AI for Sustainable and Resilient Agriculture: Responsive, Explainable, and Deployable

Prof Po Yang
Pervasive Computing Group
School of Computer Science
The University of Sheffield
29/08/2026

University of Sheffield

Professor of Pervasive Intelligence (PerCom Group)
Turing BridgeAI Independent Scientific Advisor

- Pervasive Computing, Mobile Intelligence
- Data Science, Artificial Intelligence
- Smart Agriculture, Pervasive Healthcare
- 6 Aacademics, 8 PDRA, and 16 PhD students.

Pervasive computing is a rapidly advancing field where technology is deeply integrated into everyday life, processing data continuously to create smarter environments.

Core Mechanism

Continuous and embedded data collection, processing, analysis, understanding, and communication co-exist seamlessly.

Socio-Economic Impact

Technologies are woven into the fabric of lives, work, and leisure, driving significant societal and economic change.

Research Focus

Design, development, deployment, and evaluation of methodologies, algorithms, and tools—considering ethical implications.

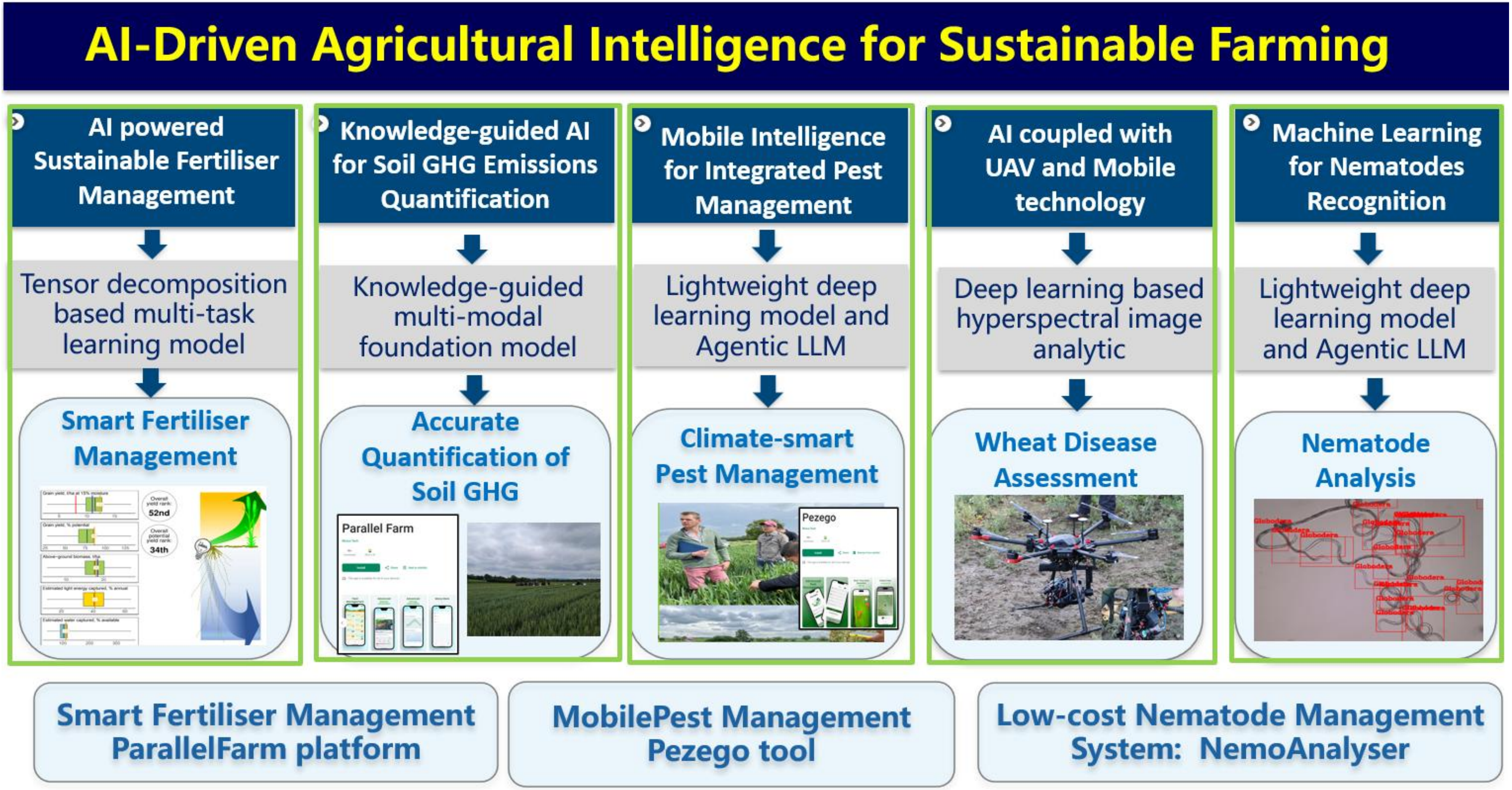
Key Application Areas

- Health & Wellbeing
- Smart Cities
- Agriculture
- Assisted Living

Collaborative Approach

We undertake fundamental and applied/translational research, working closely with key stakeholders such as the **National Health Service (NHS)** to ensure real-world impact.

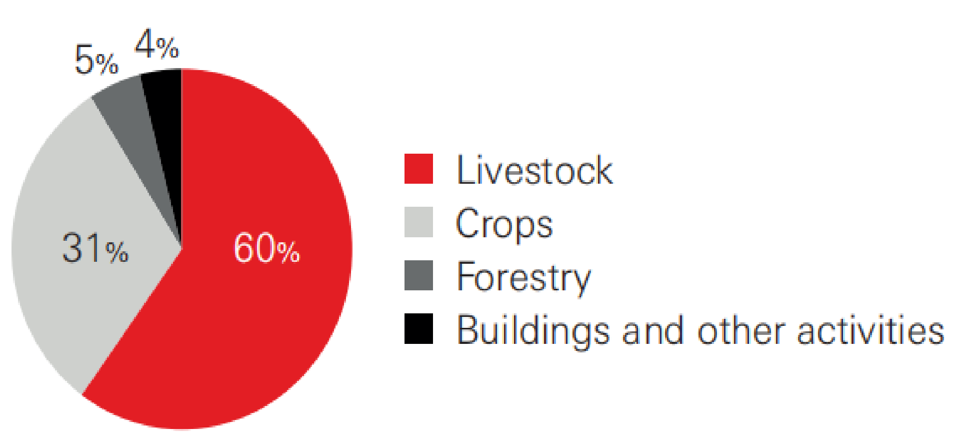
Since 2020, >£ 12 Million grants, > 40 Top AI conference and journal publications, >20 industrial consultancy contracts

