Integrated scenarios of socio-economic and climate change

a framework for the ‘Climate *changes* Spatial Planning’ programme

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Samenvatting

Dit rapport is een werkdocument binnen het kennisprogramma 'Ruimte voor Klimaat'. In dit programma heeft het project LANDS (LAND uSe and climate change) tot doel de door klimaatverandering gedreven veranderingen en aanpassingen in landgebruik te identificeren en daarmee bij te dragen aan nationale beleidsvisies en regionale oplossingsrichtingen.

Landgebruik wordt sterk beïnvloed door sociaal-economische en klimatologische veranderingen. Deze ontwikkelingen waren in 2006 onderwerp van twee afzonderlijke studies: de Welvaart en Leefomgeving (WLO) scenariostudie en de KNMI klimaatscenario's voor Nederland. De vier WLO scenario's zijn: *Global Economy (GE), Transatlantic Market (TM), Strong Europe (SE) and Regional Communities (RC).* De vier klimaatveranderingscenario's zijn: Gematigde temperatuurstijging met (G+) en zonder verandering in luchtcirculatie (G) en sterke temperatuurstijging met (W+) en zonder circulatieverandering (W).

In de hoofdstukken 3 en 4 worden deze twee scenario sets beschreven. Hoofdstuk 5 integreert vervolgens de twee sets tot een overzichtelijk aantal van vier scenario's. Van de WLO studie worden de twee uitersten gekozen: *Global Economy* en *Regional Communities.* Bij het GE scenario wordt een hoge stijging in temperatuur (W of W+) verondersteld, bij RC een gematigde stijging (G of G+). Dit levert het volgende schema op:

	RC	**GE**
Circulatie verandering	Gematigde temperatuurstijging (G+)	Sterke temperatuurstijging (W+)
Geen circulatie verandering	Gematigde temperatuurstijging (G)	Sterke temperatuurstijging (W)

In hoofdstuk 6 worden de vier scenariocombinaties nader beschreven. Deze scenario's zijn als input gebruikt voor verschillende sectorspecifieke regionale modellen en vervolgens ingebracht in de RuimteScanner voor simulatie van toekomstige ruimtegebruikspatronen. Alle sociaal-economische scenario's laten een terugval in de bevolkingsgroei zien na 2020. Verder kenmerken ze zich door een groeiend areaal voor de sectoren wonen, industrie, natuur en recreatie ten koste van het areaal landbouw. Het groeipercentage zal in de periode 2020-2040 kleiner zijn als gevolg van vergrijzing, verkleining van de beroepsbevolking en toename van de dienstensector.

De klimaatscenario's gaan uit van een temperatuurstijging van 1 of 2 graden Celsius tussen 1990 en 2050, en van een absolute zeespiegelstijging van respectievelijk 15-25 cm of 20-35 cm. Het veranderen van de luchtcirculatiepatronen heeft als effect dat de winters in Nederland milder en natter worden door toegenomen westenwinden. De zomers worden dan warmer en droger door toenemende oostenwinden in de '+' scenario's.

Summary

This report serves as a working document within the research programme 'Climate *changes* Spatial Planning'. The project LANDS (LAND uSe and climate change) is part of this programme and seeks to identify climate change driven changes and adaptations in land use, and to contribute to the formulation of national policy visions and regional solutions.

Land-use changes are driven by socio-economic developments and climatic changes. These developments were the topic of two recent, independent studies. The *Welvaart en Leefomgeving (WLO)* study described four new socio-economic scenarios: Global Economy (GE), Transatlantic Market (TM), Strong Europe (SE) and Regional Communities (RC). KNMI published a report with four new climate change scenarios: moderate temperature increase with circulation change (G+) and without circulation change (G), strong temperature increase with circulation change (W+) and without circulation change (W).

In chapter 3 and 4, these two sets of scenarios are described. Chapter 5 integrates them into four workable scenarios by reducing the set of socio-economic scenarios to the two scenarios that describe the broadest range in the possible futures: Global Economy and Regional Communities. GE is likely to have a strong temperature increase (W or W+). RC can be associated with a lower increase in temperature (G or G+).

	RC	**GE**
Circulation change	Moderate rise in temperature (G+)	Strong increase in temperature (W+)
No circulation change	Moderate rise in temperature (G)	Strong increase in temperature (W)

Chapter 6 describes the scenarios in detail. These scenarios are then used as input for sector specific regional models and, subsequently, for simulation of future land-use patterns in the Land Use Scanner model. In general, it can be said that all socio-economic scenarios have a decrease in population growth after 2020. In all scenarios the amount of land used for sectors such as residences, industry, nature and recreation increases at the expense of agriculture. The volume of change between 2020 and 2040 is smaller than in the preceding 20 years, as a consequence of aging, a decrease of the labour force and an increase of the service sector.

The climate scenarios are characterised by a 1 or 2 degrees Celsius temperature increase between 1990 and 2050 and by a 15-25 or 20-35 cm absolute sea level rise. Due to a change in atmospheric circulation the winters will be mild and wet because of increased westerly winds in the '+' scenarios. Summers will be warmer and dryer because of increased easterly winds in these scenarios.

Contents

1. Land use and climate change

1.1 Project context

It is widely believed that climate change and increased variability will have an impact on land use in the Netherlands through affecting different economic sectors such as agriculture, housing, nature and ecosystems, and by changing the water resources system (Commissie Waterbeheer 21e eeuw, 2000;IPCC, 2001b;Verbeek, 2003). In order to accommodate these impacts, pro-active adaptation measures within the area of spatial planning are prerequisite to cope with climate change and will offer new opportunities for rearranging land use in the Netherlands (Parry, 2000a;Parry, 2000b). However, such rearrangements will pose challenges and conflicts between the national and regional policy levels, and between sectors. For instance, when problems concerning water storage and flooding are tackled with spatial rather than technical measures, the capital-intensive agricultural or urban functions of these buffering areas will be highly restricted (Borsboom-van Beurden et al., 2005).

The research programme 'Climate *changes* Spatial Planning' aims to develop an adequate and timely set of policies for mitigation and adaptation to cope with the impacts of climate change. The research programme is centred on four main research themes:

- Climate scenarios: climate scenarios & climate data management for decision support in spatial planning;
- Mitigation: decreasing greenhouse gas emissions in relation to land use and spatial planning;
- Adaptation: dealing with the effects of climate change in spatial planning;
- Integration: methods for research exchange and integration.

Figure 1.1 illustrates the main themes the research programme plan builds on. Currently, around 30 projects are active covering those sectors that have been identified as particularly relevant to climate and spatial planning. These sectors include biodiversity, agriculture, fisheries, fresh water, coastal areas, finance and insurance, transport on land and water, land-use related energy production, business and institutional setting. A consortium consisting of a wide range of knowledge institutes and other organisations are working on these themes.

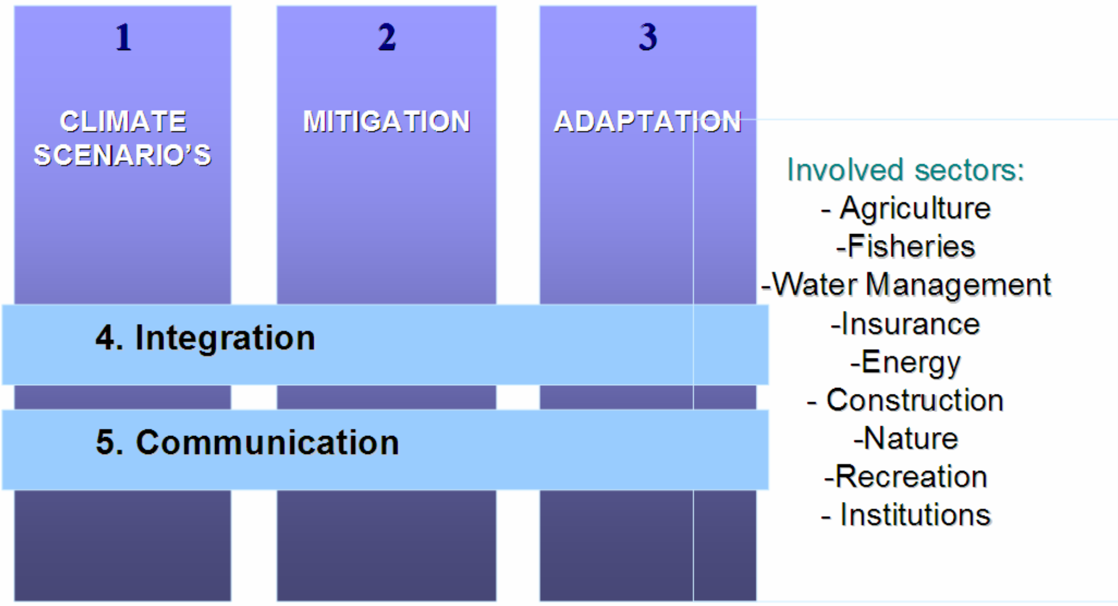

Figure 1.1 Structure of the 'Climate changes Spatial Planning' research programme.

This report serves as a working document within the 'Climate *changes* Spatial Planning' programme. It is written as part of the integration project 'LANDS' (IC3) that seeks at identifying climate-change driven spatial changes in land use and land development. The project integrates changes in agriculture, industry, housing and nature sectors into balanced national visions and regional solutions.

1.2 Climate change as a driver of land-use change

Socio-economic developments and climate change are important drivers of land-use change (Table 1.1). In fact, these developments interact (Dale, 1997;Watson et al., 2006). For example, economic and population growth cause increased emission of greenhouse gasses, which influence the global climate. As a result, changes in annual regional rainfall patterns could impact agricultural production or cause the tourist industry to migrate to other regions. Prolonged droughts and other extreme weather are other examples of climatic changes that impact the economy.

Socio-economic factors	**Climate factors**
• Economic development • Population statistics • Agricultural policy • Spatial policy • Nature policy • Water management policy • …	• Temperature • Precipitation • River discharge • Sea level rise • Number of cold and warm days • …

Table 1.1 Socio-economic and climate factors driving land use change.

Climate change impacts the natural and socio-economic factors under which land use evolves. It directly affects, for example, local agricultural and hydrological conditions and consequently influences the economic development potential. Climate change thus modifies the demand and supply for space, as well as the suitability of space for certain uses (Beinat and Nijkamp, 1998). These processes can be assessed through land-use simulation models that integrate sector specific demands (for housing, agriculture, etc.) and land suitability for certain uses and provide an indication of the likely land use in the future under different climate conditions. Climate change modifies the mechanisms of the demand-supply interplay as well as the boundary conditions and scenarios within which it unfolds. The main processes through which climate change and socio-economic developments may affect demand and supply of space are:

- The physical modification of the suitability of certain areas for some uses of the land;
- The modification of productivity and production processes within sectors such as agriculture, forestry, and nature;
- Changes to the primary functioning of economy and society leading to a different set of policies that influence for instance economic development (growth) or the type of development (e.g. free market versus government);
- The extra demand for space as a result of adaptation strategies within various sectors.

Integration of these processes is needed since climate-change and socio-economic factors both unmistakably influence future land use. The scenarios used in land-use allocation tools like the Land Use Scanner, are usually neutral to climate change, as only socio-economic factors are taken into account. This assumption appears inappropriate in the case of major climatic modifications. Climate change may affect land use directly by changing for instance the suitability of certain portions of land for some functions, but also through its impact on the economy, the society and the policy arena. In an indirect way climate change may thus be reflected in a changed demand for land of various functions.

An exact image of future land use cannot be given. However, insight in and awareness of possible future spatial conflicts will support current spatial policy. In other words, by formulating several storylines policy makers can cater on climate change. In this report four scenarios, based on socio-economic scenarios and climate models, will be presented. These scenarios will be used as input for various sector models and for an initial simulation of land-use change in the Land Use Scanner model.

1.3 Methodology

To ensure that the different results and model outputs coming from the different projects are compatible, it is important that they all take the same starting point and use the same set of scenarios. Therefore, we need to know what kind of information is needed and wished for by the different projects. In order to facilitate this analysis of information needs, a survey has been conducted during the workshop 'Synergie in Klimaat voor Ruimte onderzoek' organised for project leaders on June 6-7 in 2006 (Figure 1.2). Similar events are scheduled for the future. Furthermore, in order to develop consistent scenarios the developers of the socio-economic scenarios and climate change scenarios have been interviewed.

This report uses the results of the project CS7: Tailoring Climate Information for Impact Assesment – KNMI (Van den Hurk et al., 2006). Furthermore, it is based on the results of the scenario study 'Welvaart en Leefomgeving' (CPB et al., 2006a;CPB et al., 2006b) made by three Dutch planning agencies: the Netherlands Bureau for Economic Policy Analysis, the Netherlands Environmental Assessment Agency and the Netherlands Institute for Spatial Research. The latter study explores which socio-economic developments can be expected in the future and how these influence the physical environment where current and future generations live, work and reside.

The main objective of this report is to construct a set of integrated scenarios that take the recently developed climate scenarios as a basis and combine these with related socio-economic conditions. These scenarios are then fed into the Land Use Scanner model to obtain simulations of future land use that serve as a starting point for the different adaptation and mitigation projects in the 'Climate *changes* Spatial Planning' research programme.

The 'integration' issue at hand calls for a description of the background of the scenario studies. First, a general background of scenario studies will be described in Chapter 2. Then, we introduce state-of-the-art socio-economic and climate change scenarios (Chapter 3 and 4) and integrate these (Chapter 5). From the resulting set of scenarios we present the major socio-economic developments, the related land-use simulations and their climatic dimension (Chapter 6). The final chapter then summarises these results and discusses their possible use in the various adaptation projects of the 'Climate *changes* Spatial Planning' research programme.

