Drivers and consequences of adaptation by farmers

Work package leader : Dr. M.M. Bakker

Content

1 Description work package

1.1 Problem definition, aim and central research questions

Problem definition

Agriculture in developed countries has changed considerably over the past decades. Technological innovations often combined with (common) agricultural policies have boosted agricultural productivity. As total food production cannot expand as much as total production in the economy as a whole, because of limits to the demand for food (as well as other agricultural products), ever fewer farmers are needed for the total agricultural production, at least in Europe. Farmers are therefore faced with the choice between expanding their farms, finding additional sources of income or quitting farming. In scientific debates the notion has risen that modern agricultural regimes have moved from productivism, to post-productivism, to multi-functionality. Many researchers have attempted to conceptualize this transition, but found that diversity and spatial heterogeneity are important complicating factors that should be taken into account. Also Dutch agriculture has experienced the above-sketched development, and indeed the diversity and spatial heterogeneity of farming strategies is considerable. Over the past 50 years, the overall number of farms decreased by 75%, while the average farm area increased from 6 to 26 ha. For many farmers producing food for the market is still the primary source of income, and the tighter global food markets provide new perspectives for these farmers. But because space is a limiting factor in the Netherlands, and not all farmers have the means or the will to expand, many opt for diversification, such as landscape management, recreation and other service-provision that is not directly related to production of food for the market (i.e. the multi-functionality course).

In the future, climate change may also become a driver of importance. Although the impacts of gradual climate change are projected to be minor compared to the other drivers, the increasing frequency of extreme events, such as heat waves and hail storms, are expected to cause problems for certain crops.

Famers may decide to change crops and their management to avoid climate-induced income losses, and they may even capitalize on changing circumstances, for instance by growing water-logging resistant energy crops.

The different directions of development sketched here can be considered adaptation strategies. Not primarily to climate change but to global change in the widest sense (i.e. economy, demography, international policy). As global change is an important driver for agriculture, this is the context that determines what (climate-related) services farmers are able to provide in the future. This work package contains two projects: one aims at identifying the driving factors behind these adaptation strategies; the other focuses on the consequences of adaptation strategies in termsof services provided and the overall viability of the farms.

With respect to the drivers of adaptation strategies and their spatial variability different studies use a range of assumptions, but these are poorly underpinned by empirical evidence. For instance, some assume that farm size is an important determinant: small farms probably diversify to continue farming, while large farms specialize in food production and do not need to diversity; others assume that young and innovative farmers are more multifunctionally oriented than older traditional farmers; and yet others consider the regional demand for diversification functions as the main determinant. As the different distinctions do not coincide, more empirical research is needed of what determines farmers' preferences for adaptation strategies.

The feasibility and viability of present and future adaptation strategies require an assessment from an integrated economic, environmental and societal perspective and at multiple scales. Policy makers, farmers and other actors cannot always oversee the consequences of their actions, and their preferred adaptation strategy may not be as effective as foreseen, or produce negative effects for nature, agriculture or society which should be timely monitored.

Aim

This work package aims at (i) identifying the driving factors behind adaptation strategies, and (ii) investigating the consequences of adaptation strategies in terms of feasibility and viability for the farm itself and the services provided to nature and society.

Research questions

- How do climate and global change affect the viability of agriculture? Which farm types will survive and which not?
- What are feasible and effective adaptation strategies for different farm types and which services can farmers provide?
- What are the effects of food production and other services provided by farmers on nature conservation? What are the success and failure factors for synergies between agriculture and nature at farm, field and regional level?

1.2 Interdisciplinarity and coherence between the projects

This work package focuses on (a) the decision-making processes related to land-use management and (b) how changes in management affect the performance of a range of functions. The work package contains two corresponding projects: one assesses the drivers of adaptation; the other assesses the consequences of adaptation. The adaptation itself is simulated in project 1.2, which therefore forms an important link between the two projects in this work package.

