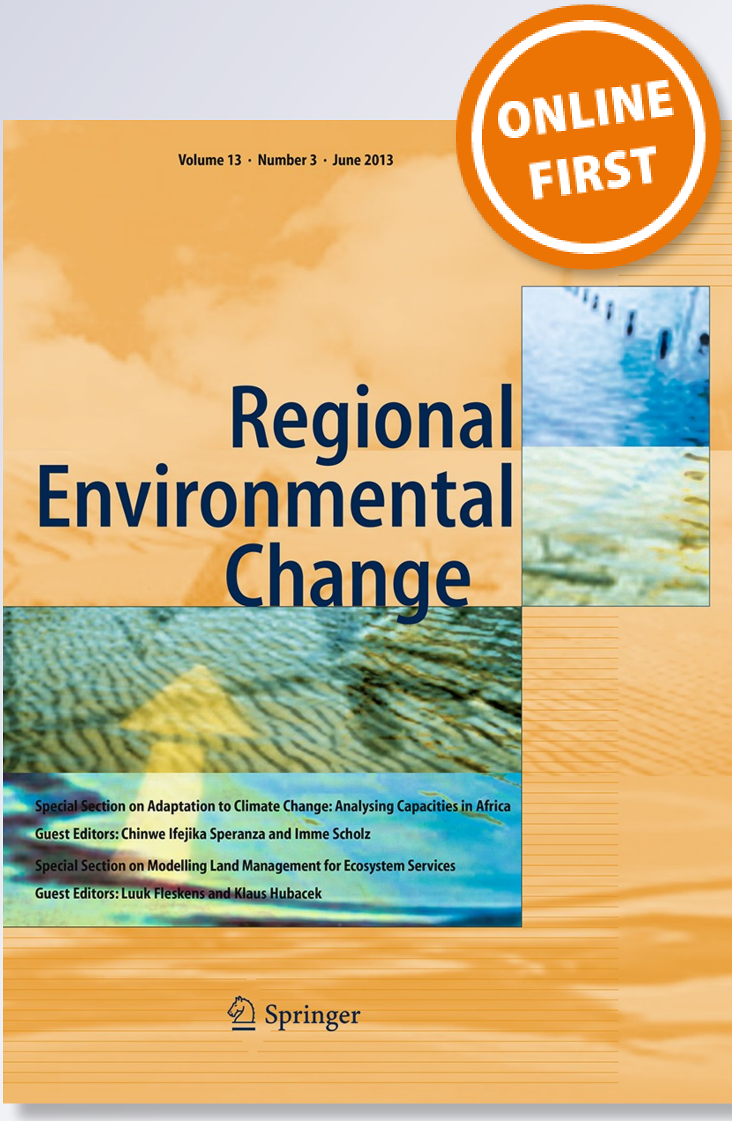
Climate proofing the Zuidplaspolder: a guiding model approach to climate adaptation

M. A. M. de Groot-Reichwein, H. Goosen & M. G. N. van Steekelenburg

Regional Environmental Change

ISSN 1436-3798

Reg Environ Change
DOI 10.1007/s10113-013-0509-4



Springer

Reg Environ Change
DOI 10.1007/s10113-013-0509-4

ORIGINAL ARTICLE

Climate proofing the Zuidplaspolder: a guiding model approach to climate adaptation

M. A. M. de Groot-Reichwein · H. Goosen · M. G. N. van Steekelenburg

Received: 21 June 2012 / Accepted: 6 July 2013

Abstract Climate change will have an impact on various sectors, such as housing, infrastructure, recreation and agriculture. Climate change may change spatial demands. For example, rising temperatures will increase the need for recreation areas, and areas could be assigned for water storage. There is a growing sense that, especially at the local scale, spatial planning has a key role in addressing the causes and impacts of climate change. This paper promotes an approach to help translate information on climate change impacts into a guiding model for adaptive spatial planning. We describe how guiding models can be used in designing integrated adaptation strategies. The concept of guiding models has been developed in the 1990s by Tjallingii to translate the principles of integrated water management in urban planning. We have integrated information about the present and future climate change and set up a climate adaptation guiding model approach. Making use of climate adaptation guiding models, spatial planners should be able to better cope with complexities of climate change impacts and be able to translate these to implications for spatial planning. The climate adaptation guiding model approach was first applied in the Zuidplaspolder case study, one of the first major attempts in the Netherlands to develop and implement an integrated adaptation strategy. This paper demonstrates how the construction of climate adaptation guiding models requires a participatory approach and how the use of climate adaptation guiding models can contribute to the information needs of spatial planners at the local scale, leading to an increasing sense of urgency and integrated adaptation planning process.

M. A. M. de Groot-Reichwein (✉) · H. Goosen
Wageningen University and Research Centre,
Wageningen, The Netherlands
e-mail: monique.degroot@wur.nl

M. G. N. van Steekelenburg
Xplorelab, The Hague, Zuid-Holland, The Netherlands

Keywords Climate change · Adaptation · Spatial planning · Guiding models · Participative approach

Introduction

The changing climate increases the vulnerability of societies around the world (Adger 2006; Adger et al. 2005; Parry 2007; Smit and Wandel 2006; Swart and Raes 2007). There is a growing sense that, especially at the local scale, where the specific realities of climate change occur (Davoudi et al. 2009; Wilson 2006), spatial planning has a key role in addressing the causes and impacts of climate change (Biesbroek et al. 2009; Kabat et al. 2005; Smit and Pilifosova 2003). However, the discussion on the role of spatial planning in the climate change debate has only recently started to take place in the planning community (Biesbroek et al. 2009). Only a few examples of climate adaptation policy assessments recommending specific spatial measures for reducing the vulnerability to future climate changes exist today (Füssel and Klein 2006; Runhaar et al. 2012; Wilson 2006). Several authors recommend the identification of adaptation options as an important step of the adaptation planning process (Klein et al. 1999; Lim et al. 2005; Willows et al. 2003). However, existing tools solely focus on the assessment of impacts and vulnerabilities. Only very limited literature is devoted to guidelines or tools for the design of adaptation options in a spatial planning context. This paper presents a methodology to support the design of adaptation options in a coherent and consistent way.

