Applying WLO for Climate Change

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1. Introduction

Assessments about the nature, rate, impacts and responses to climate change deal with change in coupled environmental-human systems. In making future projections of climate variability and change, mitigation and adaptation, assessments are therefore faced with making assumptions about the future social and economic changes, often over the long-term. These assumptions will have an important influence on results of assessments, either because they are inputs for emissions scenarios that drive climate models, or because they portray the context in which climate change impacts and adaptation are analysed.

The WLO study (Welvaart en Leefomgeving - The Future of the Dutch Natural and Built Environment) (WLO, 2006) assesses the long-term effects of current policy, given the international economic and demographic context of the Netherlands. Its qualitative and quantitative results should serve as a reference for policy-makers. By exploring how land use and various aspects of the living environment may develop on the long run (2040), the study shows when current policy objectives may come under pressure, and which new issues may emerge.

The question we want to address in the Climate Changes Spatial Planning (KvR, 2007) project *IC11 Socio-economic scenarios for climate change assessments* is how we can extend or how we can adapt WLO to make it more suitable for the purposes identified in other KvR projects.

2. Methods

In principle there are two possible methods to address this question, which probably should be carried out in parallel. In the first method the starting point is the demand side: what kind of questions require socio-economic scenarios? Examples of such questions may include:

- What would be the damage of a major flood in the Betuwe?
- Where can we grow energy crops in 2015?

The demand side method will be elaborated in Section 5.

In the second method the starting point is the current WLO study. In Section 4 we will elaborate the supply- driven method: what can WLO do for climate assessments? The following section elaborates how WLO works.

3. How WLO works

3.1 WLO summary

The WLO website (WLO, 2006) presents the following summary of WLO:

> "[The WLO] study assesses the long-term effects of current policy, given the international economic and demographic context of the Netherlands. Its qualitative and quantitative results should serve as a reference for policy-makers involved in spatial planning, housing, natural resources, infrastructure, and the environment. By exploring how land use and various aspects of the living environment may develop on the long run (2040), the study shows when current policy objectives may come under pressure, and which new issues may emerge.
>
> The long-term future of the Dutch population and economic development and, consequently, of its natural and built environment is highly dependent on international factors. Two critical factors of uncertainty stand out: (1) to which extent will nations and international trade blocks cooperate and exchange, giving up some of their cultural identity and sovereignty? (2) how will governments balance between market forces and a strong public sector? These international political choices determine four possible scenarios for the Netherlands:
>
> - **Global Economy**: emphasis on international cooperation and private responsibilities.
> - **Strong Europe**: emphasis on international cooperation and public responsibilities.
> - **Transatlantic Markets**: emphasis on national sovereignty and private responsibilities.
> - **Regional Communities**: emphasis on national sovereignty and public responsibilities.
>
> The study builds on earlier work by CPB and RIVM [...] in which these scenarios were translated into four development paths for the Dutch economy and demography. In the current project, the resulting economic and population scenarios, including their international contexts, were elaborated for application to the built and natural environment. This required both conceptual thought and extensive integrated modeling, e.g. regarding the coherence and consistency of all different aspects of regional economy, internal migration, urbanization, and environmental pollution. The modeling framework generated quantitative indicators to illustrate the scenarios and support the conclusions.
>
> Scenarios should include national policy to be realistic. To allow for statements on the future effects of current government policy and to compare these with alternative policies, trend-based policy is assumed in all scenarios. However, on the long run the four scenario contexts will diverge too much for a uniform policy to be realistic. Consequently, beyond 2020 policies may slightly differ among scenarios, as long as they are plausible and consistent with the scenario logic."

WLO employed the scenario axis technique as a basis of the four scenarios. The central graph in this technique is shown in Figure 3.1.

Figure 3.1 The four WLO scenarios. Key uncertainties are individualization (horizontal axis) and globalization (vertical axis).

In WLO approximately forty quantitative models were coupled. These models include a global model that assesses economical developments, trade and energy supply, national and regional demographic models, a labor market model, transport models for persons and freight, an agricultural model, energy models and environmental models (WLO, 2006: 205-209). The models are hosted by many different governmental and non-governmental organizations, such as CPB, MNP, RPB, CBS, RIVM, ECN, LEI, ABF Research and Louter Advies. In the calculations no feedbacks were included, such as the effects of congestion on economic growth and the recreational area size decrease on the demand for houses with gardens.

