A data-driven agent-based modelling approach to agricultural transition in England

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Introduction:

Following its departure from the EU, the UK government has embarked on ambitious reforms in its agricultural policies to address the imperatives of food security, sustainable farming practices, livelihood maintenance, and environmental conservation (Defra, 2023). In England, the European Union's Common Agricultural Policy (CAP) has been succeeded by Environmental Land Management schemes (ELMs). This transition entails the gradual phasing out of direct income support to farmers, which was based on the amount of land they maintained, within the period spanning 2022–2028. The surplus budget is now redirected towards incentivising farmers and land managers to deliver environmental benefits alongside agricultural production. Given the substantial implications of ELMs on farmers' income and the pivotal role of farm-level agents in navigating this transition, an ex-ante assessment of their decision-making processes, interactions, and adaptive behaviours in response to the new policies assumes paramount importance. While empirical data on the impacts of these policies remain limited, socio-ecological simulation models offer robust and reliable insights into their efficacy (Huber et al., 2023).

Aim and Objectives:

This research utilises agent-based modelling (ABM) *to construct a data-driven simulation model of farm-level agents for the ex-ante evaluation of ELMs in England*. The study particularly investigates the potential of the new policy to incentivise English farmers to embrace agroforestry and mixed farming practices, both deemed crucial in facilitating an agroecological transition. The resulting model aims to achieve the following objectives:

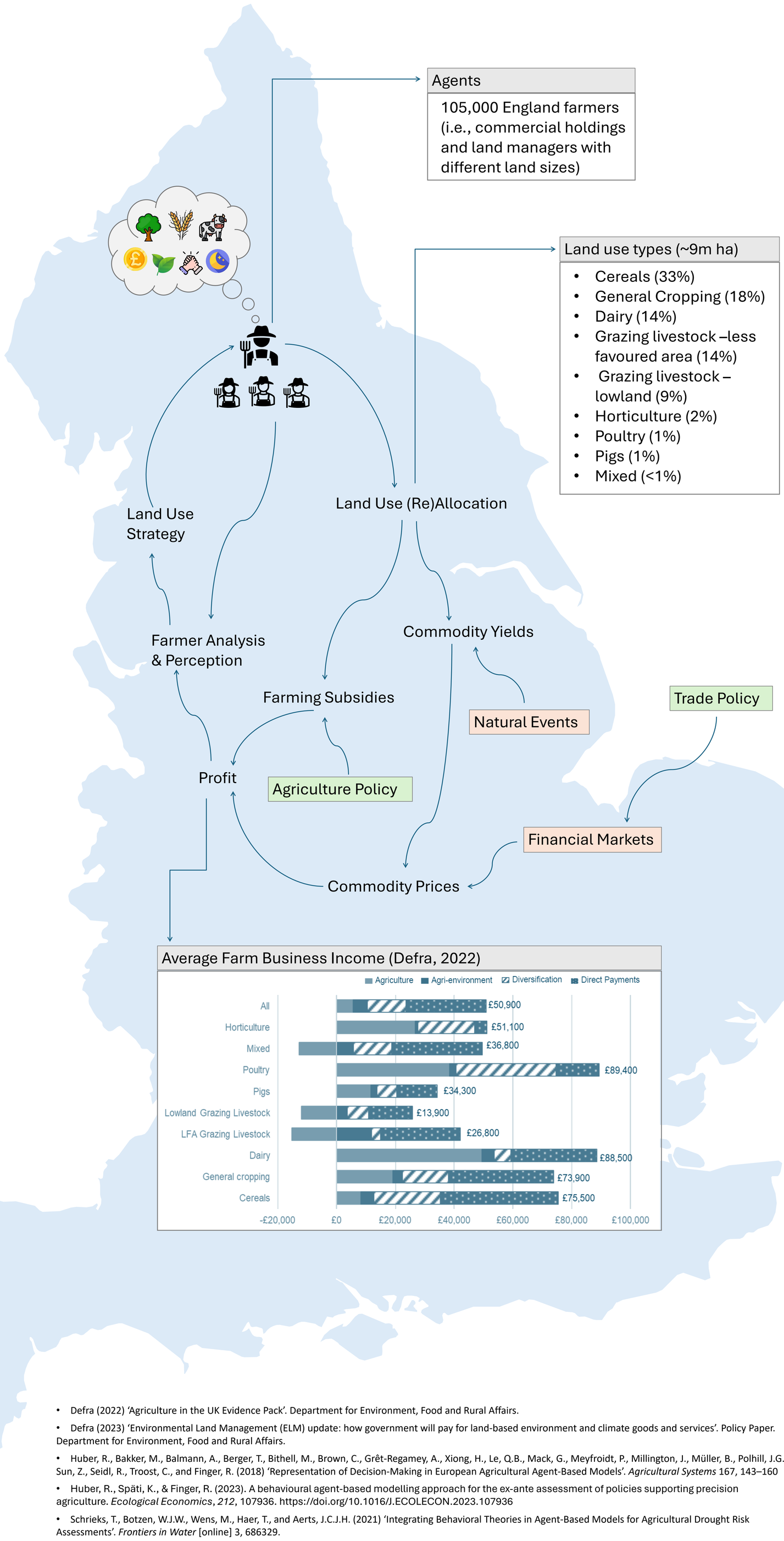
1. Analyse the impact of ELMs and alternative policy scenarios on land allocation to identify optimal strategies for promoting agroforestry and mixed farming.
2. Assess the ramifications of policy adoption on regional land use dynamics and resilience to external perturbations, including climate-induced events (e.g., storms, droughts) and socio-economic stressors (e.g., pandemics, conflicts).