Published online: 23 July 2013

We argue that the climate adaptation guiding model approach as presented in this paper can combine down-scaled impact projections with local knowledge of existing vulnerabilities and local area characteristics leading to specific spatial measures for reducing the vulnerability. This paper discusses whether this approach can contribute to better reach the spatial planning community regarding adaptation planning.

Guiding models are simple spatial schemes of combined measures and solutions based on practical experience and technical knowledge that fit the local situation. They provide a system of functional relationships that structure spatial planning land-use elements. Guiding models were developed in the 1990s to conceptually and schematically represent the basic principles of water management (Tjallingii 1996). Urban planning and water management were fairly separated worlds, and the guiding models were developed to offer a common language and to help communication between urban planners and the water experts with often a technical engineering background.

In this paper we address the question whether the guiding model approach can successfully capture the principles of adaptation to increase the awareness of climate change adaptation in spatial planning. We address:

- how the principles of adaptation to climate change have been incorporated into the guiding model approach and
- how the climate adaptation guiding model approach helps the communication between climate scientists and spatial planners.

The Zuidplaspolder will be analysed as a case study. The Zuidplaspolder is an area located in the south-western part of the Netherlands. The polder is located almost 7 m below sea level and bordered by the river "Hollandsche IJssel", which is a branch of the River Rhine. Located in the economic heart of the country, close to the port of Rotterdam, the cities of The Hague, Rotterdam and Amsterdam and the airport Schiphol, the Zuidplaspolder was selected for urban development, focused on new residential, commercial and further agricultural development (greenhouse horticulture). The decision to urbanise the lowest part of the Netherlands was heavily debated. The political debate included the argument of climate change. Some political parties argued that due to the likely impacts of climate change, further urbanisation of the lowest part of the Netherlands would cause unacceptable future risks. In order to analyse whether the developments could be implemented in a climate-proof way, a research project was commissioned in which the likely impacts of climate change were analysed and translated into possible adaptation options, using the guiding model approach. For the definition of climate proofing, we adopted the definition of the Netherlands National Research Programme "Climate changes Spatial Planning", which defines climate proofing as […] *the capacity of a system to continue to function well as the climate changes* (van Drunen et al. 2009). Taking new urban developments and climate change impacts into account, the risk of a climate event (as a combination of probability and consequences) must remain at the same level. However, both climate change and socio-economic developments include inherent uncertainties. The level of risk and changes therein are therefore difficult to determine. The guiding model approach approaches this issue from a different angle. Rather than determining the optimal adaptation measures to cope with future threats, the guiding model approach seeks to integrate adaptation objectives with other spatial planning objectives first. In that sense, it is a design approach rather than a technological problem-solving approach.

Besides this object-oriented dimension—which relates to objects (e.g., buildings and infrastructure) that shall better withstand or absorb the impacts of climate changes—the climate adaptation guiding model approach includes the subject-related dimension of climate proofing. The subject-related definition regards individuals/subjects that shall improve their knowledge/capacities in a way that the results of the actions they take are adapted to the changing climate (Birkmann and Fleischhauer 2009). We set up a transdisciplinary and iterative design process in a 'laboratory' setting enabling exchange of ideas and local and global knowledge about the impacts of climate change scenarios and possible design principles of adaptation options. The importance of a transdisciplinary and iterative research approach when a diversity of stakeholders are involved was already mentioned by Klein et al. (2007) and Swart and Raes (2007).

Planning approaches

Dutch spatial planning is traditionally about identifying and balancing different sectoral spatial demands. From various government departments, sectoral policies for housing, employment, water, environment, infrastructure and nature are formulated as spatial demands. Mostly, these demands are based on targets and standards set by laws or regulated sectoral policy objectives. For example, new urban developments should be compensated by a minimum percentage of open water. This planning approach can be described as an object-oriented approach (Faludi and van der Valk 1994). In an object-oriented planning approach, the process is structured by given targets. Such a technocratic approach can be used when both problem and possible solutions are clear. Van de Ven et al. (2005) described the negotiation approach as a promising approach when the problem is clear, but the preferences regarding possible outcomes are still unclear.

Due to a number of reasons, it can be difficult to integrate climate change in an object-oriented or negotiation approach. Firstly, climate change includes inherent uncertainties that make it difficult to precisely consolidate the impacts of changing on sectoral spatial demands. Secondly, often no accepted targets and policy standards exist. For example, for relatively new phenomena like the urban heat island effect, no standards exist as of yet. Some standards exist, for instance for flooding, but these may not be able to cope with more extreme storm waters. Thirdly, the effectiveness of some adaptation measures is not clear yet, making it difficult to consolidate the measures as a spatial demand. For example, we do not know how many green areas we need to reduce the urban heat island impact. Fourthly, extreme events have a low frequency of occurring, which can make certain demands seemingly unnecessary (for instance, the creation of a water storage basin for a 1:1,000-year event).

Van de Ven et al. (2005) mention the guiding model approach as a planning approach to deal with complex and uncertain urban water issues. The guiding model approach is based on a learning-by-doing process and meant to inspire participants to seek for solutions that fit the local situation. This is also underlined by de Boer et al. (2010) who describe different decision-making strategies for adaptation planning. They argue that when the cause–effect relations are unclear, one should seek for expert judgement or—in case when both cause–effect relations and preferences regarding possible outcomes are unclear—an inspirational strategy. In this paper we address whether the guiding model approach could be promising for integrating climate change adaptation in the spatial planning community.