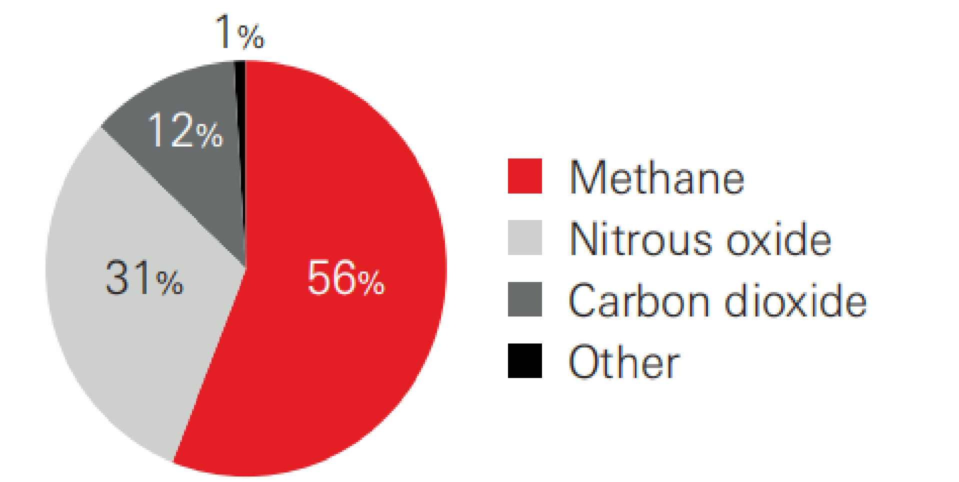

AI-Driven Agricultural Intelligence for Sustainable Farming
AI powered Sustainable Fertiliser Management
Tensor decomposition based multi-task learning model
Smart Fertiliser Management
Knowledge-guided AI for Soil GHG Emissions Quantification
Knowledge-guided multi-modal foundation model
Accurate Quantification of Soil GHG
Parallel Farm
Mobile Intelligence for Integrated Pest Management
Lightweight deep learning model and Agentic LLM
Climate-smart Pest Management
Pezego
AI coupled with UAV and Mobile technology
Deep learning based hyperspectral image analytic
Wheat Disease Assessment
Machine Learning for Nematodes Recognition
Lightweight deep learning model and Agentic LLM
Nematode Analysis
Smart Fertiliser Management ParallelFarm platform
MobilePest Management Pezego tool
Low-cost Nematode Management System: NemoAnalyser

Towards Net Zero in UK agriculture

Agriculture is a major contributor to 10% - 16% of UK greenhouse gas (GHG) emissions

- **The global food system is responsible for ~21–37% of annual emissions**
- **Agriculture has significant impacts on**
  - Soil quality, water resources, biodiversity, etc
- **UK agricultural emissions**
  - from livestock, agricultural soils, stationary combustion sources and off-road machinery.
  - greenhouse gas emissions from agriculture is up to **16%.**
  - **68% of** total UK Nitrous Oxide emissions come from the agricultural sector,
  - **66% of** these emissions estimated to be direct soil emissions





Source: Defra, 2018. Sources of agriculture emissions in the UK

Towards Net Zero in UK agriculture

UK Net Zero Goal : a 78% reduction in GHG emissions by 2035

- A productive, profitable and sustainable agriculture sector, with skilled, capable and innovative farmers accelerating UK national transition to a net zero economy.

Pillar 1

Boosting productivity to reduce emissions:

Improving farming's productive efficiency will enable farmers to produce the same quantity of food, or more, with less inputs, in smarter ways. This, in turn, will reduce greenhouse gas emissions.

Pillar 2

Storing of carbon on farmland:

By conserving what's already there and changing land management and use we can capture more carbon – in soils, bigger hedgerows and trees.

Pillar 3

Renewables and the bioeconomy:

To displace greenhouse gas emissions from fossil fuels and to create GHG removal through photosynthesis and carbon capture.

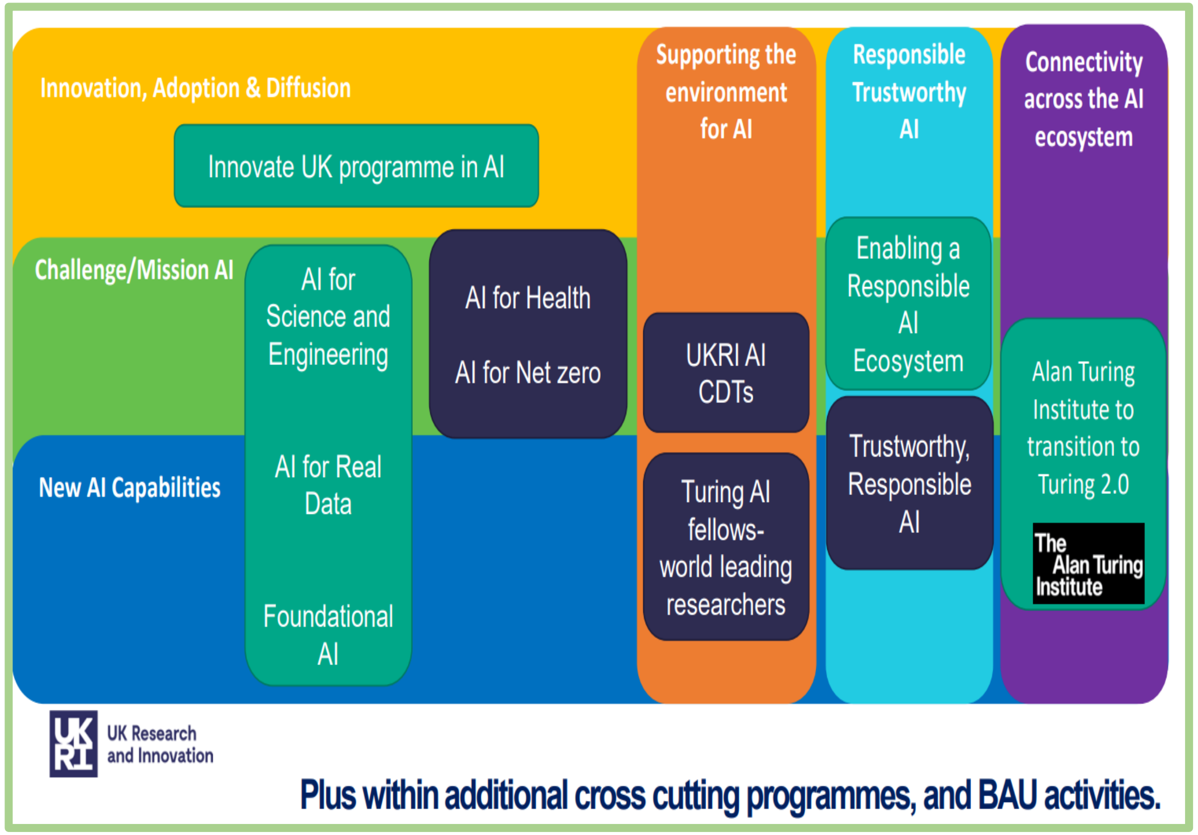
UK DEFRA

- The 25 Year Environment Plan
- Net Zero and climate change adaptation
- Supply chain and food policies

