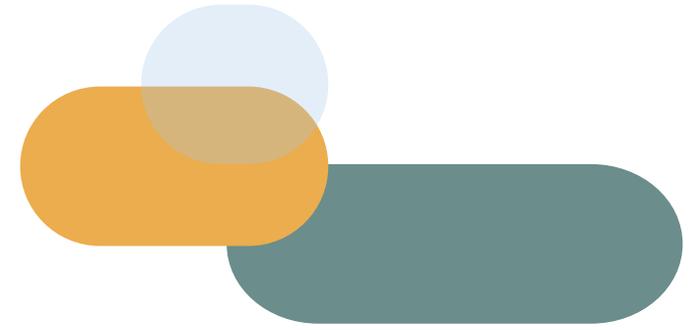


ThinkingEarth: Causality for food security under Climate Change



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Project Overview

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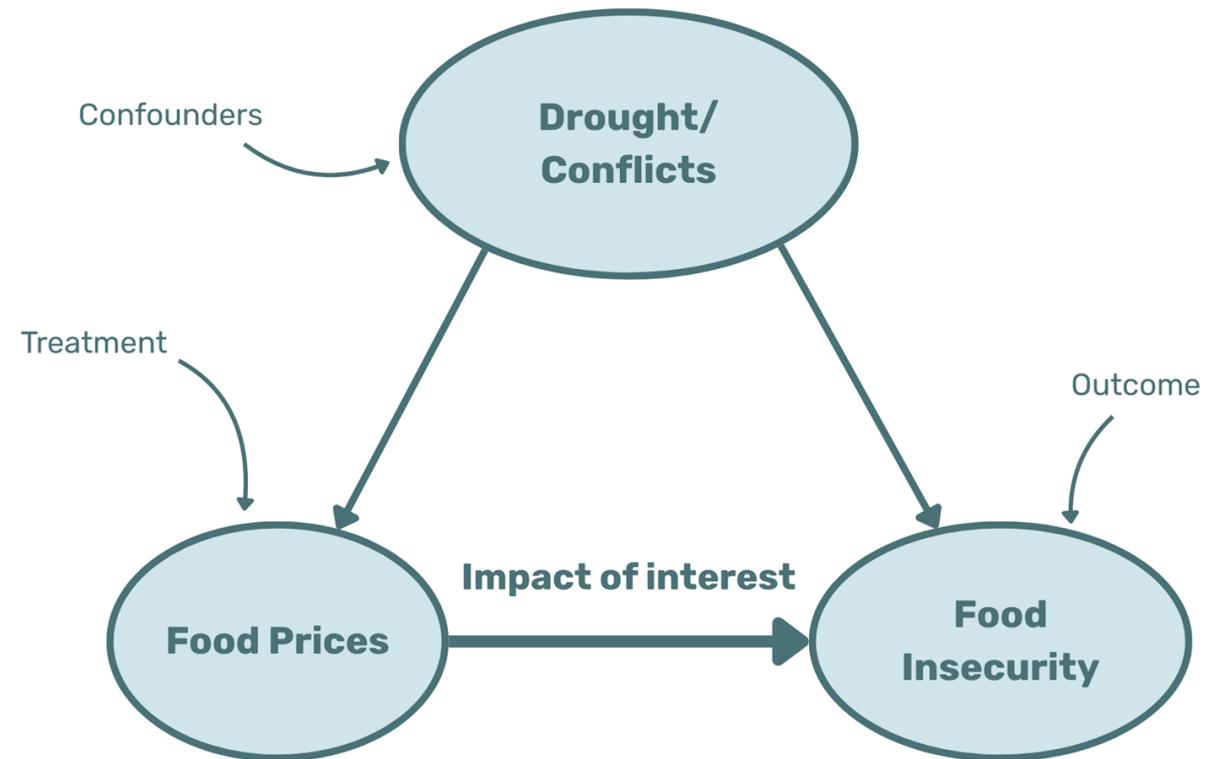
- We view Earth as a complex, unified, and interconnected system.
- We use cutting-edge AI techniques: deep learning, causality, explainable AI, and physics-aware machine learning, to exploit the availability of Copernicus data.
- Using Self-supervised learning and graph neural networks, we aim to develop Copernicus Foundation Models and a Graph representation model of the Earth.