Guiding models: making the layer approach operational

In the Fifth National Policy Document on Spatial Planning (Ministry of Housing 2002), the Dutch government presented the layer approach as an integrated analytic concept for the Dutch urban and rural landscape. The approach (Fig. 1) distinguishes three layers:

- the ground layer, involving the soil and water system, including their abiotical and biotical systems;
- the network layer, consisting of physic and invisible routes and links like roads, railways, waterways, ecological networks and energy networks including their hubs like harbours and airports.
- The occupation layer, consisting of patterns of habitation, employment and recreation.

The ground layer is the least dynamic layer, where changes only take place over hundreds of years. The infrastructural network has a changing time of 20–80 years. The occupation layer, with a changing time of 10–40 years, is the most dynamic layer. Based on the difference in the level of dynamics, the layer approach centres on the conditioning effect of each layer of spatial structures on the next layer up.

According to the Social and Economic Council (2001), the Fifth National Policy Document on Spatial Planning lacks a clear link between the policy strategy and the control of land use and changes in the future. The council promotes an approach of organising principles, which is defined as: “a set of structures with functional coherence, that fits the layer approach, granted to structure space”. The council recommends the guiding model approach as such an organising principle, suitable to make the layer approach operational, since guiding models provide a system of functional relationships between urban networks, the water system and ecological concerns.

The strategy of the two networks (S2N) is one of the guiding models as developed by Tjallingii (1996). The strategy (Fig. 2) provides a strategic framework that takes water and traffic networks as carrying structures for zoning

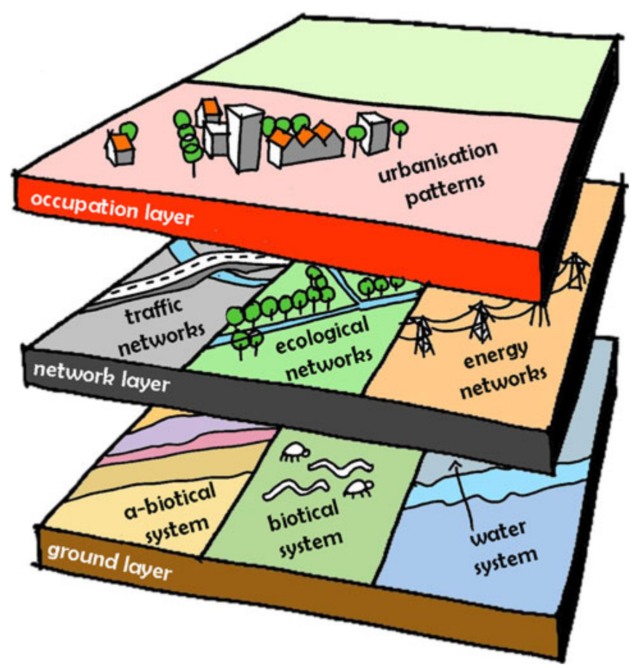


Fig. 1 Schematic representation of the layer approach (Dauvellier Planadvies 2003a): the ground layer, network layer and occupation layer are all connected. Recognising the layer relationship allows the development of a clear vision that promotes sustainable land use and resilient ecosystems and economy

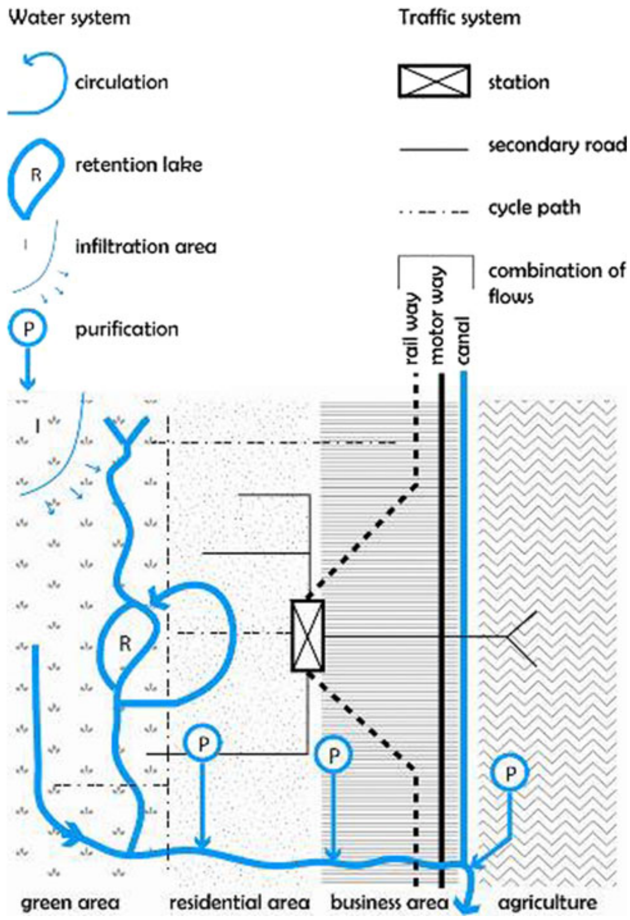


Fig. 2 Scheme of the strategy of the two network guiding models (Tjallingii 1996). The water and network structures act as a backbone for low- and high-land-use functions, respectively. Housing is situated in between

of land-use functions in order to create contrast, diversity and flexibility. The water network can be seen as a carrier or backbone of the low-dynamic functions like wildlife and extensive recreation and agriculture, while the traffic network channels high-dynamic-economic human activities like industry, business, mass recreation and modern agriculture. Housing is situated in between these areas, within easy reach of both the low- and high-dynamic functions. The land-use functions around the water network should be arranged in a way that water could flow from clean to polluted areas. The infrastructural network should be zoned in corridors in order to concentrate pollution and noise and to easy overcome infrastructural barriers and stimulate modal shift.

The strategy of the two networks can be applied at various levels of scale, varying from local to regional and national. It creates a durable spatial framework based on the least (water) and middle (infrastructural) dynamic structures of the layer approach. The frameworks act as a backbone for development, able to capture future (uncertain) spatial demands. Guiding models such as the cascade model, circulation model and infiltration model are developed to tailor the structures.

