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Modelling Resilience against Fluctuating Yields in Cooperatives Using Virtual Agents

Clara Seinsche

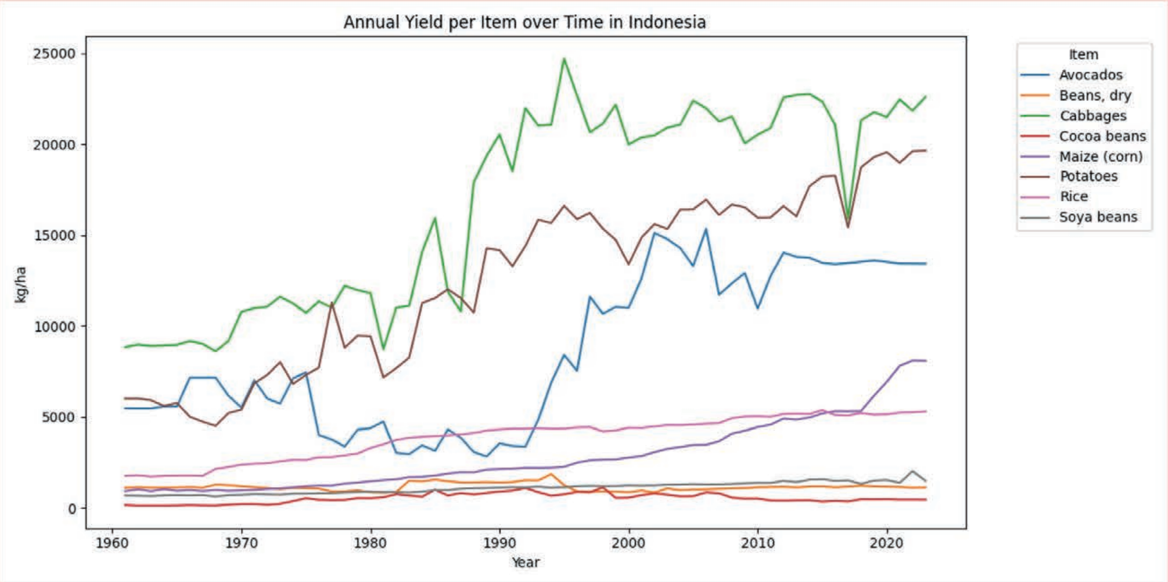
1 NO POVERTY

8 DECENT WORK AND ECONOMIC GROWTH

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Data

This project draws on historical **crop yield data** from the **FAO (1961–2023)**. I focus on Indonesia, where climate change and El Niño-related extremes have caused significant yield variability in a variety of crops. As **a highly climate-vulnerable country** with a large rural population[3], **Indonesia** serves as a critical case study for resilience-building through cooperative models.



Data Source: FAOSTAT (https://www.fao.org/faostat/en/#data/QCL)

Introduction

One of the biggest threats to agriculture today is climate change, which intensifies **yield fluctuations** and exposes smallholder farmers to existential risks[1]. Cooperatives are regarded to **foster resilience**—by pooling risks, sharing resources, and distributing profits more evenly. Yet not all cooperatives are equally suited to buffering climate-driven shocks[2]. This project explores how cooperative designs affect long-term sustainability of the group under volatile conditions.

Image Source: Freepik.com

The Cooperative Model

'Hybrid' Profit-Sharing

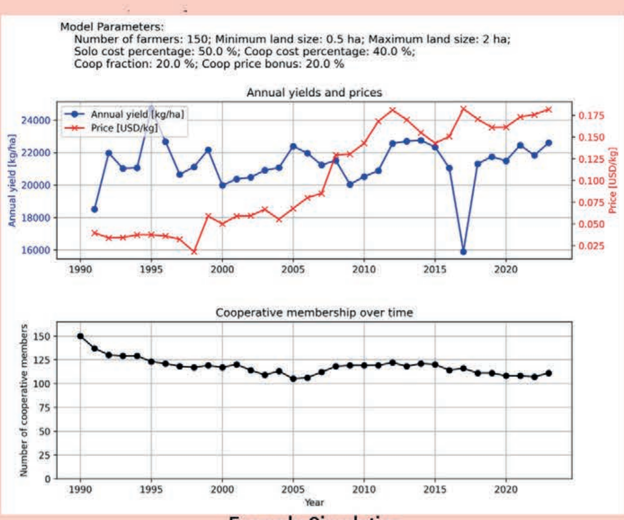
Farmers sell all their produce through the cooperative, with one part of income being pooled and redistributed evenly among cooperative members and the other part kept individually.

Income fluctuates with yield, but risks and gains are distributed across all members[4].

In the model, each agent/farmer can choose to **stay, join, or exit** based on a satisfaction score, shaped by **their relative profit in the past and present. Cooperative robustness** is measured by dropout and re-entry rates over time.

In Python

- Compute farmers income solo vs. as a cooperative-member
- Probabilistic function for leaving and entering
- Tracking membership numbers and cooperative land area over time
- Coefficient of variation as robustness index



Example Simulation

Research Question

I want to investigate how different cooperative setups affect the resilience of smallholder- cooperatives under conditions of high yield volatility.

My approach is via **modelling**, using:

- Virtual agents (farmers)
- Historical yield data
- Variable cooperative setups, i.e. membership numbers

Relevance & Outlook

Understanding how cooperatives mediate the impacts of yield shocks is increasingly urgent, especially in vulnerable agricultural systems like Indonesia's.

This simulation provides an adaptable framework for comparing cooperative resilience under fluctuating yields. While simplifications are necessary — e.g., homogeneous agents — this approach allows for controlled comparison and highlights how institutional design shapes long-term robustness and resilience among cooperatives and individual smallholders. Model complexity can easily be increased, e.g. by implementing more complex decision-making behaviour.

References

1. Intergovernmental Panel On Climate Change. Climate Change and Land: IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems. 1. Aufl. Cambridge University Press, 2022. https://doi.org/10.1017/9781009157988.
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3. Food and Agriculture Organization of the United Nations. „Evaluation of FAO's contribution to the Republic of Indonesia 2016-2020. Country Program Evaluation Series." Rome, Juli 2021.
4. Höhler, Julia, und Rainer Kühl. „POSITION AND PERFORMANCE OF FARMER COOPERATIVES IN THE FOOD SUPPLY CHAIN OF THE EU-27". Annals of Public and Cooperative Economics 85, Nr. 4 (Dezember 2014): 579–95. https://doi.org/10.1111/apce.12052.

Contact

Clara Seinsche, M.Sc.

clara.seinsche@student.hu-berlin.de

Student in M.Sc. Integrated Natural Resource Management

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