The interdisciplinary of this work package consists of combining and integrating biophysical and behavioural sciences. Project 3.1 aims at identifying the goals, decision-making processes, and the constraints faced and perceived by farmers from observed behaviour (available statistics) and from interviews and questionnaires. It has the ambition to feed the agent-based model in WP1 with decision rules. These decision rules will be translated into spatially explicit land use and management maps, which will be used by project 3.2 to compute the economic and biophysical consequences of different adaptation strategies. The triggers and constraints to which the virtual farmers in the agent-based model are sensitive, partly come from the conditions imposed (global and climate change scenarios), but also result from their own autonomous behaviour.

1.3 Stakeholders

See Section 4B.

2 Project 3.1 Drivers of adaptation by farmers

Project leader: Dr. M.M. Bakker

2.1 Problem definition, aim and central research questions

Problem definition – societal

Much of the Dutch rural area - and virtually all agricultural land - is privately owned. As Theme 3 focuses on feasible development pathways towards a climate robust rural area, we have to take into account the personal goals of farmers. Farmers have different adaptation perspectives (Agricola et al, 2008; Van der Ploeg, 2009) that can be summarized as follows:

- Continue producing food for the market, by:
  - increasing land and labour productivity (by adapting management or by reaping economies of scale), or
  - adapting the product mix
- Diversify, by:
  - providing green-blue services in return for governmental compensation, or
  - (further) develop non-agricultural income-generating activities (tourism, on-farm processing).
- Quit farming and sell the land

When policy (i.e. incentives, but also the planning of new nature and urban areas) takes into account these different preferences, it can achieve that agricultural developments contribute to societal goals with the least possible intervention. At the same time the potential of farming can be maximized which ensures a vital rural area.

Problem definition – scientific

Until now, farmers' decisions are often predicted using economic farm models, fed with biophysical knowledge on crops, farm management and farm resource endowments under a range of biophysical, economic and policy constraints (Janssen and Van Ittersum, 2007). Although these models can include multiple objectives (such as riskavoidance), the basic assumption is that farmers will attempt to maximize their profit. In reality, we know that farmers are only partly driven by economic motives and often they are satisficers instead of maximizers. Farmers choose to farm because they appreciate independence, because of family traditions, because they love their land, the countryside, their animals, etc. (Schnabel, 2000; Willock et al., 1999). Moreover, alternatives to farming are in practice often limited for a number of reasons that are not easily captured in economic and biophysical models (Schnabel, 2000). Therefore, a more sociological approach is required so as to strike a balance between generalization (needed to make the results applicable to quantitative models), and attention to the complexity of individual motives.

Aim

The aim of the project is to understand what moves farmers and to classify them according to their preferences and perspectives. In this way (i) the (current and future) adaptation preferences can be identified in a spatially-explicit manner; and (ii) policy instruments can be tailored to achieve maximum efficiency. Also, this project will generate information to feed the agent-based model in project 1.2.

Central research questions

- First, we are interested in which characteristics of farms, farmers and locations are associated to the different adaptation perspectives. We aim to understand the associations found and identify which ones contribute most to the climate-robustness of rural areas (e.g. the preference to provide water retention services by extensive livestock farmers in areas with periodical excess of water) and which ones are unfavourable in this respect (e.g. the preference for intensification by pig and poultry farmers adjacent to urban areas);
- Secondly, we aim to understand what makes a farmer choose a particular strategy and what constraints farmers face. Some of these triggers and constraints are exogenous (i.e. climate change, commodity prices, EU subsidies), while others are the result of policies designed by the stakeholders of this project. The latter will allow the stakeholders to explore (the limitations of) their influence on farmers' adaptation behaviour.
- This project provides input for project 1.2, which will eventually simulate the future distribution of farms, and the performance of these farms and the services they provide will be identified in project 3.2 and 1.3.

2.2 Approach and methodology

The research consists of two parts: one is an analysis of statistical data, i.e. the data on farm, farmer and location properties; the other is an analysis of value-driven data, i.e. farmers' perception of and attitude towards future problems and opportunities. The first part will cover the national level; the second part covers the case study areas.

