# Integration: multifunctional adaptation to climate change

**Work package leader : Dr. C.C. Vos**

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## 1 Description work package

### 1.1 Problem definition, aim and central research questions

**Problem**

Better understanding of adaptation is urgently needed for society to be able to cope with the consequences of climate change. Importantly, adaptation has to be framed within the wider context of land use change and not just climate change alone. The central goal of our project is to develop effective multifunctional adaptation strategies that will increase the adaptive capacity of regions to cope with effects of climate change. Whether a regional adaptation strategy will be effective depends on both biophysical as well as socio-economic components. From the biophysical point of view a regional adaption strategy would be regarded effective when the problems caused by climate change for different functions in the regions are solved. From the socio-economic perspective effective implementation of regional adaptation strategies also depends on the willingness of actors to participate. For instance are farmers willing to carry out particular ecosystem services on their land that contribute to the adaptive capacity of ecosystems or regional water storage? Policy makers have insufficient understanding about personal motivations of actors to participate and how incentives (policy instruments) might stimulate this willingness. Therefore regional policy makers need information on:

- needs: *what* is required, *how much* is required and *where* to make a function resilient to climate change and
- opportunities: under *what conditions* and *how many* and *where* are farmers and other landowners willing to facilitate ecosystem services to increase regional resilience to climate change?

The planning challenge can be conceived as a process in which local stakeholders and landowners find a match between needs to adapt the landscape to climate change and opportunities to amend the landscape system to socio-economic demands. The needs represent the physical changes required to improve the adaptive capacity of the physical landscape to climate change induced perturbations. These needs will have to be spatially explicit. Opportunities on the other hand are determined by the socio-economic and ecological demands that the local society aims for, while considering the national and regional constraints and demands for biodiversity conservation and quality of life. The aim for WP1 is then to explore how demands for change driven by climate adaptation needs can be matched with opportunities to combine such a change with social and economic challenges in the use of land. The results of the design sessions (Project 1.3) will contribute to learning about how to detect such opportunities in a planning context, and how these are perceived and rated by different stakeholder groups. The ABM (Project 1.2) will contribute to a mechanistically based insight into the assumed land use transformations.

**Aim**

This work package brings needs and opportunities together and develops designs for regional integrated adaptation in different case study areas. Understanding how needs and opportunities can be integrated and how this integration process can be stimulated through policy options and (spatial) incentives will greatly increase the regional adaptive capacity to cope with climate change.

**Central research questions**

- How can climate adaptation strategies for water management, nature conservation and agricultural management be integrated in the case study areas? What are the cross-sector benefits and disadvantages of adaptation strategies?
- What are useful criteria for integrated multifunctional adaptation strategies?
- What are the various decision-making strategies of farmers and nature managers towards climate change adaptation?
- How should landscape planning, design and management be organized in order to be effective, efficient and sustainable?
- Which adaptation strategies (ecosystem services) are available to land resource managers and policy makers and which seem most beneficial for rural areas?

## 1.2 Interdisciplinarity and coherence between the projects

Project 1.1 Phase 1 coordinates the contacts with the regional case studies and the scenario development within the project as a whole. Two consistent national scenarios will be developed based on climate and socio-economic variables. From these regional case-study specific scenarios will be developed in interactive sessions with stakeholders. The outcome of these interactive sessions are an analysis of potential climate change problems and possible mono-functional and multifunctional adaptation options. A selection of the case-study specific problems are adopted by the projects in WP2 and WP3 and effects and adaptation strategies are explored.

In the projects 1.2 and 1.3 the actual integration and design of regional adaptation strategies of the case studies takes place, using knowledge on needs and opportunities derived from the WP2 and WP3 projects. Questions answered are: Are provided ecosystem services in the right locations and is the robustness of these services expected to be sufficient? How can financial and spatial incentives help to bring required and offered ecosystem services together?

In project 1.2 agent based models will generate understanding where opportunities for adaptation occur because farmers and other landowners (nature managers, estate owners) are willing to provide ecosystem services. Also it is being explored how policy options and (spatial) incentives might improve these opportunities.