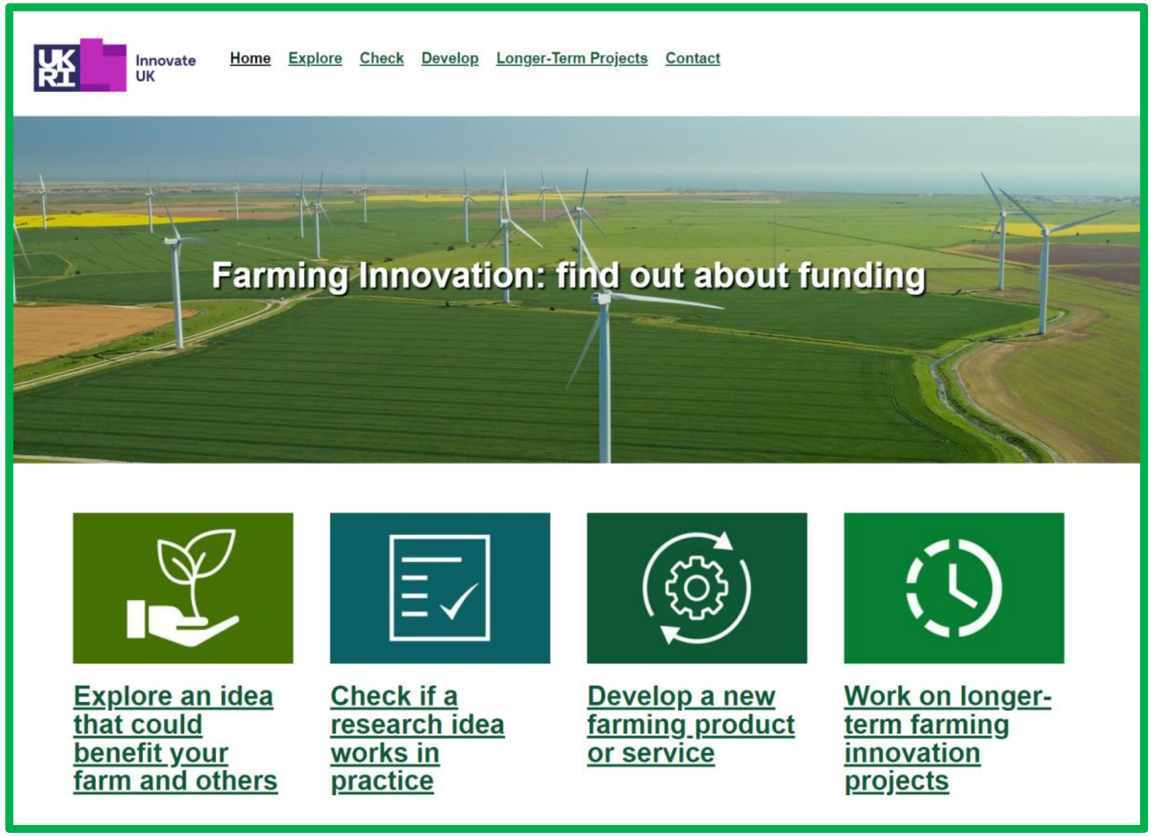
Source: Climate Change Committee, "Net Zero Technical Report," 2019.

Towards Net Zero in UK agriculture

A productive, profitable and sustainable agriculture sector, with skilled, capable and innovative farmers accelerating UK national transition to a net zero economy.



Source: EPRC, AI for Net Zero 2023.



Source: https://farminginnovation.ukri.org/

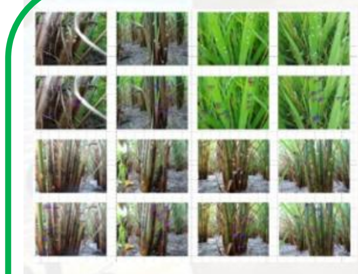
Our Vision to AI enabled Agriculture

- **Digital agriculture : Smart Sensing + Pervasive Computing + Artificial Intelligence**
    - connecting a set of interconnected devices to create an IoT network devoted to acquire large-scale agriculture data.
    - transforming agriculture more sustainable and resilient by creating new **AI-driven technologies and tools**
- **Benefits**
    - Sustainably increase productivity
    - Resilience (adaptation)
    - Reduce/removes greenhouse gases (mitigation)
    - Enhances achievement of national food security

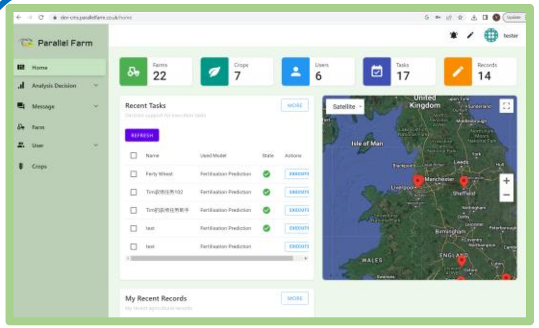
- **Government's net zero carbon emissions**
    - The UK agricultural transition plan "Path to sustainable farming".

Roadmap to Smart Agriculture

Shaping the idea and building connections



Data collection and model development



System integration and development

Products, services and standardisation

2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025

Automated Big-Data Driven Approach for Crop Disease Detection", 04/2018 – 10/2018, £23K, Newton/GCRF fund

SmartFertiser: Farmer-centred Interoperable Mobile-Cloud System, 03/2021-02/2024, £669,820, InnovateUK

MobilePest: Mobile Intelligence Solution for Sustainable Management of Wheat Pests, 09/2021 - 03/2023, £190K, InnovateUK

AI-AMMS: AI coupled with Aerial iMaging and Mobile Sensing, RCUK, 09/2022 - 09/2023, £24,954 STFC

Adaptive AI-enabled Mobile Intelligence for Climate-smart Pest Management 04/2023 – 03/2025 £480K, InnovateUK

PestGPT: Integrating Visual Intelligence and ChatGPT into a Mobile Solution for Sustainable Pest Management 09/2023 – 02/2024, £50K , InnovateUK

NemaRecognition: An AI-and molecular-driven pipeline for nematode recognition, 04/2023 – 03/2025, £74,954 , BBSRC

AIPPN: Interpretable AI enabled Molecular Identification Pipeline for Plant-parasitic Nematodes 09/2023 – 02/2024, £50K , InnovateUK

AI-enabled Climate-Smart Fertiliser Practice for Sustainable and Resilient Farming 01/2024 – 06/2026 £870K, InnovateUK

Knowledge Distillation empowered Mobile Intelligence Solution for Sustainable Management of Crop Pests and Soil Health , 02/2024 – 01/2025, £320K, InnovateUK

University KE Fundings

Investigating Deep Learning enabled UAV Image Analysis Models for Crop Disease Detection and Monitoring, 07/2023 - 06/2024, £30,017,

AI-enabled and Context-enhanced Mobile Intelligence for Sustainable Pest Management in Arable Crops, 03/2023 – 03/2024, £64,000

SmartFertiser 1.0 : Farmer-centered Interoperable Mobile-Cloud Systems, 03/2021 - 02/2024, £660K

SmartFertiser 2.0 : AI-enabled Climate-Smart Fertiliser Practice for Sustainable and Resilient Farming, 01/2024 - 09/2026, £870K

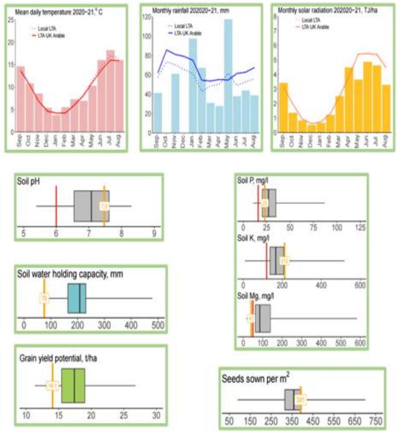
SmartFertiser 3.0 : AIFT: AI-Enabled Fertiliser and Tillage Optimisation for Sustainable Wheat Farming, 10/2026 - 03/2028, £498K

Timely delivery of AI-based fertiliser management for improved nutrient use efficiency and reduced over application of nutrients.