The circulation model (Fig. 3), for example, is tailored to situations with limited infiltration. Instead of draining, water is retained in the area. The model centres on a retention lake with a fluctuated water table to create sufficient retention capacity for the urban area to pass dry periods without an inlet of water from other areas. This prevents the input of polluting water. The retained water circulates through canals and a wetland area to improve water quality. Less polluting and less peak-generating land-use functions are positioned upstream allowing the water to flow from clean to polluted.

Guiding models were first applied in Morrapark, a small housing estate in Drachten, the Netherlands, designed as an example plan in the context of the Fourth National Policy Document on Spatial Planning. Other applications are Wageningen Ecopolis and Waalsprong. These and other examples are all well described in Planning with Principles (Aalbers et al. 2003).

These examples clearly reveal that guiding models supports an interactive participative design process and can be highly effective as a planning instrument since it steers the optimal use of landscape potentials (Meeus 2000; Schrijnen 2000). Functioning as a toolkit for designers, guiding models create customised solutions and provide a learning design process (van de Ven et al. 2005). There is, however, a risk of misuse when the guiding models are used as blueprints.

Climate adaptation guiding model approach

Climate change affects the different strata as described by the strata approach and therefore has an impact on the soil, water and landscape structure of an area as well on the built structure and on the functioning of the more high-dynamic strata. For example, frequent periods of drought will

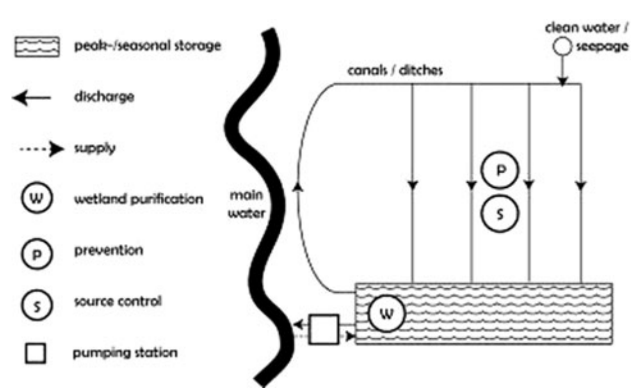


Fig. 3 Scheme of the circulation guiding model (Tjallingii 1996)

decrease groundwater levels, while storm waters will require more open space for water retention. Incorporating these changes in climate adaptation guiding models can be subsidiary in integrating climate, soil, ecology, landscape and water structures in one spatial structure. We argue that integrating information about the present and future climate change in climate adaptation guiding models should help designers to better cope with complexities of climate change impacts and to be able to translate these to the implications for spatial planning.

Whether a structure is suitable as a carrying structure depends on the situation of the different strata, the impacts of climate change on these strata and the density of the programme to be developed. We therefore came up with a step-by-step approach in which an analysis of the ground layer (step 1) and impact assessment (step 2) for the area are performed before one can select suitable guiding models to elaborate the carrying structures and steer local planning process (step 3). Subsequently, the selected guiding models are used to implement new spatial demands into a spatial structure plan (step 4).

In this section we will present our results by describing the different steps of setting up and implementing the guiding model for one of the five spatial plans as designed for climate proofing the Zuidplaspolder.

Step 1: Analysing the geomorphologic, network and urbanising patterns

Step 1 focuses on the analysis of the composition and structure of the area. A spatial intervention requires a thorough understanding of the form and function of the area (De Jong 2002). Specific attention is given to the relationship between the layers as described above:

- the underlying structures and landscape and its effects on and conditions for networks and urban form and
- the geomorphologic processes and landscape architectural traditions that have played an important role in the development of the area.

The aim of the analysis is to understand the spatial composition of the area as a whole. In order to do so, we also take into consideration both the position of the area in its (surrounding) context and the key components of the composition. All the information is presented on a map of the area so it can directly be used in the design process.

The genesis of the Zuidplaspolder can be well written in the composition and structure of the area. The polder was reclaimed in 1840 when, due to peat digging, a lake had arisen. In the southern part of the polder, peat remains can still been found. In this area continuous draining has led to soil subsidence. As a result of the peat digging and soil subsidence, a large part of the polder is located at 4–7 m below sea level. In fact, the Zuidplaspolder is the lowest urbanised area in Western Europe. In the northern higher part of the polder, clay grounds can be found. A cross section (Fig. 4) illustrates the different soil types and ground-level heights. The difference in soil types can also be seen in the water structure of the polder. The pattern of ditches to draining the polder is less dense in the northern part of the polder. The water is pumped out of the polder via a pumping station close to the Hollandsche Ijssel. The rational pattern of ditches and the canal around the polder are characteristic of a reclaimed marshland.

Step 2: Identifying the impacts of climate change

The importance of spatial information on climate change impacts in planning and decision-making processes is evident (Pettit 2011), but making this information relevant at the local scale has become an important debate in adaptation planning (Al-Kodmany 2001; Burch et al. 2010; Dockerty et al. 2005; Shaw et al. 2009; Wilson 2006).