In project 1.3 design options for the optimal allocation of adaptation measures will be generated for landscapes in a broader context including e.g. recreation and heritage. Options for integrated multifunctional adaptation will be developed in interactive sessions with the stakeholders. Also the pros and cons of multifunctional integration are being explored.

Project 1.1 Phase 2 will undertake an interpretation of the new knowledge and insight into the adaptive capacity to climate change, generated through the various WPs of the project. This synthesis will include a comparison of the efficacy of alternative adaptation options within different biophysical and socio-economic contexts and future environmental change scenarios.

**Risk management**
The ABM is a very innovative part of our program, which unavoidably also has some potential risks. We have managed this potential (but not expected) risk by putting the ABM approach (project 1.1) on an equal level with the interactive design approach ( project 1.3). If the ABM project is succesfull results will be fed into the interactive design approach. However if this is not the case, spatially explicit adaptation options from WP2 and WP3 will form direct input for project 1.3.’

## 1.3 Stakeholders

The integration and development of multifunctional adaptation options are elaborated specifically for each case study area. The regional stakeholders participate in interactive sessions for regional scenario development, the diagnoses of climate change problems and adaptation options. Incentives for ecosystem services and design options are developed and evaluated with the regional stakeholders. See also Section 4B.

# 2 Project 1.1 Development of scenarios, coordination of case studies and synthesis effective adaptation strategies

**Project leaders: Dr. C.C. Vos , Dr. E. Koomen , Prof. Dr. M.D.A. Rounsevell**

## 2.1 Problem definition, aim and central research questions

This project coordinates the integration of knowledge towards effective adaptation strategies. It also coordinates the development of scenarios and it organizes the communication between the case study areas and the individual projects of the research program as a whole. The main aim of the project is to develop a coherent set of national and regional scenarios (phase 1) and propose a set of effective adaptation strategies for selected case study areas (phase 2).

More specifically the first phase aims to:

a) develop a set of consistent scenarios based on climate change and socio-economic variables; b) develop case study specific policy alternatives in close interaction with regional stakeholders; c) transfer knowledge effectively between the regional case studies, the single projects (WP2 and WP3), and the integration projects WP1.2 and WP 1.3.

The second phase aims to: a) develop a conceptual framework based on the provision of ecosystem services for the integration of nature and agricultural management, b) identify the alternative options available to land resource managers and policy makers in adapting to climate change, c) identify appropriate adaptation strategies that minimize the negative effects of climate change on rural areas and maximize the opportunities.

## 2.2 Approach and methodology

The project consists of two subsequent phases:

1. Development of national and regional scenarios at the start of the research program; and
2. Synthesis of effective adaptation strategies at the end of the research program.

These phases are discussed below.

***Phase 1 Scenario development***

<u>National scenarios</u>

We will address pressures and drivers of climate and land use change through a scenarios-based approach. Two consistent scenarios will be developed based on climate and socio-economic variables (e.g. demographic and economic changes, total urban expansion and total water demand for drinking water and industry). For example Riedijk et al. (2007) integrated the climate change scenario with a strong temperature increase (KNMI W+) with a ‘global economy’ scenario and the climate change scenario with a moderate temperature increase (KNMI G) with a 'regional economy'. As consistency of scenarios throughout the Knowledge for Climate Program (KfC) and the preceding Climate Changes Spatial Planning Program (CcSP) is of vital importance, we will not develop new national scenarios in this project, but build further on existing approaches and frameworks (e.g. CsSP IC3, KfC Tailoring, KfC Theme 8, see Riedijk et al., 2007; Koomen et al., 2008). To ensure that our results are also applicable in an international context, we will undertake a systematic but brief review of existing scenario exercises at a range of spatial and temporal scales for Europe, the Netherlands and the regions of the Netherlands. Over the last decade a large number of studies have developed scenarios to explore potential future changes at different geographical scales (Rashkin, 2005), including many scenario studies focusing on Europe (Metzger et al., in press; Rounsevell et al., 2006). The aim of the review is to secure the Dutch scenarios are properly embedded in an international context.