- Reducing crop growth stage and environmental conditions to provide climate-smart fertiliser recommendation.
- Accessing and optimising use efficiency of advance fertiliser with urease or nitrification.
- Quantification of soil GHG flex response to fertiliser applications.

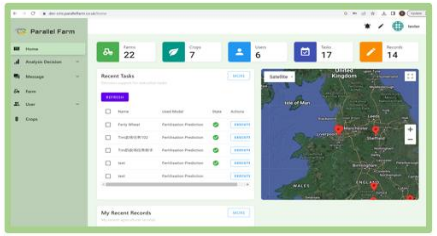
What we have done:

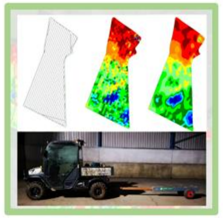
- Multimodal agriculture data acquisition



- AI model constructions
  - Fertiliser use prediction
  - Soil properties analysis
  - Crop yield prediction

- Platform development





University of Sheffield

Harper Adams University

VELCOURT

Mutus Tech

Science Island 中国科学院合肥物质科学研究院 智能机械研究所 IIM

SmartPest 1.0: Adaptive AI-enabled and Context-enhanced Mobile Intelligence for Climate-smart Pest Management to Optimise Sustainable and Resilient Farming, 03/2023 - 09/2024, £490K

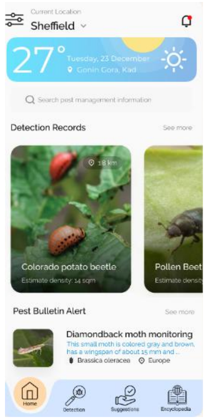
SmartPest 2.0: Adaptive AI-enabled Mobile Intelligence for Climate-smart Pest Management 04/2023 – 03/2025 £480K,

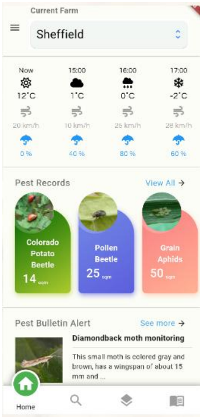
SmartPest 3.0: SmartPest-Ghana: Exploring LLM-driven mobile solutions for climate-smart pest management in maize farming 09/2025 – 03/2026 £112K,

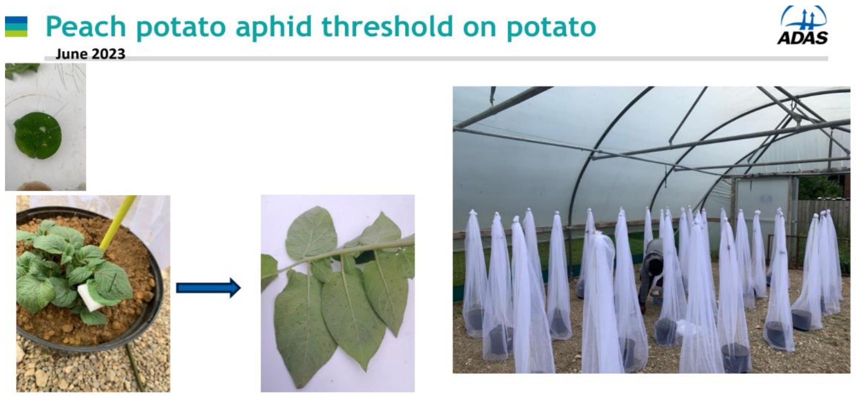
We will investigate the technical feasibility of integrating contextual and visual information **with adaptive AI techniques into a mobile solution** that offers:

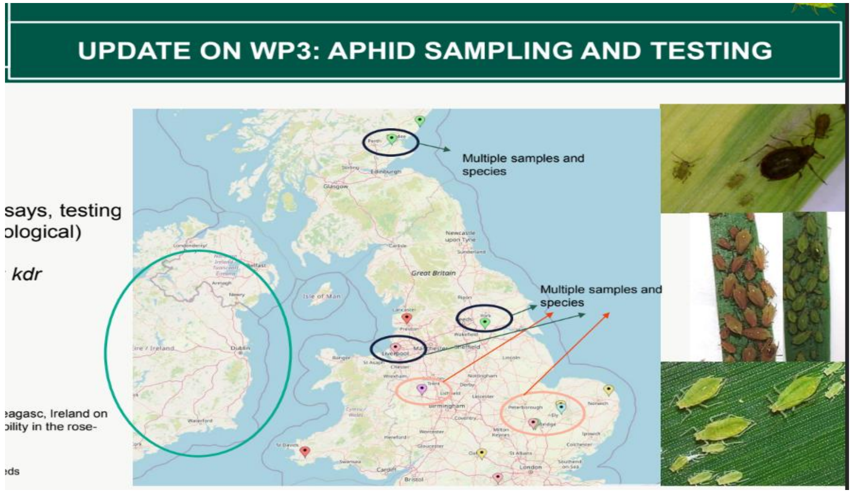
- Rapid detection and quantification of **foliar pests** using mobile devices;
- Provision of information on **accepted pest thresholds** to support sustainable pest management (including improved thresholds developed as part of the project);
- **Estimation of insecticide efficacy based on resistance** monitoring data

University of Sheffield
Mutus Tech
ADAS
RSK
UNIVERSITY OF LIVERPOOL









NemaRecognition: An AI- and moleuclar-driven pipeline for throughoput plant parasitic nematode recognition, BBSRC, 05/2023 – 10/2023, £75K

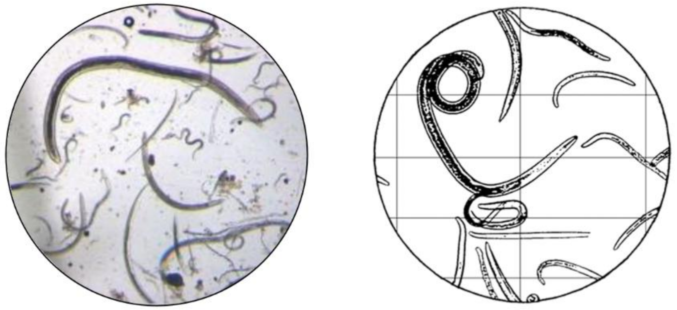
Development of an AI-driven Imaging Analysis System with Low-cost Equipment for Fast Onsite Quantification of Plant-parasitic Nematodes, 08/2024 – 03/2025, , £52K

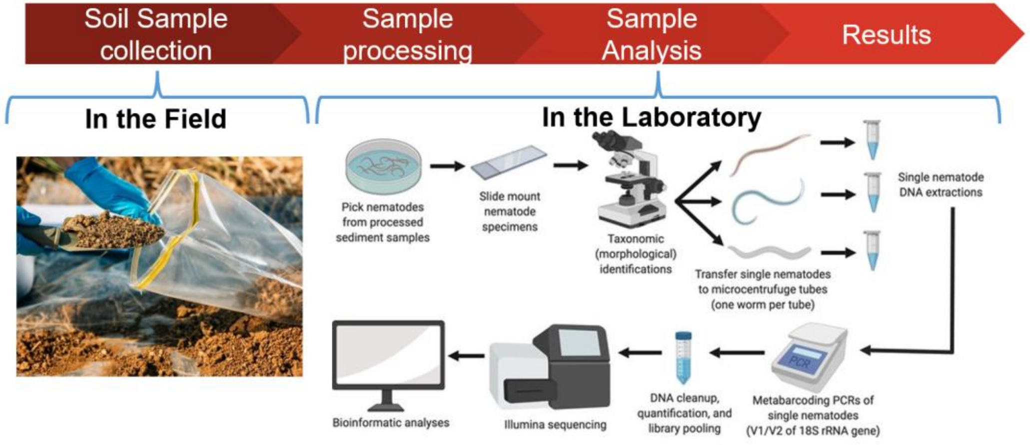
PPNMix: Knowledge Distillation empowered Automatic Molecular Identification Pipeline for Plant Parasitic Nematodes in Complex Mixtures, 07/2024 – 03/2025, £120K