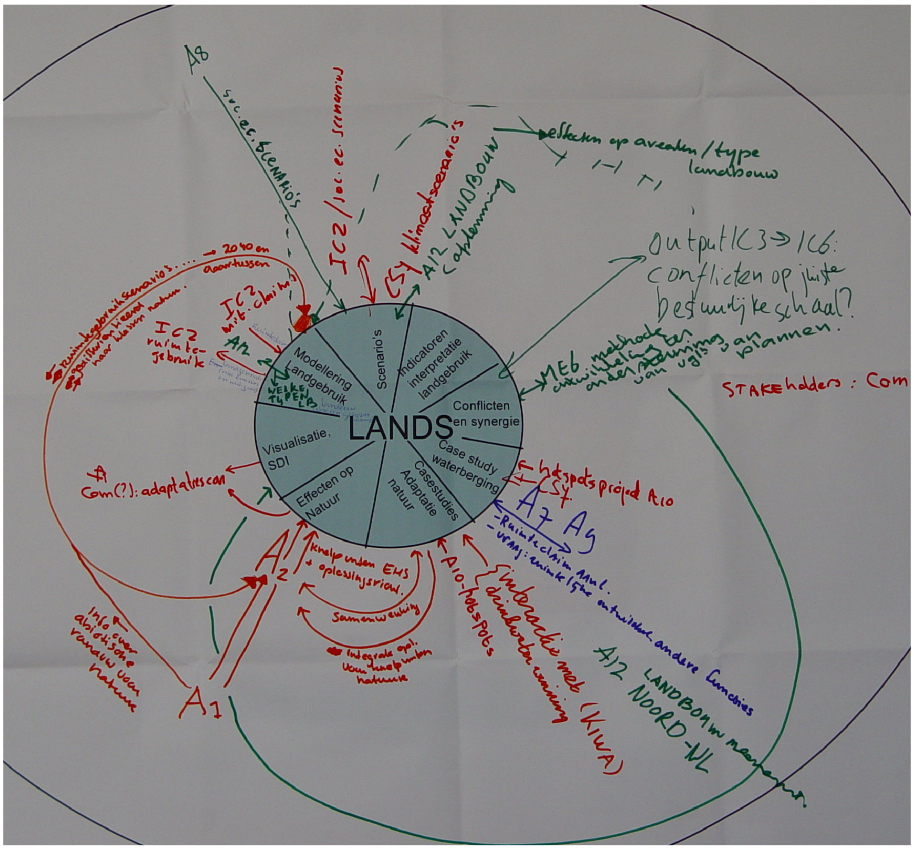

Figure 1.2 Discussing the position of the LANDS project during the 'analysis of information needs' workshop.

2. The scenario method

2.1 *The need for scenarios in forecasts and planning*

Land-use planning is by definition concerned with the future. The difficulty in planning is the uncertainty about the future. How can we make a plan without knowing what the situation will be a couple of years or decades ahead? A fortune-teller might have an idea, or we can just guess, but the chance that we are far from the truth is realistic.

A much favoured approach to deal with the uncertainties relating to future spatial developments is the use of scenarios. The aim of the scenario method is to gain strategic insight by means of enlarging knowledge over the future (De Waard, 2005). Policymakers need scenarios to assist in formulating appropriate response and the general public needs to be informed on changes (Dammers, 2000). Scenarios are used in science to assess impacts of change and to study effects of certain changes on the adaptive capacity of the system. Scenarios make it possible for people to anticipate on the effects that changes imply.

By describing a set of opposing views on the future as is common in the IPCC (Intergovernmental Panel of Climate Change) reports, we can simulate a broad range of spatial developments, thus offering a full overview on possible land-use alterations. Each individual outlook on the future will not necessarily contain the most likely prospects, but as a whole the simulations provide the bandwidth of possible land-use changes. The individual scenarios should in fact not strive to be as probable as possible, but should stir the imagination and broaden the view on the future. Important elements are: plausible unexpectedness and informational vividness (Xiang and Clarke, 2003).

2.2 *What are scenarios?*

Future land use depends on many variables that interact and change over time. The complexity and the uncertainty of this interaction are so high, that we don't know exactly what will happen. We can only describe likely scenarios based on known models. All scenario methods have three components in common (De Waard, 2005):

1. An initial situation;
2. A final situation at a fixed time horizon;
3. A pathway to the final situation.

The transition between the initial and the final stage, the pathway, is based on one or more models. Modelling is used to describe and understand processes in the real world. Changes over time can be modelled. Models are built using causal or mathematical methods or developed by extrapolating observations in the past (RIVM, 1999).

When the causality of events is known, the possibility to model the future improves. In case there is a high availability of data the uncertainty becomes less and clear predictions are possible. However, when the uncertainty is high, but the causality is known we can estimate a situation in the future by the using the scenario method. When the causality is low and therefore the possibility to model developments is low we can only project or speculate about the future (Becker and Dewulf, 1989).

2.3 *SRES scenarios*

Much referred to in the field of land-use change and climate change are the SRES scenarios of the IPCC. Established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP), the role of the Intergovernmental Panel on Climate

Change (IPCC) is: “to assess available scientific and socio-economic information on climate change and its impacts and on the options for mitigating climate change and adapting to it” (IPCC, 2001a). IPCC publications are prepared by three Working Groups (WG I, II and III) composed of hundreds of scientists from many countries. These publications are generally recognized as providing the scientific consensus on climate change.

In 2001 the IPCC in its Third Assessment Report (TAR) linked socio-economic scenarios to global climatic change. The report emphasizes quantitative scenarios that provide estimates of emissions of carbon dioxide and other greenhouse gases. These scenarios are based upon emission scenarios from the IPCC Special Report on Emission Scenarios (SRES) in 2000. All together, six models were used to generate 40 scenarios. The 40 scenarios were grouped together in 4 scenario families that have a similar demographic, societal, economic and technical-change storyline. The four scenario families are illustrated as branches of a two-dimensional tree (Figure 2.1). The two dimensions indicate two different axes of uncertainty. One axis opposes a global versus a regional orientation, whereas the other axis confronts an economic versus an environmental focus (IPCC, 2000). A short description of storylines related to these four SRES scenarios, taken from the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001a), is provided in the following text box. The relation between these scenarios and the current climate change and socio-economic scenarios will be described in Chapter 5.

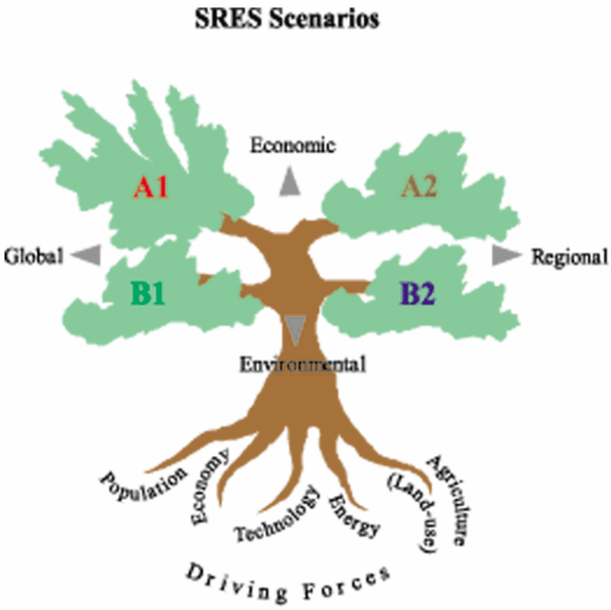

Figure 2.1 Schematic illustration of SRES scenarios (IPCC, 2000).

Abstract of the Special Report on Emission Scenarios (SRES)

A1 Rapid Global Growth Scenario.
The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2 Regional Growth Scenario.
The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1 Global Service Economy Scenario.
The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2 Increasing Population Scenario.
The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

(IPCC, 2001a)

3. Climate scenarios

3.1 Background

This paragraph presents a short description of the background and characteristics of the Dutch Climate Scenarios that have been published by the KNMI in June 2006. These climate scenarios are based on the most recent IPCC global climate projections. In 1990, the *Intergovernmental Panel on Climate Change* (IPCC) developed the first long-term emission scenarios. Their Third Assessment Report was completed in 2001. These reports provide the overall policy framework for addressing the climate change issue. For example, the negotiations on the Second Assessment Report in 1995 led to the adoption of the Kyoto Protocol in 1997 (IPCC, 2006). The IPCC global climate change scenarios represent the relation between greenhouse gas emissions and complex dynamic systems (determined by driving forces such as demographic development, socio-economic developments, and technological change) on a global scale. The four scenarios by IPCC, or storylines, are shortly described in the previous chapter.

The IPCC global storylines are the basis for a set of climate change scenarios for the Netherlands. The first initiative to develop adaptation strategies to cope with climate change in the Netherlands was made by KNMI as part of an outlook on Water Management in the 21st century (Commissie Waterbeheer 21e eeuw, 2000). This national investigation presented three scenarios[1] for 2050 and accompanying adaptation strategies to cope with the impacts of land subsidence and climate change. Increasing water supply as a result of sea level rise, precipitation, river flow discharge and soil level decline, has been linked to the effects on the general water system, agriculture, nature, urbanization, shipping industry, recreation and drinking water supply.

3.2 KNMI Climate Scenarios 2006

The Royal Dutch Meteorological Institute (KNMI) recently published new climate change scenarios for the Netherlands for temperature, precipitation, potential evaporation and wind for 2050, and for sea level rise for 2050 and 2100. The KNMI Climate Change Scenarios 2006 have been formulated on the basis of current knowledge and uncertainties with the ambition of providing professionals with the best possible advice.

Uncertainties arise from imperfect models, internal variability of the climate system, and unknown future evolutions of anthropogenic forcings of the climate system. Potential future evolutions of the climate (so-called projections) are explored with the help of sophisticated global climate models (General Circulation Models, GCMs). These models differ considerably in their projections, scale level and regional focus: outcomes for in particular Western Europe are highly diverging. To capture the possible range of future climate changes an ensemble approach is required in which boundary conditions, initial conditions and model formulations are varied. To construct the KNMI '06 climate change scenarios for the Netherlands, KNMI used the methodology represented below in Figure 3.1. Global climate models are used to diagnose the global temperature rise and circulation effects above Europe. Regional climate models and local observations are used to construct regional climate scenarios.

[1] The minimum (+0,5°C), central (+1 °C) and maximum (+2 °C) scenario.

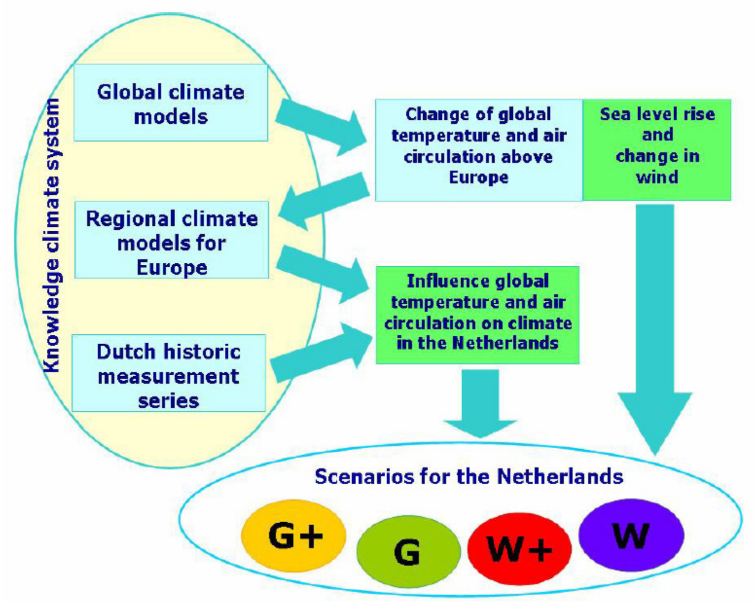

Figure 3.1 Schematic representation of the methodology used for the construction of the KNMI'06 climate change scenarios (Van den Hurk et al., 2006).

The scenarios that are addressed in this study are a group of general climate change scenarios constructed by KNMI for the Netherlands for the target periods around 2050 and 2100. The scenarios include values of changes of a set of variables, where relevant per season, in particular winter (December, January and February) and summer (June, July, August). The scenarios consist of values for the changes in both climatologic means and extremes on the daily time scale. The variables included in the KNMI climate scenarios are listed in Table 3.1.

Scenario	Global temperature Increase	Change of atmospheric circulation
G	+1 ºC	Weak
G+	+1 ºC	Strong
W	+2 ºC	Weak
W+	+2 ºC	Strong

Table 3.1 Values for the steering parameters used to identify the four KNMI'06 climate scenarios for 2050 relative to 1990.

Climate change is represented by changes in many different climate indices, related to the means and the extremes on different temporal and spatial scales. It is practically impossible to represent the range spanned by the full set of indices by a limited set of scenarios. Therefore a selection has been made in order to focus the scenarios on the indices that are most relevant to society. On the basis of user consultations KNMI fine-tuned the list of variables included in the climate scenarios, resulting in the list in Table 3.2. The climate scenarios mainly focus on changes for 2050, since most potential users of the scenarios do not have a longer planning horizon.

Besides the increase in temperature, a further analysis of global and regional climate model output for typical regional quantities revealed the importance of changes in circulation patterns over Europe for the climate in the Netherlands. It was found that for a given global temperature rise the range of future climate conditions for the Netherlands could be very well spanned by specification of differences in the simulated circulation change. Two anticipated circulation regime changes are included in the scenarios: a strong change of circulation, which induces warmer, and moister winter seasons and increases the likelihood of dry and warm summertime situations, and a weak change of circulation. Both regimes are presented for the +1°C and +2°C global temperature increases, producing a total of four scenarios. Figure 3.2 and Table 3.2 give an overview of the scenario labels. "G" is taken from the Dutch word "Gematigd" (= moderate), while "W" is taken from "Warm". "+" indicates that these scenarios include a strong change of circulation in winter and summer.

For assessing the potential mean sea level rise in the North Sea that is not clearly related to regional patterns of atmospheric circulation, a different approach was chosen. In fact, only two scenarios were distinguished (high global temperature and low global temperature rise) and for each scenario the uncertainty range is quantified based on an analysis of all available GCM output and results from the recent literature. Sea level scenarios are given for both 2050 and 2100 (Van den Hurk et al., 2006).

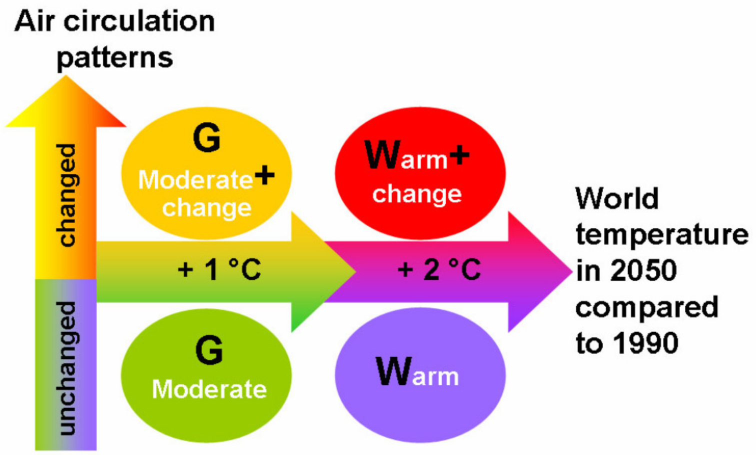

Figure 3.2 Overview of the four KNMI'06 climate scenarios. For the legend, see Table 3-1.