Regional scenarios

The central objective of our study is to develop regional adaptation strategies for rural areas. The case study areas of the involved hotspot regions form the on-the-ground experimental areas where different adaptation options are being explored based on realistic problems. Thus it is of vital importance that regional stakeholders are actively involved in the development of case study specific scenarios. Therefore we will develop regional specific scenarios taking the national scenarios as a starting point. We will organize interactive workshops with local stakeholders making use of interactive sketching environments (such as the TouchTable, see Scotta et al., 2006) in combination with the Land Use Scanner model. This allows for the combination of design-oriented tools with a more rational, economics-based modeling environment. Initial attempts to combine these hitherto separate worlds offer promising results, but indicate the need for well-structured and well-guided sessions in which objectives and boundary conditions are clearly specified (Jacobs et al., 2009; Koomen et al., 2010). The incorporation of interactive or tangible presentation media such as the 'TouchTable' allows multiple users to view, query and edit geographical information in group sessions. This allows for an active contribution of stakeholders in the definition of regional problems in the face of climate change and potential adaptation options. The outcome of these interactive sessions are sketch maps indicating locations where climate change problems are to be expected and sketch maps indication potential locations for adaptation. The Land Use Scanner model is applied to test whether these suggested solutions comply with the overall scenario-based boundary conditions in terms of land demand and documented location factors that steer spatial developments. The stakeholder workshops will also help us to sharpen the discussion on multi-functionality by addressing issues such as: what are typical mono functional policy options? where do we need multi-functionality? To what degree do proposed functions provide conflict or synergy? Water storage may, for example, only occur once every 20 years and thus only pose limited restrictions to an otherwise mono-functional area.

Communication between case studies and individual projects

Specific questions on effects of climate change and possibilities for adaptation on nature, agriculture and water management that have come up at these interactive stakeholder sessions are adopted by the specific projects in WP2 and WP3. These projects will develop scientifically underpinned standards for adaptation being specific about the required spatial and abiotic conditions for adaptation. Also the attitude of different actors to provide ecosystem services that contribute to regional adaptation are being explored. The results are again taken up in the integrating projects WP 1.2 and WP 1.3.

***Phase 2 Synthesis of effective adaptation strategies***

The need for a synthetic treatment of adaptation strategies

Whilst there has been much research on the impacts of climate change and other environmental change drivers on rural land resource systems (Adger et al., 2007), the assessment of adaptation to change is less well developed. Better understanding of adaptation is urgently needed for society to be able to cope with the consequences of climate change (Wilson and Piper, 2008). Adaptation strategies are essential processes for all societies to consider, but their development pose significant challenges to scientists and policy-makers alike. Importantly, adaptation has to be framed within the wider context of environmental change and not just climate change alone. This project, through its various WPs, will generate considerable new knowledge and insight into the adaptive capacity of land managers to climate change. Phase 2 of WP1.1 will undertake an interpretation of this new knowledge by synthesising the adaptation options and strategies available to land resource managers. This synthesis will include a comparison of the efficacy of alternative adaptation options within different biophysical and socio-economic contexts and future environmental change scenarios. In doing so, Phase 2 will address the research questions:

- What options are available to land resource managers in adapting to climate change?
- Which adaptation strategies would most benefit rural areas?

A common framework to interpret adaptation strategies

The Phase 2 synthesis will be structured within a conceptual framework based on social-ecological systems thinking and the ecosystem service approach. The framework will facilitate the integration of the various methods, models and outputs generated in WP1, WP2 and WP3. The conceptual framework will be used to identify and structure the multiple relationships between people and their environments, including the role of autonomous and planned adaptation, and to integrate and apply the project's various models. This will include, for instance, both mono and multifunctional adaptation options; the functional and service beneficiaries, the ecosystem service providers; explicit standards for required spatial and abiotic conditions; the effectiveness of economic incentives and other policy options (e.g. spatial zoning), etc.

The new knowledge generated by the project WPs will be supplemented by a literature review of the various options for adaptation available to land resource managers and policy makers in adapting to climate change. This review will include research undertaken outside of the Netherlands that will serve to put the adaptation measures addressed here into an international context. This will allow parallels to be drawn between the adaptation options and strategies identified in this project with analogous regions of the world. The outcome of the review and synthesis will be a series of adaptation typologies linked to real management and policy strategies that are referenced to future scenarios.