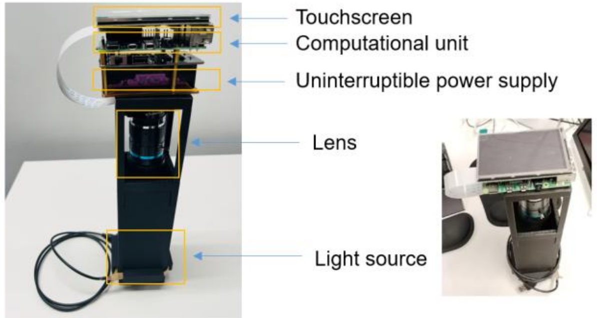
We investigate knowledge-guided multimodal AI to enhance automatic PPN quantification and field-level infestation estimation. The solution will:

- Enhance detection of multiple PPN genera by integrating domain knowledge to improve quantification accuracy
- Extract morphological features from mixed PPN samples to support result verification and analysis;
- Leverage multi-modal agricultural data to accurately predict field-level PPN infestation.

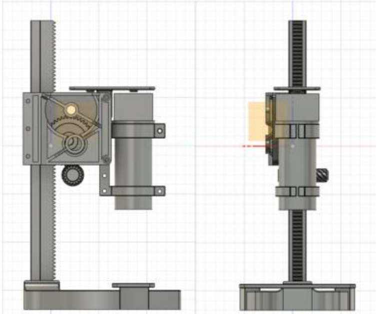
SPARKSOFT
Harper Adams University
The University Of Sheffield.
ADAS



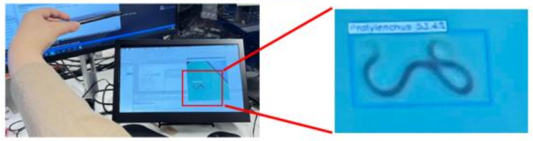




HandHold Device



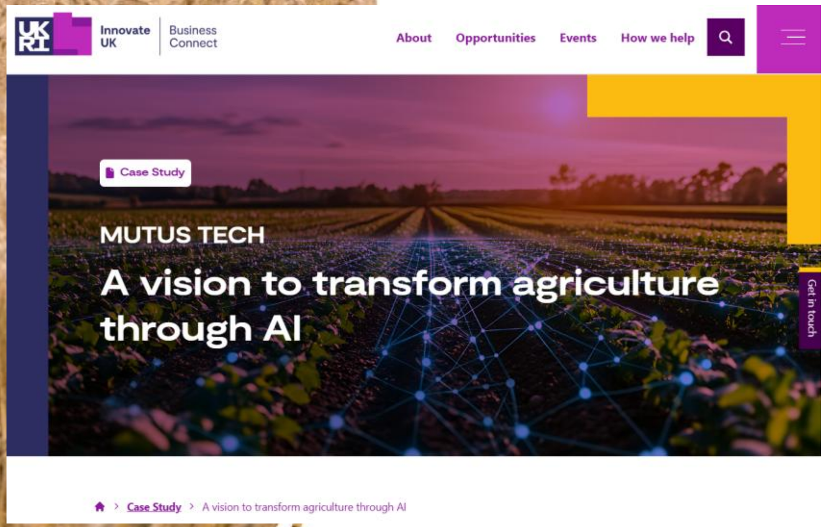
Fixed Device

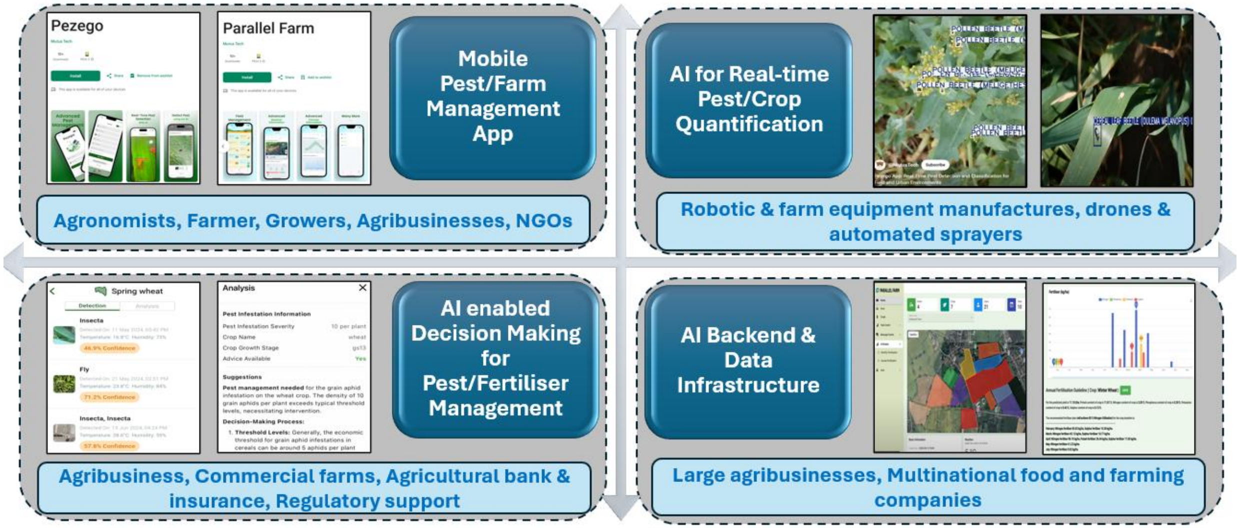


Detection on the Device

Commercialisation -- UK, Ghana, India


STANDARD POST
www.standardpost.in
ENGLISH DAILY
Vol.12. No.130 MUMBAI Saturday, March 22, 2025 Pages : 8 Rs.1
Mumbai – Page 4
Five UK agri-tech companies selected for UK-India Agri-Tech Accelerator Programme





Commercialisation -- Explainable AI inspection

SPARKSOFT

Products Solutions Technology Company Contact **Become a design partner**

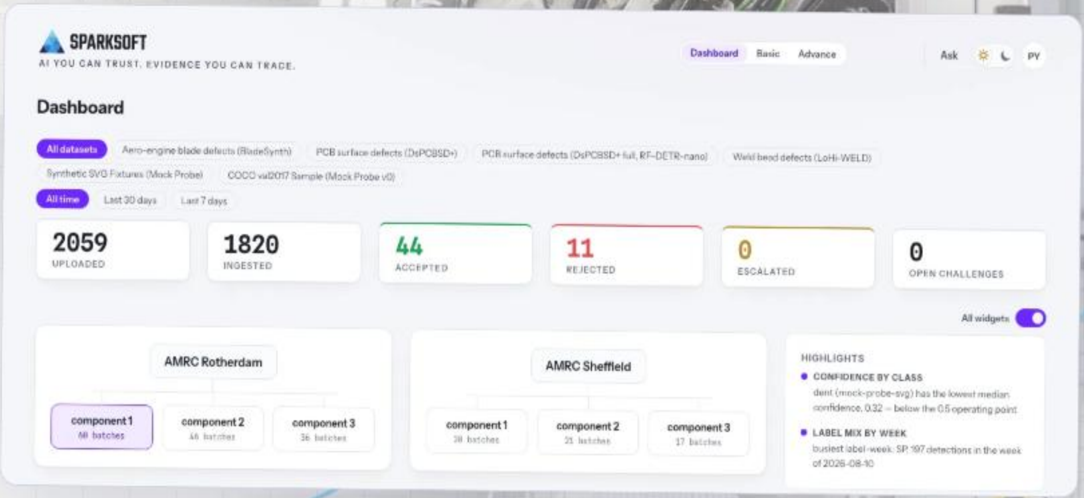
AI you can trust. Evidence you can trace.