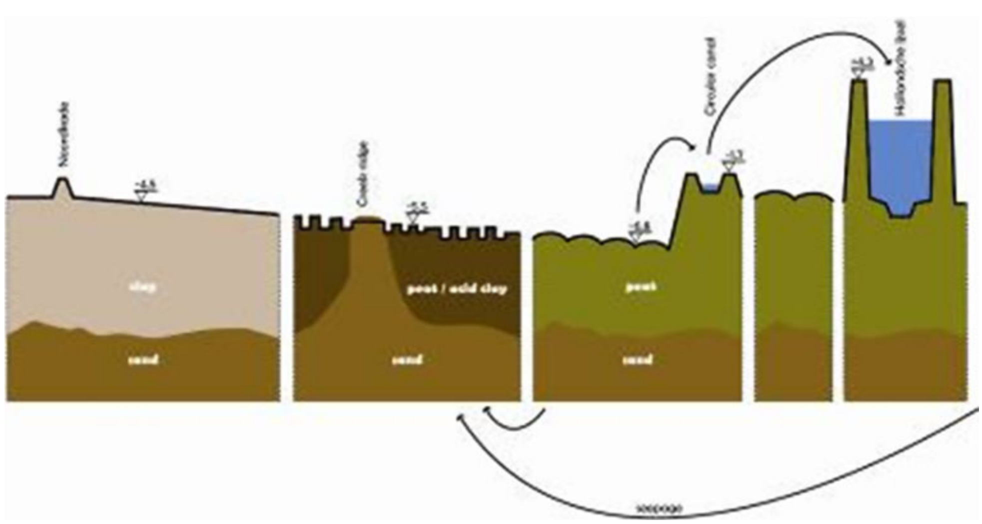


Fig. 4 Cross section of the Zuidplaspolder (north–south) revealing the different ground-level heights and soil types

Adaptation to climate change can be evaluated through generic principles of policy appraisal with wider sustainability (Adger et al. 2005). Sustainability assessments have so far often relied on a reductionist problem-oriented approach (Gasparatos et al. 2008). The reductionist problem-oriented approach can be characterised by the use of a single measurable indicator, a single dimension, a single scale of analysis, a single objective and a single time horizon (Munda 2006). Due to the uncertainties, climate change impact is hard to express in a measurable indicator or objective at a single time horizon or dimension, which might be a reason why the impacts of climate change are not taken into account. To translate climate information into real-life action at the local scale, a more dynamic process of incentive realignment is needed (Meinke et al. 2006). We suggest an iterative impact assessment process, where the combination of local knowledge, expert opinion (GIS) modelling and design leads to a spatial and local translation of possible climate change impacts. As in step 1, all the information is presented on a map of the area so it can directly be used in the design process.

To reveal possible changes in the three strata, the impacts of climate change were assessed for the area of the Zuidplaspolder in close collaboration with scientists and stakeholders. The meteorological effects of the four national climate change scenarios for the Netherlands of the Royal Dutch Meteorological Institute (Van Den Hurk et al. 2006) were interpreted for the specified area of the province of Zuid-Holland where the Zuidplaspolder is located. The four scenarios differ in assumptions regarding global temperature rise (1° or 2° in 2050) and atmospheric circulation (no change or a change to more easterly circulation). In separate background studies, experts together with stakeholders and policy makers analysed the effect of these climate projections on flooding, inundation due to heavy rainfall, water shortage, salinisation and heatwaves.

The most important effect of climate change on the ground layer is drought and the accompanying freshwater shortages and salinisation. It can have irreversible effects on the subsoil structure and soil conditions and, therefore, on the ambitions for the development of the polder. Since the Zuidplaspolder has a risk of flooding, the impact on both the infrastructural and occupation layer has been measured. As part of the infrastructural layer, also impacts on ecological networks were object of research, especially wet ecosystems turned out to be vulnerable to drought and increasing evaporation. Besides, due to a rise of temperature, a shift of climate zones will occur. Urban heat island effect and rainwater flooding can be seen as impacts on the occupation layer. The risk of heatwaves will increase when the amount of summer day with a temperature above 25 °C will increase. As a result, tourism and the need for recreation will grow. In the urban area, the heat will be retained, due to the use of materials, which effectively retain heat, especially during the night cities are hard to cool down and the so-called urban heat islands arise.

Step 3: Selecting suitable guiding models

Processes in the strata are part of cycles (e.g. water, energy, materials) on all levels of scale, from the local to the regional, the national and sometimes even the global scale. Clearly visualising these cycles as main structures of an area (i.e. water, soil, landscape and urban) will give a better understanding of the interactions between these systems and provides a durable framework for further development. Making use of these natural structures as a fundament for adaptation measures ensures that the landscape becomes less vulnerable to the impacts of climate change.

Whether a structure is suitable as a carrying structure for an area depends on the current situation of the ground layer; the specific impacts on the ground, network and occupation layer and the density of the programme to be developed. Based on the assessment of the former steps including the programme set by the master plan for the area, we have designed a spatial plan for climate proofing five specific areas within the Zuidplaspolder. In this section we described the spatial plan for the Rode Waterparel to demonstrate our approach. De Rode Waterparel is situated in the central part of the polder where an inversion of soil developed and creek ridges have become visible at the top surface. A creek ridge is a former creek bed. Since it was filled with clay, which is a more steady soil, it stayed on the same level, while the surrounding peat layer has subsided due to the oxidation processes.

The main impact of climate change for the ground layer in this area is drought and the accompanying attendant (fresh) water shortages and salinisation. Water shortage will occur due to a lack of rain (drought), combined with an increased evaporation, due to higher temperatures. Internal salinisation caused by the upwelling of seepage. The seepage came from deeper marine deposits with high concentrations of chloride (salt), but also a high concentration of iron, nitrogen and phosphate. The seepage ends up in the ditches and has a negative impact on the local water quality. At this moment, internal salinisation is not a problem, due to the existence of so-called rainwater lenses. However, when summer rainfall decreases as a result of climate change, these lenses might disappear, allowing the seepage to reach the root zone.