## 2.3 Scientific deliverables and results

Phase 1 A peer-reviewed book chapter or journal paper describing the combined application of design-oriented tools and more rational, economics-based modeling environment to develop regional climate adaptation scenarios.

Phase 2 will deliver a synthesis of adaptation options and strategies in response to climate change that reflects the diversity of biophysical and socio-economic contexts within the Netherlands. The synthesis will also draw parallels with the potential for adaptation in other parts of the world that will allow the Netherlands to learn from ongoing international initiatives.

## 2.4 Integration of general research questions with hotspot-specific questions

The stakeholders of the case study areas participate in interactive sessions for regional scenario development, the diagnoses of climate change problems and adaptation options. The stakeholders are involved in the synthesis of the adaptation strategies (ecosystem services) available to land resource managers and policy makers and which seem most beneficial for rural areas.

## 2.5 Societal deliverables and results

A conference presentation of the suggested regional adaptation scenarios for Dutch research institutes involved in climate adaptation (e.g. the annual Ruimte Conferentie).
A report for policy and resource managers with a synthesis of adaptation options in response to climate change.

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# 3 Project 1.2 Modelling different farm types and resource management strategies based on an analysis of the attitudes of farmers and resource managers to ecosystem services

**Project leader: Prof. M.D.A. Rounsevell**

## 3.1 Problem definition, aim and central research questions

**Problem definition**

Understanding the complex, dynamic and non-linear relationships between humans and the environment remains a complex problem (MA, 2005). Models have traditionally tackled this problem by assuming economically rational actors who make decisions to optimise their profit or utility. But, this completely ignores the social dimension of the decision making problem that includes, amongst other factors, differing preferences, culture, traditions, imitation and cognition. Moreover, existing modelling strategies are poor at representing the capacity of individuals to adapt to change through learning, which is an important component of research into the effects of climate change.

Agent Based Models (ABM) provide a tool to explore through simulation the complex decision making in land use and ecological systems (Matthews et al., 2007, Parker et al., 2003, Clifford, 2008). ABM originated in the computer sciences in the 1970s through artificial intelligence research (Hare and Deadman, 2004), but has recently gained popularity in the social sciences and is increasingly applied to the problem of land system change. Examples of ABM applications in human and land system analysis include: (a) reproducing spatial and demographic features to understand the evolution of society (Kohler and Gumerman 2000); (b) evaluating economic systems when rational agents and equilibrium conditions are not limiting assumptions

(Duffy 2001); (c) simulating production decisions to assess adoption of new agricultural practices (Balmann 1997; Berger 2001; Polhill et al., 2001); and (d) linking human and natural systems at different spatial and temporal scales to understand changes in land cover and land use change (Parker et al., 2003).

A common phenomenon in modelling is a progression from early, stylised and simplistic models to more complex, empirically grounded models (Sinclair and Seligman, 1996), and ABM is no different. Early agent-based models (Schelling, 1971; Hagerstrand et al., 1967) were devised to have the simplest possible rules necessary to produce the desired behaviour. This allowed for a large degree of clarity in exploring theoretical hypotheses, but did not provide ways of using this new technique to investigate real-world problems. Consequently, ABM has undergone an evolution towards increasingly complex and empirically grounded models (Janssen and Ostrom 2006, Clifford 2008), used to produce results of increasing specificity. Consequently, ABM has great potential in the exploration and testing of theories about complex human behaviour and decision making processes, where these theories are linked to empirical analysis (Acosta-Michlik and Rounsevell, 2005). Only a very limited number of ABM studies have attempted to do this for rural land systems and so, we propose to develop these approaches further as part of this project.

**Aims**

The project aims to: a) use the ABM to explore the potential response of farmers and nature managers to future climate change through adaptive learning. and b) test alternative theories of decision making by rural land resource users, including farmers and nature managers, within an ABM framework.

