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Rob Roggema

Swarm Planning

The Development of a Planning Methodology to Deal with Climate Adaptation

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Supervisor's Foreword

It was less than 10 years ago when spatial planning was entirely ignorant of issues related to climate change and energy. The world had been comfortably served by means of fossil fuels, which are extracted from the earth in specific places, but afterwards can be transported easily to any generic place across the globe. Even longer than the fossil-based Industrial Revolution the earth's climate has been relatively friendly since roughly 10,000 years ago—mind you, the period during which all human civilisations evolved. During this timeframe, humans have learned to react to the whims of their climate and versatile weather, mainly by combating these or avoiding dangerous sites.

For those who may have been living under a stone: that period is over now.

The world's climate—already positioned between two ice ages, so close to geologic summer—is now with near certainty severely influenced by man. Exponential growth and growing prosperity have led to a throughput of energy resources and emission of greenhouse gases unprecedented in history, and still increasing. At present some 'new' strongly polluting fossil resources (tar sands and shale gas) stretch the debate of energy prospects, but everyone knows that even the deployment of these fuels cannot save the Fossil Age. With underground packages of mega-joules depleting, renewable sources need to fill in the needs of generations. And these can only be won at the earth's surface.

Here the battle for space starts: conversion, storage and transport of renewables will compete with spatial functions as agriculture and nature, leisure and living. New Planning involves energy as a decisive factor for landscape design and spatial organisation.

The indirect effect of energy has also encouraged another element to be included in spatial planning: climate adaptation. Expected increase of sea levels and storm water discharge, hurricanes and typhoons, droughts and bushfires are so beyond the imaginary that traditional solutions will soon (perhaps a few or more decades…) become obsolete. Adaptation is the new hope; not fighting the human-incited power of nature, however dealing with its devastating effects in a benign way, and perhaps even trying to merit from climate change.

I was very lucky that in the year 2005 Rob Roggema drew me into an unexpected joint voyage that would explore the new scientific area of energy potential mapping and climate adaptive planning. As strategic manager of the Dutch province of Groningen, Rob incited a range of studies in the area of energy and climate that generated new insights, methods and solutions. Groningen probably was the first region in the world that had a Master Plan for a society fully run on sustainable energy and spatially ready for climatic extremes.

As so often, reality turned a different path after Rob's departure and Groningen now hosts two new giant power plants run on fossils.

A Dutchman used to the struggle with water from three sides (sea, sky and continent) he is now working in Australia, a country experiencing the freak excrescence of climate change in different directions: extreme temperatures, bushfires and floods. This may seem a different narrative but the Swarm Planning method Rob developed can be used everywhere, so probably better execute it where the urgency is most strongly felt. With the experience of the two countries, Rob finished his excellent Ph.D. research on Climate Adaptive Planning, an enterprise he managed to do alongside his other work.

This book is the outcome of that doctoral work, for which Pavel Kabat and I were the fortunate supervisors. It is a great accomplishment of Rob Roggema. Moving faster than most scientists in this area, he has crossed the Rubicon to merge spatial planning with climate adaptation, meanwhile illustrating how an urgent necessity can also be turned into something attractive.

The future is not totally doomed.

Savour the flavour of positive and proactive planning—hop on the same voyage, learn and enjoy. This Doctoral thesis is accepted by the supervisors, on behalf of the College for Doctoral Graduations, 15 May 2012.

Delft, January 2013 Andy van den Dobbelsteen

Acknowledgments

In my opinion it is an important task of science to initiate new developments and to discover new routes. Therefore, I view conducting doctoral research not only as a process to prove the candidate's ability to independently conduct scientific research, but also as a way to chase innovations and come up with new solutions. This thesis is the result of a quest for both.

During, and also before, executing this doctoral research many people supported me in achieving my goals. And this was not always a joyful experience for those involved. Because my initial urge would always be to look for new solutions, without accepting existing answers. This means that in the collaboration with others it is crucial to be able to operate on the basis of equivalence, to set aside hierarchical positions. A boss, who plays the boss because he is the boss, creates inequality. Hence makes collaboration more complicated. The employee, who just follows and does what the boss tells him to, also frustrates collaboration. With everyone I mention here I have found a high level of equivalence.

Jón Kristinsson was the first to kindle the desire for research in me. He gave me confidence and trust and after a couple of weeks he sent me to Taiwan for a conference. Very special! Apologies to you Jón, at the time I couldn't convert this beautiful start into finalising my Ph.D..

Later, during the Grounds for Change project the wish to conduct scientific research became prevalent again. I enjoyed the collaboration with Andy, Kees, Sebastian, Sanjay and many others a lot. So much that the regional ministers at the provincial government in Groningen started to call me 'the intellectual'. Seemingly, the desire to research and to develop new concepts outpaced policymaking within a certain political context. Despite the fact that this attitude, within the walls of the governmental building, met with the usual tensions, Dick Bresser gave me the room to explore, to orientate myself externally and to go off the beaten track. He didn't have to mention that a second time! I connected with emerging themes such as energy and climate change. In the INCREASE conference series we developed, together with Abdulsalam, Wim, Sven, Tim, Gert-Jan, Victor, Sebastian, Andy and many others, new concepts to plan renewable energy sources in a spatial way. It occurred to me quite rapidly that the current spatial planning practice had severe difficulties with integrating these new developments in a meaningful way. The core theme of my research was found.