	G	G+	W	W+
Worldwide temperature rise	+1°C	+1°C	+2°C	+2°C
Change in air circulation patterns	No	Yes	No	Yes
Absolute sea level rise	15-25 cm	15-25 cm	20-35 cm	20-35 cm
WINTER[2]				
Mean temperature	+0.9°C	+1.1°C	+1.8°C	+2.3°C
Yearly coldest day (K)	+1.0°C	+1.5°C	+2.1°C	+2.9°C
Mean precipitation (%)	+4%	+7%	+7%	+1.4%
Wet day frequency (%)	0%	+1%	0%	+2%
10 year return level daily precipitation sum (%)	+4%	+6%	+8%	+12%
Yearly maximum daily mean wind spread (%)	0%	+2%	-1%	+4%
SUMMER				
Mean temperature	+0.9°C	+1.4°C	+1.7°C	+2.8°C
Yearly coldest day (K)	+1.0°C	+1.9°C	+2.1°C	+3.8°C
Mean precipitation (%)	+3%	-10%	+6%	-19%
Wet day frequency (%)	-2%	-10%	-3%	-19%
10 year return level daily precipitation sum (%)	+13%	+5%	+27%	+10%
Potential evaporation (%)	3%	+8%	+7%	+15%

Table 3.2 KNMI '06 climate change scenarios in the Netherlands for 2050 relative to 1990 (Van den Hurk et al., 2006).

[2] Winter is December, January and February. Summer is June, July and August.

4. Socio-economic scenarios

4.1 Introduction

The study 'Prosperity, wellbeing and quality of the living environment' (*Welvaart en Leefomgeving),* in this document called 'WLO', was conducted by three Dutch planning agencies (CPB et al., 2006b). The aim of the study is to investigate long-term-reconnaissance of the developments in prosperity and their effects on the physical environment, amongst other via the demand for space. Three publications served as a point of departure for the assessment of the impact on the physical environment in the WLO-study. These are briefly discussed below.

Future trends with respect to European integration, social security and energy provision were originally explored in 'Four Futures of Europe' and 'Four futures for Energy' (Bollen et al., 2004;de Mooij and Tang, 2003). The four international scenarios presented in these publications are partly based on the IPCC SRES scenarios. They have been enriched by adding assumptions on the progress of European integration and globalisation: an open Europe with much interaction with the rest of the world or a more closed Europe with a lot less interaction with the outside world. Besides, the axis concerning environmental or economic orientation was slightly altered into an axis representing a society emphasizing solidarity or equity, usually interpreted as an increase or decrease of the influence of market processes and government regulation and a possible shift in responsibilities to more private or more public.

Abstract of 'Four Futures of Europe'
Europe is at a crossroad. It is hard to predict how the European Union and its members states will look like ten years from now, let alone twenty or thirty years ahead. Yet, policy makers must take decisions today that have long-lasting consequences. Scenarios bring together various uncertain developments. The study 'Four Futures of Europe' identifies two groups of the "key uncertainties". The first concerns international cooperation: to what extent are nation states willing and able to cooperate within international organisations like the WTO and the European Union? The second key uncertainty concerns national institutions: to what extent will the mix of public and private responsibilities change? Combining the two key uncertainties leads to four different scenarios: Strong Europe, Global Economy, Transatlantic Market, Regional communities.
(de Mooij and Tang, 2003).

In a subsequent step, the international scenarios were elaborated for the Dutch economic and demographic situation in 'Four views on the Netherlands: Production, labour and sectoral structure in four scenarios until 2040' (Huizinga and Smid, 2004). This publication contains for each scenario figures on population and its composition, economic growth and the development of specific economic sectors.

The WLO study uses estimates of the distribution of households and employment per COROP as a basis. These have been created using the PRIMOS and RAM model (CPB, 2002;Heida, 2002). Based on these distributions, traffic and transport figures have been calculated. In a later stage, the distribution of households has been translated by CPB to demand for space using information on the average land use per housing type. The distribution of employment was translated with help of the Business Area Monitor (Schuur, 1999). The demand for agricultural land use has been derived from the DRAM model of the Agricultural Economics Research Institute (Helming 2005). With respect to the influence of policies, it has been presumed that current policies will linearly extend into the future. The above four types of land use form the basis for energy use figures and these subsequently predict health effects and environmental quality.

The WLO study presents its results for three different development zones in the Netherlands: the Randstad (already densely populated western part of the Netherlands), the Intermediate Zone (rapidly urbanizing area between Randstad and Periphery) and Periphery (predominantly rural area). The underlying calculations used more detailed spatial units such as the administrative COROP regions and the postal code zones, but the results in the main report are presented on the much higher aggregation level of the three national zones.

The WLO study uses the old central scenario of the KNMI (+1°C) as input for inundation estimations and water safety. This scenario is more or less compatible with the current KNMI 'G' scenarios for the wet predictions, but it differs with regards to the anticipated drought problems. Local land subsidence is not taken into account, but a moderate sea level rise is.

4.2 The four storylines

By refining the four European scenarios for the Dutch situation the WLO eventually developed a set of four scenarios that will be discussed in more detail in this section. The scenarios are set around two key uncertainties expressed in Figure 4.1. The vertical axis ranges from successful international cooperation at the top, to an emphasis on national sovereignty at the bottom; the horizontal axis ranges from a strong role for the public sector at the left, to private responsibility at the right. The combination of the two key uncertainties yields four scenarios for Europe and its countries (de Mooij and Tang, 2003). Each of the four scenarios is described by a specific storyline.

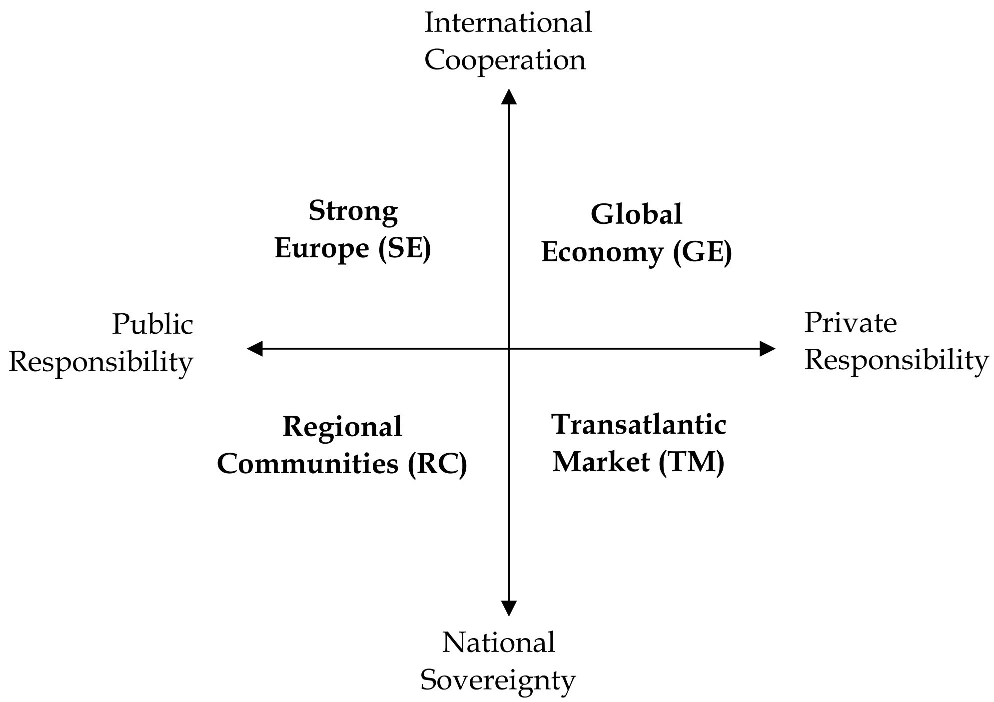

Figure 4.1 Schematic overview of the WLO scenarios.

The four scenarios all have different assumptions on population size and the state of the Dutch national economy. Table 4.1 gives an overview of the main macro-economic indicators of the four scenarios. The differences in population growth per scenario cause large variations in population size. The Regional Communities scenario foresees a population of about 16 million inhabitants in 2040, while close to 20 million are expected in the Global Economy scenario. Economic growth, as expressed in the yearly increase in Gross Domestic Product (GDP), also differs considerably per scenario. These and other developments are described briefly for each scenario in the following sections.

	1971-2001	GE 2002-2040	SE 2002-2040	TM 2002-2040	RC 2002-2040
Population growth*	0.7	0.5	0.4	0.2	0.0
Population 2040 (x million)	-	19.7	18.9	17.1	15.8
Labour supply growth*	1.1	0.4	0.1	0.0	-0.4
Labour productivity growth*	1.9	2.1	1.5	1.9	1.2
Employment growth*	0.9	0.4	0.1	0.0	-0.5
Unemployment level**	5.5	4.1	5.7	4.6	7.3
GDP growth*	2.6	2.6	1.6	1.9	0.7
GDP per capita growth*	1.9	2.1	1.2	1.7	0.7
GDP per capita 2040 (2001=100)	-	221	156	195	133
Demand for residential land***	-	94	49	47	11
Demand for commercial land***	-	45	20	23	-2
Demand for recreational land***	-	49	31	22	12
Demand for nature***	-	115	140	98	123

Table 4.1 Selected macro-economic indicators for the WLO scenarios (CPB et al., 2006b).
* Mutations per year in %, ** Average level in % of potential workforce, *** Demand for additional land in 2040 (x 1000 hectares).

4.2.1 Global Economy (GE)

In the scenario 'Global Economy' the EU will expand towards the East. Apart from Turkey, also Ukraine will join. The WTO-negotiations are successful and international trade flourishes. However, political integration will not take off and international cooperation, other than trade negotiations, fails. Just like in the Transatlantic Market scenario the Government will emphasize private responsibility; compared to Transatlantic Market the growth in labour productivity will get an extra impulse because of worldwide economic integration.

The growth of material welfare and population, especially through immigration, will be highest in this scenario. Just like in Transatlantic Market there is not going to be an agreement that deals with border-crossing environmental issues. This, together with the high economic global growth causes serious environmental pollution. But the higher welfare leads to local environmental initiatives.

4.2.2 Strong Europe (SE)

In the scenario 'Strong Europe' much attention will be given to international cooperation. The European institutions are successfully reformed and countries abandon part of their sovereignty. Consequently Europe will become a strong player in the global economy. It will also be possible to deal with international environmental issues in an efficient way. Europe will compromise with the US in order for the US to ratify the Kyoto protocol. Turkey will become a European member state.

The socio-economic policy is, as in Regional Communities, based on solidarity and equal income distribution, with only small reforms. These reforms and high investments in research and education, combined with a larger economy, lead to a higher labour productivity than in Regional Communities. Also economic and demographic growth, basically through immigration, is higher in this scenario.

4.2.3 *Transatlantic Market (TM)*

In the scenario 'Transatlantic Market' the expansion of Europe fails. Countries are reluctant to give up their sovereignty and prefer to solve their problems on a national level. Instead, the European Union redirects her attention to the United States; it agrees upon transatlantic economic integration. This trade liberalization leads to new internal markets. Governments that emphasize private responsibility characterize this scenario. The welfare state will be restricted and public services will be lessened. Due to this the income inequality will increase. The declining power of labour unions makes the labour market more flexible.

The economizing of the social security raises labour participation, the international competition is an incentive to innovate and the larger income inequality stimulates the need for higher education. The growth in labour productivity and the economic growth are larger than in Strong Europe in case the population growth is moderate. Border-crossing environmental issues will not be dealt with, but higher welfare leads to local environmental investments and to more private investments in nature.

4.2.4 *Regional Communities (RC)*

In the scenario 'Regional Communities' countries strongly favour their own sovereignty; therefore the EU does not succeed to implement institutional reforms. International trade reform will not succeed either and as a consequence the world will fall apart in different trade blocks. International environmental issues will not be dealt with. However, environmental pressure will be low due to low population and economic growth. There will be few, if any reforms in the collective sector in this scenario.

European countries rely on collective arrangements to maintain an equitable distribution of welfare. Because of lower incentives in social security and due to higher tax tariffs, labour participation will be relatively low and unemployment high. Less competition decreases the need for companies to innovate. Dispersed markets prevent fast knowledge transfer and the small differences in income prevent an increase in human capital. Yearly increases in labour productivity and economic growth are small.

5. Linking the socio-economic and climate scenarios

5.1 Introduction

The main objective of this report is to construct a set of integrated scenarios that take climate variables as a basis and incorporate them with related socio-economic conditions. The climate scenarios of the KNMI can, however, not be linked directly in a one-to-one manner to the socio-economic scenarios of the WLO.

Different institutions have developed different scenarios to predict future energy use and future climate. Many scenarios recently published, fit in the conceptual framework of the four well-known SRES-scenarios developed by IPCC in 2000. We will link the climate scenarios of the KNMI with the socio-economic scenarios of the WLO by using the SRES scenarios of the IPCC. The motivation is twofold:

- The IPCC links climate and socio-economic change by modelling temperature change based on the socio-economic SRES-scenarios.
- The KNMI and WLO scenarios are both (partly) based on the SRES-scenarios

IPCC states in its Third Assessment Report (TAR) that the climate varies for natural reasons, but human activities are significantly increasing the concentrations of certain greenhouse gases in the atmosphere (mainly carbon dioxide), which tend to warm the earth surface, and anthropogenic aerosols, which mostly tend to cool it (IPCC, 2001a).

Models were used to make projections of atmospheric concentrations of greenhouse gases and aerosols, and hence of future temperature rise, based upon emissions scenarios from the IPCC Special Report on Emission Scenarios (SRES), see Figure 5.1. The figure shows that, on average, the average global temperature rise is lowest for the B scenarios and highest for the A scenario family.

