1. **Project title. Harper Farm Digital Twin crop system model: towards data-informed future farming with DSSAT and Shiny**

Proposed by: E. Harris, M. Butler and G. Wager

1. **Background & underlying rationale, including which ES Farm group (listed below) has been engaged.** A principal challenge for agriculture production systems is to improve sustainability and resilience while continually improving productivity and efficiency. An area of promise is that of regenerative farming, where crop inputs (nutrients, water) are minimised by precision application and expected crop yield is maximised while input expenditure and impact to the environment are minimised, while other farm activities support soil formation and adjacent habitats for ecosystem services. A big focus of innovation in agriculture production systems is technology, with a recent emphasis on the role that big data and information systems can play in supporting decisions that are scalable and feasible in different sectors and across global supply chains, while being practical to use on any farm of any size. What is required to achieve this is a data platform that can be used to join disparate data associated with farm practice and the environment, and which supports modelling of inputs, and yield in order to support planning and outcomes.

A solution is that of an agriculture ‘Digital Twin’ approach (Verdouw et al. 2021), where real-world processes are represented digitally to provide a summary of past events, a representation of real-time state, and a toolset to model future outcomes based on agronomic practice. The toolset must be robust and accessible for different stakeholders, and while there are challenges in this, the availability of remote sensing information and agriculture systems modelling tools make the only barrier the availability of data and the practicality of implementation.

1. **Specific objectives of the project/activity towards the priority areas.**  Our overall aim is to create a cutting-edge crop Digital Twin crop systems model, while providing a user-friendly web-based interface as a sandbox for farm decision support, research, and teaching.

* Create an evaluate a crop model system tool for Harper Farm that can predict yield and crop phenology under a variety of scenarios including nutrient inputs, alternative nutrients (e.g. manure), soil properties, crop rotation and weather uncertainty
* Create and evaluate a simple input and output scenario tool for non-crop modellers

These objectives support the priority areas of efficient resource use, crop nutrients, use of data on farms, regenerative agriculture, road to net zero, and potentially, through alternative nutrient evaluation, manure valorisation.

1. **Programme and methodology.** Here, we propose using the Decision Support System for Agrotechnology Transfer (DSSAT) to model farming practice for the Harper Farm. This tool works for a range of common crops, soil types and agronomy systems. DSSAT is open source (MIT licence) and widely used and proven scientifically (Jones et al 2003), however it is difficult to use (EH, MB and GW all recently attended advanced DSAAT training). To mitigate this, we will:

- **create and implement a DSSAT interface** in the R programming language to streamline the decision support tool for research and teaching, and

- **create a Digital Twin dashboard** interface as a web-based Shiny app for non-technical users.

- **test model yield prediction accuracy based on yield data from Harper Farm**

- **evaluate user feedback** from the Harper academic and farm communities

1. **Detailed costing include a (FEC costing spread sheet from finance if appropriate e.g. employing staff) and justification of resources.** This work requires specialized skill in the DSSAT programme and in R programming. DSSAT is widely used globally but is not commonly used in the UK. Our programme will be to recruit an MSc Data Science student or graduate with good R skills, who will have the baseline training to rapidly up-skill in DSSAT. While the SSFF timeline is challenging, the core skills on our project team are ample to support and train a student, who will be primarily supervised by EH, and supported by MB and GW.

Data Science technician (150 hours) £3,000

Travel and publication £2,000

**Total £5,000**

1. **Anticipated achievements and outputs with specific timeline.** Our primary intended outputs will be:

* Data collation and modelling, R DSSAT Github package – 2022-01
* Launch and test Shiny dashboard 2023-01 to 2023-02
* A refereed journal article in e.g. *Precision Agriculture*, or *Remote Sensing - 2023*
* An academic seminar e.g. *International Symposium on Precision Agriculture*, and the *Harper Adams Research Symposium - 2023*

1. **How research outputs would be communicated to the wider community. Examples could be webinar, video or short course.**

Wider communication to the Harper Community will be in the form of **a series of three workshops** session introducing the basics of DSSAT and our Digital Twin Dashboard beginning in 2023-01. This will provide a forum to include and upskill colleagues and research students and will mesh with the ongoing R and statistics training community led by EH (The Harper R Users Group, HARUG!), which will include **video for asynchronous delivery**.