Methodology:

Agent-based modelling (ABM) has emerged as a popular approach for analysing the heterogeneous decision-making processes of farmers within agricultural and land management systems. As a bottom-up, process-based methodology, ABM proves instrumental in unravelling emergent farmer behaviours in response to changes in economic, social, and ecological dynamics stemming from policy interventions or external disruptions (Huber et al., 2018). However, extant ABMs often lack a nuanced portrayal of intricate human decision rules drawn from the expansive social science literature (Schrieks et al., 2021). Moreover, while agroforestry and mixed farming are acknowledged as pivotal policy measures for facilitating the agroecological transition, their representation within ABM frameworks remains relatively scant in the literature. Addressing these gaps, this study aims to present an in-depth data-driven ABM that represent complex farmers' decision-making processes in the agroecological transition context.

Progress:

An initial version of the model was developed in 2022 to explore the behavioural patterns of virtual farm agents in response to hypothetical policy scenarios. Currently, the model is undergoing further refinement to incorporate economic dynamics, enhance decision rules grounded in pertinent social science theories, and integrate real-world data for facilitating ex-ante policy assessments in England.



- Defra (2022) 'Agriculture in the UK Evidence Pack'. Department for Environment, Food and Rural Affairs.
- Defra (2023) 'Environmental Land Management (ELM) update: how government will pay for land-based environment and climate goods and services'. Policy Paper. Department for Environment, Food and Rural Affairs.
- Huber, R., Bakker, M., Balmann, A., Berger, T., Bithell, M., Brown, C., Grêt-Regamey, A., Xiong, H., Le, Q.B., Mack, G., Meyfroidt, P., Millington, J., Müller, B., Polhill, J.G., Sun, Z., Seidl, R., Troost, C., and Finger, R. (2018) 'Representation of Decision-Making in European Agricultural Agent-Based Models'. *Agricultural Systems* 167, 143–160
- Huber, R., Späti, K., & Finger, R. (2023). A behavioural agent-based modelling approach for the ex-ante assessment of policies supporting precision agriculture. *Ecological Economics*, *212*, 107936. https://doi.org/10.1016/J.ECOLECON.2023.107936
- Schrieks, T., Botzen, W.J.W., Wens, M., Haer, T., and Aerts, J.C.J.H. (2021) 'Integrating Behavioral Theories in Agent-Based Models for Agricultural Drought Risk Assessments'. *Frontiers in Water* [online] 3, 686329.

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