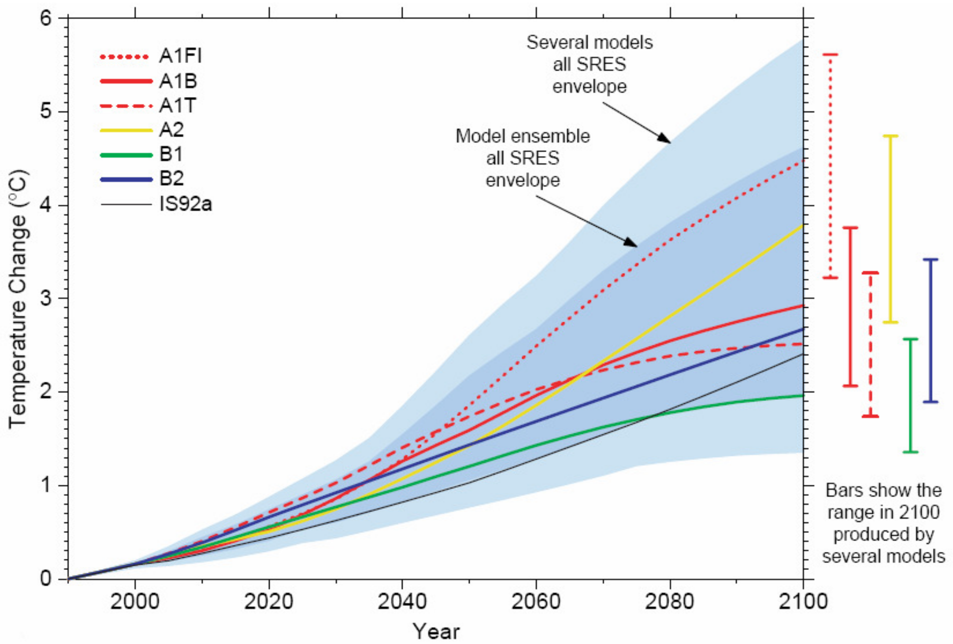

Figure 5.1 Projections of global temperature, calculated with a simplified climate model calibrated to a range of state of the art Global Climate Models (GCMs). Coloured lines show the temperature evolution for six representative SRES scenarios, averaged for seven GCMs. The error bands on the right show the spread of the GCMs for each emission scenario. The grey area shows the spread of all temperature projections (IPCC, 2001a).

5.2 *Relating the KNMI and IPCC scenarios*

The global climate predictions of the IPCC are based on differences in emission, which are the outcome of the different SRES scenarios. The IPCC global climate scenarios are the basis for a set of climate change scenarios for the Netherlands. These climate change scenarios differ from the global models due to scale effects. The KNMI used these global climate models with additional regional European climate models and Dutch weather trends throughout history. Land use is not being included as a driver in the climate models on a national scale.

However, the predicted temperature rise of 1 to 2 degrees in the year 2050 by KNMI falls within the bandwidth for the temperature rise that is predicted by the IPCC for that time period, see Figure 5.1 (Van den Hurk et al., 2006).

5.3 *Relating the WLO and IPCC scenarios*

The SRES-scenarios are closely related to the WLO scenarios, all the more since IPCC also divides possible futures along similar axes. Figure 5.2 illustrates the concordance by mapping the SRES scenarios in the WLO scenarios.

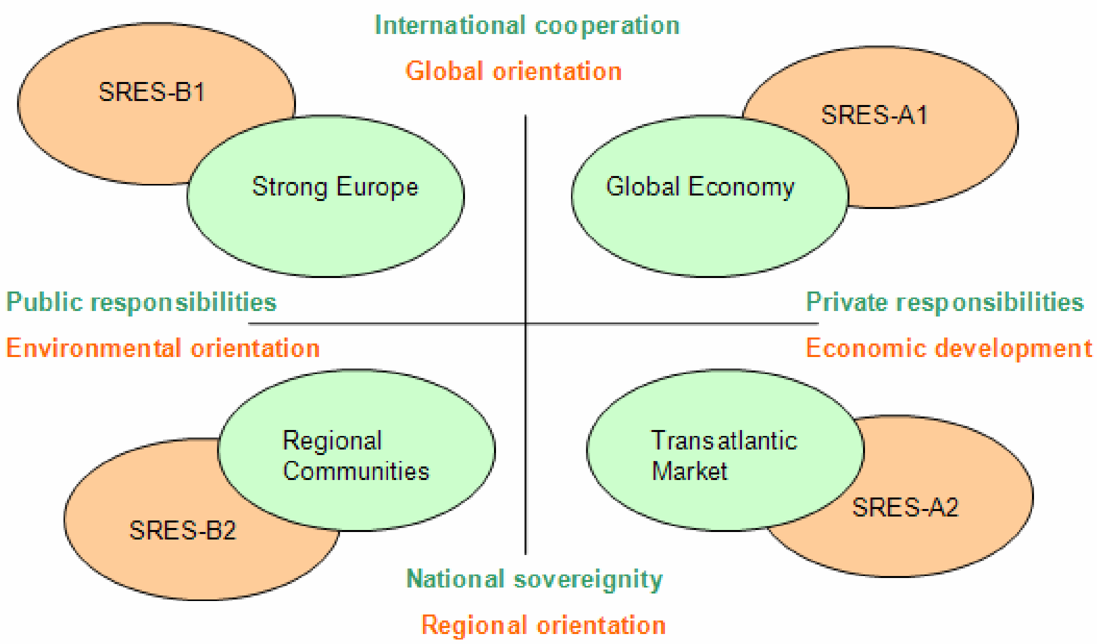

Figure 5.2 Relating WLO scenarios to IPCC-SRES (Bollen et al., 2004).

However, Bollen and others (2004), stress that even though the SRES and WLO scenarios are closely related, there are differences. The axes stress slightly different uncertainties. One axis in SRES represents globalisation. It moves from an emphasis on regions and local identity to convergence and increasing interregional interactions. The other axis moves from a focus on equity and the environment to a focus on economic growth. Hence, there is no one-to-one mapping between the two different sets. There are more differences. Four Futures focuses especially on Europe and addresses predominantly institutional and economic questions. SRES is more globally oriented and focuses on emissions and the energy system. Both studies use a different time frame: Four Futures has a time horizon of 2040. SRES covers the whole century. Explicit policies to reduce emissions of greenhouse gases are absent in SRES, while climate policy is a key element of Strong Europe (Bollen et al., 2004). The influence of this climate policy will only be noticeable after 2050.

5.4 Linking the KNMI and WLO scenarios

In linking the KNMI and WLO scenarios three main issues had to be taken into account. These dealt with the different time span of the KNMI and WLO scenarios, the wish to obtain a limited, workable set of scenarios and the desire to cover a wide range of socio-economic developments within this limited set of scenarios. These three issues are discussed below.

The time span or horizon of the KNMI and WLO scenarios differs. KNMI provides climate information for 2050 and 2100, whereas WLO takes 2040 as the final year. By definition, however, climate is the average weather in a 30-year period. The KNMI results for 2050 thus represent the mean values of their 2035-2065 scenario calculations. One can thus argue that the climate indicators have a comparable value for 2050 and 2040. The socio-economic models and assumptions that underlie the WLO scenarios, on the other hand, are more specifically tuned to the year 2040. Therefore, we have selected this year as the focal point year for the LANDS scenarios.

To be able to formulate a workable set of scenarios, we have chosen to select only a limited number of scenarios. We furthermore gave preference to the climate scenarios of KNMI that were specifically drafted for the 'Climate *changes* Spatial Planning' programme and decided to use these as the four base scenarios to which socio-economic components will be added. To simply couple all four available socio-economic scenarios to the four climate scenarios would result in 16 different combinations. We considered this an overflow of information for the various adaptation and mitigation projects and, furthermore, saw the risk that each project would select its own specific combination to start from. The latter would imply that the proposed adaptation or mitigation measures can not be readily integrated into a coherent set of spatial strategies as they all start from different assumptions regarding climate and society. Therefore it was decided to reduce the set of socio-economic scenarios to the two scenarios that describe the broadest range of possible futures. In order to further reduce the set of scenarios climate and socio economic scenarios will be linked in a logical way.

Taking the extremes on both sides of the bandwidth in terms of socio-economic developments leads to the selection of Global Economy (GE) and Regional Communities (RC). We have, thus, not chosen for the more moderate, business-as-usual type scenarios Transatlantic Market or Strong Europe, because we consider it important to present the full extent of possible changes in land use and climate.

Following the above considerations, we combine the KNMI and WLO scenarios based on their common roots in the SRES story lines (Table 5.1). The Global Economy (GE) scenario is associated with the SRES A1 scenario family as is the high temperature rise (W or W+). Regional Communities (RC) can be related to the SRES B2 family as can be done with the lower rise in temperature (G or G+).

	RC	**GE**
Circulation change	Moderate rise in temperature (G+)	Strong increase in temperature (W+)
No circulation change	Moderate rise in temperature (G)	Strong increase in temperature (W)

Table 5.1 Overview of the four integrated scenarios.

The proposed combination links the strong economic growth of the Global Economy scenario with the larger climatic changes. This is expected to cause tension between the increased demand in land for various types of urban use (residential, commercial), while at same time providing ample space for coping with the increases in precipitation, river discharge and sea level. How will the Government and the market respond to that? In the light of debates around 'shrinking cities' the Regional Communities scenario is highly interesting because an other kind of tension related to adaptive measures is expected here: is a shrinking population able to finance the needed adaptation measures? The regional differences in growth in the RC scenario are large; therefore the competition between different regions will be large. Will the transition zone become a competitor of the Randstad, since there is likely to be less inundation risk? Chapter 6 further discusses the storylines, socio-economic and climate indicators, as well as the accompanying land-use simulations of the four scenarios.

6. The LANDS scenarios

6.1 Introduction

This chapter presents the scenarios that are to be used in the LANDS project and related projects in the 'Climate *changes* Spatial Planning' programme. We refer to these scenarios as the G and W scenarios, following the names given by KNMI. To these scenarios we have added the socio-economic components of the scenario study 'Prosperity, wellbeing and quality of the living environment' (CPB et al., 2006b) according to the relations we have established in the previous chapter. A further addition consists of the regional projections of anticipated land-use change and the related land-use simulations. This chapter start with a brief description of the simulation process and, more specifically, the Land Use Scanner model.

The Land Use Scanner produces simulations of future land use that are based on the integration of sector specific inputs from dedicated models (Dekkers and Koomen, 2007;Hilferink and Rietveld, 1999). The model is based on demand-supply interaction for land, with sectors competing for allocation within suitability and policy constraints. Land-use simulations are generally scenario driven, with series of coherent assumptions regarding variables such as economic growth or level of government intervention, determining the way the land demand-supply unfolds (Borsboom-van Beurden et al., 2007;Koomen et al., 2005). The model requires specific inputs from sectors such as agriculture, housing and nature, in terms of suitability maps and land-use demand. This input is derived from various sector-specific regional models of specialised institutes and consulted experts. The model-configuration used for this project applies a 100-meter grid offering a very detailed view on possible spatial patterns in the future. It distinguishes 17 land-use types, out of which the model allocates 11. The remaining six land-use types, mainly related to infrastructure and water, have a pre-defined location that is not influenced by model-simulation. Their location is either a continuation of current land use or consists of pre-defined, approved plans, as is the case with, for example, long-planned railway links. See Appendix 2 for a full account of the applied land-use typology. For a more detailed description of the most recent model version and its calibration and validation the reader is referred to other publications (Loonen and Koomen, 2007;Tijbosch et al., 2007).

The Netherlands Environmental Assessment Agency (MNP) has created the land-use simulations provided in this report. These simulations were initially prepared for the Environmental Outlook 6 report (MNP, 2006) and form a spatially detailed elaboration of the four socio-economic scenarios described in the 'Prosperity, wellbeing and quality of the living environment' scenario study. The associated Environmental Outlook 6 report, however, only presents the Global Economy scenario and refrains from discussing the simulation results and underlying input data in detail.

Land-use simulation starts by creating a 2015 land-use map from a 2000 base map (Figure 6.1). In this step current, explicit land-use plans, mainly taken from the new map of the Netherlands survey (NIROV, 2005) are included in the simulation to represent autonomous developments. Based on this situation the simulations for 2040 are made for the G and W scenarios according to the scenario-specific assumptions and sector-related developments discussed in the following sections. The general scenario descriptions have been made spatially explicit with the help of several sector-specific models and a number of additional assumptions. These calculations have been performed by various specialised institutes: CPB and ABF have provided the expected amount of residential development (ABF, 2006;CPB et al., 2006b), CPB has delivered the demand for industrial and commercial land use and office space (CPB, 2002;CPB et al., 2006b) and LEI the projections for agricultural land-use changes (Helming 2005). A concise description of the basic characteristics of the underlying regional models and a short discussion on the related quality issues is provided elsewhere (Dekkers and Koomen, 2006). Appendix 2 provides a full overview of these regionalised land-use demands. The demands were subsequently inserted in the Land Use Scanner model together with a spatially explicit translation of the scenario-assumptions into suitability maps.

The presented land-use simulations integrate expert-knowledge from various research institutes and disciplines and thus represent the best-educated guess regarding the possible spatial patterns. It should be noted however that the simulations are based on many assumptions. They can by no means be seen as exact predictions and should therefore not be treated like that.