3.2 Reviewing WLO

Climate scenarios

For climate assessments it is of course interesting to investigate the effect of climate change on the socio-economic scenarios. The KNMI scenarios for The Netherlands show that for 2050 the differences in between its four scenarios are quite substantial. E.g. average winter temperature is 0.9ºC higher in the moderate G scenario and 2.3ºC higher in the warm W+ scenario, compared to the average situation in the period 1974-2005 (KNMI, 2006). WLO did not use the KNMI 2006 scenarios but the central scenario published in 2000 that indicated an average temperature increase of 1ºC in 2050. This central scenario can be compared to the KNMI 2006 G scenario (Riedijk *et al*., 2007).

In general, in WLO it is assumed that lifestyles do not change. However climate change may significantly change e.g. recreational behavior.

Models

Dekkers and Koomen (2006) assessed several models that were applied in WLO, including PRIMOS, ABF, BLM and DRAM, which are used for estimating demographic trends, trends in locations of enterprises and agricultural trends, respectively. They conclude that PRIMOS and DRAM are well validated, calibrated and documented. Hence

their model results can be considered reliable. Yet the ABF model is not well documented *et al*. Therefore it is difficult to assess its reliability.

Dekkers and Komen did another interesting observation: the BLM model draws heavily on governmental policies on nature and recreation. On the one hand that is logical, because *in the current situation* governments determine where infrastructure and natural and recreational areas will be situated. On the other hand it is inconsistent with the storylines in Global Economy and Transatlantic Market, where governments play a less dominant role.

WLO and historic determinism

In general scenarios can be set up according to three different approaches:

- Exploratory (evolutionary or discontinuous);
- Extrapolatory (including 'business as usual');
- Normative (backcasting).

These approaches are elaborated in Box 3.1. WLO has both exploratory and extrapolatory characteristics. The WLO research team initially divided the time frame into the period until 2020 and the period 2020-2040. They argued that the first period could be explored by trend extrapolations based on historical data sets. The second time period was considered as 'the far future'. The researchers acknowledged that it in this time period existing structures and mechanisms will be changing or replaced by others. Therefore they wanted to explore a range of possible futures and uncertainties. However in the process of refining the scenarios, future images that are quite different from our existing world were considered unrealistic and therefore dropped in the analysis. This was observed by Van 't Klooster (2007: 140) who concluded that in WLO the historic-deterministic pattern of reasoning dominated not only in the time period until 2020, but throughout the whole period that was investigated.

Box 3.1 Exploratory, extrapolatory and normative approaches in scenario analysis.

Exploratory approaches create a stylised 'model' of a system (such as the scenario-axes technique) and make projections for the system given assumptions about the determinants of change. Most scenario studies take an exploratory approach. Extrapolatory approaches come closer to classical forecasting in which existing numerical models – that make assumptions about the sign and strength of relationships between variables – are used to make projections of the future. While such models may be very useful to forecast the relatively near-term, they are typically poor at making projections over the longer-term, primarily because relationships between variables change with time (Berkhout and Van Drunen, 2007).

Normative studies posit a (desirable) state for the system at some future date and then 'backcast' to understand what changes need to occur for this to be achieved (Dreborg, 1996). Many global scenario studies have normative elements in the specification of desirable and undesirable outcomes.

Most scenarios are evolutionary: they are consistent with the notion of a gradual, incremental unfolding of a world pattern or system through time and space. In the dominant evolutionary scenario paradigm it is difficult, if not impossible, even to imagine discontinuity. Abrupt discontinuities give society a jolt, though possibly only a temporary and reversible one. Although many problems arise if discontinuities are incorporated into scenarios (Van Notten *et al.*, 2005), in climate scenarios these may be particularly relevant since climate change itself can cause such discontinuities.

4. What WLO can do for climate assessments

4.1 How WLO was used in other studies

LANDS

The KvR project LANDS (LAND uSe and climate change) 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' (Riedijk *et al*, 2007). In LANDS the Land Use Scanner (*Ruimtescanner*) is used to simulate future land-use patterns.

LANDS combined the WLO scenarios with the KNMI 2006 scenarios. Because there are sixteen possible combinations the LANDS team decided to include only 'the extremes on both sides of the bandwidth in terms of socio-economic developments' (Riedijk *et al*, 2007: 23). Hence they decided to include only the Global Economy (GE) scenario and the Regional Communities (RC) scenario in their analysis. Furthermore, LANDS associated the GE scenarios with the warm (W) KNMI 2006 scenarios and the RC scenario with the moderate (G) scenarios. The LANDS team argues that the RC scenario would lead to less greenhouse gas emissions resulting in a lower average temperature increase. Table 4.1 shows the resulting four combinations of scenarios investigated in LANDS.