The work will explore preferences, behaviours and cognitive strategies as the human characteristics that determine how agents make decisions about rural land use under different conditions (scenario + policy option). It will combine empirical analysis of human behaviour undertaken through social survey (projects WP2.5 and WP3.1) with a typologies based on the fundamental socio-economic characteristics of individual decision makers, as well as eliciting information about the preferences that different agent types attribute to the economic, social or environmental components of ecosystem services. Agent-Based Models (ABM) will be constructed for the project's case study areas to test the alternative theories and thinking about human land use decision making that come out of the empirical analysis. By constructing virtual worlds within the case study areas the ABM will also permit explorations of alternative, future socio-economic development pathways that are constructed through the scenarios (WP1.1).

**Central research questions**

- Which socio-economic attributes represent different profiles (types) of farmers and nature managers?
- What are the various decision-making strategies of farmers and nature managers and how do these differ across agent types?
- What can new knowledge about decisional processes tell us about the adaptive capacity of farmers and nature managers?
- How will farmers and land managers adapt to climate change in the future?

## 3.2 Approach and methodology

This project will create maps of future land use and management for three to four case study areas, for different conditions (i.e. combinations of exogenous scenarios and local policy options). It will use the empirical data about farmer and nature manager decision making collected in projects WP2.5 and WP3.1. The social survey data will be used to develop typologies of agent types that reflect their socio-economic attributes, behaviours and decision making processes with respect to land use change. This will include individuals (farmers and nature managers) and institutional structures within rural environments. Alternative decisional strategies will be formulated as sets of rules that will form the basis of the Agent-Based Model developed here. The outcome of this analysis will be a comparison of the distribution of agent types in different socio-cultural contexts in the project case studies. This will result in an evaluation of whether geographic location is a primary determinant of the presence of certain types of agents, or whether agent distributions are not linked to place.

This project will provide projects WP2.1-.2-4 and WP3.2 with the spatial distribution of land use and land management. In turn, it will receive feed-back from these projects, in the form of maps with indicators on, say, nitrate emissions or the degree to which biodiversity targets have been achieved. This feedback will be established periodically within the modelled period (2010-2050), and may make agents adjust their goals or their actions. The agent behaviours and decision rules derived from the social survey will be applied to the project case studies using an existing ABM framework development within the EU-funded Ecochange project (http://www.ecochangeproject.eu/). Model applications will be used to explore the consequences of different assumed land use decision making strategies by comparing model results with the observed data of land system change. This analysis will provide insight into the types of decision strategies adopted by agents in different socio-cultural contexts, and will provide an opportunity to test the alternative decision making strategies hypothesised from the social survey work. The model will be spatially explicit and so used to generate maps of future landscape change for rural areas based on the socio-economic and climate change scenarios developed in WP1.1.

The proposed ABM work is highly novel and will provide a dynamic systems approach to rural land use modelling. Although the current project will focus on the development of the method for a restricted set of case studies, the methodology could potentially be implemented across broader geographic regions. In doing so, this study will examine the potential of using ABM to simulate human responses to a range of environmental change drivers, including climate change and alternative policy regimes.

## 3.3 Scientific deliverables and results

This project will deliver: a) a typology of agent types (of farmers and nature managers) that reflects their socioeconomic attributes, cognitive strategies and decision making processes, b) a rule-base of agent behaviours and characteristics, c) an ABM of farmer and nature manager behaviour in making decisions about rural land use change, d) maps of land use change in response to the range of future socio-economic and climate change scenarios developed in 3.1 and the range of land resource agents.

### 3.4 Integration of general research questions with hotspot-specific questions

Projects 2.5. and 3.1 will generate valuable information about what current actors in rural areas will do in the near future. Many of our stakeholders, however, are interested in what the rural area will look like beyond the timehorizons of local actors. Moreover, they may want to explore different types of conditions (including incentives or remuneration strategies) than those the interviewees have been confronted with. This project allows them to do so. It lifts the findings of projects 2.5 and 3.1 to a more theoretical and therefore universal level allowing an exploration of adaptation strategies beyond the immediate scope of the individual actors. Moreover, it will allow the behaviour of a theoretical population of rural-area agents to be explored for times beyond the experience of current agents in rural area, feeding these insights into the design options of 1.3.