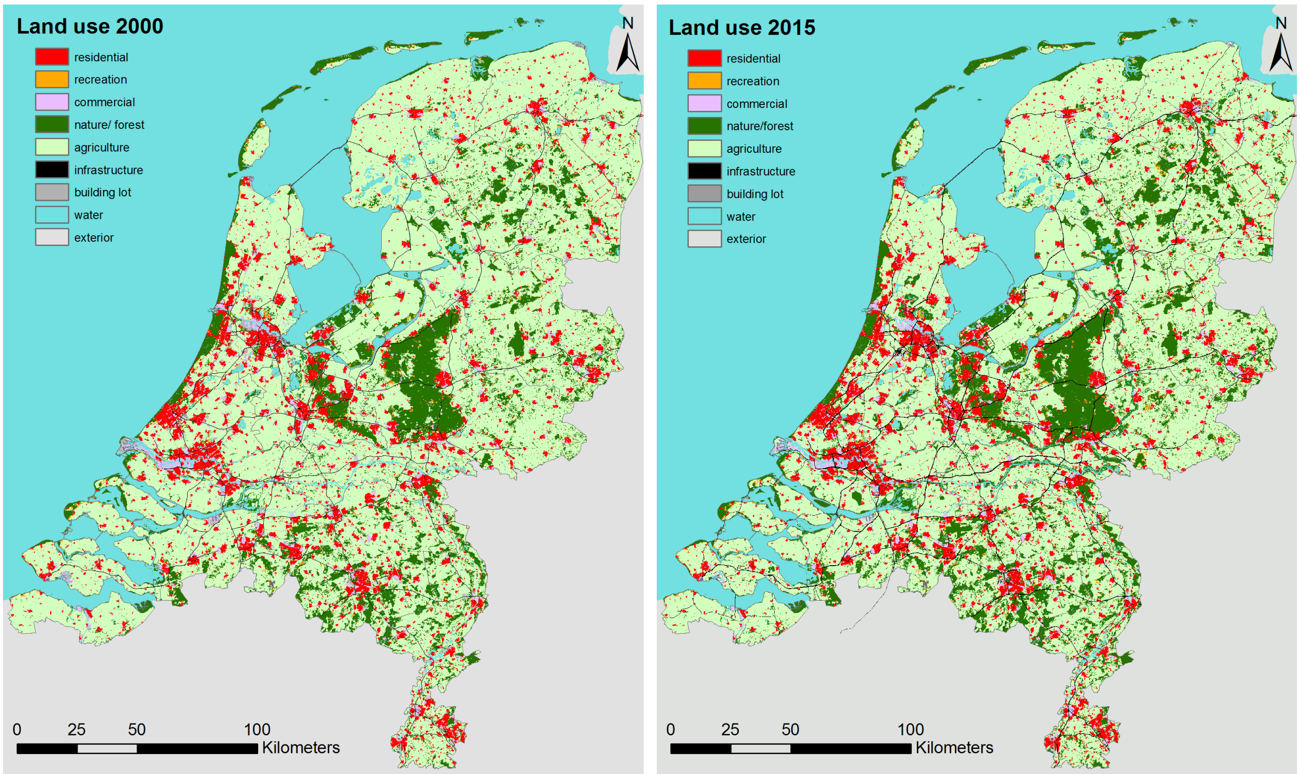

Figure 6.1 Land use base maps of the Netherlands for 2000 and 2015 following autonomous developments.

6.2 The G scenarios

The G scenarios are linked to the Regional Communities scenario whose general characteristics are:

- Moderate population growth until 2010 and a slight decline thereafter;
- Modest economic growth;
- High unemployment rate;
- Trade blocks and taxes for protection of the environment;
- Emphasis on national environmental policy;
- Increased public environmental awareness;
- Extension of rail and motorway infrastructure.

This section first summarises the macro-economic changes and their regional impact (6.2.1) as well as the related sector specific developments (6.2.2). We then describe the more detailed land-use projections (6.2.3) and finally provide the climatic projections for the G and G+ scenarios (6.2.4).

6.2.1 Macro-economic changes and regional distribution

The expected macro-economic changes in the G scenarios can be grouped into four themes. The main characteristics of each theme are provided below and in Table 6.1:

- *Population forecast*: As compared to the 1971-2001 period, population growth is expected to slow down in the future, but considerable differences exist between the scenarios. In the G scenarios population increases until 2010. Afterwards it decreases due to strict immigration policy and low birth rates, leading to approximately the same population size in 2040 as in 2000. In spite of this more or less stable population, the number of households will increase slightly due to ageing and increased prosperity.
- *Employment*: The potential labour force decreases strongly in this scenario. Labour supply decreases about 0.5% yearly due to stagnating population growth and an increasing ageing pressure. This will only be partly compensated by the increased labour participation of women and elderly.
- *Economic growth:* Gross Domestic Product (GDP) per capita rises due to increasing labour productivity. Despite the fact that the working population shrinks, this scenario will have a modest increase in prosperity: GDP will grow 1 % per year until 2020, and 0.5% between 2020 and 2040.
- *Economic structure:* The physical environment is not only influenced by the magnitude of economic growth, but also by the performance of different economic sectors. The sector-specific prospects influence to a large extent the actual spatial developments and emission rates. In line with recent trends, the sectors agriculture, industry, energy and building will decrease marginally, whereas commercial services, health care and public services will grow slightly in this scenario.

Both scenarios indicate that the amount of land used for sectors such as residences, industry, nature and recreation increases at the expense of agriculture. Figure 6.2 depicts these national changes and especially shows that the increase in residential land is more moderate in the G scenarios. However, urban sprawl is expected to continue due to the continuing demand for rural residences and green, spacious urban housing. The extent of this sprawl is limited however, due to population growth coming to a halt in all regions. The regional development in employment is strongly related to the provision of consumer services. Employment in this type of services (banks, care institutions, retail etc.) increases mostly in the Intermediate Zone. A further decrease is expected in agriculture and industry, mostly in the Randstad. Unemployment rates are slightly higher in the Periphery, leading to a marginal migration towards the Intermediate Zone and Randstad in the long term. Furthermore, the willingness to commute will increase. Most commuter traffic takes place within the so-called COROP regions. A detailed account of the projected regional land-use changes is provided in Appendix 2.

Indicator	G scenarios	W scenarios
Population, in millions	15.8	19.7
Households, in millions	7.0	10.1
Labour participation (as % of the professional population)	68%	74%
Ageing population (share 65+)	25%	23%
GDP per capita (2001=100)	133	221
Increase in energy usage per capita, compared to 2002	-5%	+30%
Increase in car use in kilometres, compared to 2002	+5%	+40%
Increase in goods traffic, ton per kilometre, compared to 2002	-5%	+120%
Increase waste total	+11%	+100%
Increased land demand for waste disposal in other countries	+4%	+55%
Housing demand, compared to 2002 (excl. demolition):		
• Single family dwellings, in millions	+0.3	+1.9
• Multiple family dwellings, in millions	+0.1	+1.2
Commercial area demand, compared to 2002, per type		
• Business parks	-3%	+43%
• Offices	+1%	+34%
• Informal locations	+7%	+46%
• Sea harbour	-9%	+30%
Rural area development:		
• Area agriculture, compared to 2002	-10%	-15%
• Area cultivation under glass, compared to 2002	-45%	+60%
• Dairy farming, number of cows compared to 2002	-15%	+25%
• Pig farming, number of pigs compared to 2002	-55%	-5%
Demand for nature and recreation, compared to 2002, x1000ha		
• Demand nature, compared to 2002	+123	+115
• Demand recreational green, compared to 2002	+10	+49
• Demand sports fields	+2	+20
Additional area for water retention, compared to 2002, x1000ha		
• Near major rivers	+2	+5
• Near urban extensions	+2	+3

Table 6.1 Overview of socio-economic, demographic and land-use change indicators for the G and W scenarios in 2040 (CPB et al., 2006b).

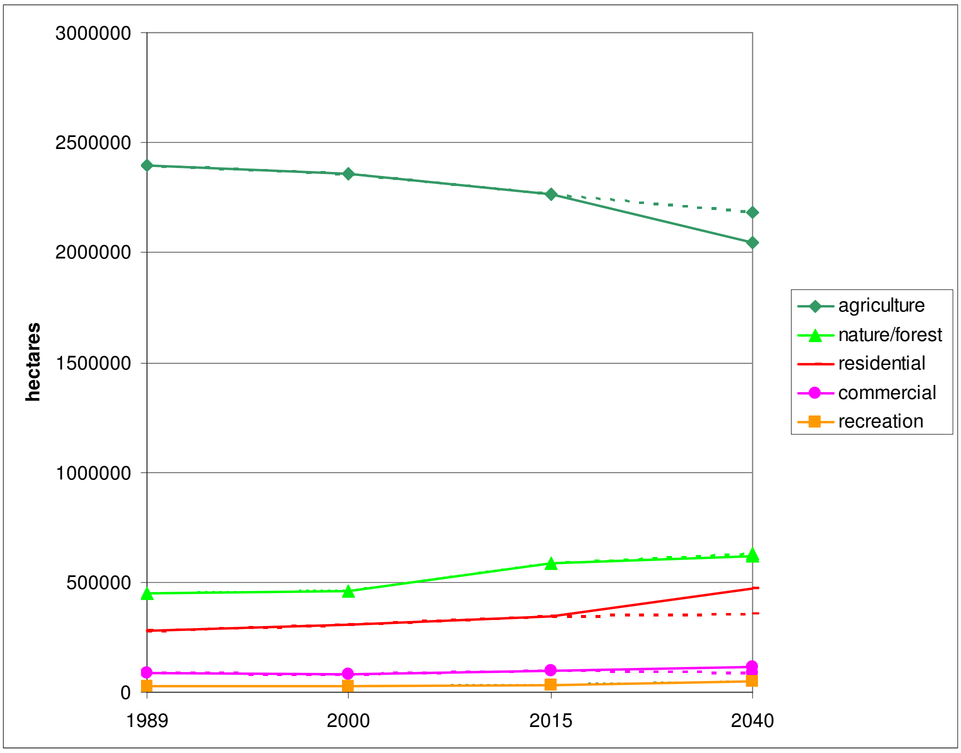

Figure 6.2 Land use in the Netherlands 1990-2040. The land use in 2040 is shown for both the G (dotted line) en W (solid line) scenarios.

6.2.2 *Sector-specific developments*

Based on the aforementioned assumptions related to macro-economic changes and their regional impact a number of developments are anticipated in specific socio-economic sectors (CPB et al., 2006b). These are listed below:

Housing

Housing demand, especially for owner-occupied housing and apartments, increases in line with household growth until 2020. This will result in a demand for residential land. From 2020 onwards population decrease may result in unoccupied houses in all regions, but probably most in the Periphery. Until 2020 annual housing production will be around 30,000 new houses (including 20,000 to 30,000 houses that will be replaced). After 2020 more houses are expected to be demolished than to be built.

Industry, commerce and offices

Until 2020 the demand for office space will increase by 10% compared to the total area in 2002. From 2020 onwards the total demand will be -14% leading to obsolete office buildings. This may results in a decrease in the price of land and an extensification in its use. Other consequences can be the deterioration of these areas or a change in their function for, plausibly leading to a mixing with other types of activities.

Mobility

The extensions of road and rail infrastructure as proposed in the National Traffic and Transport Strategy (V&W and VROM, 2006) will be realized by 2020. This construction of an extra 2900 kilometres of traffic lanes increases the length of the main road network with 23%. Because traffic problems will not be fully solved then, it is assumed that between 2020 and 2040 the main road network will expand by a more moderate 14%, or about 2000 kilometres of new traffic lanes. Parking prices and tariffs for public transportation do not change. Depending on the density of the built-up areas, people will use public transportation more frequently. The amount of private cars will increase from the current 7 million to about 8 million in 2040. Passenger traffic by train will not increase during off-peak hours, but more commuter traffic is expected during peak hours. Total freight transport stays at the current level, but the share of road transport increases. In all, the pressure on the road network will increase by 20% due to developments in passenger traffic, freight transport and infrastructure expansions. Congestion hours however will decrease by 70% and the emission of carbon dioxide will decrease by 5%.

Agriculture

Agriculture will face a continuing demand for space from residential and commercial functions, infrastructure, recreation, water and nature development. Competition will be high since the market values for these sectors are much higher than for agriculture. Also, European environmental policy is assumed to play a role in limiting the growth potential of agriculture. Still, agriculture is expected to cover about 93% of its current surface area in 2040. Arable farming will concentrate in the Peripheral areas. In the Randstad and Intermediate Zone, the agricultural area decreases due to the demand for land of other functions. The greenhouse horticulture area will decrease by 50% due to strong environmental policies and inflexible labour relations. Employment in the agricultural sector will decrease by 50 to 65% in 2040. The characteristic values of the agricultural landscape related to, for example, biodiversity, cultural history will partially be preserved or even restored through (European) subsidies.

Energy

This scenario does not foresee a global climate policy but the Netherlands will have agreements with neighbouring countries, resulting in a carbon dioxide price of €20 per barrel from 2030. Current subsidies for renewable energy will continue. Demand for energy will decrease slightly leading to a decrease of carbon dioxide emission. The share of renewable energy in 2040 will be at least 10%. Dutch gas fields will decrease their production, making the country more dependent on imported energy.

Environment

The limited economic growth in the Regional Communities scenario will lead to a modest increase in the amount of waste. Accumulation of phosphor in soil decreases when international environmental policy remains effective. The leaching of nitrogen to groundwater will diminish because of national regulations. In general, emissions will further decrease because of the continuation of existing national and international policies.

Nature, biodiversity and outdoor recreation

Nature areas, biodiversity and outdoor recreation areas remain under pressure because of the continuing demand for land from other functions. At the same time, the demand for nature and recreation areas increases with the growing population and prosperity. The biodiversity in surface waters will improve as a result of strict environmental policies, but the biodiversity in agricultural areas is expected to decrease slightly. In the Regional Communities scenario, 25,000 hectares are reserved for nature development in National Landscapes such as the Achterhoek and Limburg. Furthermore, the standard in town and country planning of 75m^2 of outdoor recreation area for each house is expected to be realised. This standard already exists, but is currently not met. On top of that, the Government will develop about 20,000 hectares of recreational area outside the cities to solve the current shortage. In addition, the demand for sports fields and golf courses will increase.

6.2.3 Land-use simulations

The resulting simulation (Figure 6.3) shows a modest increase in residential areas, despite the fairly limited population growth. This growth can be largely ascribed to the minor increase in households and residential preferences for a rural living environment. Urban growth is most notable in the central and western part of the Netherlands. Arable farming diminishes strongly in this scenario. Greenhouse horticulture disappears in many areas; especially from its current stronghold south of The Hague. From the map it can be concluded that existing nature areas are enlarged in a number of cases. New nature areas are developed along the rivers Waal, Rhine, Meuse and IJssel. Clusters of outdoor recreation arise in attractive landscapes, in particular in the northern and western part of the Netherlands.