An important 'tipping point' appeared to be located in the Land van Kockanje (The country of Kockanje), a restaurant in the inner city of Groningen. It was a warm afternoon in 2005 and I had a very pleasant dinner with Dany Jacobs, professor strategic innovation at the University of Groningen. Via many U-turns, short cuts, wrong tracks and even more subjects we finally invented Swarm Planning, as a way to plan for something that is uncertain. What ultimately became this thesis announced itself.

I undertook my first explorations of Swarm Planning at the faculty of Spatial Sciences, University of Groningen. Quite rapidly it became clear to me that this was not the environment that would allow me to confidently pursue finalising my doctoral thesis. I stopped the research at that point, but the idea to develop a planning framework that is suitable for climate change and sustainable energy did not leave me. I was lucky to find in Delft University of Technology and Wageningen University and Research Centre the ideal combination of knowledge and context to finally start my research.

The design of a sustainable built environment, in which renewable energy plays an important role (TU), in combination with knowledge of climate change and water and ecological systems, and also Landscape Architecture (WUR) proved a fertile environment for my research. Andy and Pavel, both my promotors, allowed me the freedom to conduct the research in the way I wanted. You gave me, at important bifurcation points in the research, invaluable feedback, which always advanced the research with giant leaps. Wherever on the Globe we resided you were always there for advice, support and critique. No matter how short our conversations were, the impact was enormous every time! Moreover, in 2010 you gave me the room to accept a position as inaugural visiting research fellow in Melbourne; a change that still persists.

Early 2008 my research could finally take off. Meanwhile the then Ministry of Housing, Spatial Affairs and the Environment (which is now the Ministry of Infrastructure and the Environment, I&M) gave its support to the research (and not only financially). Pieter Bloemen and Meinte de Hoog supported aim and content of the research and made sure that it was linked with the National Program for Spatial Adaptation to Climate Change (ARK) within the ministry. Apart from this, close ties with the Climate Changes Spatial Planning (CCSP), in which the connection between Spatial Planning and Climate change was central, arose. Florrie and Marit, you played a crucial role in developing the Groningen-Drenthe projects, which contributed substantial amounts to my research: the Hotspot Groningen and the Hotspot Peat Colonies. Thank you for the high quality collaboration and very pleasant contacts! I would like to also thank my colleagues in the Program Board of CCSP for the often inspiring meetings in Amersfoort and the lively congresses, which happened with great regularity.

David and Twan, you taught me that it is possible to be boss without playing the boss solely because you are the boss. You knew how to deal with me and did not make yourself more important than the content of the case. This way we progressed and were able to find new ways. Ways that were necessary to deal with the problems of the future.

Erwin, you were always there to convert my higgledy-piggledy and twists of mind in beautifully designed products. The birth cards of Anouk, Inez and Micha, the winning submissions for design competitions, such as the Rising Tides Competition in San Francisco and this thesis are the living examples.

Herald, you were there from the beginning and followed all my wanderings. Often from a distance, sometimes close, but always full of questions and remarks. Truly the best reason to be there as paranymph during the public defence!

Wim, somewhere in the beginning of the 1990s Breda was the centre of the universe en we made war with the establishment of existing planners. Breda has not been the same since! Soon, we shared a passion for the complexity of spatial planning processes, each from our own point of view. And also our Kort Besteck, the columns, which Erwin graphically designed, for Duurzaam Bouwen, which invariably were conceived in the Groene Olifant (The Green Elephant), are a proof of our 'one of a mind'. I am proud to have you next to me as second paranymph; the tails suit you prodigiously!

Finally, despite the fact that it is consuetudinary to illuminate your family at the end of this acknowledgement, I will do the same. Lisa, thank you a lot for all the support you gave me in the recent (and the coming as well) years. Wherever I went, my thoughts went, you were always there and always willing to think along, operate as native and give me a new insight along the way. Besides the love you give me, you are also an ambassador, never stopping to whoever wants to listen, start telling about Swarms and how they play a role in planning as well as in organisational change. Most beloved Anouk, Inez and Micha, I will end with the three of you, because you are the most important. Blessed with a strange dad, who wanted to conduct his Ph.D., you ended up living in Melbourne. Coincidentally, the city that is declared the most liveable city in the world for the second year in a row, since we started living here two years ago (Economist Intelligent Unit, 2012 www.eiu.com/liveability2012). By the way, there is no proof yet for a causal relation in this matter. You must have thought, every once in a while: "is he annoyed again with the enormously slow website of an academic journal, where uploading your article takes longer than writing it?" In any case, it is a joy to have you around me and to enjoy your smart little jokes!

Thank you all for the support in the years that lay behind (also for the ones I forgot to mention)!

Contents

Introduction

Climate Adaptation faces difficulties to be integrated in spatial planning. The consequence of this is that in spatial plans only few measures are taken to anticipate future climate change. This means that land use insufficiently is prepared for future impacts. In other words: the adaptive capacity in land use is low and could prove insufficient when the impacts of climate change become apparent. This thesis aims to identify a way to increase the adaptive capacity of land use through the creation of plans and designs, which increase the resilience of the landscape through what it is better prepared for future impacts of climate change.

The cause of the difficult integration of climate adaptation in spatial planning lies in the different characteristics of the both.

