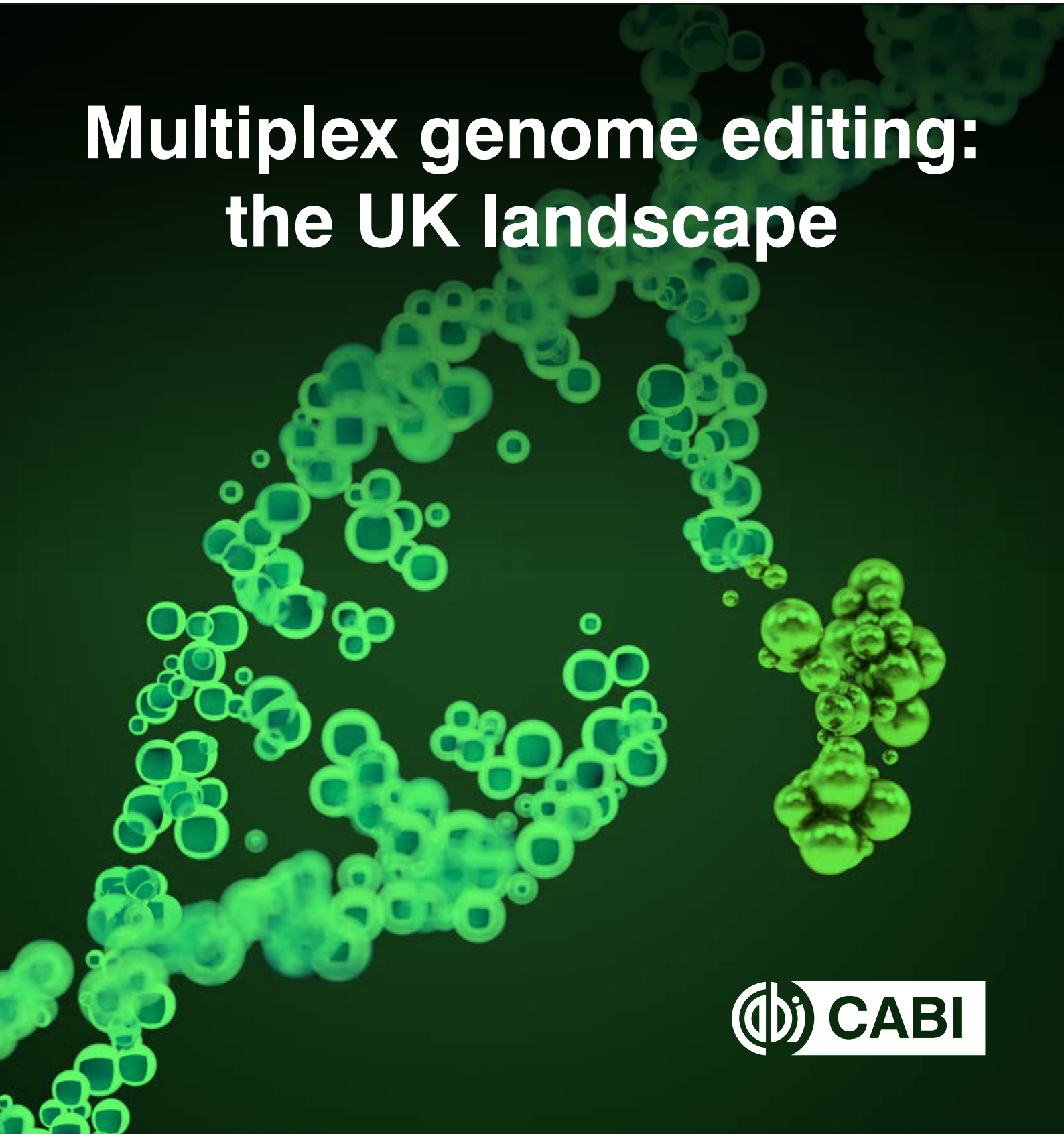
UK-CGIAR CENTRE

Collaboration in Science and Innovation

Multiplex genome editing: the UK landscape



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Context

Multiplex gene editing is a powerful biotechnological tool that allows multiple genes or genetic regions to be modified in a single step. For **agricultural crops**, this results in a new plant genotype with several introduced genetic modifications generated in a single generation. The technology can also be used to target multiple sites in the genome to fine-tune complex traits, such as yield or climate resilience. Many desirable traits, such as stress tolerance and disease resistance, are linked to **more than one site or region** within the genome. This makes multiplex gene editing attractive as a method to more efficiently increase or maintain crop yields as the climate changes and therefore safeguard food security around the world. Moreover, gene-editing technologies, such as **the CRISPR-Cas system**, are becoming more widespread and commonly used. This is **driving innovation** in agricultural crop breeding **globally**. AI approaches are currently underutilised in conventional crop breeding but are considered essential for effective multiplex gene editing. In the coming years, AI will continue to develop, and these powerful tools offer an important opportunity to improve crop breeding.