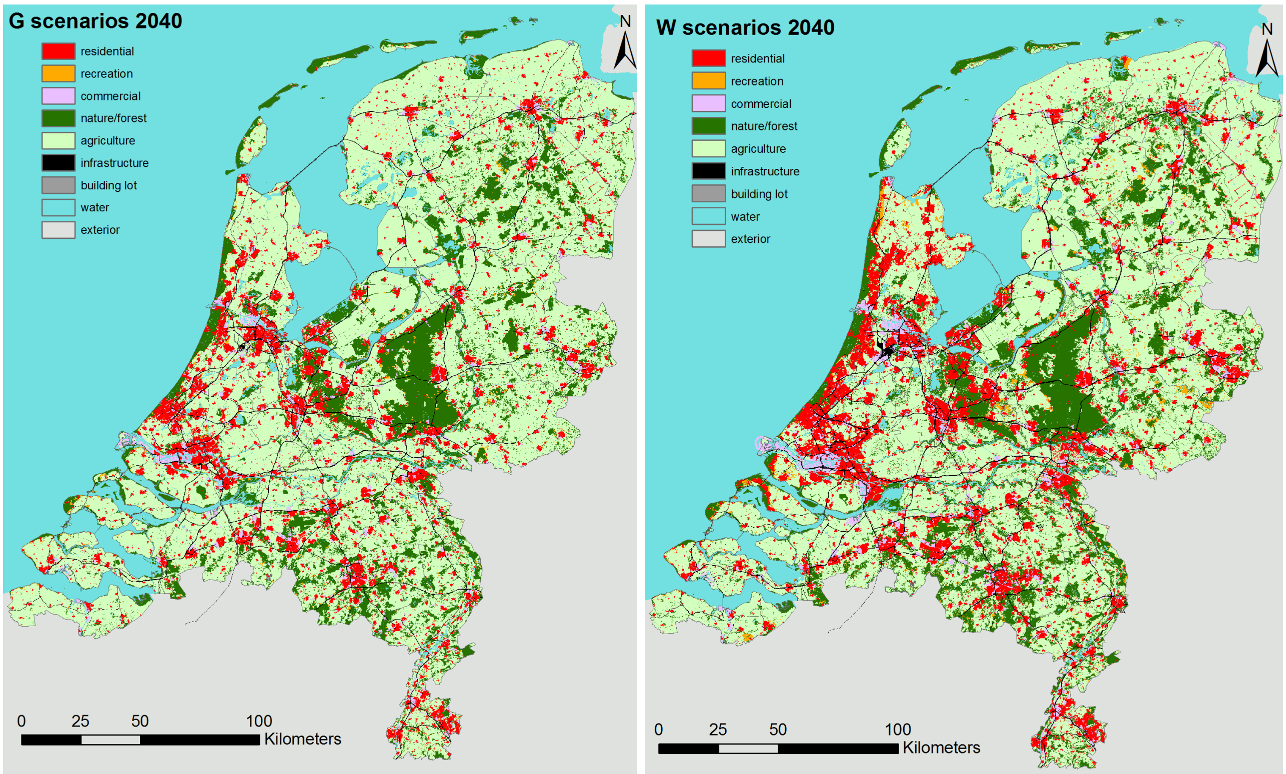

Figure 6.3 Simulated land use for the G and W scenarios.

6.2.4 The climate dimension

The G scenarios are characterised by a 1 degree Celsius temperature rise between 1990 and 2050. Due to a change in atmospheric circulation the winters (December, January and February) will be mild and wet because of increased westerly winds in the G+ scenario. Summers (June, July and August) will be warmer and dryer because of increased easterly winds in this scenario. Further details are provided in Table 3.2.

6.3 The W scenarios

The W scenarios are linked to the Global Economy scenario and have the following general characteristics:

- High population growth;
- High economic growth;
- Expansion of the EU to the east;
- Global free trade without political integration;
- No initiatives on international environmental agreements;
- Extension of rail and motorway infrastructure

This section first summarises the macro-economic changes and their regional distribution (6.3.1) as well as the related sector specific developments (6.3.2). We then describe the local land-use projections (6.3.3) and finally provide the climatic projections for the W and W+ scenarios (6.3.4).

6.3.1 Macro-economic changes and regional distribution

The anticipated macro-economic developments for the W scenarios are provided below and in Table 6.1:

- *Population forecast*: In this scenario, population increases to 20 million people in 2040. This is caused by a high birth rate and an open immigration policy that brings many new people to the country. The total number of households increases even more as a result of further individualisation and ageing.
- *Employment:* The working population decreases due to ageing but this will be counterbalanced by increased labour participation women and elderly (50+) people.
- *Economic growth*: Gross Domestic Product (GDP) per capita will more than double as compared to 2001.
- *Economic structure:* A further shift towards a service economy is the main underlying trend in all WLO scenarios. Nevertheless, all economic sectors show an increase in the volume of production in this particular scenario. Also agricultural production increases significantly. The total employment in this sector, however, decreases. The same development is seen in the industrial sector. The demand for health care increases significantly, as well as employment in this sector.

Well-educated immigrants are expected to come to work in the Netherlands in this scenario. They will spread across the country but will, relatively, reside more in the Intermediate Zone where employment is growing strongly. Urban sprawl is anticipated to continue due to the need for rural living. This domestic migration process will first focus on the Intermediate Zone but later also spread to the Periphery. Regional employment development is influenced by an increase in consumer services like banks, care institutions and retail. Employment in this sector increases most in the Intermediate Zone. Employment decreases strongly in agriculture and industry, mostly in the Randstad. Just as in the G scenarios, unemployment rates are slightly higher in the Periphery, leading to a marginal, overall migration towards the Intermediate Zone and Randstad in the long term. Furthermore, the willingness to commute will increase, with most commuter traffic taking place within COROP regions. A detailed account of the projected regional land-use changes is provided in Appendix 2.

6.3.2 Sector-specific developments

The developments anticipated in specific socio-economic sectors as a result of aforementioned macro-economic changes and their regional impact are listed below (CPB et al 2006a). These developments show some overlap compared to the G scenario developments, but they are reiterated in this paragraph to make the two scenario storylines independently readable.

<u>Housing</u>

Housing demand increases in line with the enormous household growth. Until 2020 the annual housing production will be around 120,000 new houses (including 30,000 houses that will be replaced). After 2020 the annual production will be 105,000 houses. Due to income increase, owner occupied private properties will become more popular than rental houses. The average size of these houses will also increase with increased prosperity, thus causing a large demand for residential land. This land demand will be highest in the Randstad. The relative increase in residential land will be largest in the Intermediate Zone, possibly causing conflicts with nature and landscape development without proper government intervention. In the Periphery the demand for housing will be marginal.

Industry, commerce and offices
Until 2020 the demand for extra land for office parks will be 36% compared to 2002. From 2020 till 2040 this demand will be 7%. The demand for industrial development will be highest in the Randstad and in the province of Noord-Brabant. The relative centre point or all commercial activity will move from the Randstad to the Intermediate Zone from 2020 onwards.

Mobility
The current planned extensions (an extra 3000 kilometres of traffic lanes) of the road network will be executed before 2020. From 2020 to 2040 the road network will be expanded with another 2000 kilometres of traffic lanes. Parking prices and tariffs for public transportation do not change. More people will use public transport. The amount of private cars will increase vastly from the current 7 million to 12 million in 2040. Passenger traffic by train will not increase during off-peak hours but an increase is expected in peak hours due to more commuter traffic. In the Randstad train traffic increases twice as much as in the Intermediate zone and Periphery. Freight transport by rail grows due to more international trade and replacement of production activities. The share of freight transport that is distributed by road doubles compared to 2002 at the cost of transport via waterways and pipelines. In all, the pressure on the road network will increase with 80% due to developments in passenger traffic, freight transport and infrastructure expansions. Congestion will increase and concentrates around the major cities of the Randstad. Emission of carbon dioxide will increase with 70% in relation to 2000.

Agriculture
Agriculture will face a continuing demand for land from housing, industry, infrastructure, recreation, water and nature. Competition will be high since the market value for these sectors is much higher than for agriculture. Also, European environmental policy plays a role in the limited growth in agriculture. Still, agriculture is expected to cover a substantial part of the Netherlands in 2040. The economic potential for greenhouse horticulture is promising. Dairy farming will grow only if milk quota regulations will be abolished. Arable farming as well as intensive livestock farming will be subject to high pressures on prices due to liberalization. Employment in the agricultural sector will decrease with 50-65% due to increased labour productivity. Arable farming will concentrate in the Periphery. In the Randstad and Intermediate Zone, the area under agriculture decreases due to the need for other land-use functions. The greenhouse horticulture area will increase in the province of Zuid-Holland to 4.5% of its surface area. Subsidies for the preservation of the characteristic values of the agricultural landscape related to, for example, biodiversity, cultural history are unlikely in this scenario.

Energy
This scenario does not anticipate global climate policy and expects the emission trade to be ceased by 2020. Current subsidies for renewable energy will cease by 2020 as well. Demand for energy will increase with 50% leading to an increase of carbon dioxide emission. In this scenario, natural gas will be the main supplier of energy. There will be room for new technologies only if costs are acceptable. Natural gas however will be nearly depleted by 2040 forcing the increase of imported energy. Small spatial reservations have to be made for safety zones around transport lines and storage facilities of imported natural gas. Wind parks also demand limited amounts of land since they cause visual and noise pollution.

Environment
The prospering economy in the Global Economy scenario will lead to a doubling of the amount of waste, causing a strong increase of the waste volume that will be reused (+70%) and incinerated (+200%). This calls for investments in additional incineration capacity that will have adverse consequences for the living environment. An additional possibility would be to export waste, but this requires an 'open market' whose existence is not certain. This scenario foresees an increased accumulation of phosphor in the soil. The leaching of nitrogen to groundwater will diminish because of Dutch nitrogen regulations. Air quality will improve due to cleaner production methods and technological innovations.

Nature, biodiversity and outdoor recreation
A permanent pressure remains on nature, biodiversity and recreation, because of the continuing demand for land for various, mainly urban uses. At the same time, the demand for nature and recreation areas increases with the strongly growing population and prosperity. Biodiversity in surface waters like lakes and streams will improve due to better environmental conditions, but biodiversity in agricultural areas will decrease. No additional areas for nature development are expected besides the current plans for an ecological main structure (EHS). Due to diminishing governmental interference it is possible that some of the planned nature areas will be located on other than planned places. The current policy strives to realise $75m^2$ green space for each newly built house. On top of that, the Government will develop about 20,000 hectares of recreational area outside the cities. Also, the demand for private recreation, such as sports fields and golf courses, will increase; the current trend of 15-20 m^2 per citizen will increase in Global Economy to 26 m^2 per citizen.

6.3.3 Land-use simulations
The most striking land-use change in the W scenarios is the strong increase in urban land use. Residential land use expands substantially around the larger cities in the Randstad, as well as around many smaller villages in the rural areas. Commercial land use also increases strongly. This increase takes place in the Randstad and bordering parts of the Intermediate Zone. The urbanisation causes a serious deterioration of the quality and openness of the landscape, also in the designated national landscapes.

The appearance of the rural areas will also change. Arable farming will, to a large extent, disappear and be replaced by grassland for dairy farming. Capital-intensive forms of farming will also demand more land. Greenhouse horticulture expands around the main ports of Rotterdam and Schiphol. New nature will mainly be developed along the major rivers, where strong constraints are imposed on the expansion of urban functions and capital-intensive forms of farming. Recreation also claims more space, especially in the attractive small-scale landscapes of, for example, the Achterhoek. A limited description of the land-use simulations for the W scenarios has also been published in the 6th National Environmental Outlook (MNP, 2006).

6.3.4 The climate dimension
The W scenarios are characterised by a 2 degrees Celsius temperature rise between 1990 and 2050. Due to a change in atmospheric circulation the winters will be mild and wet because of increased westerly winds in the W+ scenario. Summers will be warmer and dryer because of increased easterly winds in this scenario. More details are provided in Table 3.2.

7. Conclusion and discussion

The current report proposes a combination of existing scenarios of climate and socio-economic change as a starting point for further research into the adaptation and mitigation measures that may be needed to face the future in the Netherlands. The selected scenarios are fed into the Land Use Scanner model that simulates future land-use patterns. The G scenarios with a moderate temperature rise are combined with a socio-economic scenario that combines an orientation on national sovereignty with clear public responsibilities. The related land-use simulation for 2040 depicts a limited amount of urban growth, predominantly in the central and western part of the country. The W scenarios with a higher temperature rise are combined with socio-economic conditions that favour international cooperation and private responsibilities. These simulations show a much stronger urban growth, especially of rural types of residences in attractive landscapes.

The results presented in this report are intended especially for the 'Climate changes Spatial Planning' research programme. As such they are closely related to a number of projects within this programme. These are foremost two Climate Scenarios projects (CS6 and CS7) and the 'Socio-economic scenarios for climate change assessments' Integration project (IC11). The former projects have provided the climate scenarios described in this report and continue to elaborate on specific climatologic variables. The latter project discusses possible combinations of socio-economic and climate scenarios in a similar fashion as the current report. The project aims to provide researchers with a set of components to analyse possible adaptation and mitigation measures. The reader is referred to their upcoming publications for further information.

For the LANDS project, that produced this report, the presented results are a first step towards the creation of an integrated outlook on a climate-proof future for the Netherlands. To achieve this ambitious objective the project relies on the integration of the results from many other projects in the 'Climate changes Spatial Planning' research programme that analyse and propose possible adaptation and mitigation measures for different societal sectors. The relation of the LANDS project and its current scenario report with these other projects is depicted in Figure 7.1. The figure shows that the integrated climate and socio-economic scenarios, described in this report, are not only intended to feed into the Land Use Scanner model for the simulation of future land-use patterns. The scenarios also provide the starting point for the different sector-specific studies. The possible impact on water management and nature is studied as part of the LANDS project, as well as in several other climate-related projects focussing on flood risk (Aandacht for Veiligheid-AVV), adaptation measures in the Rhine basin (ACER-A7), the spatial distribution of vegetation (A1), optimizing the nature conservation potential (A2). Other projects dealing with possible climate-adaptation measures for, amongst others, agriculture (carried out by LEI), transport (A8), specific local or regional circumstances (hospots-A10) and fen meadows (ME5/ME6) can also use the scenario assumptions and simulated land-use patterns as a reference point for their analyses. Subsequently, the results of these projects will be fed into the Land Use Scanner to simulate adjusted land-use patterns that take the possible impact of climate change into account.