Build AI into real workflows.
Keep every decision traceable.

SparkSoft helps manufacturers, labs and commercial teams assure, build and automate AI workflows across images, tables, signals over time and text — without replacing the AI you already use.

Become a design partner Explore the products →

BACKED BY INNOVATE UK · SOVEREIGN AI PIPELINE PHASE 2 · ONE OF 17 UK COMPANIES



SPARKSOFT ASSURE · ASSURANCE DASHBOARD · ILLUSTRATIVE

THE PROGRAMME

Deployable and Scalable Symbolic Capsule Neural Networks for Auditable Zero-Shot Object Detection

Selected by Innovate UK under **Sovereign AI Pipeline Phase 2** — one of **17 companies across the UK**, backed by a grant of around £770k. In plain terms, the programme funds detection designed to name its evidence and flag defect types it was never trained on. Now identifying manufacturing use cases and design partners with the AMRC — the University of Sheffield's Advanced Manufacturing Research Centre — for a demonstrator that proves technical performance and business value together.

FUNDED BY

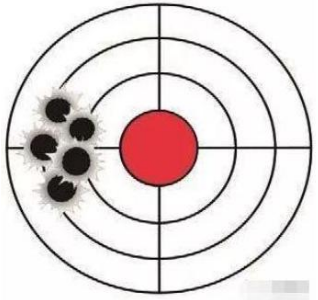
Innovate UK · UK Research and Innovation

Grant record available on request for due diligence.

AI-enabled Sustainable and Resilient Agriculture

Key challenges

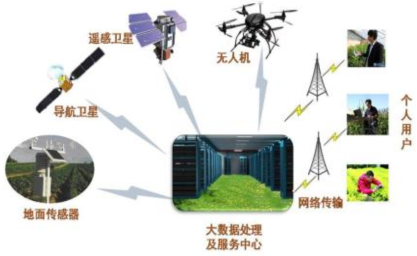
Lack of system-level data storage, management for large-scale, heterogeneous data



Diversity and adaptability of AI technology application scenarios

Unclear identification of end-user needs, lack of data standardisation

Lack of accurate and robust AI models for precise fertiliser prediction



Lack of training mechanisms to farmers

Alan Turing BridgeAI programme

BridgeAI Agri-Food Portfolio: The UK agri-food sector has received substantial support through the UKRI BridgeAI funding programmes（**£100 million UK government initiative**）, encompassing **72 funded AI adoption projects across feasibility studies, collaborative R&D, and innovation-driven deployments.**

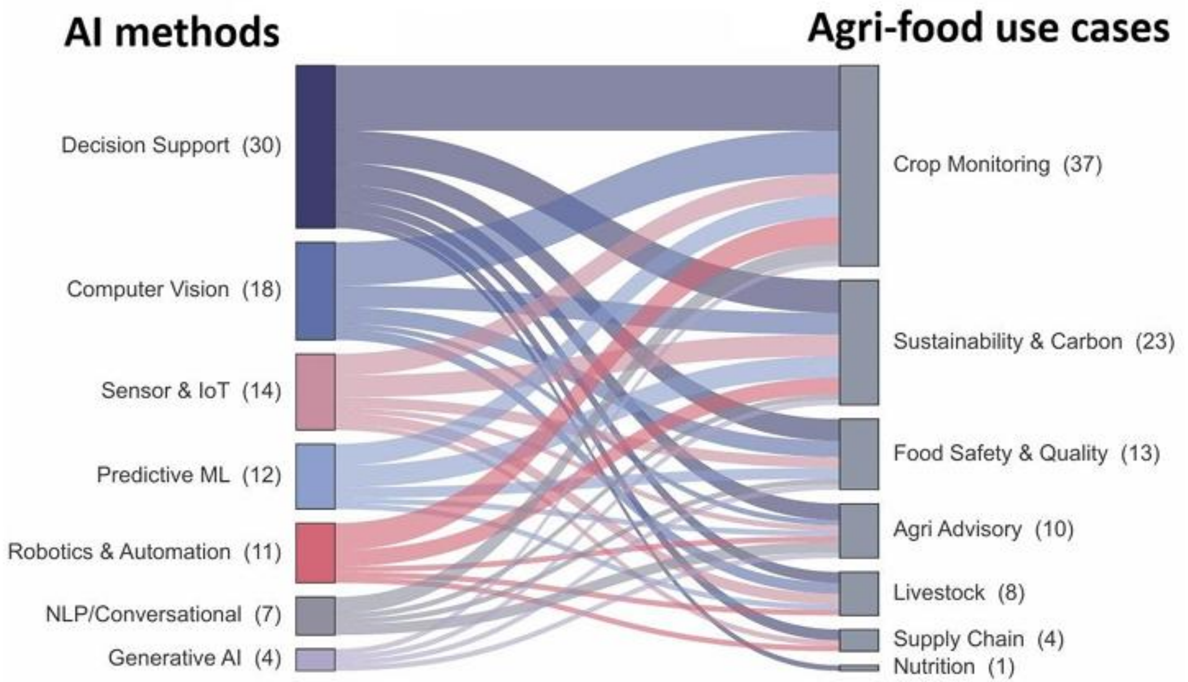
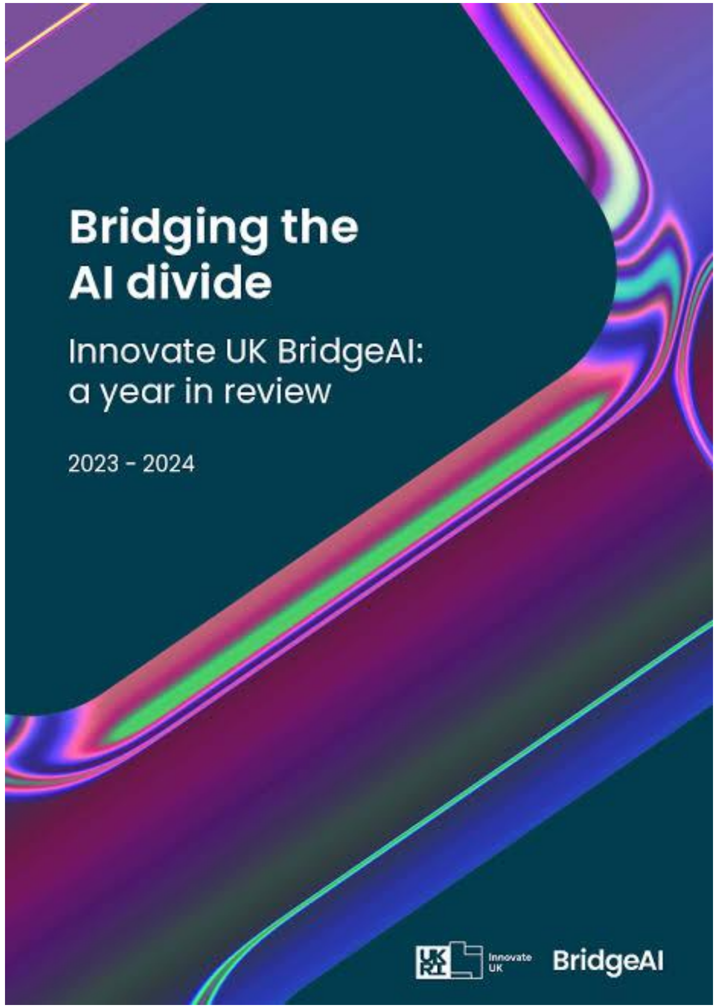