Climate adaptation is seen as a wicked problem (VROM-raad, 2007; Commonwealth of Australia, 2007) or even a super-wicked one (Lazarus, 2009). Rittel & Webber (1973) described these kinds of problems as ‘a class of social system problems, which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing. Most of the design problems contain a fundamental indeterminacy, which implies that these problems need to be dealt with in a permanent condition of uncertainty and of a situation in which a preferred path only gradually emerges’. The following characteristics are attributed to wicked problems:

- They have no definite formulation.
- They have no stopping rules.
- Their solutions are not true or false, however better or worse.
- There is no immediate and ultimate test of a solution.
- Every solution is a ‘one-shot operation’ since there is no opportunity to learn by trial-and-error, every attempt counts significantly.
- They do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
- Every wicked problem is essentially unique.

- Every wicked problem can be considered as a symptom of another (wicked) problem.
- The causes of wicked problems can be explained in numerous ways; the choice of explanation determines the nature of the problem's resolution.
- (With wicked problems) the planner has no right to be wrong.

On the other hand, spatial planning aims to arrange land use in a way that does not harm its citizens. He or she may assume that change in land use will have no negative impacts on his/her property. In general, this means a playing field in which changes in land use are prevented. Spatial planning is, in this sense, conservative. Moreover, when academic literature is analysed it turns out that the majority of recent articles are oriented on regulatory issues, on a status quo, on a single, specific subject and the subject judge as static (this thesis, chap.3). Additionally, in planning processes problems of the past are often solved instead of problems of the future, in particular when the problem is a long-term or uncertain problem.

The wicked problem of climate adaptation and the way current spatial planning is practiced live at odds. In short, it is difficult to integrate a wicked problem in a system that does not aim for (big) change. And because this is difficult it is also a problem to orientate the content of design on change. This implies the difficulty to capture a long-term, wicked and sometimes uncertain problem in spatial planning or to give it a valuable place.

In order to improve the integration of climate adaptation in spatial planning a new adjusted framework, which allows more room for unpredictable, wicked, dynamic and non-linear processes, is required. To develop such a framework inspiration is found in swarms, because bees, ants, birds and fish are capable of self-organisation, which enables the system to become less vulnerable for (sudden) changes in the environment (Fisher, 2009; Miller, 2010). Swarms perform 'swarm behaviour, which is characterised by high resilience and is very capable to minimise the impacts of uncertainty, complexity and change through developing emergent patterns and structures' (Van Ginneken, 2009)

The proposition in this thesis is therefore to develop a spatial planning framework in which the landscape is seen acting as a swarm in order to easily adapt to unprecedented, unpredictable and unexpected change. This framework forms the core of the thesis.

Swarm Planning Framework

The Swarm Planning Framework consists of the following four components (Fig. 1):

Two Levels of Complexity

As Portugali (2000) describes the city performs self-organisation on two levels: the level of the whole city and the level of individual components. What is described for the system 'City' is likely to be true for the system 'Landscape' too. When the aim is to perform better adaptation in the landscape it is therefore important to enhance self-organising capacity on both levels. On the level of the whole system this is achieved through implementing strategic interventions, where the system as a whole can be best influenced. These locations can be discovered on the basis of a network analysis. The nodes in the network that are most connected with other nodes and the most important nodes are the most likely places to intervene. On the second level of individual components (e.g., a road, a building, a canal) each component is individually attributed with self-organising capacities. As an example, a house, built at the edge of a lake can be attributed with waterproof elements (wall, door, floor, window) or can be attributed with a base that can float. Every individual component has different properties and therefore needs to be attributed with accompanying capacities. Which of the capacities are most suitable to enhance the self-organising capacity depends also on the environment (e.g., the expected climate impacts. Heat and drought demand other capacities than rain and floods). All components attributed with capacities to increase self-organisation form a self-organising entity, which as a whole developed a higher adaptive capacity. Both levels of complexity together determine the final adaptive capacity of the entire system.

Five Layers

Not every part of the landscape (and the city) changes at a similar pace. A tree, once planted, only changes on the longer term, while an outside café terrace changes more rapidly, especially when the weather is nice. When spatial elements of similar changeability or 'time-rhythm' are connected with one spatial layer, the spatial dynamic can be captured and it becomes possible to enhance, predict or facilitate transformations. Each of the five layers is also connected to a spatial scale. Fast change happens often at a smaller scale, while slow changes take place at higher spatial scales. Five layers are distinguished, two more than the three layers of the original layer approach([Frieling et al., 1998): networks, focal points, unplanned space, natural resources and emerging occupation patterns.

Non-linear Processes

For the different spatial elements are specific time-rhythms distinguished. This implies that in the different parts of the Swarm Planning Framework other non-linear processes emerge. Each of these processes contributes to the overall adaptation of the system. *Emerging patterns* and *connectedness* takes predominantly place in networks and between the most intensive nodes. *Tipping points*, defined as the moment the system 'flips' from one state to a new one (Gladwell, 2000), can be spatially identified as the most important nodes in (a combination of) networks. In the unplanned space the impacts of a strategic intervention, a tipping point, can be mitigated. The impact of the intervention on its environment will form *new spatial patterns* through *self-organisation*. The *fitness landscape* is mainly related to natural resources. These resources, such as clean water, nature, food and clean energy often benefit from a stable environment in which natural processes can develop. Changes will happen very slowly in these systems until the system no longer can function properly. At that moment the system jumps to a new state where it can operate in a stable way. The continuous search for this most optimal stable state is called fitness landscape. The emergent occupation patterns develop as a result of self-organisation. This happens more easily when many elements are close together.

