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Integrated impact assessment of climate and socio-economic change on dairy farms in a watershed in the Netherlands

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ABSTRACT

Climate and socio-economic change will affect the land use and the economic viability of Dutch dairy farms. Explorations of future scenarios, which include different drivers and impacts, are needed to perform ex-ante policy assessment. This study uses a bio-economic farm model to assess impacts of climate and socio-economic change on dairy farms in a sandy area in the Netherlands. Farm data from the Farm Accountancy Data Network provided information on the current production levels and available farm resources. First, the farm plans of individual farms were optimized in the current situation to benchmark farms and assess the current scope for improvement. Secondly, simulations for two scenarios were included: a Global Economy with 2 °C global temperature rise (GE/W+) and a Regional Community with 1 °C global temperature rise (RC/G). The impacts of climate change, extreme events, juridical change (including abolishment of milk quota), technological change and price changes were evaluated in separate model runs within the predefined scenarios. We found that farms can increase profit both by intensification and land expansion; the latter especially for medium sized farms (less than 70 cows). Climate change including the effect of increased occurrence of extreme events may negatively affect farm gross margin in the GE/W+ scenario. Lower gross margins are compensated for by the effects of technology and price changes. In contrast with the GE/W+ scenario, climate change has positive impacts on farm profit in RC/G, but less favourable farm input-output price ratios have a negative effect. Technological change is needed to compensate for revenue losses due to higher input prices. In both GE/W+ and RC/G scenarios, dairy farms increase production and the use of artificial fertilizer. Medium sized farms have more options to increase profit than the large farms: they benefit more from the abolishment of the milk quota and better adapt to negative and positive impacts of climate change.

While the exact impact of different drivers will always remain uncertain, this study showed that changes in prices, technology and markets have a relatively larger impact than climate change, even when extreme events are taken into account. By using whole farm plans as activities that can be selected, the model is grounded in observations, and it was shown that half of the farms are gross margin maximizers as assumed in the model. The model therefore indicates 'what could happen if', and gives insights in drivers and impacts of dairy farming in the region.

1. Introduction

Climate change is expected to affect food production, land use and economic viability of farms across the world [1]. The chapter on food security and food production systems in the latest IPCC WG2 report [1] shows that advances have been made in the assessment of climate change impacts on crop yields, but considerably less research has been conducted on the impact of climate change on livestock systems. In addition, the impacts of crop yield changes have been included in the food systems and food security research, but not in the context of other drivers of global change such as technology, prices and policy. These socio-economic changes also influence food production, land use and economic viability [2,3] and need to be considered when the impact of climate change is studied [4–6].

Until now, technological development, by genetic improvement as well as crop management, had a much larger influence on crop yields than climate change, and this is expected to remain so in

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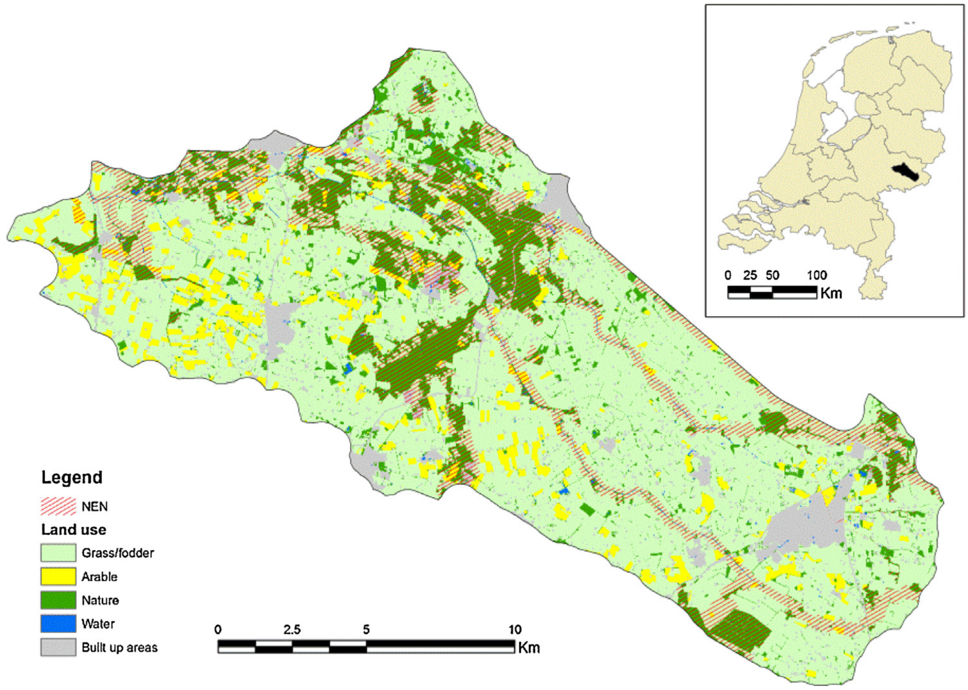