Fig.1, BridgeAI Agri-Food Portfolio Mapping: AI Methods and Use Cases: *Decision Support Systems are the most prevalent AI method (~22 projects), followed by Computer Vision (~17), Predictive Machine Learning (~13), Sensor and IoT systems (~9), Robotics and Automation (~9), Natural Language Processing (~7), and Generative AI (~4). On the application side, Crop Monitoring and Precision Farming dominate (~32 projects), followed by Sustainability and Carbon (~14), Agri-advisory and Knowledge Systems (~9), Livestock Management (~6), Supply Chains (~5), Food Quality and Safety (~5), and Nutrition (~2–3).*



Alan Turing BridgeAI programme

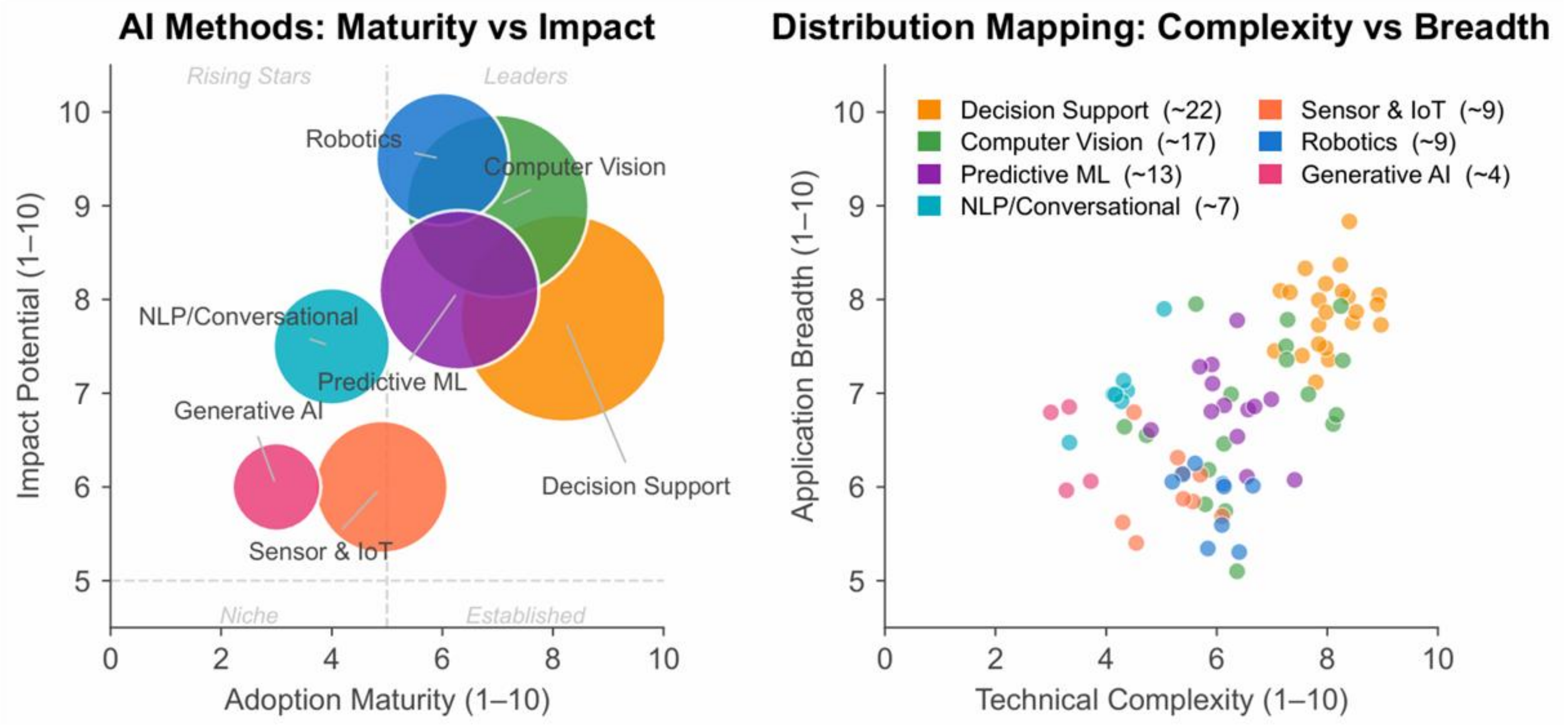


Fig.2, BridgeAI Agri-Food Portfolio Mapping: AI Methods and Use Cases: Decision Support Systems are the most prevalent AI method (~22 projects), followed by Computer Vision (~17), Predictive Machine Learning (~13), Sensor and IoT systems (~9), Robotics and Automation (~9), Natural Language Processing (~7), and Generative AI (~4). On the application side, Crop Monitoring and Precision Farming dominate (~32 projects), followed by Sustainability and Carbon (~14), Agri-advisory and Knowledge Systems (~9), Livestock Management (~6), Supply Chains (~5), Food Quality and Safety (~5), and Nutrition (~2–3).

Alan Turing BridgeAI programme

Why Existing Responsible AI Falls Short

- GenAI-first, Problem-last
- Ignores Deployment Reality
- Decision AI is Marginalised
- Ethics Added Too Late
- Fragmented Governance & Accountability

Table 1: A deployment-centric map of AI adoption failure in the UK agri-food sector.