Two Planning Processes

In the Framework two ways are described to use the components in a planning process. The first way is 'from small to large'. In this variant the planning starts with an analysis of the slowest changing elements (the natural resources). This forms the basis within which choices can be made for the second slowest layer, the networks. This layer determines subsequently the playing field for the nodes, after which occupation patterns may emerge. Finally, the remaining space is unplanned. The second way to use the Framework in planning is 'on the list of partners'. The analysis of the first layer, the networks, happens in this case first. On the basis of this analysis the most intense and important nodes are determined. These nodes are the most suitable to execute a strategic intervention. The first two layers are also seen as the ones to influence the landscape as a whole and are able to enhance its adaptability at the system level. When the most important nodes are identified and the places for strategic interventions are chosen the space around these nodes is kept unplanned in order to allow the impacts of the intervention emerge freely. The remaining space in the landscape can be used for natural resources. Finally, emerging occupation patterns are identified in the fifth layer and added to the plan.

Both usages of the Framework are valid and will lead to adaptive plans, which enhance the adaptive capacity of the landscape for uncertain future developments.

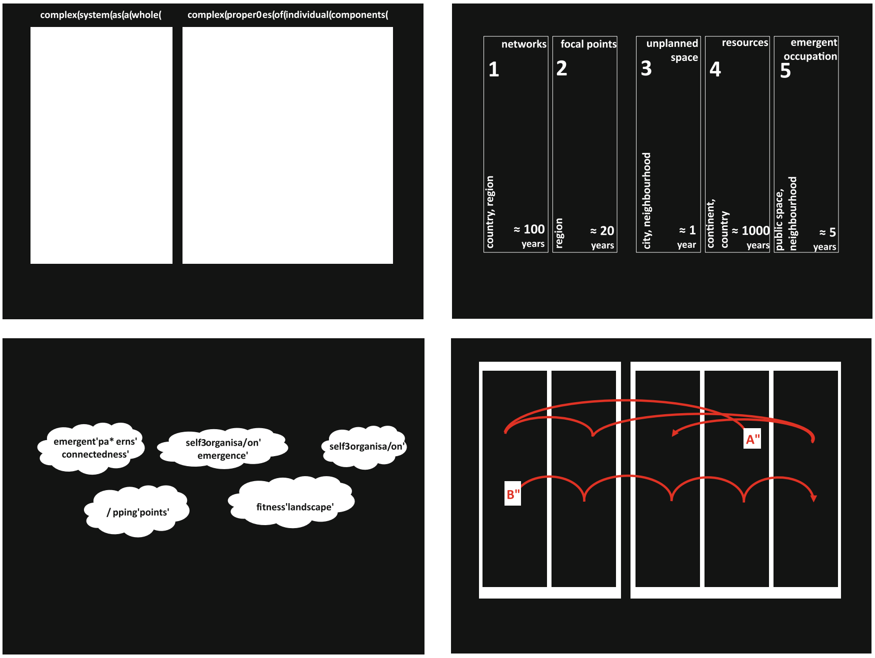

Fig. 1 Four components of the Swarm Planning Framework

The four components together form the Swarm Planning Framework. In Fig. 1 examples of spatial elements are added for each layer. These lists are not complete, nor extensive, but give an indication of the sort elements that belong to each layer.

The Framework is evolved from and tested in pilot designs. During the design of a few pilot designs (Floodable Landscape, Idea Map Groningen en Zero-Fossil Region) parts of the Framework arose. The Framework was subsequently used in the design of other pilots (Peat Colonies, Bendigo).

All design were appraised using criteria for an adaptive landscape: reducing vulnerability of the social, physical and spatial system, reducing of the impact of climate hazards and disasters, the ability to respond to unexpected hazards and whether the plans contain adaptation strategies that were implemented. The results show that the use of the Swarm Planning Framework reduces the vulnerability of landscapes as well as the impact of climate hazards and disasters, better respond to unexpected hazards and contain adaptation strategies.

This thesis consists of ten chapters. The Chaps. 2–9 have been published previously as an academic article, as a book chapter or as part of conference proceedings, and all are (except for Chap. 8) at least double blind peer reviewed. Therefore, each chapter can be read as a stand-alone article. The flipside of this approach is that amongst several articles/chapters there is a slight overlap in content and it sometimes lacks that a logical next chapter evolves from the previous.

In order to overcome these downsides and to increase understanding and readability of the thesis, the chapters will be 'bridged' through short explanatory intermezzos.

Samenvatting

Klimaatadaptatie kan maar moeilijk worden geïntegreerd in de huidige ruimtelijke ordening. Het gevolg daarvan is dat in ruimtelijke plannen slechts in beperkte mate voorzieningen zijn opgenomen die anticiperen op de toekomstige gevolgen van klimaatverandering. Dat betekent dat het landgebruik onvoldoende is voorbereid op deze toekomstige gevolgen. In andere woorden: de adaptieve capaciteit (de aanpasbaarheid) in het landgebruik is niet groot en kan onvoldoende blijken als de gevolgen van klimaatverandering zichtbaar worden.

Dit proefschrift heeft als doel te onderzoeken of er een manier te vinden is die de aanpasbaarheid van het landgebruik kan vergroten door maken van plannen en ontwerpen waardoor het landschap een grotere veerkracht (resilience) verkrijgt en het dus beter bestand is tegen toekomstige gevolgen van klimaatverandering.

De oorzaak voor de moeizame integratie van klimaatadaptatie in de ruimtelijke ordening is gelegen in het verschil in kenmerken van beide.