Key findings

- The gene-editing regulatory landscape differs across the UK. England is governed by the **Genetic Technology (Precision-Breeding) Act** – signed into law in May 2025 – which differentiates between precision-bred and genetically modified organisms (GMOs). Precision-bred plants could have arisen naturally or through traditional breeding practices but have been created through new breeding technology. They do not contain foreign DNA. The act creates a **streamlined regulatory pathway** to field trials and commercialisation in England, which brings the country's practice in line with the likes of the **United States**. The regulations are not applicable in Northern Ireland, Scotland or Wales, however. In the devolved nations, precision-bred plants **continue to be treated as** GMOs, as is the case in the European Union. Research institutes in devolved nations would therefore need to partner with organisations in England to undertake field testing in the UK.
- There is a global push towards creating efficient regulatory systems for plants bred using new techniques. Many countries, such as the United States, **do not consider** precision-bred plants to be GMOs, but the European Union continues to do so. England's stance on precision-bred organisms (PBOs) and historic expertise make it an attractive location in the European region to localise plant gene-editing investment and innovation.
- Artificial Intelligence (AI) technologies can accelerate plant trait improvement and crop development. The UK is positioning itself as an **AI superpowe**r, which should give its researchers a competitive advantage in AI-backed plant gene-editing research and development.
- The UK has well-established plant biotechnology institutes and world-leading researchers. AI technologies offer an untapped opportunity in crop trait discovery and genetic-target identification research. This is a potential area of innovation and investment.

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- There are challenges, ranging from scientific to regulatory. For example, there are concerns around the technology's precision and **off-target effects**, as well as **unintended environmental or physiological interactions**. However, rapidly developing AI algorithms allow improved identification of genetic targets, improved guide RNA design and better prediction of off-target effects. Nevertheless, questions remain about **regulatory readiness** and the uptake and marketability of precision-bred crops in the rest of the UK, the European region, and in low- and middle-income countries where these technologies could strengthen resilience and food security in the face of climate change.

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Examples of UK research

1. The John Innes Centre

The **John Innes Centre** is an independent research centre in England, specialising in plant science, genetics, and microbiology. The centre has expertise in a diverse range of disciplines. It leads trait discovery across diverse germplasm and integrates genebank genomics with multiplex genome editing, although it typically focuses on disease and agronomic performance rather than environmental traits. The organisation has a strong track-record of collaboration and successful research, particularly in wheat, brassicas, sugar beets, potatoes, and legumes. It works with international partners in its effort to understand the genomes and traits of their crops in a variety of environments.

2. Roslin Institute

The **Roslin Institute**, part of the University of Edinburgh, specialises in sustainable agriculture. It has extensive experience in trait discovery and prediction in animals, with expertise in cross-cutting data solutions and conventional machine-learning approaches. Roslin is developing ancestral recombination graphs and biological sequence-based models with significant potential to inform multiplex genome editing and phenotypic prediction. Roslin has established links with CGIAR breeding programmes.

3. Earlham Institute

The **Earlham Institute**, funded through the Biotechnology and Biological Sciences Research Council, is a life-science research institute in Norwich, England. It has significant expertise in academic research, combining genomics, data science, and biotechnology. It has **notable expertise** in wheat, brassicas, potatoes, and barley. **In 2024**, the institute spun out agritech company TraitSeq. **TraitSeq** uses AI to train predictive models for complex traits in agriculture. The institute has established collaborations with industry players, as well as a track record with other research institutes, such as the International Rice Research Institute and CIMMYT.

4. The James Hutton Institute

The James Hutton Institute is an interdisciplinary scientific research institute in Scotland. It has expertise in **potatoes** and **barley**, among others, and experience with stacking targeted gene knockouts. The institute **developed MAXY-ID**, a high-throughput genotyping platform for plant breeding which allows for the prediction of crop performance under changing conditions. It **has links with** international research organisations like the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Potato Center (CIP) linked to its established expertise in potato and barley genomics.