Table 4.1 Integrated scenarios in LANDS (Source: Riedijk et al., 2007: 23)

	Regional Communities	Global Economy
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)

By choosing these combinations, LANDS is able to evaluate:

- The combined spatial pressures caused by rapid economic growth (residential and commercial demand for space) and those by larger climatic changes (increased river discharge, sea level rise and precipitation); and
- The effects of slow economic growth and decreasing population size ('shrinking cities') combined with moderate climate change on regional development and affordability of required adaptation measures.

The project used the Land Use Scanner enabled LANDS to translate the scenarios into maps that show the locations for residential, recreation, and commercial purposes, nature, agriculture, infrastructure, building lots and water in 2015 and 2040 for the G scenarios and the W scenarios. The spatial resolution is 100 m.

Nederland Later

In MNP's *Duurzaamheidsverkenning Nederland Later* ('sustainability outlook': MNP, 2007) WLO was used to investigate what policies are required to attain sustainability targets in the physical environment. Its Trend Scenario was based on WLO's Transatlan-

tic Market and its alternative High Spatial Pressure Scenario was based on Global Economy [1]. The scenarios time horizon is 2040.

Nederland Later also applies the Land Use Scanner to translate its scenarios into maps. Unlike LANDS, it does not explicitly incorporate the KNMI 2006 scenarios. However it indicates to include features of the W-scenarios such as a 2ºC increase in 2050, and a sea level rise at the 'upper side of the KNMI range' (MNP, 2007).

For the theme Climate and Flooding Security, *Nederland Later* assesses three alternative spatial strategies to prevent flooding: 'differentiation security', 'shifting to high Netherlands', and 'broadened coastal zone' (MNP, 2007: 54). Also for Mobility three alternatives to decrease congestion are introduced. Hence, *Nederland Later* does not only include current policies (as WLO does), but also investigates the effects of alternative new policies.

Interestingly *Nederland Later* also indicates six important uncertainties that may cause trend reversals, such as migration, individualization, preferences for housing types, economic development, climate change and technological innovations (MNP, 2007: 47). However these uncertainties were not included in the two scenarios.

Climate related studies that applied WLO

A quick internet search revealed that WLO has already been applied in several climate related studies. Below they are briefly discussed.

De Routeplannerstudie 'Nulmeting' (Kwadijk *et al*., 2006) used WLO to compare the anticipated impacts of climate change to other impacts in the sectors flood security, public health, public services, water resources, nature, agriculture, and the private sector. For instance climate change has effects on human health in The Netherlands, such as heat stress, but its impact on the sector public health will be only minor compared to the effects of the aging society. The *Nulmeting* applied numerous WLO results (and also results from *Vier Vergezichten op Nederland*, Huizinga en Smid, 2004), including investments in flood security, costs of health care, energy consumption, nature development, employment and land use by agriculture. Kwadijk *et al*. (2006) used the results of all four WLO scenarios.

The Urgentieprogramma Randstad (Randstadurgent, 2007) quotes a number of qualitative WLO results such as the destruction of Dutch landscapes and nature as a result of urbanisation, increase of traffic and transport, internationalization and increased share of services in the economy, and a growing population. The programme does not specify which scenarios were applied.

DHV wrote a report about the spatial impacts of climate change in the Province of Groningen (Provincie Groningen, 2007). In the draft version the province only used the anticipated increase in living area per household from WLO. The region Haaglanden translated WLO to socio-economic trends relevant for Haaglanden (Haaglanden, 2007). It also assessed the risks for flooding for the region based on WLO. Both studies do not specify which scenarios they used.

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[1] Note that both these scenarios constitute a high level of individualization.

ECN and NMP used the draft version of the WLO Global Economy scenario outcomes for energy consumption, oil prices, and air emissions as a reference in their *Optiedocument energie en emissies 2010/2020* (Daniëls and Farla, 2006).

The renewable energy initiative Green4Sure (Blom *et al*, 2007) used WLO scenarios to compare the Global Economy and Strong Europe[2] greenhouse gas emission scenarios to the Green4Sure sustainable energy scenario.

