightforward graphical form, as Figures 5.1 and 5.2 demonstrate.

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