Project Title: Biomarker sensing and monitoring for agricultural health

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Project description

Pesticide overuse remains a major contributor to biodiversity loss, soil degradation and greenhouse-gas emissions. Yet current monitoring methods for pesticide residues and plant health rely on laboratory-based analysis, making real-time decision-making in the field nearly impossible. This project will develop and apply a new generation of **battery-free, smartphone-readable biosensors** to quantify agrochemical residues and early indicators of crop disease directly in the field.

The technology, recently developed in the Guder Lab and protected by two Imperial patents, transforms standard lateral-flow assays (LFAs)—widely used disposable test strips—into **quantitative, data-rich diagnostic tools**. By embedding a novel electrochemical chip powered by near-field communication (NFC) from a smartphone, results can be digitised, geo-referenced and transmitted instantly to a secure cloud platform for AI-based analysis. This approach can effectively track damage to plants and soil, while eliminating the need for batteries and plastic-intensive optical readers, drastically reducing electronic and material waste.

The PhD will advance both the **analytical science** and **environmental applications** of this platform. Key objectives include:

1. Developing and validating quantitative electrochemical LFA assays for (a) pesticide residues and (b) plant stress biomarkers.
2. Building and training algorithms to correlate disease onset, pesticide use and environmental variables from geo-referenced datasets.
3. Evaluating how such tools can guide **precision spraying**, enabling farmers to apply pesticides only where and when needed, potentially reducing chemical use by > 80%.
4. Demonstrating how real-time biosensing networks could support **regenerative agriculture**, providing verifiable monitoring of soil and plant health for sustainable-finance schemes and policy frameworks.

Working within Imperial's Department of Bioengineering and in collaboration with agritech partners in the UK and abroad, the student will gain interdisciplinary experience across **bioelectronics, environmental chemistry, data analytics and sustainability assessment**. The project connects directly to Grantham priorities on "pesticides in the environment" and "regenerative agriculture," contributing to climate adaptation and mitigation through reduced greenhouse gas emissions from agrochemical production and avoid yield losses equivalent to tonnes CO_2 annually, avoided crop loss and improved resource efficiency. The student will engage with the Grantham Institute

network to translate technical outputs into evidence for sustainable-finance schemes and policy design.

The resulting datasets and sensing framework will form the foundation for a **climate-resilient agricultural monitoring system**, capable of informing both farmers and policymakers. Beyond its immediate agricultural applications, the underlying technology offers a pathway toward distributed biosensing across plant, animal and human health.

To apply:
Please email f.guder@imperial.ac.uk with the following documentation:
- Statement of Purpose
- Your CV
- At least two references must be emailed to *Firat Guder* (by the referees)