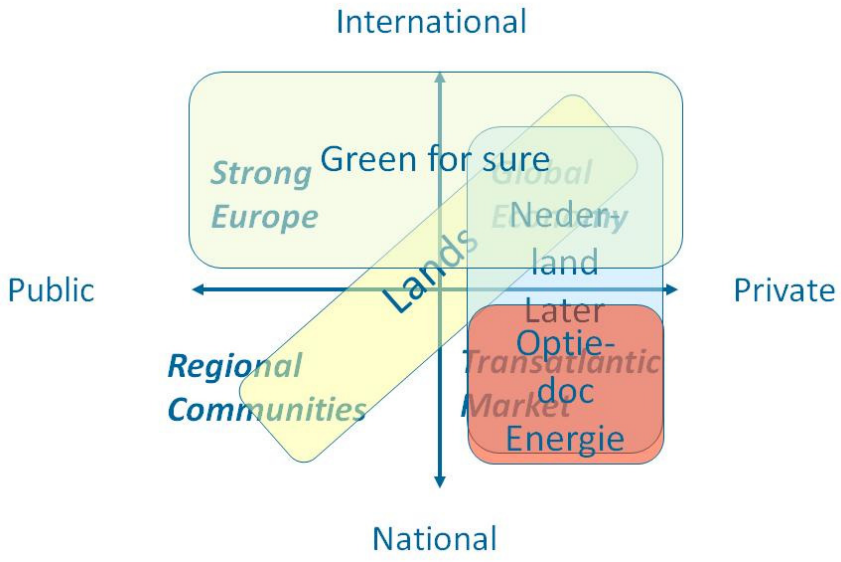

Figure 4.1 'Shopping' of WLO scenarios by the studies Green for Sure, Optiedocument energie, Nederland Later en LANDS.

[2] Note that both these scenarios assume a high level of globalization.

5. What do KvR researchers want from scenario studies?

During a workshop (Van Drunen *et al*, 2007) we assessed the applicability of WLO in climate assessments. Participants were researchers and regional policymakers who are active in the Dutch Climate Changes Spatial Planning program. Themes that were addressed include extremes, the time horizon, behavioral parameters and feedback mechanisms between climate and socio-economic scenarios. In general the participants were impressed by the WLO framework, the narratives and the quantitative support of the scenario outcomes. However they preferred to have a longer time horizon: 2100 instead of 2040. Furthermore they concluded that, although WLO was set up as an exploratory scenario study, it has mainly extrapolatory characteristics, because the four scenarios are quite similar. This was already elaborated in Section 3.2.

We surveyed the KvR project list (KvR, 2007a) for projects that require inputs from socio-economic scenarios. This resulted in Table 6.1. A closer look at the main questions reveals that several projects 'only' need a broad picture of possible future societies, often for specific locations (ME6, A9, A13-17, IC12). For these projects the WLO outputs as such can be used, although some projects prefer a longer time horizon, or a higher spatial resolution.

Other projects aim to test the results of specific mitigation and adaptation strategies (A2, A7, IC3, IC5). For these projects the WLO 'toolbox' must be opened because the strategies to be investigated need to be included in the models. *Nederland Later* (MNP, 2007) used the Land Use Scanner and underlying models to do this (see also Section 4). The LANDS project (IC3: Riedijk *et al*, 2007) already supplied high resolution maps with the Land Use Scanner that may be useful for the projects ME6, A9, A13-17 and IC12.

6. WLO beyond 2040

In this section we summarize some thoughts about extending WLO until 2100.

As discussed in Section 3.2, the historic deterministic characteristics may be problematic if one aims to extend WLO's time horizon. The main reason for this is that WLO (implicitely) assumes that the structure of the Dutch society remains the same, i.e. that the relationships among the economic sectors do not change in character. Of course this assumption does not hold: by looking e.g. 20 years back it is easy to predict that in 2027 the structure of the society will be quite different from the present structure.

The quantitative models, as used in WLO, would have a limited value, because such models are usually calibrated with historic datasets. Instead of trying to apply these models it may be worthwhile to develop simplified models that indicate not only future trends, but also the range of uncertainties in these trends.

Furthermore it is inevitable to include policies that are not currently being prepared on such a long time horizon. Nederland Later (see Section 4.1) showed an elegant way to deal with this by including three policy options for dealing with flooding in its Trend scenario that was based on the WLO Transatlantic Market scenario. However such an approach is impossible to extend to other policy fields and to all four scenarios because it would imply an enormous workload and hundreds of possible scenario results.