We have selected the creek ridge and the pattern of lanes and ditches as carrying structures for new urban developments (Fig. 5). The creek ridge reveals the historical identity of the location and suits as a durable higher sandy fundament for building houses. The pattern of ditches and lanes reveals the characteristic orthogonal grid of a

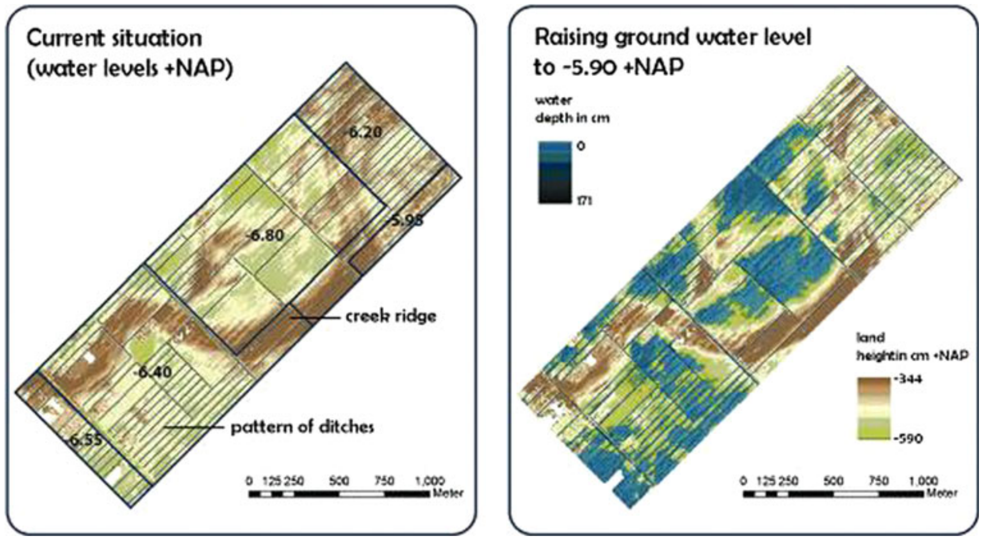


Fig. 5 Carrying structures of the area: creek ridge and the pattern of lanes and ditches. In order to improve the water quality, the principle of raising the groundwater level has been applied to the surrounded areas

reclaimed marshland and suits as a durable carrier for water and ecological networks. The circulation model is tailored to situations with limited infiltration. We therefore have selected this model to elaborate the water structure to fit the local situation. Digging in a peat soil causes risks of surface rupture. Instead of a lake, existing ditches were enlarged to create peak storage. In order to improve the water quality, the principle of raising the groundwater level has been applied to the surrounded areas. Raising the groundwater level will reduce the upward seepage of salty water and prevents further subsidence of the peat soil. Water tables are allowed to fluctuate in order to increase peak storage, since the impact assessment revealed that under the most extreme scenario for extreme rainfall (the KNMI'06-W scenario), additional measures are needed in order to comply with the Dutch inundation standards in urban areas. Besides, enlarging the ditches and raising the groundwater level emphasise the landscape characteristics of the creek ridge and the pattern of ditches.

Step 4: Implementation of new spatial demands into a spatial structure plan

Guiding models are meant as a principle solution. A spatial plan requires a customised design. Step 4 can be seen as the actual design phase, in which the carrying structures of the guiding model have to be translated into a main structure and detailed development plan. This design process took place through workshops, consultation of stakeholders, educational courses and design ateliers with various experts.

In the final design, the groundwater level has been raised to −5.9 m NAP, whereby the contours of the original creek bed in the centre of the Zuidplaspolder stand out. Based on the different soil structures, three residential areas are designed: a rural low-density residential area at the creek ridge bed, a wetland residential area along the edges of the area and upper residential squares along the pattern of lanes and ditches (Fig. 6). The designs were evaluated on their effectiveness and cost–benefits as described in De Bruin et al. (this issue).

Discussion

In this paper we demonstrate how the guiding model approach can successfully capture the principles of adaptation and increase awareness of climate change adaptation in spatial planning. The Zuidplaspoder case study reveals how the approach can contribute to implement technical model results on potential climate impacts in the design process. In order to do so, impact information has to be translated to the local level and should not only be made accessible for local planners, but also in ways that are relevant to them and connect with (often non-climate) priorities (see also Goosen et al.; this issue). It is important that information on potential impacts of climate change addresses the specific needs and perceptions of municipal and district or provincial spatial planners (Ford et al. 2011). The guiding model approach as described in this paper offers a common language to help communication between urban planners and climate scientist on both directions. Strength of the approach is that information is directly projected on a map of the area. In this way the design process is stimulated. The given information, however, highly depends on the input of the participants involved. In the present case study, we created a laboratory setting in which only spatial planners, policy makers and climate scientist were involved. We suggest involving local stakeholders as well. The involvement of stakeholders in

Fig. 6 Aerial overview and cross section illustrating the three characteristic residential areas: a rural low-density residential area at the creek ridge bed, a wetland residential area along the edges of the area and upper residential squares along the pattern of lanes and ditches

the planning process can contribute to a successful implementation of adaptation measures (Klein et al. 1999). The guiding model approach can stimulate a participative process. However, it requires understanding and trust between experts, stakeholders and spatial planners.

One of the limitations of the present case study is that the project area boundary and the programme of spatial developments were already set. We took the programme of developments as a fact and applied the guiding model approach only at the local scale. We therefore took the risk of flooding as a precondition for design instead of applying a guiding model for flooding. Striking is the fact that a guiding model for flooding until recently even not exists (Tjallingii 2011). In planning practice, the project area boundary and the programme of spatial developments are mostly already set when experts get involved. Climate adaptation guiding models could be implemented more successful in a multiscale approach, since successful adaptation is a combination of efforts from the local to the regional, national and international scale (Adger et al. 2005). Adaptation planning should be implemented in an early stage of the spatial planning process. To achieve this, a climate-driven approach should be enforced by national government. This statement is confirmed by a review of one hundred climate adaptation projects (Pijnappels and Seedee 2010).