Use Case 3 - Causality for food security under Climate Change

- When resources are limited, we need to understand what is impacting food insecurity, not just what correlates with it.
- We apply **causal inference** methods to estimate the **impact of key drivers** on the state of **food security**.

Correlation vs Causation

- If we see high food insecurity when food prices are high, does **lowering prices reduce food insecurity**? Or do both rise because **drought/conflicts hit the region**?
- We aim to **estimate the causal impact** of key drivers (food prices, access to credit) **accounting for those shared drivers** so we don't mistake coincidences for impact.
- By accounting for the common drivers, we can **isolate the impact of interest**.



Step 1: Identify the problem

- Select which **impact we want to estimate** (e.g., food price spike → risk of acute food insecurity).
- Identify the **region of interest**.
- **Map the main variables** that affect both driver and outcome (climate, conflict, market, displacement, etc).
- **Harmonize a dataset** with all the variables of interest (usually, at ADM1/ADM2-per-month resolution).

Step 2: Causal effect estimation

- Develop **causal ML techniques** to compare samples (variables at region x and time t) where a treatment, **T**, has happened, and samples where it has not.
- The estimation can be averaged to the area of interest (**ATE**) or stratified given some condition (**CATE**).

Step 3: Robustness checks

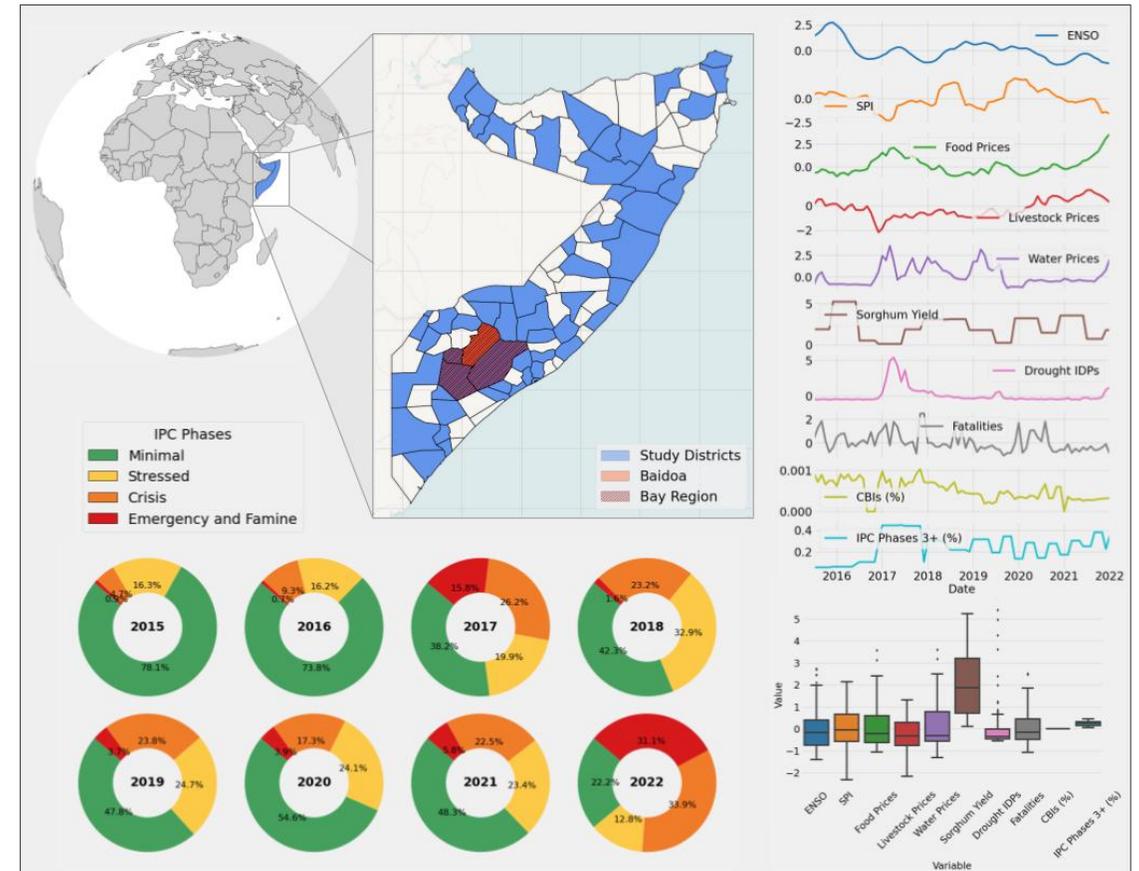
- Test whether the estimations **survive stress tests**.