Table 6.1 KvR projects requiring socio-economic scenario inputs.

Code	Title	Main questions	Horizon	Contact
ME6	Spatial decision support for management of Dutch fen meadows	How big are agricultural, residential and natural areas in Dutch fen meadows?	2050?	Ron Janssen / VU
A2	Strategies for optimizing the nature conservation potential of the Dutch Ecological Network and the surrounding multifunctional farm landscape under predicted climate change scenarios	What are opportunities do develop strategies to strengthen the Dutch Ecological Network in combination with food production, recreation, landscape conservation and water management?	2050?	Claire Vos/ WUR
A7	Adaptations to extreme events in transboundary river basins	What institutional arrangements, flood risks related values, protection levels, and flood-proof strategies exist in the River Rhine basin?	2050-2100	Gert Becker / VU
A9	Financial arrangements for disaster losses under climate change	What is the damage potential in areas exposed to flood risks?	2050	Laurens Bouwer / VU
A12	Possibilities for climate-proof and climate-friendly agriculture on the long term	What is the role of the Dutch agricultural sector for food production and biofuel production?	2050?	WUR?
A13	Attention for security	What are the land use and institutional context in areas with flood risks?	2050 - 2100	Jeroen Aerts/ VU
A14, A15, A16	Hotspot projects	What is the institutional context in the Zuidplaspolder, Biesbosch-Haringvliet, Tilburg? What are the cultural and socio-economic developments in these areas?	2050	Marco van Steekelenburg/ PZH Jan Schouw / CEA
A17	Adaptation to climate change in urban areas	What are the cultural and socio-economic developments in urban areas?	2050?	Florrie de Pater / VU
IC3	Designing national land use adaptation and mitigation strategies under changing climate conditions	What is the effect of specific adaptation and mitigation strategies on the land use in the Netherlands?	2050-2100	Eric Koomen / VU
IC5	Cost-benefit analysis of adaptation and mitigation options for climate change: methods and applications	What are the costs and benefits of different adaptation strategies in the Netherlands?	2050	Ecco van Ierland / WUR
IC12	Institutions for Adaptation	What is the adaptive capacity of the current institutions?	2050	Joyeeta Gupta/ VU

Another option for extending WLO is to link its scenarios with global scenarios for the whole century. Bollen *et al*. (2004), cited in the LANDS project (Riedijk *et al*, 2007: 22), explained the similarities and differences between the WLO scenarios and the IPCC SRES scenarios (IPCC, 2000; see also Figure 6.1). Especially the storylines, demographic developments and the regional economic growth numbers may be useful. However mitigation policies are absent in the SRES scenarios, while in some WLO scenarios these are included. This will have major impacts on the energy sector and in the second half of the century possibly also on the required adaptation measures, because serious mitigation measures would lead to less severe climate change impacts.

Figure 6.1 Relating the WLO scenarios (black) to the IPCC SRES scenarios (red) (source: adapted from Riedijk et al, 2007).

The Routeplanner project (Van Drunen, 2007) takes a normative approach: it aims to formulate strategies that would lead to a climate-proof Netherlands in 2050 and 2100. Such a backcasting method may be most useful for other KvR projects. Probably backcasting is less data-intensive although it is still necessary to investigate a broad range of possible future images because the strategies must be affordable and 'fit' in the future society. For example to deal with an increased flood risk, insurance schemes would be acceptable in the Global Economy scenario but may be unacceptable in the Regional Communities scenario.

Royal Dutch/Shell recently developed an alternative to the scenario axis method (Shell, 2007). Main reason behind this development is Shell's acknowledgement that a third major key driver determines future development, namely security (Figure 6.2). Shell argues that it is impossible to me*et al*l three objectives in a future world, because meeting one objective would lead to trade-offs regarding the other two. Therefore Shell explores the dilemma's (or *trilemmas*) involved in the pursuit of the objectives security, social cohesion and efficiency. Possibly such a trilemma approach would be fruitful when exploring the future of the Dutch natural and built environment in the second half of this century.

