Leverhulme Doctoral Scholarships Programme for Interdisciplinary Resilience Studies (PIRS)

University of Southampton

RECRUITMENT CYCLE for studentships starting: October 2025 (Cohort 2)

SUPERVISORY TEAM

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STUDENTSHIP PROJECT TITLE

Exploring the resilience of global food systems and nutritional impacts through network theory

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OVERVIEW

This project investigates climate change's impacts on global food production and trade networks, focusing on food security and nutrition outcomes. Using network analysis, it aims to identify pathways for enhancing global nutritional sustainability and resilience in a changing climate.

SUMMARY

With climate change increasingly challenging global food security and nutrition, this PhD project investigates the interplay between climate variability, food systems, and nutrition through the lens of network theory. The research will analyze global food production and trade networks to evaluate their resilience, adaptation, and vulnerability to climate-related disruptions. By constructing models that capture the complex interdependencies within food systems, this work

aims to provide critical evidence for policymakers, helping to shape strategies that support resilient, sustainable food networks capable of withstanding future climate pressures.

Research efforts will center on how climate change and shocks, spanning historical events to future projections, impact global food systems, altering accessibility to food security and nutrition. Through detailed historical data analysis, the proposed research aims to reveal adaptive responses of food systems to climatic stressors, laying groundwork for future scenario predictive modeling. The project prioritizes understanding climate change's comprehensive effects on food system robustness and nutrition security, spotlighting vulnerability, and devising adaptation measures to withstand climate variability.

This initiative aligns with the PIRS program by combining mathematical and network theory with the pressing climate-related issues in global food and nutrition systems. It seeks to generate impactful insights for bolstering food system resilience and inform policy, practice, and community strategies for maintaining food and nutrition security in uncertain times and risky localities.

Participants will join an interdisciplinary team, partnering between experts from the University of Southampton and the World Bank. This collaboration aims to advance our understanding and strategic planning at the nexus of climate change, global food systems, and nutrition security.

PROJECT CONCEPT

Rationale, Aim, and Novelty

Climate change is a critical challenge to global food security and nutrition, with rising temperatures, shifting precipitation patterns, and more frequent extreme weather events disrupting agricultural yields and supply chains. These impacts ripple through global food production and trade networks, affecting food availability, accessibility, and nutritional status worldwide. To build resilience, it is essential to understand how climate variability influences these interconnected networks as a holistic body and to identify intervention points for sustaining nutrition security.

Existing studies on climate impacts tend to focus on either production losses, economic outcomes, or localized food security issues in isolation, with focus on starchy staples foods and trade commodities. Few have adopted a holistic, network-based approach to analyze the interconnectedness of global food production and trade, and even fewer have linked these networks to nutritional implications and outcomes.

The aim of this project is hence to understand how climate change affects the global food system by modelling the interconnected networks of food production, trade, and access to nutrition. This project will use network theory to model the effects of climate change on food security and nutrition. By analyzing historical data and future projections, the research will identify systemic vulnerabilities and develop strategies to enhance resilience, promoting sustainable and adaptive global food systems.

Key Objectives

To reach that aim, 3 objectives are to be achieved:

1. **Understand Climate Impact on Food Systems:** Assess the effects of climate change on food production, trade, and nutrition by analysing historical data to identify key patterns and vulnerabilities.
2. **Evaluate Resilience Using Network Theory:** Use network theory to evaluate the resilience of global food production, trade, and nutrition systems, and identify pathways to enhance resilience.
3. **Predict Future Resilience Under Projected Scenarios:** Model future climate scenarios to predict changes in food system resilience and evaluate the effectiveness of adaptive strategies.

Methods

Three work packages (**WP**) will be proposed, each aligning with a key objective.

Work Package 1: Historical Analysis of Climate Impacts on Food Systems

This WP focuses on understanding climate impacts on food systems by conducting a comprehensive historical analysis. This will involve collecting and analysing historical data related to **climate** (Daily Temperature and Precipitation data from the Global Historical Climate Network), **food production** (the Food and Agriculture Organization database), **trade** (the UN Com-trade database and the World Bank and International Trade Centre datasets), and **nutrition** (including the USDA Food Composition Databases and World Bank and FAO's price data). The goal is to use statistical methods to identify patterns and vulnerabilities that emerge from climate-related events, quantifying how climate variability has affected global food security in the past.

Work Package 2: Resilience Evaluation through Network Theory

This WP aims to evaluate the resilience of global food systems using network theory. This involves developing network models to represent interconnected food production, trade, and nutrition systems, plugging in historical values diagnosed from WP1, and applying **resilience metrics** (such as centrality, system robustness, redundancy and path diversity) and **dynamic system stability assessments** (such as linearization and eigenvalue analyses) to assess these networks. The work package will identify critical nodes and links and potential points of failure and will outline pathways to enhance the resilience of these complex networks.

Work Package 3: Scenario Modelling and Adaptive Strategy Evaluation

This WP addresses future scenarios and the effectiveness of adaptive strategies. It will use state-of-the-art climate projections from the Coupled Model Intercomparison Phase 7 (**CMIP7**) to drive the network model developed in WP2, for evaluating future changes in food system resilience under various climate conditions. Additionally, this WP will evaluate the impact of adaptive strategies, providing evidence-based recommendations for interventions that enhance long-term sustainability and nutrition security in the face of climate challenges.

Wider implications

This research has significant implications for both regional and global food security policies. By identifying key vulnerabilities and proposing adaptive strategies, the findings can inform policies aimed at enhancing food system resilience, ensuring equitable access to nutrition, and minimizing risks from climate-driven disruptions. Policymakers, international agencies, and community planners can use these insights to proactively strengthen food networks against

future climate variability, promoting sustainable food security practices at local, national, and international levels.

Contribution to interdisciplinary resilience studies:

This project makes a substantial contribution to interdisciplinary resilience studies by combining climate science, network theory, and food security analysis. By integrating climate data with food production, trade, and nutrition datasets, the research takes a holistic approach to understanding the complex relationships between climate variability and food systems. Network theory, traditionally used in systems engineering and social sciences, is employed here to assess the resilience of the complex interconnected global food production and trade networks, demonstrating how disruptions propagate and identifying critical vulnerabilities. Moreover, the use of predictive modelling and climate scenarios links natural science with forward-looking strategic planning, fostering collaboration between climate scientists, policymakers, and food system experts.

Please list and describe any specific/additional technical training or support to undertake and successfully deliver this project. *Note that students recruited into this programme will undertake a bespoke training curriculum. Students and their supervisory teams will also identify generic skills gaps to address through training courses offered by the University's Doctoral College.*

Advanced network theory applications to understand and model the complex interdependencies within global food systems under climate stress. Participants will gain hands-on experience with mathematical network models and tools, data visualization techniques and predictive modelling to forecast climate impacts on food security and nutrition. Workshops on resilience thinking and adaptation strategies will equip researchers to design solutions for climate-resilient food systems. Collaboration with global partners, such as the World Bank, provides real-world context and policy engagement experience.