Looking to the future

- **Emerging area**: The use of AI in plant gene editing is an emerging area, but it could address some of the technical concerns around multiplex gene editing. AI algorithms could improve genetic-target identification, improve guide RNA design, and better predict off-target effects.
- **AI integration**: AI technologies are emerging as important tools in plant biotechnology. Their rapid global growth offers institutes in the UK an opportunity to boost their trait discovery and target identification.
- **Competitive advantage**: England's PBO regulations give its plant biotechnology research institutions a competitive advantage over others in the UK and Europe, which do not have England's streamlined regulatory pathway.
- **Regulation**: The uneven regulatory landscape – within the UK and globally – could constrain the uptake and marketability of precision-bred crops.

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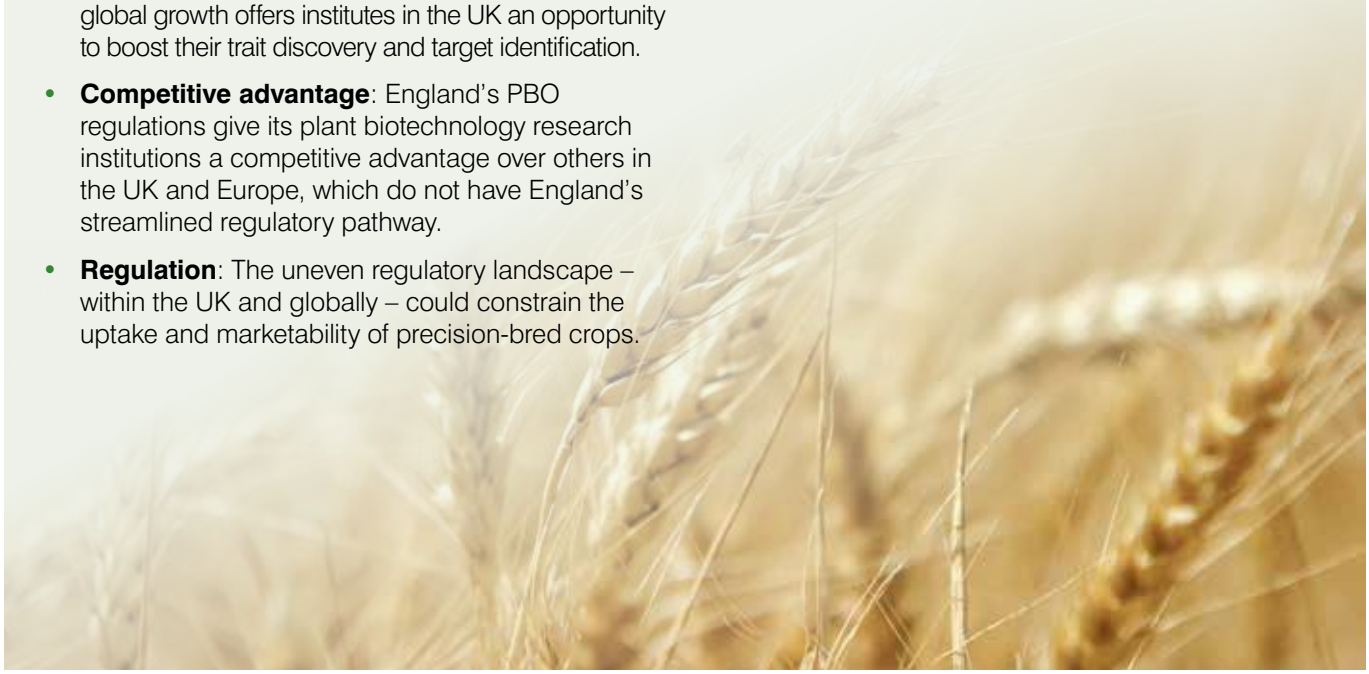

Methodology

This research project involved a bibliometric analysis and web crawl to identify leading researchers and research groups investigating AI in crop breeding and multiplex genome editing. A landscape mapping exercise supplemented the bibliometric analysis and stakeholder surveys helped to identify organisations with expertise in using AI in crop breeding. One-on-one interviews facilitated the creation of a shortlist of leading institutions.

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