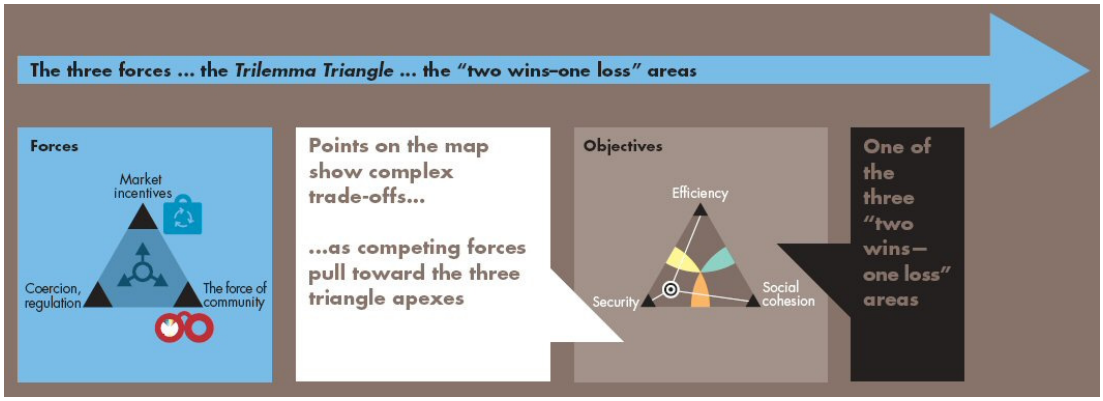

Figure 6.2 In Shell's Trilemma approach three scenarios are constructed based on the assumption that it is impossible to meet the three key objectives. In each scenario, two objectives 'win' and one 'looses' (source: Shell, 2007).

7. Discussion

This section discusses the implications of the above findings for the Climate changes Spatial Planning programme.

First it was shown that WLO scenarios have already been applied in climate assessment studies. Apparently, WLO generated figures and data that are useful. Interestingly, several studies picked only one or two of the scenarios generated by WLO. The studies also chose different sets of scenarios: e.g. LANDS chose Regional Communities and Global Economy, *Nederland Later* Transatlantic Market and Global Economy, and *Optiedocument energie* only Global Economy. *Nederland Later* considers Transatlantic Market as 'business as usual' and thereby it implicitly considers WLO as an extrapolative scenario study. LANDS considers Regional Communities and Global Economy as 'extremes' but they could have chosen Transatlantic Market and Strong Europe as well with the same argument.

From a theoretical point of view this selective 'shopping' may lead to a tunnel vision, because it is impossible to estimate which scenario is more probable than the others (Foresight Futures, 2002). At the other hand it is often impractical to explore all four scenarios. Some participants of the January workshop (Van Drunen *et al*., 2007: 19) argued that in practice only the WLO Regional Communities scenario deviated much from 'business as usual'. This is reflected in the land use maps of the Netherlands in 2040 in *Nederland Later* (MNP, 2007: 41, 43) of the Trend Scenario (based on Transatlantic Market) and High Spatial Pressure Scenario (based on Global Economy). These two maps show only few differences. On the other hand the land use maps based on Regional Communities and Global Economy (Riedijk *et al*., 2007: 42-43)[3], show significant differences in e.g. grassland and residential areas.

This suggests that it would be advisable to include at least the Regional Communities scenario in the analysis, if not all four scenarios can be considered. Following the line of reasoning in the LANDS project explained in Section 4, the RC scenario could be combined with the Global Economy scenario. It is also legitimate to combine scenarios in specific cases (Foresight Futures, 2002). Hence, Regional Communities could also be combined with hybrid scenarios that are composed of e.g. Global Economy and Transatlantic Market features.

The second finding deals with the time horizon extension. As it is probable that the structure of society has changed significantly by 2040, it is difficult to quantitatively support the storylines as was done in WLO, because many model assumptions are not correct anymore. Furthermore the government must respond to certain trends in society and therefore new policies must be taken into account, e.g. in a similar way as in *Nederland Later*.

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[3] These two scenarios are combined with different climate scenarios, but the effects of the different climate scenarios on land use are considered small compared to the effects of socio-economic trends.

Possibly it is better to take a backcasting approach for the second half of the century for the purpose of the Climate Changes Spatial Planning programme, as was done in the Routeplanner. Such a normative approach is not in contradiction to the programmes mission 'to introduce climate change and climate variability as one of the guiding principles for spatial planning in the Netherlands' (KvR, 2007). Nevertheless, also a backcasting approach requires information about possible futures, because it is necessary to develop strategies that are robust, i.e. the strategies must 'work' irrespective of the extent to which the world is internationalized and individualized, or alternatively, objectives regarding security, efficiency or social cohesion are met. It may also useful to adopt the Shell Trilemma approach instead of the scenario axis method, because the latter does not sufficiently deal with the 'key driver' security.

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