The first part will use various sources of information: (1) The agricultural census, comprising data about farm type, farm size, labour force (family and non-family, permanent and casual), management, produce, livestock, diversification, equipment, etc.; (2) the InfoGroma database[1], an extract of the cadastre, in which all transactions of parcels outside urban areas in the Netherlands are recorded. For each transaction, characteristics such as price, date of sale, type of buyer and seller, and parcel location are included. Both the agricultural census and the InfoGroma database will be linked in a GIS to (3) location characteristics such as accessibility, soil type, water level, geomorphology, and neighbourhood characterization. This part will provide insight into correlations between the characteristics of farms, farmers, and locations, so that clusters can be identified. This will guide our orientation on the case study areas, by revealing which (groups of) farm(er)s can be expected here (relative to the agricultural population in general).

The second part consists of in-depth interviews, followed by a questionnaire survey. We opt for in-depth interviews rather than workshops because the latter approach tends to generate a biased sample (e.g. of active, well-informed farmers). Moreover, farmers may get weary of participating in sundry workshops. This can be avoided by visiting them at home and have a face-to-face conversation. Also, semi-structured interviews allow optimal exchange of information. Interviewees will be selected based on the clusters identified in part 1. During the interviews farmers will be confronted with a certain future scenario concerning climate, market, EU policy, and national and regional policy (including impacts on crop productivity and externalities, should the farmer not already have this knowledge his/herself). Given this scenario, the farmers can indicate their preference for one of the four (or even alternative) adaptation strategies. This will also generate a good view on whether (certain) farmers tend to specialize in or spread across adaptation strategies. Next, they will be asked whether and how this preference will change when individual scenario constituents change (e.g. water price or other climate variables), so as to identify the sensitivity to individual driving factors.

The open nature of the interview will furthermore allow an in-depth elaboration of drivers and constraints the farmers' experience. In relation to this, a link with project 3.2 from Theme 7 is envisaged. That project examines policy instruments for service provision (e.g. water retention by farmers) with respect to trade-offs between acceptability (legitimacy and fairness) and efficiency. Also, for the future simulation of project 1.2, determinants of farm continuity (e.g. presence of a successor) will be discussed.

The results of the interviews will be coupled to the sub-databases[2] generated in the first part, to explore whether or not certain patterns emerge (e.g. large arable farms aim to intensify). Based on the interviews, a survey (regionspecific) will be designed and circulated among the non-interviewed farmers, in order to see whether these preliminary patterns can be statistically confirmed.

[1] Endorsement of this project by DLG should allow this database to be available for study
[2] sub-databases are extracted from the national database for each case study area

2.3 Scientific deliverables and results

- Input for project 1.2: information to construct rules for agent-behaviour
- Input for project 3.2: information to feed models that compute consequences of adaptation strategies
- Scientific knowledge (i.e. peer-reviewed papers) of driving factors of land use / management change
- Scientific knowledge (i.e. peer-reviewed papers) of how farmers perceive climate change, and their preferred adaptation strategies.

2.4 Integration of general research questions with hotspot-specific questions

The hotspots are particularly interested in future farm management. They want to know whether and how the future perspectives of farmers and the corresponding adaption strategies match with certain societal / governmental aims. They acknowledge the fact that farmers are generally independent decision-makers and are highly aware of the limitations of policy instruments to steer farmers' behaviour. For that reason they appreciate the approach to follow the autonomous tendencies of farmers as much as possible. They also appreciate the method of in-depth interviews with farmers, particularly when this method is used to hear from the farmers themselves on what conditions they choose strategies preferred by government. The spatially explicit nature of this research is of particular interest for the hotspots, as it gives them guidelines on where to implement certain policies, and what responses to policies to expect where.

2.5 Societal deliverables and results

- A description of preferred adaptation strategy for each farm type (including sensitivity to triggers and constraints);
- Maps indicating the spatial distribution of preferred adaptation strategies;
- Maps indicating the obstacles to match with certain societal / governmental aims
- Farm(er)-, service- and region- specific guidelines for remuneration for the provision of services

2.6 Most important references

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3 Project 3.2 Consequences of adaptation by farmers

Project leaders: Dr. P. Reidsma and dr. Ir. M.K. van Ittersum

3.1 Problem definition, aim and central research questions

Problem definition

Although adaptation to climate change and global change is considered an important issue for the development of agriculture in the coming decades, no studies have assessed the likely adoption of adaptation strategies and their effectiveness from an integrated and multi-scale perspective. Socio-economic and political conditions and farm management strongly influence current farm performance and will also influence adaptation to future changes (Reidsma et al., 2010). In the context of climate change, the identification and assessment of impacts have focused on food production, while in the multifunctional landscapes envisaged in the Netherlands, there is a need to identify adaptation strategies that are effective in achieving a climate-robust, resilient multifunctional landscape, which contribute to both economic and environmental objectives.