In order to integrate the outcomes of the different, sector-oriented projects into coherent maps of future land use, as is one of the ultimate goals of the 'Climate changes Spatial Planning' research programme, it is essential that they all start from the same assumptions regarding the possible future developments. It is therefore that we have described these in the current report. To be able to actually use the output of the individual projects it is needed that they provide quantitative information related to the regional land-use demand (claim) and location preferences (suitability) for their specific sector. This information can then be included in the Land Use Scanner model to simulate new land-use patterns

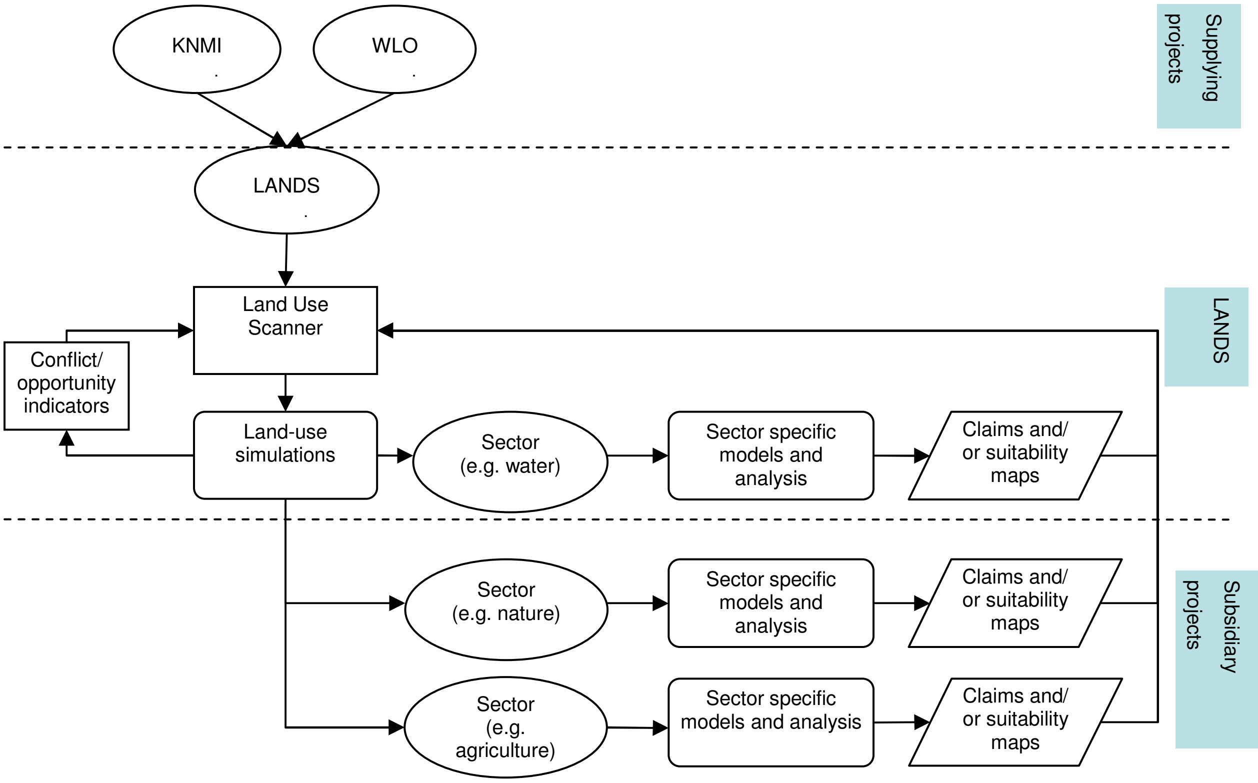

Figure 7.1 LANDS project scheme.

The preliminary attempts to integrate results from the AVV and agriculture project indicate the importance of actually starting from the same assumptions. The diverging character of their respective research results makes clear that substantial post-processing and intensive cooperation are essential to successfully integrate the various results. We hope that the current report provides a first step in this direction and we are happy to intensify cooperation.

Appendices and references

Appendix 1 Detailed land-use maps

This appendix presents the detailed land-use maps for 2000, 2015 and 2040 according to the G and W scenario.

The 2000 land use is based on a combination of the spatial land-use statistics (CBS, 2002), land cover maps based on satellite images (LGN4, see (De Wit, 2004) and additional information related to, for example, prevailing types of residences (den Otter and Heida, 2003). This combination of spatial datasets produces a base map that distinguishes over 70 types of land use at a 25 metre resolution. These data are aggregated into 17 main types at a 100 metre resolution for the simulation of future land use. For cartographic representation we simplify this to one dominant type for each grid cell of 1 hectare. So the dominant land use may, theoretically, cover only slightly more than 1/17 = 0.06 hectare[3]. Land-use types that on average cover a large part, but not all of a grid cell, are overrepresented in the above map. This is the case with, for example, the residential functions that cover an approximate 6% larger area on the map than in the original base data. The opposite, under representation, is true for land-use types such as roads and railways that, generally, only cover a small part of a cell.

The 2000 land-use dataset is used as a starting point for the simulation of land use in 2015. In this step current, explicit land-use plans, mainly taken from the new map of the Netherlands survey (NIROV, 2005) are included in the simulation to represent autonomous developments. Based on this situation the simulations for 2040 are made according to the G and W scenarios. The simulation process only results in homogenous cells, so the maps for 2015 and the G and W scenarios offer an accurate description of the simulation outcomes and do not suffer from the under or over representation discussed above.

[3] In fact, the situation is more complicated as the resolution of the original base map only allows the distinction of surface areas of 25x25 metre = 0.0625 hectares. This smallest possible surface area is, however, almost equal to the 1/17 (= 0.0588) minimum described above.

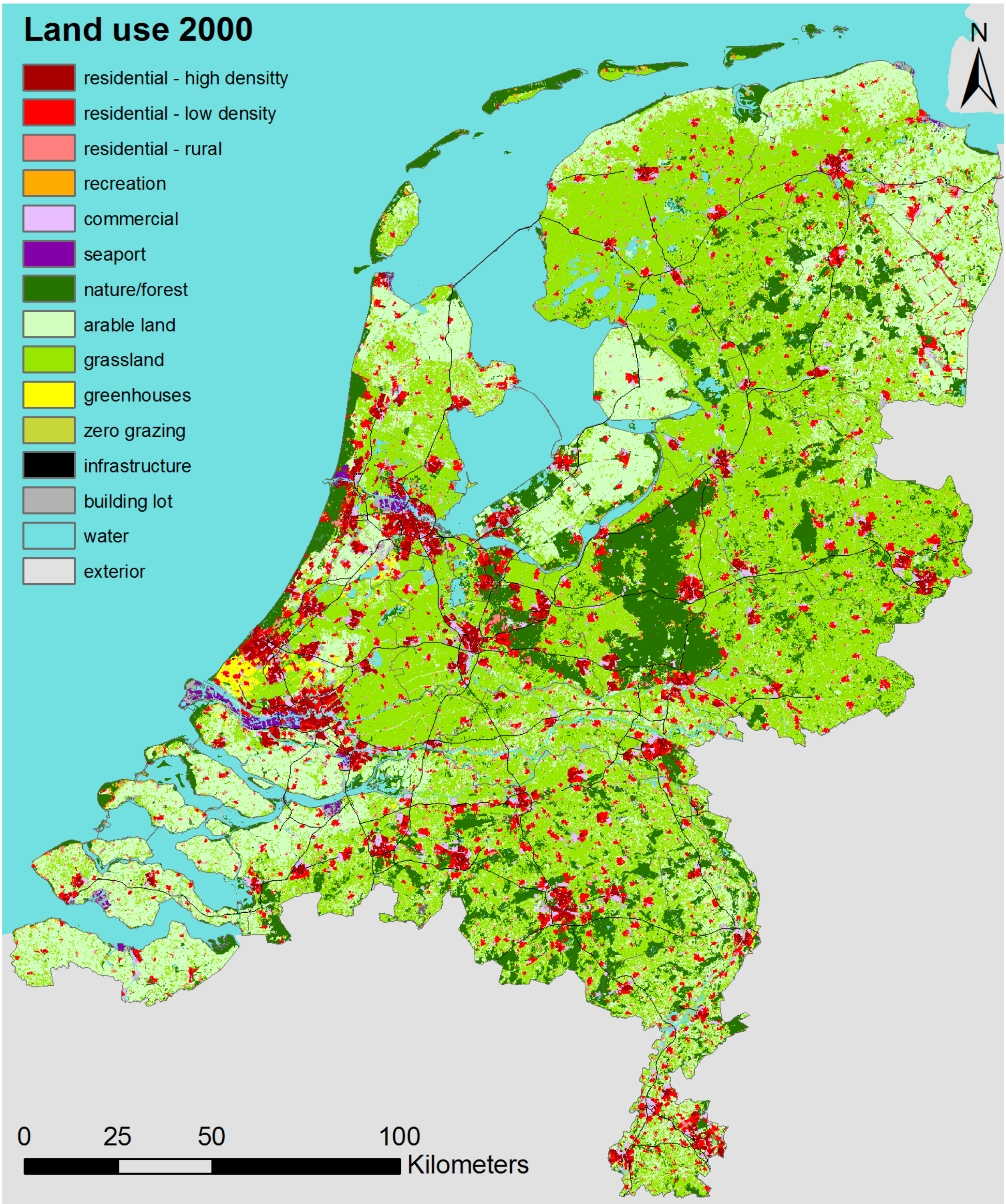

Figure A.1: Detailed, dominant land use 2000.

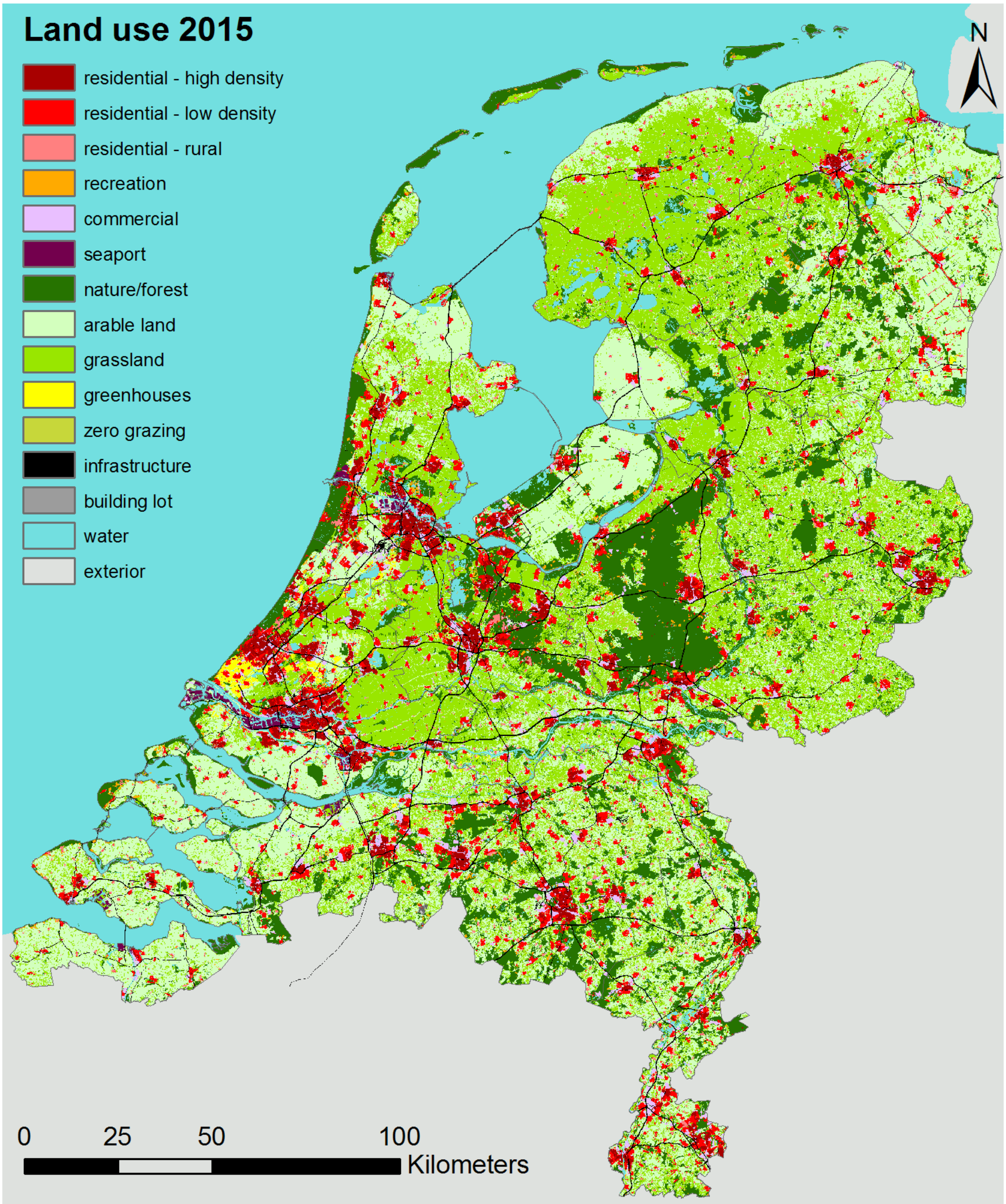

Figure A.2: Detailed, simulated land use for 2015.

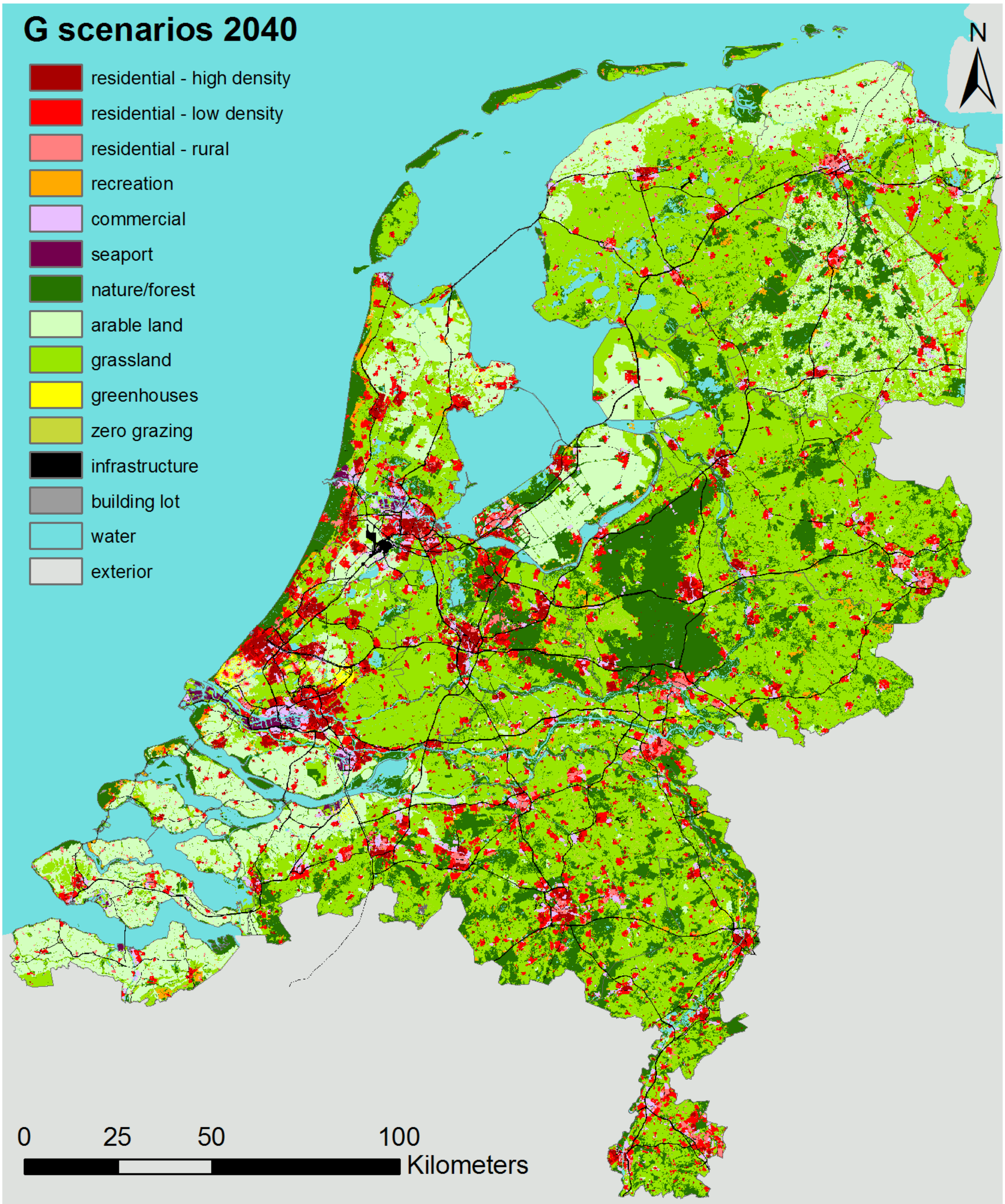

Figure A.3: Detailed, simulated land use for the G scenarios.