Drivers	Failure Points	Outcomes	Deployment-Centric Resolution
Strong policy push and funding for AI adoption; pressure to demonstrate innovation	Conceptual narrowing of AI to GenAI/LLMs; over-reliance on general-purpose tools	GenAI-first, problem-last adoption; misaligned solutions	**Problem-First AI:** Start from clearly defined agri-food decision problems; align AI selection with domain needs rather than technology trends
Market competition, media hype, and executive urgency to adopt AI	Lack of coherent AI strategy and weak alignment with operational workflows	Pilot proliferation with limited transition to deployment ("pilot fatigue")	**Deployment-by-Design:** Embed deployment constraints (workflow, users, environment); Design for operational integration
Increased availability of cloud AI tools and external vendors	Marginalisation of domain-specific, interpretable, and decision-focused models	Poor fit with real-world agri-food decision-making; low usability	**Decision-Centric AI Systems**: Prioritise interpretable, Auditable, and decision-support models tailored to specific use cases
Emphasis on ethical AI principles and compliance frameworks	Separation of ethics from system design (post-hoc governance)	Responsibility treated as an afterthought; Limited real-world accountability	**Responsibility-by-Design**: Integrate responsibility, safety, and compliance into the full AI lifecycle (design → deployment → monitoring)
Fragmented stakeholder landscape (farmers, advisors, tech providers, regulators)	Governance structures; unclear ownership and risk-sharing mechanisms	Low trust, liability concerns, stalled adoption despite technical feasibility	**System-Level Governance & Integration**: Establish clear accountability, risk-sharing frameworks, Continuous feedback loops across the value chain

Alan Turing BridgeAI programme

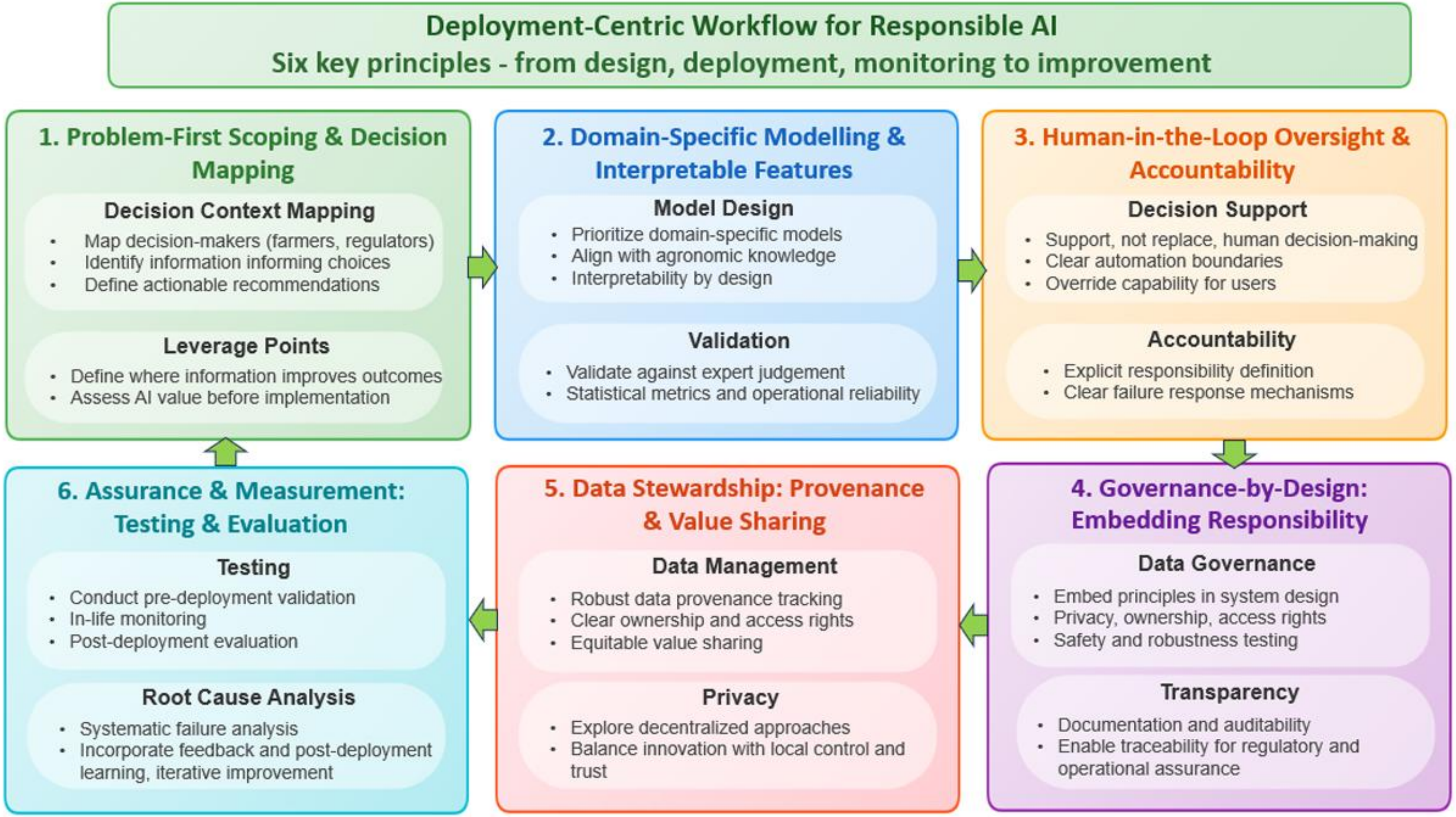
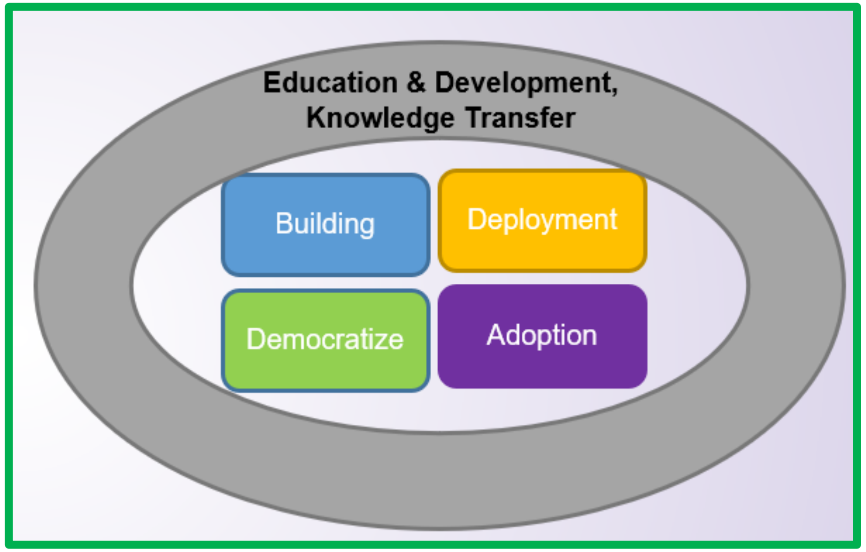


Fig.3 illustrates how these principles span the entire AI lifecycle, from initial problem formulation through deployment and long-term monitoring, highlighting that responsibility cannot be retrofitted, but must be continuously enacted in practice.

Summary

- Responsible AI depends on deployment, not just model performance or compliance.
- AI must be aligned with real-world decisions, institutions, and human needs.
- Shift from technology-led adoption to outcome- and problem-driven innovation.
- Adopt adaptive, risk-tiered governance with stronger assurance for high-risk AI.
- Invest in deployment-ready infrastructure, domain-specific AI, and shared testbeds.
- Build an ecosystem that connects innovation, governance, and operational practice.
- Targeting with end-users, policy-makers and other stakeholders

(Build – Deploy – Adopt – Democratise)



谢谢

ADAS RSK
VELCOURT
The James Hutton Institute
ANT DATA
Harper Adams University
AHDB AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD
ROTHAMSTED RESEARCH
University of Sheffield
COLLABORATIONS IN CHINA
AGRI-TECH IN CHINA: NEWTON NETWORK + (ATCNN)
Newton Fund
GCRF Global Challenges Research Fund
Science & Technology Facilities Council
UK Agri-Tech Centre
BridgeAI
UK Research and Innovation
EPSRC Engineering and Physical Sciences Research Council
BBSRC bioscience for the future
Innovate UK