Work 1

Question

In Somalia, does having higher access to credit reduce the risk of acute food insecurity?

- **Outcome:** Share of population at IPC 3+.
- **Treatment:** Share of population with access to credit.
- **Confounders:** ENSO, rainfall anomalies, market prices, conflict events, displacement and agricultural production.



Work 1

- We estimate this causal effect for **four different temporal aggregations**: annual, seasonal, when an IPC analysis occurs, and monthly.

Main Takeaway

- Districts with higher credit access show **2-4 % less cases of acute food insecurity (IPC 3+)**.

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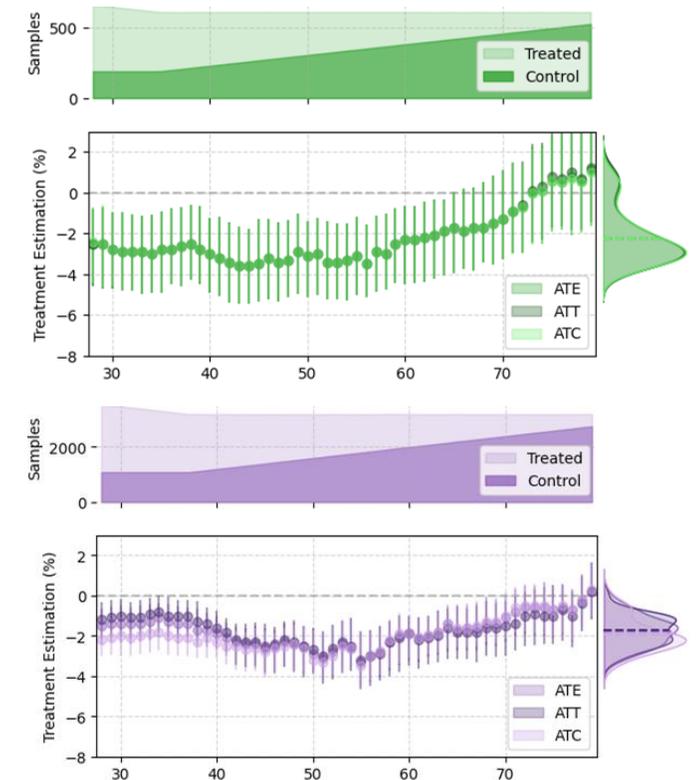
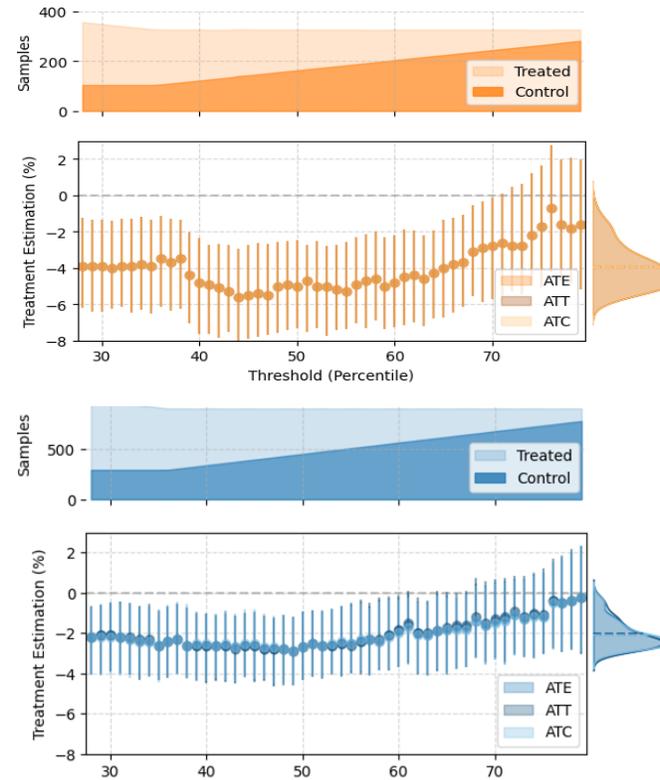