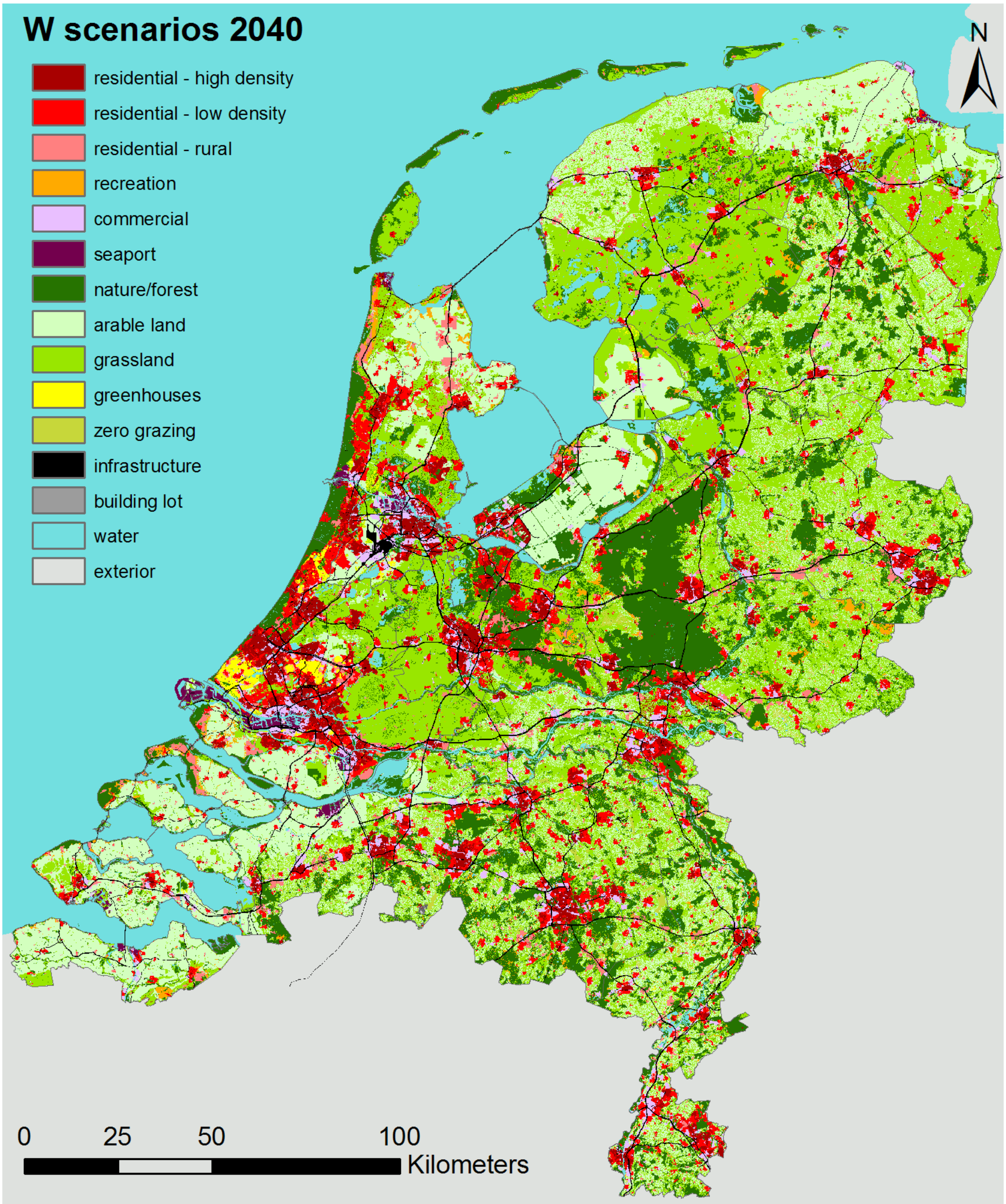

Figure A.4: Detailed, simulated land use for the W scenarios.

Appendix 2 Regional land-use statistics

2000	Residential - high density	Residential - low density	Residential - rural	Recreation	Commercial	Commercial - seaport	Nature/forest	Agriculture - arable land	Agriculture - grassland	Agriculture - greenhouses	Agriculture - zero grazing
Outside Provinces	5	20	2	8	17	0	247	378	456	1	13
Groningen	1970	9147	3278	979	3684	436	13011	110158	83674	98	229
Friesland	2260	8852	4038	2072	3536	52	38610	43929	222951	95	392
Drenthe	1603	9405	2210	2099	3327	0	43045	90179	106034	373	436
Overijssel	6179	13918	1605	2332	6131	0	47316	38663	206658	102	1814
Gelderland	9526	26125	3835	5394	10742	0	116135	66276	241875	671	4307
Utrecht	8361	10349	1579	1046	4549	0	20729	11811	73975	249	534
Noord-Holland	16181	23667	2241	3528	7171	2812	30928	77242	87732	1762	91
Zuid-Holland	22536	24756	1620	3201	9280	4828	20559	73923	94276	9424	262
Zeeland	1436	5560	2152	2097	2188	856	12172	111248	31232	123	94
Noord-Brabant	12536	33843	3808	3486	14819	662	84432	109035	205373	1124	6292
Limburg	6193	16732	2568	1958	7578	0	35282	65699	68512	906	2033
Flevoland	2307	4844	341	1458	1865	0	22611	86525	16715	263	50
Total	*91094*	*187215*	*29277*	29658	*74887*	*9645*	*485077*	*885066*	*1439462*	*15191*	*16547*
2015											
Outside Provinces	1	9	0	27	6	0	138	122	27	3	14
Groningen	2154	10288	4004	1151	4421	497	18824	118018	70710	102	183
Friesland	2463	9645	4810	2443	4392	59	45057	53649	210198	101	327
Drenthe	1813	10145	2641	2459	3912	0	52894	104757	82408	425	364
Overijssel	6594	15398	1854	2751	7319	0	59531	78467	156231	107	1445
Gelderland	10564	28198	4852	6278	12419	0	135359	105817	179681	706	3635
Utrecht	9035	11936	1867	1200	5064	0	26683	14722	64243	245	480
Noord-Holland	17908	26609	2732	4179	8333	2937	37544	81021	79602	1747	79
Zuid-Holland	24536	27956	2876	3836	10608	5482	30009	76413	83594	9749	245
Zeeland	1560	6250	2502	2446	2600	901	15654	118583	24116	112	77
Noord-Brabant	13772	37193	4729	4040	17372	782	96614	187046	115019	1137	5557
Limburg	6695	18498	2904	2276	8744	0	42993	86168	39963	913	1851
Flevoland	2626	6041	958	1722	2640	0	24006	90828	11547	310	44
Total	*99721*	*208166*	*36729*	*34808*	*87830*	*10658*	*585306*	*1115611*	*1117339*	*15657*	*14301*
W scenarios 2040											
Outside Provinces	1	9	0	27	6	1	138	50	53	2	61
Groningen	3200	10771	5725	1680	5061	842	19088	86988	95937	119	201
Friesland	3810	10224	8153	3402	5475	87	46366	53595	199813	428	354
Drenthe	2723	10933	5307	3354	4452	0	51444	77546	104186	1038	397
Overijssel	8594	17938	5801	3761	9035	0	57048	68028	156231	241	1542
Gelderland	15142	30033	14508	8717	13927	0	152566	64931	179681	1234	3869
Utrecht	11721	16593	4936	1708	5790	0	30167	1142	61128	263	511
Noord-Holland	23524	34776	12156	5992	10154	3409	40137	59264	67279	2009	85
Zuid-Holland	32688	35013	14365	5547	12516	7589	29540	44257	78860	11924	262
Zeeland	2630	6791	4326	3326	2987	1163	17789	112344	22604	207	83
Noord-Brabant	18287	42766	11594	5683	19735	1807	103980	127692	139404	2307	5883
Limburg	7947	19744	4934	3188	9168	0	48441	61069	51512	1552	1954
Flevoland	3791	6699	3035	2493	3877	0	25503	74369	18319	954	48
Total	*134058*	*242290*	*94840*	*48878*	*102183*	*14898*	*622207*	*831275*	*1175007*	*22278*	*15250*
G scenarios 2040											
Outside Provinces	1	9	0	27	6	0	138	35	115	0	16
Groningen	2405	10278	3853	1680	4123	453	17671	76804	112179	41	125
Friesland	2829	9362	5205	3402	3985	68	44950	46832	214577	261	221
Drenthe	1965	10196	2797	3354	3530	10	54194	97472	87259	349	254
Overijssel	6805	15515	2511	3761	6335	0	59798	3262	229201	106	919
Gelderland	10761	28357	5460	8717	10993	0	159483	8529	249433	386	2312
Utrecht	9065	11974	2042	1708	4486	0	28750	2016	73488	98	311
Noord-Holland	17892	25999	3392	5992	7429	2542	38721	67534	88465	618	55
Zuid-Holland	25451	27824	4655	5547	9031	4983	28123	60222	101109	4403	162
Zeeland	1456	6506	2824	3326	2423	391	16372	114901	25781	70	40
Noord-Brabant	14221	37722	5876	5683	15097	544	106730	42625	246224	813	3533
Limburg	6808	18725	3201	3188	7390	204	51191	3782	113143	547	1210
Flevoland	3011	5808	1354	2493	2550	0	24086	77486	21963	307	30
Total	*102670*	*208275*	*43170*	*48878*	*77378*	*9195*	*630207*	*601500*	*1562937*	*7999*	*9188*

The above table presents an overview of the land use per province in 2000, 2015 and 2040 according to the two scenarios. The listed land-use types are actually simulated with the Land Use Scanner. The remaining land-use types, related mainly to infrastructure and water, have a fixed location. Occasionally an increase is expected in some types of infrastructure (e.g. the new high-speed train links) and water (additional water storage areas). This increase is allocated at predefined locations, according to current plans. The figures related to 2000 reflect the actual land use in the original data set, so they deviate slightly from the statistics related to the dominant land-use map presented in Appendix 1. The land-use statistics of the scenarios are based on the simulation results and may, occasionally, differ from the original demand per land-use type when their regional totals are higher or lower than the total amount of available land.

A short description of the land-use types used in the simulation is provided below.

1. Residential - high density: residential areas in the central city districts, including shops, restaurants, cafes, hotels and socio-cultural facilities such as schools, churches, hospitals and theatres.
2. Residential - low density: residential areas in the green outskirts of cities and centres of villages, including burial grounds, parks, sports fields and allotment gardens.
3. Residential – rural: residential areas in rural environments.
4. Recreation: recreational facilities for overnight stay (including camping's, bungalow parks and second homes) and the predominantly green recreational facilities for daytrips (including: theme parks, zoos and open air museums).
5. Commercial: commercial areas on business estates, mining and dump sites including public facilities such as municipal offices, government buildings, police stations et cetera..
6. Commercial – seaport: large coastal harbour areas.
7. Nature/forest: all types of natural vegetation including forest, heath land, dunes, marshes et cetera.
8. Agriculture - arable land: land used for potatoes, beets, cereals, flower bulbs and similar crops. This land-use type also two other types of agriculture that claim relatively little space: orchards and tree nurseries
9. Agriculture – grassland: agricultural land for grazing livestock consisting of grassland and, to a lesser extent, maize.
10. Agriculture – greenhouses: greenhouse horticulture.
11. Agriculture - zero grazing: capital intensive zero-grazing livestock or intensive animal husbandry.

The following land-use types are present in the maps of current and simulated land use, but are not allocated by the simulation algorithm:

1. Infrastructure – rail: railways and related buildings (e.g. stations).
2. Infrastructure – road: main roads and related buildings (e.g. bus and petrol stations)
3. Infrastructure – airport: runways and related buildings (e.g. hangars), unpaved grounds and buildings of service providing companies are not included here.
4. Exterior: land outside Dutch territory, i.e. Belgium or Germany
5. Water: including all types of water: large sweet-water bodies (IJsselmeer with the connecting lakes and water storage basins for drinking water and industry), the Rhine and Meuse river courses, water with a predominant recreational function, the North Sea and neighbouring salt water bodies (Waddenzee, Oosterschelde, Westerschelde and closed off estuaries) and the remaining inland water bodies wider than 6 meter such as canals, lakes, ditches and harbours. Also included here are the water bodies in use for the extraction of sand or gravel and the storage of industrial waste water.

In total the model distinguishes 17 types of land use. Apart from the 16 listed above it also includes a rest category that consists of building lots (where construction has started or will start in the future) and other partially paved terrains. The former category of construction sites is available for new land-use functions in the simulation, leading to a strong decrease in the surface area of this category.

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