Klimaatadaptatie wordt gezien als een ongetemd (wicked) probleem (VROM-raad, 2007; Commonwealth of Australia, 2007) of zelfs een super-ongetemd probleem (Lazarus, 2009). Dit soort problemen worden door Rittel en Webber (1973) omschreven als 'een categorie problemen van sociale systemen, die slecht zijn geformuleerd en waar de informatie verwarrend is, waar vele klanten en beslissers met conflicterende waarden zijn en waar de onderdelen van het gehele systeem ernstig verwarrend zijn. De meeste ontwerpproblemen bevatten een fundamentele onbepaaldheid, hetgeen veronderstelt dat met deze problemen moet worden omgegaan in een permanente staat van onzekerheid en in een situatie, waarin een voorkeur zich slechts geleidelijk ontwikkelt'.

De volgende karakteristieken worden aan ongetemde problemen toegedicht:

- Ze kunnen niet in een definitieve vorm geformuleerd worden;
- Ze zijn niet eindig;
- De oplossingen zijn niet waar of onwaar, maar beter of slechter;
- Er is geen directe en ultieme test voor een oplossing;
- Elke oplossing is enig in zijn soort, omdat er geen mogelijkheid is om al doende te leren, dus elke poging is belangrijk;
- Er is geen opsomming (of een uitputtende beschrijving) van een groep mogelijke oplossingen, en er is geen duidelijk omschreven groep toelaatbare activiteiten die kunnen worden opgenomen in het plan;
- Elk ongetemd probleem is in essentie uniek;

- Elk ongetemd probleem kan gezien worden als een symptoom van een ander (ongetemd) probleem;
- De oorzaken van ongetemde problemen kunnen op ontelbare manieren begrepen worden. Hoe de oorzaak van het ongetemde probleem wordt uitgelegd bepaalt het soort oplossing;
- (Met ongetemde problemen) heeft de planner geen reden voor fouten.

Ruimtelijke ordening, aan de andere kant, is er op gericht het ruimtegebruik te regelen op een manier die de burger niet voor verrassingen stelt. De burger mag er van uitgaan dat een veranderend ruimtegebruik geen negatieve gevolgen heeft voor zijn eigendom. In het algemeen betekent dit dat er veel krachten in het spel zijn die verandering van het ruimtegebruik tegengaan. In die zin is de ruimtelijke ordening conservatief. Ook wanneer academische literatuur in ogenschouw wordt genomen blijkt dat verreweg het grootste deel van de recente artikelen zich richten op regelgeving, een status quo, een bepaald en specifiek onderwerp hebben of het onderwerp zien als onveranderlijk en statisch [dit proefschrift, hoofdstuk drie]. Ook in de planvorming is het vaak zo dat een probleem, dat onderkend werd in het verleden, wordt opgelost in plaats van een toekomstig probleem, zeker niet als dat probleem op langere termijn speelt of onzeker is.

Het ongetemde probleem van klimaatadaptatie en de manier waarop de huidige ruimtelijke ordening uitgevoerd wordt leven op gespannen voet. Kort samengevat is het lastig om een ongetemd probleem in een systeem te integreren dat niet gericht is op het toelaten van (grote) veranderingen. En omdat dat lastig is, is het ook een probleem om de inhoud van plannen te richten op verandering. Daarmee wordt het ingewikkeld om een lange termijn, ongetemd en soms onzeker probleem als klimaatadaptatie in ruimtelijke plannen te vatten of een volwaardige plek te bieden. Om de integratie van klimaatadaptatie in de ruimtelijke ordening te verbeteren is er daarmee behoefte aan een nieuw, aangepast raamwerk, dat meer ruimte biedt aan onvoorspelbare, ongetemde, dynamische of niet-lineaire processen. Voor het ontwikkelen van een dergelijk raamwerk is inspiratie gevonden in zwermen, omdat zwermen, zoals bijen, mieren, vogels en vissen in staat zijn tot zelforganisatie, dat het systeem helpt om minder kwetsbaar te worden voor (plotselinge) veranderingen in hun omgeving (Fisher, 2009; Miller, 2010). Zwermen vertonen ‘zwermgedrag, dat zich kenmerkt door een hoge mate aan veerkracht en uitermate goed in staat is de gevolgen van onzekerheden, complexiteit en verandering te verminderen door het ontwikkelen van autonoom groeiende patronen en structuren’ (Van Ginneken, 2009).

De propositie in dit onderzoek is daarom om een raamwerk voor ruimtelijke plannen te ontwikkelen waarin het landschap gezien wordt functionerend als een zwerm, waarbij het zich makkelijk kan aanpassen aan onverwachte, onvoorspelbare en onvoorzienbare veranderingen. Dit raamwerk vormt de kern van het proefschrift.