Although the guiding model approach is promising, the institutional base for the approach is still low. This might be explained by the Dutch spatial planning tradition and its regulated policy objectives and instruments. For example, nature (green) starts were the city (red) ends. This paradigm of green and red can be literally written on Dutch maps. Contour lines have been drawn to prevent urbanisation of the countryside. Most exemplar is the policy objective of the Green Heart, the central green countryside of the Dutch major cities. Contour lines should prevent this area from being urbanised. However, the Zuidplaspolder area was removed from the protective veils of the Green Heart by national government in 2001 to make it possible to start a process of planning for the area (Ministerie van VROM, 2004). When (urban) activities may cause damage to nature, one can compensate this by creating "new" nature somewhere else. These kinds of instruments do not stimulate planners to think in a more ecological way (Tjallingii 2000). To integrate adaptation planning with spatial planning, a more process-oriented approach is needed. Biesbroek et al. (2009) came up with a similar conclusion by illustrating that approaches, strategies and perhaps even instruments, legislation and division of responsibilities of the planning community have to change to match the characteristics of climate change. Promising is the fact that the guiding model approach was adopted by the Ministry of Infrastructure and the Environment, who has commissioned a study to further develop the approach on a national scale. The aim of the investigation is to reveal whether the guiding model approach can be implemented in the national policy framework for the (re-)development of built-up areas as part of the new Delta law. This new law will have significant influence on the future of the Netherlands (Deltacommissie 2008).

At this moment, 15 workshops with municipalities are already held. During the workshops, the majority of the designers involved in the case studies consider the climate adaptation guiding models as a helpful instrument translating climate change impacts and measures in a spatial planning approach. However, some of them preferred a less guided approach, giving more freedom to the designer. It is important to identify such requirements in advance to avoid information to be ignored.

Conclusion

Adaptation to climate change needs to be incorporated into spatial planning. Adjustments of policies related to economic development as well as climate change adaptation policies usually have spatial consequences (De Bruin et al. 2009). A growing number of government agencies with spatial planning tasks share intention to develop 'climate-proof' policies. However, incorporating climate change into spatial plans has proven to be problematic and difficult, due to the inherent uncertainties and the absence of clear policy targets and the inability to capture extreme events in spatial claims. This paper analyses whether guiding models can contribute to increase in the awareness of climate change adaptation in spatial planning. Rather than the guiding model as spatial scheme, especially the participative process can contribute to climate adaptive spatial planning. We have offered a step-by-step approach to create such a process. Each step provides a workflow to assess the future climate impacts and to select the carrying structures and the corresponding additional adaptation measures for a durable development framework that can capture new developments.

Based on the Zuidplaspolder case study, we conclude that the approach is promising. It helps to translate technical impact information to a common language that planners and designers are used to deal with. It offers an input for the design process and sets out directions for 'climate proofing' spatial planning policies. It leaves room for creativity and room for incorporating specific local characteristics.

Although we did not yet perform a quantitative evaluation of the approach used, we have some evidence that supports our confidence in the present approach to better reach the spatial planning community. As a result, three of the plans as designed by the project (including the design for the Rode Waterparel as described in this paper) are selected by the Regional Development Authority (Regionale ontwikkelingsorganisatie Zuidplas) and the Ministry of Housing as showcase projects. These pilot projects will be implemented earlier than the surrounding housing estates, creating the possibility of scalability within the Zuidplaspolder itself. Besides, the experience can also be used for projects elsewhere in the Netherlands and abroad.

Whereas the object-oriented approach often focuses on detailed blueprints of the objects to be realised by planning, the guiding model approach contributes to a process-oriented approach to steer the making of plans, acknowledging for uncertainty and flexibility in the final result. Besides the object- and process-related dimension of climate proofing, we also succeeded in covering the subject-related dimensions. Evaluation among the stakeholders involved in the Zuidplaspolder project reveals that support, motivation and rate for adaption to climate change impacts increased by raising awareness of usefulness and necessity.

However, an institutional base for a more process-oriented approach as offered by the guiding models is needed in order to reach the whole planning community.

Based on our experiences, we encourage further application and testing of the climate adaptation guiding model approach and recommend performing evaluation studies to better assess the strengths and weaknesses of the method and its applicability to spatial adaptation planning. We hope that this research and the case study described offer the inspiration to further elaborate the guiding model approach abroad.

Acknowledgments The research was performed by Xplorelab, a laboratory for innovative learning and working established in 2007 as a unit within the council's Green Space, Water and Environment division of the province of South Holland. The project was funded by the Dutch National Research Program "Climate changes Spatial Planning". We would like to thank all the consortium partners involved. The comments by two anonymous reviewers were also gratefully received.

References

Aalbers C, Jonkhof J, Klerkx J (2003) Plannen met principes: S2N, de strategie van de twee netwerken revisited= planning on principle: S2N, the strategy of the two networks revisited. Æneas

Adger WN (2006) Vulnerability. Glob Environ Chang 16(3):268–281

Adger WN, Arnell NW, Tompkins EL (2005) Successful adaptation to climate change across scales. Glob Environ Chang 15(2): 77–86

Al-Kodmany K (2001) Bridging the gap between technical and local knowledge: tools for promoting community-based planning and design. J Archit Plann Res 18(2):110–130

Biesbroek GR, Swart RJ, van der Knaap WG (2009) The mitigation–adaptation dichotomy and the role of spatial planning. Habitat Int 33(3):230–237

Birkmann J, Fleischhauer M (2009) Anpassungsstrategien der raumentwicklung an den klimawandel: climate proofing - konturen eines neuen instruments. Raumforschung Und Raumordnung 67(2):114–127

Burch S, Sheppard SR, Shaw A, Flanders D (2010) Planning for climate change in a flood-prone community: municipal barriers to policy action and the use of visualizations as decision-support tools. J Flood Risk Manag 3(2):126–139

Dauvellier Planadvies (2003a) MIRUP: Handreiking voor milieu in ruimtelijke plannen. Stadsgewest Haaglanden

Davoudi S, Crawford J, Mehmood A (2009) Planning for climate change: strategies for mitigation and adaptation for spatial planners. Earthscan, London

de Boer J, Wardekker JA, Sluijs JPVD (2010) Frame-based guide to situated decision-making on climate change. Glob Environ Chang Part A 20(3):502–510