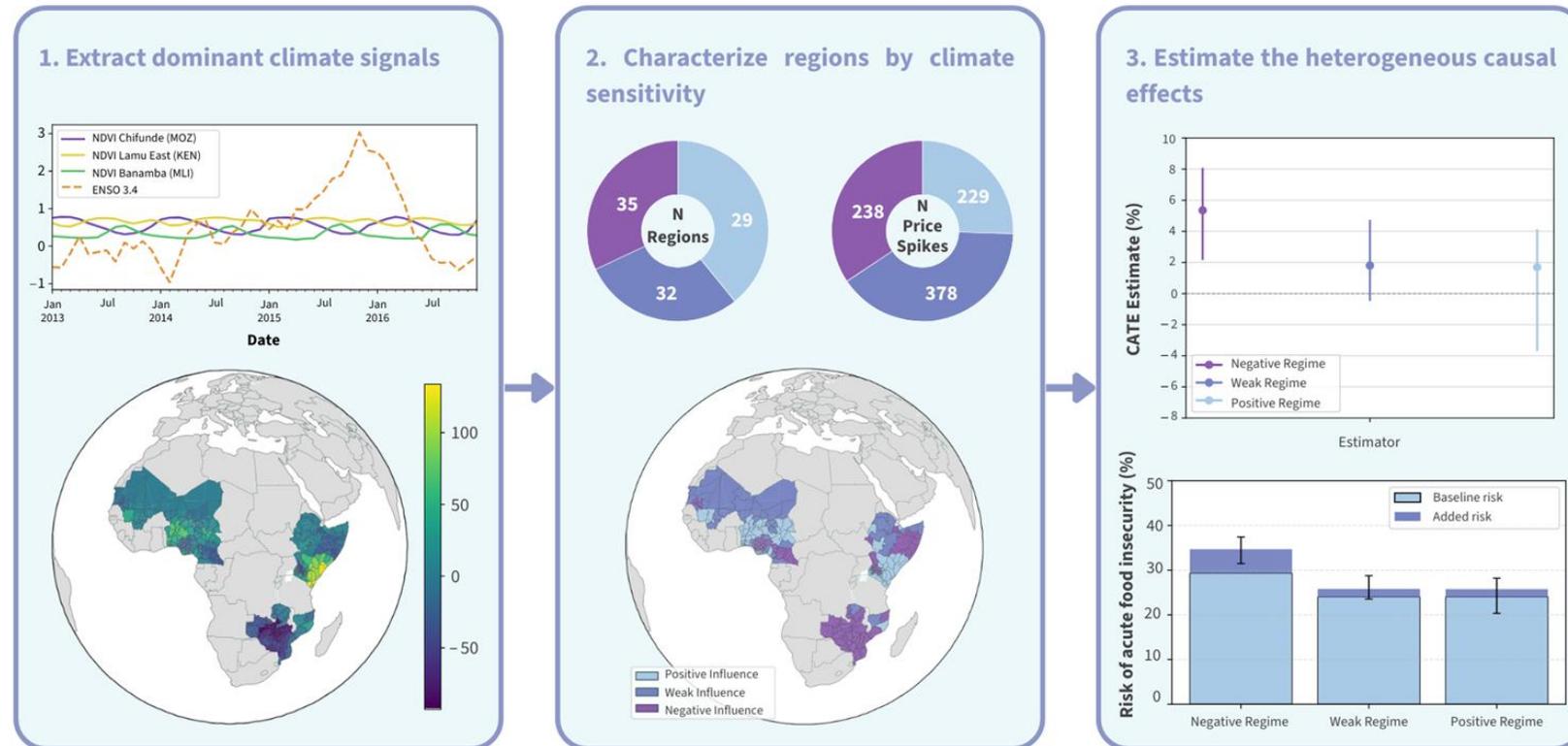
Figure: Annual, Seasonal, IPC-based, and monthly ATE estimations of credit access on IPC3+ for different treatment definitions.