Climate change must thus be considered in the context of other drivers of change, whereas assessments should shift from impacts of adaptation on food production to integrated assessments. Such assessments include other ecosystem services and a broad range of environmental and socio-economic criteria. A climate-robust, resilient multifunctional rural landscape can only be obtained if farmers contribute to nature targets. However, as biodiversity research has mainly focused on nature areas, and less on the added value of changes in agricultural practices, there is little knowledge on the cross-sectoral effects of adaptation strategies in agriculture and nature. A substantial number of farmers is willing to contribute to biodiversity conservation, but they need economic incentives. Moreover, conservation objectives can possibly be realized at different levels of scale through integration of agriculture at either farm level or at regional and national level through segregation of agriculture and nature. Trade-offs between food production, farmer's income and environmental services should be assessed to identify effective and feasible adaptation strategies.

This research will assess the consequences of agricultural adaptation strategies to climate, market and policy changes on different farm types and the implications for nature quality in the rural areas. Specific attention is given to address the impact of agricultural management on nature within the agricultural landscape and on the surrounding biodiversity. This project mainly focuses on the farm level, but as the impact of environment al services will become apparent at landscape level, farms will be considered in the multifunctional landscape.

Aim

Identifying the economic, environmental and societal consequences of agricultural adaptation strategies to climate, market and policy changes on different farm types in the multifunctional landscape

Research questions

- What are the impacts of agricultural adaptation strategies on (socio-)economic indicators such as food production and farmers' income for different farm types?
- What are the impacts of agricultural adaptation strategies on environmental indicators such as nutrient leaching, water use and biocide use for different farm types?
- How do impacts on environmental indicators relate to habitat quality and connectivity?
- How can ecosystem services provided by farmers contribute to adaptation strategies for nature?
- What are the social-economic consequences of these ecosystem services and to what extent are these compatible with different farm types?
- How can the preferred adaptation strategies of the farm types present in a region be effective to achieve a climate-robust, resilient multifunctional landscape?

3.2 Approach and methodology

In project 3.1, farm types including their characteristics are spatially allocated and their preferences for adaptation strategies are explored. In this project, we will assess for each scenario the extent to which these adaptation strategies can indeed be viably adopted per farm type, by exploring (i) the consequences on economic, ecological and social indicators, and (ii) the interaction with nature conservation aims.

All inputs and outputs of land use activities will be quantified (as far as data is available and/or can be generated), which includes monetary and physical inputs and outputs, but also other social (private and public) costs. We intend to use bio-economic farm modeling (BEFM) (Janssen and van Ittersum, 2007; Van Ittersum et al., 2008) to assess both economic and environmental aspects of adaptation. When using a normative approach, solutions of a BEFM can be based on economic objectives such as income maximization or risk minimalization, and on environmental objectives such as minimizing N leaching. Recently, the positive approach is being used in more studies, which allows calibration towards the observed situation and simulating likely changes instead of optimal solutions (Kanellopoulos et al., 2010). Farmers' behaviour is however not explicitly modelled, but implicitly included in cost functions related to the land use activities. Results from this project on both costs and effectiveness of adaptation options (within the context of EU policies) for different farm types will feed into the ABM (WP1). The ABM includes more information on farmer’s behaviour including interactions between farmers, while the bio-economic model supplies the ABM with information on the costs and benefits of different adaptation strategies. Innovative in this project is that the BEFM is further linked to the ABM to allow more explicit modelling of farmers (economic) decisionmaking processes.