Raamwerk voor 'Swarm Planning'

Het Swarm Planning Raamwerk bestaat uit de volgende vier bestanddelen (Fig. 1)

Twee niveaus van complexiteit

Zoals beschreven door Portugali (2000) vindt in de stad zelforganisatie plaats op twee niveaus: op het niveau van de gehele stad en op het niveau van individuele elementen in de stad. Er mag worden aangenomen dat wat Portugali beschrijft voor het systeem 'Stad' ook geldt voor het systeem 'Landschap'. In het creëren van een grotere aanpasbaarheid in het landschap is het dus van belang dat het zelforganiserend vermogen op beide niveaus wordt versterkt. Op het niveau van het gehele landschap wordt dat gedaan door het doen van strategische interventies op plekken waar het systeem als geheel het beste kan worden beïnvloed. Deze plekken kunnen worden gevonden op basis van een netwerkanalyse. De knooppunten in het netwerk die het meest intens verbonden zijn met andere knooppunten en de belangrijkste punten zijn het meest geschikt om een interventie te plegen. Op het tweede niveau, van de individuele componenten (bijvoorbeeld een weg, een gebouw, een kanaal), worden de elementen afzonderlijk 'voorzien' van zelforganiserende eigenschappen. Als voorbeeld kan een woning die aan de rand van het water staat voorzien worden van waterbestendige onderdelen (muur, vloer, raam, deur) of kan de woning voorzien worden van een fundament dat geschikt is om te gaan drijven. Het spreekt voor zich dat elk element specifieke kenmerken heeft en dus ook voorzien moet worden van bijbehorende eigenschappen. Welke eigenschappen het zelforganiserend vermogen het best kan vergroten hangt ook af van de omgeving (ie. het te verwachten soort van impact als gevolg van klimaatverandering. Hitte/droogte stelt andere eisen dan neerslag en overstroming). Alle elementen, voorzien van eigenschappen die het zelforganiserend vermogen vergroten, vormen samen een zelforganiserend geheel dat in zijn totaliteit een grotere aanpasbaarheid heeft verkregen. De beide niveaus van complexiteit tezamen bepalen uiteindelijk de adaptieve capaciteit van het totale systeem.

Vijf lagen

Niet elk onderdeel van het landschap (en de stad) heeft hetzelfde tempo waarin het kan veranderen. Een boom, eenmaal geplant, verandert slechts op de langere termijn, terwijl een caféterras een veel snellere verandering kan ondergaan, zeker als het mooi weer is. Door het toedelen van landschapselementen met vergelijkbare veranderbaarheid of ‘tijd-ritme’, aan eenzelfde ruimtelijke laag wordt de ruimtelijke dynamiek gevangen en wordt het mogelijk om transformaties te bewerkstelligen, te voorspellen of te begeleiden. Elke van de vijf lagen is ook gekoppeld aan een ruimtelijke schaal. Snelle veranderingen vinden vaak plaats op relatief kleine schaal terwijl langzame veranderingen plaatsvinden op hogere schaalniveaus. Er worden vijf lagen onderscheiden, twee meer dan de drie lagen waarvan deze benadering is afgeleid (Frieling et al., 1998): netwerken, knooppunten, ongeplande ruimte, natuurlijke reserves en groeiende occupatie patronen.

Niet lineaire processen

Voor de verschillende ruimtelijke elementen gelden dus verschillende tijdsritmes. Dit impliceert ook dat in de diverse delen van het raamwerk andere niet lineaire processen zullen ontstaan. Elk van de processen draagt bij aan de algehele aanpasbaarheid van het systeem. De groei van *nieuwe patronen* en *verbondenheid* vindt voornamelijk plaats in netwerken en tussen de meest intensieve knooppunten. *Tipping points*, gedefinieerd als het moment waarop een systeem van het ene toestand omschakelt naar een nieuwe toestand (Gladwell, 2000), zijn ruimtelijk vooral terug te vinden als de belangrijkste knooppunten in (een combinatie van) netwerken. In de ongeplande ruimte worden de gevolgen van een strategische interventie, het tipping point, opgevangen. De impact die deze ingreep heeft op zijn omgeving zal als een *zichzelf organiserend* proces nieuwe *ruimtelijke patronen* vormen. Het fitness landschap is vooral gerelateerd aan natuurlijke reserves. Deze natuurlijke bronnen, zoals schoon water, natuur, voedsel en schone energie, zijn vaak gebaat bij een stabiele omgeving, waarin natuurlijke processen zich kunnen voltrekken. Heel langzaam zullen er veranderingen optreden in deze systemen, net zo lang tot het systeem niet langer goed kan functioneren. Op dat moment springt het systeem over naar een nieuwe toestand waarin het weer stabiel kan opereren. Het continue zoeken naar deze optimale stabiele toestand wordt aangeduid met de term fitness landschap. De zichzelf ontwikkelende occupatie patronen tenslotte kunnen zich vormen door zelforganisatie. Dit is vooral mogelijk wanneer er veel elementen in elkaars nabijheid verkeren.

Twee planprocessen

In het raamwerk worden twee processen beschreven waarop de verschillende bestanddelen in de planvorming kunnen worden gebruikt. De eerste manier is ‘van groot naar klein’. In deze variant begint de planvorming met een analyse van die elementen die het traagst kunnen veranderen (de natuurlijke reserves). Dit vormt de basis waarbinnen ruimtelijke keuzes kunnen worden gemaakt voor de op één na traagste laag, de netwerken. Deze laag bepaalt vervolgens het speelveld voor de knooppunten, waarna nieuwe occupatiepatronen zich kunnen ontwikkelen en er tenslotte ruimte overblijft die ongepland kan blijven. De tweede manier om het raamwerk in de planvorming te gebruiken is 'op het rijtje af'. Hier wordt gestart met een analyse van de eerste laag, de netwerken. Vervolgens wordt op basis van deze analyse bepaald welke knooppunten de meest intense en belangrijkste zijn. Deze knooppunten zijn geschikt voor een strategische interventie. Deze eerste twee lagen worden bovendien gezien als degenen die het landschap als geheel kunnen beïnvloeden en de aanpasbaarheid op systeemniveau kunnen vergroten. Wanneer de belangrijkste knooppunten bepaald zijn en de plek(ken) voor een strategische interventie gekozen zijn, kan de ruimte rondom deze punten als ongeplande ruimte vrijgehouden worden. Hier wordt de ruimte gevonden waar de impact van de interventie zich vrij kan ontwikkelen. Dit laat vervolgens ruimte over in het landschap die ingevuld kan worden voor het produceren en veiligstellen van natuurlijke reserves. Tenslotte worden in de vijfde laag de nieuwe occupatiepatronen geïdentificeerd en toegevoegd aan het plan. Beide werkwijzen zijn valide en zullen leiden tot plannen waarin de aanpasbaarheid van het landschap aan onzekere toekomstige ontwikkelingen wordt vergroot.