Figure 1. The location of the Baakse Beek area, the current land use, and the location of the National Ecological Network (NEN).

the near future [2,7, 8). This is also the case for milk and other livestock products [9]. Economic development, by decreasing prices of agricultural products in the last decades, has reduced investment in agriculture, and induced farm structural change [10–12]. Finally, agro-economic and environmental policies including the Nitrates Directive [13,14], sugar beet quota [15] and milk quota [16–18] also influence production, land use and economic viability of farming within the European Union (EU). To evaluate the effects of climate change on farming systems, integrated assessments that account for yield, price and policy changes are required.

Bio-economic farm models have often been used to assess the impacts of policies, technological innovations and in a few cases of climate change on farm performance [19,20]. Kanellopoulos et al. [15] performed an integrated assessment of climate and socio-economic change on arable farming in a province in the Netherlands. This study projected positive impacts of climate change on average farm profit, but also indicated that the influence of prices, policy and technological development will likely be larger. As dairy farming occupies 66% of the agricultural area in the Netherlands, and the export value of Dutch dairy products was 5.8 billion euros in 2012 [21] it is relevant for the Dutch agricultural sector and landscape to also assess impacts of climate and socio-economic change on dairy farming. Few examples of studies assessing impacts of climate change on dairy farming exist [22–26], and to our knowledge Kalaugher et al. [5] is the only one that integrated climate change in the context of other changes.

For the Netherlands, several dairy farm models have been developed for different applications [27,28]. These bio-economic farm models optimize decision making of representative farms. For Dutch and European farms a large amount of input and output data is available for individual farms, which can be used to account for variability in resources and management when assessing impacts of changes [15].

To assess the impacts of climate change and technological innovations on crop yields, bio-economic farm models use outputs from crop simulation models [e.g. 15, 29]. For North-west Europe, these crop simulation models predicted that climate change will increase yields of most crops [2,30,31]. However, they do not consider the effects of extreme events like droughts and prolonged wet conditions. The increased frequency of such extreme events and the expected additional damage from pests and diseases might counteract the expected positive effects of climate change on yields [5,30–32]. As a result, a comprehensive assessment of the effect of climate change on dairy farming systems cannot neglect the impacts of extreme events.

To improve spatial planning policies, Dutch authorities require more knowledge on climate change impact on land use. Dry rural areas are one of the eight focus areas in the Dutch research programme Knowledge for Climate [33], as the sandy soils in these areas have a relatively low water retention capacity and are therefore vulnerable to water stress. The aim of this paper is to assess land use changes and economic performance of dairy farms in 'the Baakse Beek', a sandy area in the Netherlands. A bio-economic farm model was used to benchmark dairy farms in the region and evaluate the impacts of integrated scenarios of climate, technology, price and policy change for 2050.

2. Methodology

2.1. Case study area and data

'De Baakse Beek' is a watershed located in the East of the Netherlands, in the province of Gelderland, and covers roughly 300 km^2 (Figure 1). The region is characterized as a dry rural area in which sandy soils are predominant. Ground water levels vary over the region from 0 m to 10 m below ground with a gradient from west to east. Very dry as well as extremely wet conditions exist. In total there are 443 dairy farms which cover 59% of the total agricultural area. The main land use activities of specialized dairy farms are grass and maize cultivation [34]. Similar to other areas in Western Europe, agriculture is intensive, with average milk yields of more than 7000 kg/cow/year. The region has characteristic natural features, and spatial planning policies aim for enlargement of the National Ecological Network (NEN).

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