Work 2

Question

Do food price spikes have a higher impact in places that are more climate-sensitive?

- Classify regions by how strong is the **vegetation response to ENSO variability**.
- Estimate the **impact of a price spike on the risk of acute food insecurity within each group**.



Work 2

- **Negative Regime:** ENSO reduces vegetation health.
- **Weak Regime:** ENSO and vegetation are weakly linked.
- **Positive Regime:** ENSO improves vegetation health.

Main Takeaways

- Price spikes are linked to **larger increases** in crisis-level coping in **drought-prone zones**:
 - 6% in the **Negative regime**.
 - 2% in the **Weak and Positive regimes**.

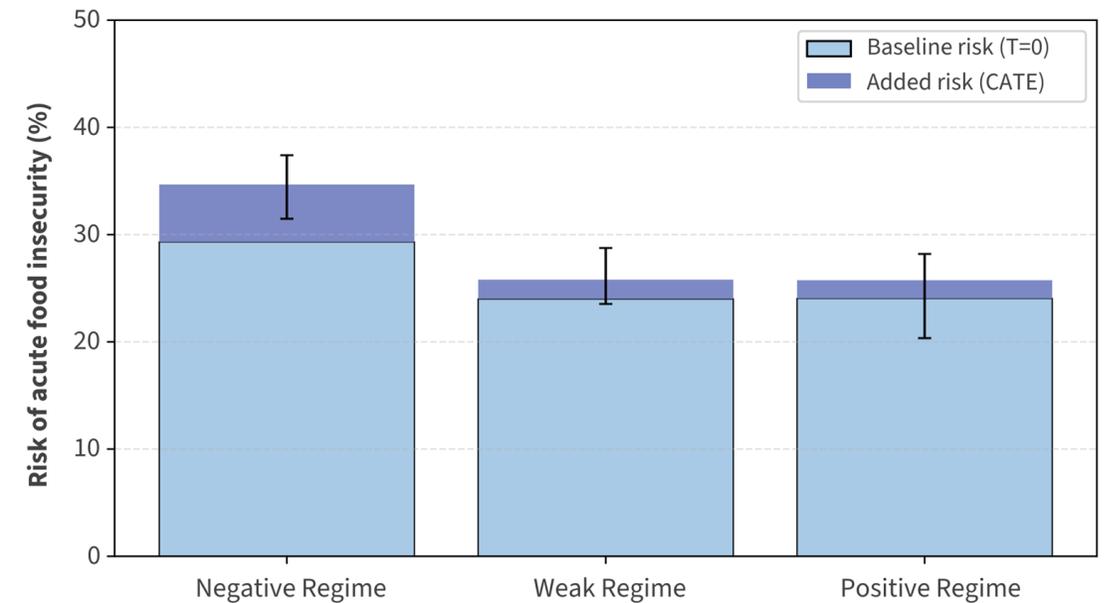


Figure: Causal estimates for the impact of food price spikes on the risk of acute food insecurity conditioned on climate regime (top), and baseline (normal conditions) plus added risk of acute food insecurity (bottom).

Work 3 (In progress)

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Question

Which food groups are most strongly associated with a lower risk of micronutrient adequacy?

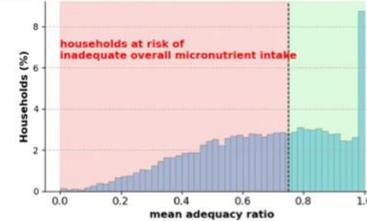
Area of Interest

Nigeria, Ethiopia and Sri Lanka

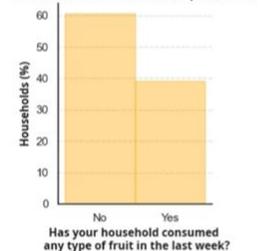
Idea

Building on a WFP predictive task, we aim to estimate and compare which food groups (rice, fruits, meat, etc.) provide a stronger protective effect against micronutrient inadequacy.