### 3.5 Societal deliverables and results

The project will deliver new ways of understanding how land resource managers make decisions about landscapes. This insight will enhance knowledge about how land managers respond to the challenges of climate change, and how policy can support the capacity of managers in adapting to climate change. The project will also identify the magnitude of the effect of climate change on rural areas, and where these changes are likely to be significant.

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# 4 Project 1.3 Design options for integrated multifunctional adaptation strategies

**Project leaders: prof.dr.ir. A.van den Brink, dr.ir. I. Duchhart, prof.dr. H. Scholten and dr. E. Koomen**

## 4.1 Problem definition, aim and central research questions

**Problem definition**

A key concept of this research program is the concept of integration. This concept is generally used in spatial and environmental sciences, but it usually seems to be taken for granted and not to be discussed. Integration refers to concepts such as multi-dimensional, inter- and multidisciplinary, comprehensive and cross-sectoral. One could say that rural development is a multi-dimensional, sector-permeating process that seeks to integrate in a sustainable manner economic, socio-cultural and environmental objectives, building upon new organizational relationships between public and private stakeholders. However, this still is a rather wide and therefore vague description. Literature shows only few attempts to systematically deal with the term ‘integrative/integration’ in spatial issues (see for example Healy, 2006; Kidd, 2007; Vanempten, 2007).

Currently the term integration is used (seemingly automatically at times) mostly in a positive way and also (often implied) as an obligation. It thus has taken on a somewhat normative dimension, i.e. approaches to rural development decision-making *should be* or even *must be* integrated. At the same time, integration seems difficult to implement, especially when it comes to conflicting interests. A systematic approach of the concept of integration could be based upon a distinction between three aspects: content, process and organization. *Content* is about the physical side of integration, the land uses and their relations. *Process* is about the way things are done or ought to be done. It has a procedural connotation, including communication and decision-making. Finally, the *institutional* aspects refer to organizations that are or should be involved in landscape development, but also to customs, cultural habits, etc. that are often very important for the way things are or will be done. But also legislation and regulation are institutions that have to be taken into account, the more so, because laws have a strong normative load.

According to most publications and official statements, landscape planners and designers are thinking about landscape in an integrative way, mostly at sub-regional and regional scales (McHarg, 1969; Steiner, 2000 and 2002; Von Haaren, 2004; Steinitz, 2008). This integrative landscape approach lends itself to applications in all contexts where an analysis, assessment and conceptualization is required that is comprehensive and includes all environmental factors. However, under the constraints of practice, different dimensions of the landscape are usually considered separately from each other before they are connected (usually by technical means such as overlay technique, matrix, synopsis, etc.), and their complex but crucial inter-relationships are hinted at but often only 'explained' over even neglected. In fact, it seems as if a growing body of environmental research in diverse disciplines (usually presented in a language that is specific to the field), is creating a fragmented and confused perspective of landscapes. At the same time, conflicting land-use demands and divided administrative responsibilities generate a 'designation mentality' (e.g. for allocation of land-use changes) inconsistent with the integrity and ecology of the landscape and lead to compartmentalized approaches to landscape management (Bruns, 2008).

In the light of the development of integrated multifunctional climate adaptation strategies it is important to understand the concept of integration in more detail. The work packages 1 and 2 produce knowledge about the biophysical and human responses to climate change in nature and agriculture respectively, including cross-sectoral effects. Based on these insights Project 1.2 will generate understanding about the opportunities for climate adaptation through the provision of ecosystem services by farmers and nature managers. The next step in project 1.3 is to explore design options (spatial visioning) on the regional level for the spatial implementation of integrated adaptation strategies. In this way it will be possible to answer questions about the effectiveness and robustness of these strategies, and about the location on which the ecosystem services will be provided.

**Aim**

To understand the concept of integration and to explore design options for the implementation of integrated multifunctional adaptation strategies at the regional level.