De vier bestanddelen tezamen vormen het Swarm Planning Raamwerk. In Fig. 2 zijn voor elke laag voorbeelden van ruimtelijke elementen toegevoegd. Deze lijstjes

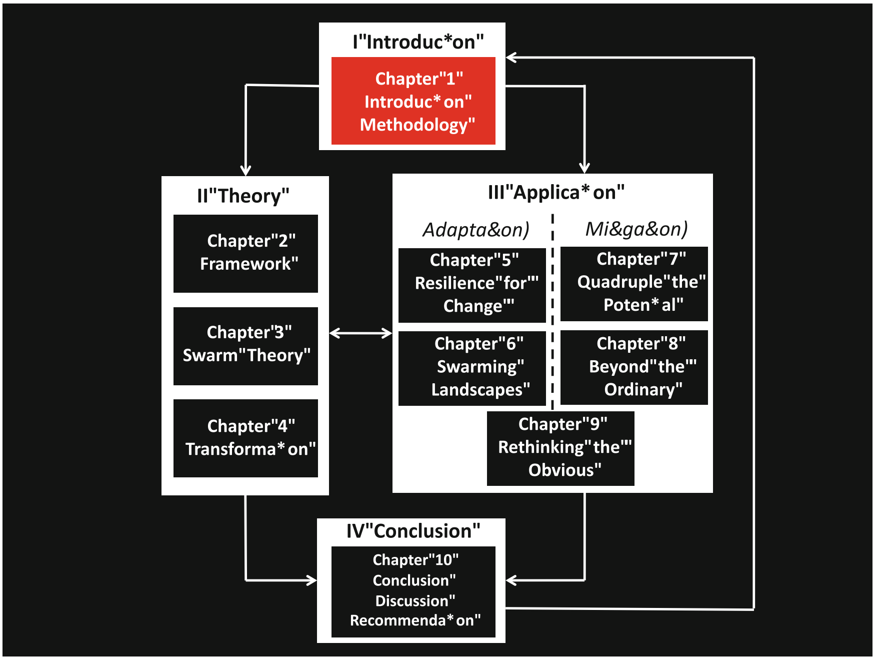

Fig. 2 The Swarm Planning Framework

zijn niet compleet en uitputtend, maar geven een indicatie van het soort element dat behoort tot de betreffende laag. Het raamwerk is ontstaan uit en getest in pilot ontwerpen. Gedeeltelijk zijn tijdens het ontwerpen van een aantal van de pilots (Floodable Landscape, Idea Map Groningen en Zero-Fossil Region) onderdelen van het raamwerk gevormd. Vervolgens is het raamwerk gebruikt bij het ontwerpen van andere pilots (Peat Colonies, Bendigo). De ontwerpen zijn vervolgens getoetst aan criteria die een aanpasbaar landschap beschrijven: verminderen van de kwetsbaarheid van het sociale, fysieke en ruimtelijke systeem, vermindering van de ernst van klimaatrisico's en rampen, het vermogen om in te spelen op onverwachte risico's en bevatten de plannen adaptatie maatregelen die kunnen worden geïmplementeerd. De resultaten van de pilot ontwerpen laten zien dat het gebruik van het Swarm Planning Raamwerk de kwetsbaarheid van landschappen vermindert, de ernst van klimaatrisico's en rampen vermindert, beter kunnen inspelen op onverwachte risico's en adaptatie strategieën bevatten.

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Chapter 1
Introduction, Methodology, Limitations

1.1 Introduction

The current status and significance of climate adaptation and its connections with spatial planning can be interpreted taking different perspectives. Scientific conferences, research programmes and writings are subsequently used as lenses of observation.

A selection of recent and future conferences in different scientific fields shows a strong focus on the specific topic. Whilst this is logical and probably inevitable, the flipside is that links with other fields are underdeveloped and the integration of different subjects is not much practiced. This can be illustrated through analysis of a couple of recent scientific, global, conferences.

The majority of scientific papers that were published in the proceedings of the first International Climate Change Adaptation Conference, held in 2010 (http://www.nccarf.edu.au/conference2010) in the Gold Coast, Australia, focuses on thematic and process oriented topics, with the top-four issues being Governance, Agriculture, Ecology and the Coast [own calculations]. Only two out of 209 oral presentations addressed integrated planning and design (Mack et al. 2010; Roggema 2010).

The second edition of this conference, held in Tuscon in 2012 (http://www.adaptation.arizona.edu/adaptation2012), focuses on similar priority themes: regional studies about the most vulnerable people, climate impact science, communication, building adaptive capacity, examples and cost benefits, funding, tools, evaluation and adapting under four degrees warming. Spatial planning and/or design are conspicuously absent.