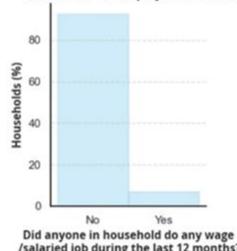
Distribution of risk of inadequate overall micronutrient intake (NGA)



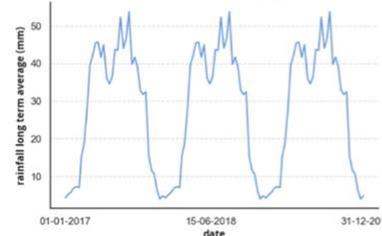
Distribution of fruits consumption (ETH)



Distribution of employment (NGA)



Rainfall in Oromia (ETH)



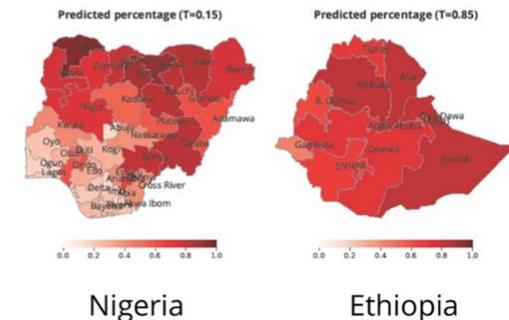
Target data

- household-level survey data
- quantitative (g per week) household consumption of specific food items (e.g., 1. yogurt, 2. wheat flour, etc)

Features

- Food group diversity**
 - household level survey data
 - binary (yes/no per week) household consumption of 8 food groups (e.g., 1. milk and other dairy products, 2. cereal, grains, roots and tubers, etc)
- Socio-economic status**
 - household level survey data
 - binary or categorical education-, labour-, housing conditions-, and assets ownership-related household level data
- Climate**
 - satellite data
 - rainfall, rainfall anomaly, and Normalized Difference Vegetation Index (NDVI) time-series

Machine-learning



What this approach enables for food security analysis

- Quantify likely impact sizes (not just rank drivers).
- Prioritize where an impact matters most (heterogeneity).
- Stress-test results so we know what's robust.

The aim is to help analysts and policy-makers decide *which* drivers impact the most, *where*, and with *what* expected effect size; with transparent uncertainty and a causal intuition.

Check our work on our website

- Explainable animated video
- Use Case infographic
- Use Case leaflet

Scan the QR code to access our resources!



Use Case 3

Causal inference for food insecurity analysis

Use Case 3 investigates the causal links between **climate change** and **food security**. This project, led by the University of Valencia in partnership with the World Food Programme, applies advanced causal machine learning to analyse the **impacts of climate events**, like droughts and floods, on **food availability and stability** in the Horn of Africa. By integrating **Copernicus data**, **socioeconomic factors**, and **food security metrics**, we aim to **enhance risk assessment**, **policy effectiveness**, and **intervention planning for vulnerable regions**.

For collaboration, contact **Prof. Gustau Camps-Valls** (gustau.camps@uv.es) or **Dr. Miguel-Ángel Fernández-Torres** (miguel.a.fernandez@uv.es).

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USE CASE 3
CAUSAL INFERENCE FOR FOOD INSECURITY ANALYSIS
University of Valencia and the World Food Programme

GAPS
Designing effective humanitarian interventions in resource-limited settings is urgent - but difficult.

- Funding gaps vs. growing needs
- Financial solutions : Effective, but hard to evaluate
- Lack of standardised methods & best practices
- Food insecurity driven by climate change, conflict, and economic issues

The Role of Earth Observation (EO)
Advancements in EO and machine learning help us:

- Monitor climate impacts on food insecurity
- Use Copernicus data + socioeconomic indicators
- Apply causal inference to link cause and effect

ThinkingEarth's Solution
Advancements in EO and machine learning help us:

- 1. Data Learning**
Use satellite, climate, and social data to track key indicators:
 - Integrated Food Security Phase Classification (IPC)
 - Reduced Coping Strategies Index (rCSI)
- 2. Root Causes**
Apply causal AI to reveal how climate and social pressures drive food insecurity.
 - Understand not just what is happening, but why
- 3. Guide Decisions**
Predict the impact of aid interventions—even where on-the-ground surveys aren't possible.
 - Enable faster, smarter humanitarian response

Project Goals and Future Impact

- New methods to understand key food security metrics
- Apply causal Machine Learning to identify climate & economic drivers
- Improve accountability & transparency in interventions
- Enable evidence-based and targeted humanitarian action

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THANK YOU

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