**Central research questions**

- What is de meaning of 'integration' and which criteria may be used to understand the integrative aspects of the landscape?
- How to apply these criteria in the development of design options for integrated multifunctional adaptation strategies in the case study areas? How should landscape planning, design and management be organized in order to be effective, efficient and sustainable?
- On what locations will these ecosystem services be provided and is the robustness of these services expected to be sufficient? How can financial and spatial incentives help to bring required and offered ecosystem services together?

## 4.2 Approach and methodology

The concept of integration will be analyzed through a desk top study that will use literature from the spatial sciences as well as from other disciplines. The semantics of integration will be studied, and also the context and connotations of the use of the term inside and outside landscape planning, design and management. The distinction between content, process and institutions will be used to develop a set of criteria that are useful for evaluation purposes.

In doing so, the landscape will be viewed from a broad perspective. Besides nature and agriculture more land-uses need to be taken into account, such as recreation and heritage. This will be based on the concept of the metropolitan landscape. This concept aims to avoid oppositional and negative connotations between urban and rural, because this distinction has lost most of its relevance in a densely populated country such as the Netherlands. 'Metropolitan landscape' refers to an environment or living space dominated both physically and socially by the impact of a metropolis, whereas the landscape in and surrounding this metropolis can be linked directly and indirectly to forms of land-use that are typical of urban life (Van den Brink et al., 2006; Van der Valk and Van Dijk, 2009).

Based on this concept of the metropolitan landscape and the criteria for integration, the optimal allocation of a selected set of adaptation measures will be simulated, using a spatial economic framework based on the Land Use Scanner (see project 3.1). the analysis starts with an economic valuation of the suitability (potential benefit) of locations for the specific uses in the case study areas. This work builds on recent research on the role of location (Scholten et al., 2009) and on land prices (Dekkers, 2010). This analysis of suitability will then be confronted with the demand for specific (combinations) of land-use functions and ecosystem services. In this context function combinations may be evaluated as involving costs (for restrictions) or benefits (in case of subsidies). The modelling framework will then simulate the competition between different functions and result in a multifunctional allocation of land-use types. An interesting challenge in this respect is the incorporation of an 'agglomeration bonus' that should arrange for the development of sizeable, contiguous areas with a similar function. Biodiversity objectives, for example, are more easily met when larger areas are devoted to nature management. This work may benefit from initial experiences with the incorporation of ecosystem values in comparable land-use modeling frameworks (Hartig et al., 2010; Willemen et al., subm.). The more generic and fundamental issues related to the incorporation of multifunctional land-use will be dealt with in Theme 8.

The resulting framework can be applied to underpin the case study specific discussions on various adaptation measures with an economic rationale. For these discussions, various design principles and options will be explored. To this end, the newly developed (but hardly tested) design option of the Land Use Scanner will be used, which allows for an active participation of local stakeholders. With the help of this *combined design and land use modelling environment* several issues related to the provision of ecosystem services will be addressed, such as the influence of scale, the role of 'ownership' (participative design activities lead to common vision and involvement but not necessarily to the ownership that is needed for change), and the influence of metropolitan landscape functions (i.e. water storage in combination with recreation lakes).

## 4.3 Scientific deliverables and results

The project will result in three scientific papers on:

- Understanding the concept of integration and developing criteria for multifunctional adaptation
- Modeling framework for the allocation of land-use types
- Development of and application of a combined design and modeling environment to increase regional adaptive capacity in response to climate change

## 4.4 Integration of general research questions with hotspot-specific questions

Many hotspot questions deal with integration issues and their practical applicability. Questions such as: what does multifunctionality mean in practice?; which functions can or should be combined?; what locations are in particular promising? Stakeholders try to find answers to these and other questions. This project contributes to finding these answers, in particular by taking a participatory approach and actively involving the stakeholders in the research.

## 4.5 Societal deliverables and results

The project will provide important knowledge for stakeholders and policy makers within the following fields:

- Understanding the concept of integration and the pros ad cons of applying this concept in practice
- Opportunities for the multifunctional allocation of land-use types and ecosystem services in a metropolitan landscape to increase regional adaptive capacity
- The role of financial and spatial incentives for the implementation of ecosystem services
- Developing ownership on possible adaptation strategies through an interactive approach

## 4.6 Most important references

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