De Bruin K, Dellink RB, Ruijs A, Bolwidt L, Van Buuren A, Graveland J, de Groot RS, Kuikman PJ, Reinhard S, Roetter RP (2009) Adapting to climate change in the Netherlands: an inventory of climate adaptation options and ranking of alternatives. Clim Chang 95(1–2):23–45

De Jong TM, van der Voordt DJM (2002) Ways to study and research: urban, architectural, and technical design. IOS Press, The Netherlands

Deltacommissie (2008) Samen werken met water - een land dat leeft, bouwt aan zijn toekomst. Den haag, p 134

Dockerty T, Lovett A, Sünnenberg G, Appleton K, Parry M (2005) Visualising the potential impacts of climate change on rural landscapes. Comput Environ Urban Syst 29(3):297–320

Faludi A, van der Valk AJ (1994) Rule and order: Dutch planning doctrine in the twentieth century. The Geojournal Library, Kluwer Academic Publishers, The Netherlands

Ford JD, Berrang-Ford L, Paterson J (2011) A systematic review of observed climate change adaptation in developed nations. Clim Chang 106(2):327–336

Füssel H-M, Klein RJT (2006) Climate change vulnerability assessments: an evolution of conceptual thinking. Clim Chang 75(3):301–329

Gasparatos A, El-Haram M, Horner M (2008) A critical review of reductionist approaches for assessing the progress towards sustainability. Environ Impact Assess Rev 28(4):286–311

Kabat P, van Vierssen W, Veraart J, Vellinga P, Aerts J (2005) Climate proofing the Netherlands. Nature 438(7066):283

Klein RJ, Nicholls RJ, Mimura N (1999) Coastal adaptation to climate change: can the IPCC technical guidelines be applied? Mitig Adapt Strateg Glob Chang 4(3–4):239–252

Klein RJ, Huq S, Denton F, Downing TE, Richels RG, Robinson JB, Toth FL (2007) Inter-relationships between adaptation and mitigation. In: Parry ML, Canziani OF, Palutikof PJ, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, pp 745–777

Lim B, Spanger-Siegfried E, Burton I, Malone E, Huq S (2005) Adaptation policy frameworks for climate change: developing strategies, policies, and measures. Cambridge University Press, Cambridge

Meeus J (2000) How the Dutch city of Tilburg gets to the roots of the agricultural 'kampen' landscape. Landsc Urban Plan 48(3): 177–189

Meinke H, Nelson R, Kokic P, Stone R, Selvaraju R, Baethgen W (2006) Actionable climate knowledge: from analysis to synthesis. Clim Res 33(1):101

Ministry of Housing (2002) Making space, sharing space. Fifth memorandum on spatial planning. The Hague

Ministerie van VROM, LNV, VenW en EZ (2004) Nota ruimte: Ruimte voor ontwikkeling. Den Haag: SDU Uitgevers

Munda G (2006) Social multi-criteria evaluation for urban sustainability policies. Land Use Policy 23(1):86–94

Parry ML (2007) Climate change 2007: Impacts, adaptation and vulnerability: working group I contribution to the fourth assessment report of the IPCC (Vol. 4). Cambridge University Press, Cambridge

Pettit CJ, Raymond CM, Bryan BA, Lewis H (2011) Identifying strengths and weaknesses of landscape visualisation for effective communication of future alternatives. Landsc Urban Planning 100(3):231–241

Pijnappels MHJ, Seedee AGJ (2010) Klimaat als kans. Kennis voor Klimaat

Runhaar H, Mees H, Wardekker A, van der Sluijs J, Driessen PP (2012) Adaptation to climate change-related risks in Dutch urban areas: stimuli and barriers. Reg Environ Chang 12(4):777–790

Schrijnen PM (2000) Infrastructure networks and red–green patterns in city regions. Landsc Urban Plan 48(3):191–204

Shaw A, Sheppard S, Burch S, Flanders D, Wiek A, Carmichael J, Robinson J, Cohen S (2009) Making local futures tangible—synthesizing, downscaling, and visualizing climate change scenarios for participatory capacity building. Glob Environ Chang 19(4):447–463

Smit B, Pilifosova O (2003) Adaptation to climate change in the context of sustainable development and equity. Sustain Dev 8(9):9

Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. Glob Environ Chang 16(3):282–292

Sociaal-Economische Raad (2001) Recommendations on the Fifth Policy Document on Spatial Planning (Advies over de Vijfde Nota over de Ruimtelijke Ordening 2000/2020). Den Haag

Swart R, Raes F (2007) Making integration of adaptation and mitigation work: mainstreaming into sustainable development policies? Clim Policy 7(4):288–303

Tjallingii SP (1996) Ecological conditions: strategies and structures in environmental planning, IBN-DLO, Wageningen

Tjallingii SP (2000) Ecology on the edge: landscape and ecology between town and country. Landsc Urban Plan 48(3):103–119

Tjallingii SP (2011) Synergie in stromenbeheer: Meekoppeling van water met andere stromen bij klimaatadaptatie in de stad

van de Ven M, Tjallingii S, Baan P, van Eijk P, Rijsberman M (2005) Water in drievoud: Benaderingen voor stedelijke waterplannen. Eburon Uitgeverij BV

Van Den Hurk B, Klein Tank A, Lenderink G, Van Ulden A, Van Oldenborgh GJ, Katsman C, Van den Brink H, Keller F, Bessembinder J, Burgers G (2006) KNMI climate change scenarios 2006 for the Netherlands. KNMI De Bilt

van Drunen M, Leusink A, Lasage R (2009) Towards a climate-proof Netherlands. In: Biswas AK, Tortajada C, Izquierdo R (eds) Water management in 2020 and beyond. Springer, Berlin, pp 165–194

Willows R, Reynard N, Meadowcroft I, Connell R (2003) Climate adaptation: risk, uncertainty and decision-making. UKCIP technical report. UK Climate Impacts Programme

Wilson E (2006) Adapting to climate change at the local level: the spatial planning response. Local Environ 11(6):609–625