As a first step land use activities (current and alternative) will be identified and quantified (Van Ittersum and Rabbinge, 1997). As inputs (e.g. fertilizer application and labour costs), and outputs (e.g. crop yield and nitrate leaching) differ per farm, data needs to be collected on the current practices and possible developments towards 2050, which will partly come from the interviews held in project 3.1. The impacts of climate extremes on a variety of crops and appropriate adaptation strategies have been explored with stakeholders for the North of the Netherlands (Schaap et al., 2009). Crop models and complementary methods will be used to translate and quantify these into land use activities. When all input-output relationships of land use activities, including adaptation strategies, have been estimated, the bio-economic model can simulate the consequences of adoption of adaptation strategies in terms of economic, environmental and social indicators. This integrated assessment will show whether preferred adaptation strategies are effective in coping with changes in climate, market and policy at farm level. The results of this assessment will be fed back to the ABM in project 1.2, so that farmer’s decisions may be influenced by the results of their actions. Interaction with the agent-based model of project 1.2 allows assessing impacts of adaptation strategies at farm level as well as structural changes at landscape level.

The innovation in this project lies in the use of bio-economic farm models for integrated assessment of adaptation strategies to climate change, and specifically in i) including the impacts of climate extremes on crop production, and ii) the development of a methodology translating the impact of environmental indicators to ecosystem habitat quality and connectivity, to enable the assessment of cross-sectoral effects at landscape level.

Adaptation strategies supporting both agriculture and nature (e.g. water retention) or strategies that are conflicting (e.g. irrigation) have been qualitatively identified (Blom et al., 2008), but not yet quantified. Agricultural models can currently provide outputs on externalities such as water quality (nitrate and phosphorus leaching), water quantity (water use by irrigation), soil acidification (NH3 emissions), air pollution (pesticide emissions, greenhouse gas emissions), and cropping pattern. These externalities will be translated into their impact on the ecosystem habitat quality and connectivity. At the same time, alternative multifunctional land use activities will be designed that can positively impact ecological and economic indicators (e.g. Korevaar et al., 2006). These include linear elements like hedgerows, field margins or canals (Jellema, 2008). Indicators of biodiversity can focus on functionality (Moonen and Bàrberi, 2008), for example pest control, but can also be aggregated into one ecosystem quality index (Reidsma et al., 2006), allowing to perform a quick-scan of biodiversity in a multifunctional landscape. In this context, a link will be developed to the model INITIATOR2 (De Vries et al., 2005) that calculates emissions of NH3, NOx, N2O, CH4 and CO2 from agricultural systems, the linkage between NH3 emissions and N deposition on nature areas and the accumulation, leaching and runoff of carbon, nutrients (nitrogen, phosphate and base cations) and metals to ground water and surface water.

3.3 Scientific deliverables and results

- Scientific knowledge (i.e. peer-reviewed papers) on the impact of agricultural management on ecosystem services including biodiversity
- Scientific knowledge (i.e. peer-reviewed papers) on impacts of adaptation strategies to climate, market and policy on multifunctional agriculture
- Input for project 1.2: Information to assess cross-sectoral effects of adaptation strategies in agriculture and nature
- Input/feedback for project 1.3: Quantified indicators per farm type, to be used in the agent-based model (ABM).

3.4 Integration of general research questions with hotspot-specific questions

The main questions in the Dry Rural Areas focus on the integrated impacts of climate change on water, nature and agriculture. A transition from a food production oriented landscape towards a multifunctional landscape is envisaged. The development of multifunctional agriculture is thus of major concern, which is also the case in the Waddenzee and the Shallow Waters and Peat Meadow Areas. Questions that can be addressed in this project include:

- What are the criteria for sustainable and climate robust development of farms and how can these be quantified?
- What are the economic perspectives of a farm in a food production oriented landscape that changes to a farm that broadens its objectives towards ecosystem services related to water and nature?

- What is optimal nutrient management in the rural area (fertilizer application, buffer zones, water management) to reduce nutrient emissions towards surface water and the atmosphere?
- How can the desired agricultural and economic development be dovetailed with communal policy?

3.5 Societal deliverables and results

By performing an integrated assessment of the impacts of agricultural adaptation strategies on food production and environmental services such as biodiversity, this project will better inform discussions between nature managers, farmers and policy makers. Nature managers will obtain more insights in the constraints of farmers to change management, while farmers will get more insight on the impacts of adaptations on the environment. Policy makers will benefit because they are provided with a better information basis to streamline autonomous developments and required adaptations.

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