What is true for adaptation conferences is also valid for other fields of research. The resilience research community, represented at the Resilience 2011 conference (www.resilience2011.org), did not address spatial planning nor climate adaptation. In reverse, the spatial planning community, convened at the World Planning Schools Congress (www.wpsc2011.com.au), save two design-oriented papers (March and Holland 2011; Roggema and van den Dobbelsteen 2011), addressed climate adaptation only in regards to specific hazards or coastal issues.

R. Roggema, *Swarm Planning*, Springer Theses, DOI: 10.1007/978-94-007-7152-9_1,

Taking two research programmes as representatives for the connections between spatial planning and climate adaptation (ESPACE, www.espace project.org and CCSP, www.climatechangesspatialplanning.nl), both programmes hardly host projects that are oriented at making/designing spatial plans, despite the fact they specifically aim to link spatial planning with climate adaptation. Most of the CCSP-projects that look into the spatial planning topic do so by developing tools to facilitate spatial planning and helping 'them' (e.g. the spatial planners) to improve climate adaptation in their plans (De Pater et al. 2011).

A broad and growing body of literature with adaptation to climate change as main topic has been released (see for example: Godschalk and Brower 1989; Godschalk et al. 1999; Berke 1992, 1997; Brower and Schwab 1994, 2002; Beatley 1994, 2009). Nearly all of these writings address a very specific theme (e.g. coastal management, biodiversity, disasters) or are specifically focused on mitigation (Newman and Boyer 2009). Moreover, it is illustrative that '*the Earthscan reader on Adaptation to Climate Change*' (Schipper and Burton 2009) has not included a chapter on spatial planning. One other major work on planning and climate change, '*Planning for Climate Change*' (Davoudi et al. 2010) focuses also mainly on processes, policies and specific topics, such as transport. Only few chapters in this book cover *spatial* planning, urban form or urban design. With the exception of Elisabeth Wilson (2009), the parts that do cover these issues are oriented on cities and urban areas.

This analysis is underpinned by the survey of Carter and Sherrif (2011), who conclude that adaptation is only just been acknowledged as an important element for cities and urban areas, the limited uptake of adaptation responses in spatial planning must change, adaptation should be seen as a constituent element of governing and designing urban areas, and the role of spatial planning in delivering adaptation responses must be strengthened.

Climate adaptation framed from a spatial planning perspective emphasises the role of spatial planning itself (Roggema 2009a). In several publications, it is acknowledged that spatial planning can (and must) play a vital role 'in every aspect of adaptation to climate change impacts' (Blanco and Alberti 2009) and spatial planning is seen to 'play a part in mitigation and adaptation efforts' because 'the nature and framing of spatial planning is changing' as a result of the 'recognition of the complexity, uncertainty and irreversibility demonstrated by climate science' (Davoudi et al. 2010, p. 14).

In the extension of the above, the main focus of my research is on the way climate adaptation can be better incorporated in spatial planning. The view I have on this matter is that to present climate change as a threat, setting aside whether the worsening of the problem is real or just a perception, paralyses action. It is more productive to frame the problem positively. This requires acceptance of the assumptions voiced by the climate science community and using this information to inform spatial planning community in a way that offers a fundamentally new way to incorporate climate adaptation. Instead of presenting the uncertainties surrounding climate change, a planning approach needs to be developed, which spatial planners experience as a part of their spatial planning discourse.

The language, the elements and topics need to be linked with the spatial reality 'out there' and the way spatial planners are used to design their plans.

In this chapter climate change and climate adaptation, spatial planning, complexity and time horizons are briefly introduced. Secondly, the problem statement, objective, hypothesis and research questions of the research are formulated. The chapter ends with an exploration on key concepts that emerged over time during the execution of the research.

1.2 Climate Change

It is not the aim of this research to contribute to scientific research and/or debate regarding climate change. As mentioned above, the starting point for the research is the assumption that global climate is changing, as stated in many scientific records (as main source: IPCC 2007) and, according to several publications, at an increasing pace (Tin 2008; Richardson et al. 2009; PBL et al. 2009; Sommerkorn and Hassol 2009; NASA/Goddard Space Flight Center 2011).

Secondly, due to the extended effect of global warming, change will continue for centuries (Fig. 1.1), even if we stop to emit carbon dioxide today. After CO_2 emissions are reduced and atmospheric concentrations stabilize, surface air temperature continues to rise by a few tenths of a degree per century for a century or more, thermal expansion of the ocean continues long after CO_2 emissions have been reduced, and melting of ice sheets continues to contribute to sea-level rise for many centuries (IPCC 2001).

The changes in climate are found to be non-linear, meaning that the estimated fluent curve of change, much used in climate science, needs to be re-adjusted in a shape that looks more like a staircase (Fig. 1.2) (Jones 2010, 2011).

It may be concluded that the effects of climate change will stay with us for an extended period of time and the changes will take place in 'jumps'. Therefore, adaptation is needed and it needs to be able to deal with the step changes as illustrated above.

1.3 Climate Adaptation

Current adaptation policies are mainly focussing on risk assessments, building adaptive capacity (of organisations, people), and financial arrangements. Many adaptation measures are taken in separated policy fields, such as coastal management, ecology, infrastructure, water management or agriculture. The question therefore is how climate adaptation is framed from a spatial planning perspective and, is it framed from a spatial planning perspective? Several scholars have published about the framing of climate adaptation. These theories all take climate adaptation as the starting point and frame 'the rest' from that point of view.