Using participatory system dynamics approaches to evaluate the nutritional sensitivity of a producer-facing agricultural intervention in India and Bangladesh

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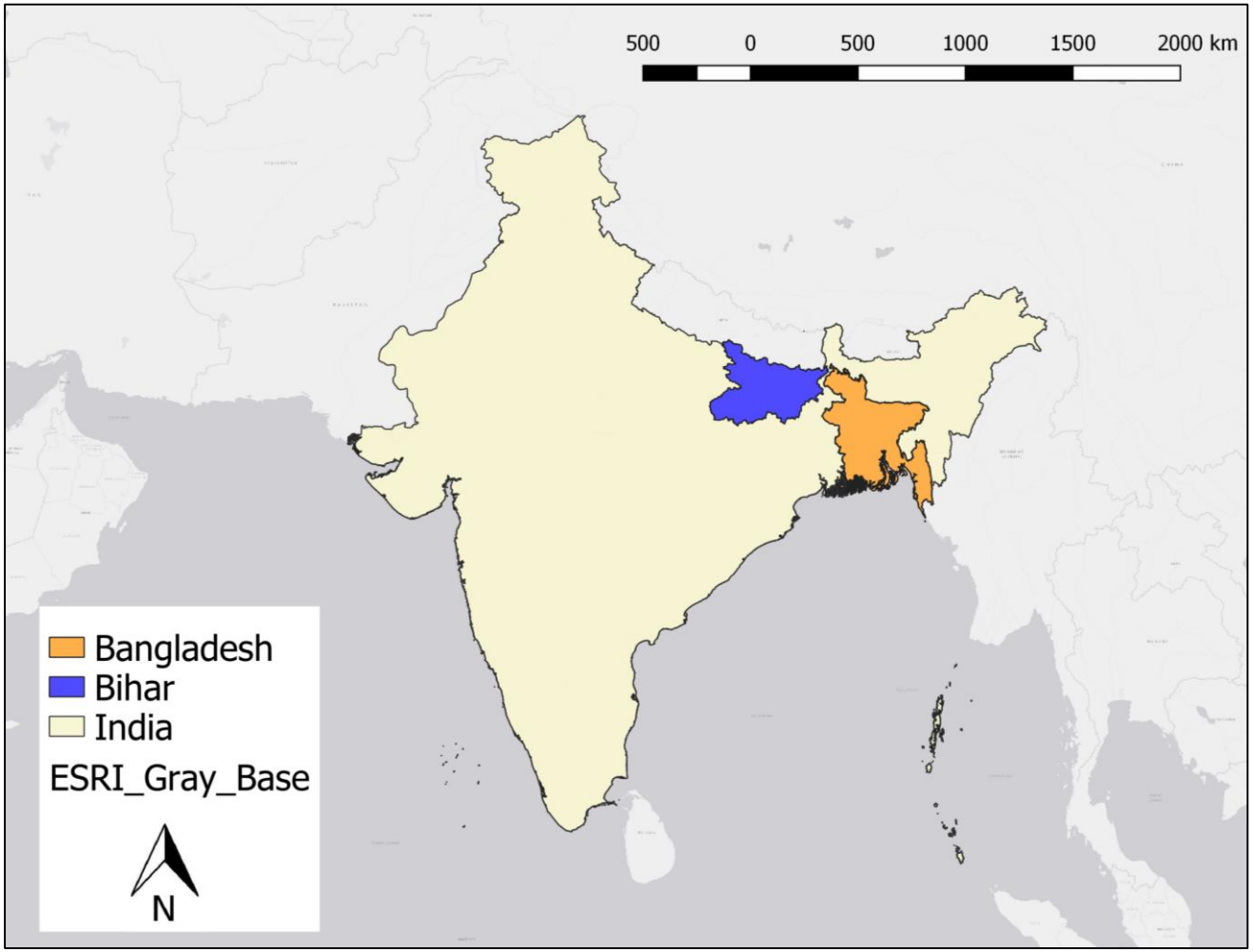
Study sites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Bangladesh
Bihar
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Study rationale

- According to National Sample Survey Organisation (NSSO) 2011-2012, average fruit and vegetable (F&V) consumption in Bihar equalled 132 g/capita/day
- People in Bihar consume less than half of the global recommendation of 400 grams/capita/day (FAO and WHO, 2014)
- Consumers dependent upon nutritionally vulnerable markets (i.e. traditional, small and often rural) likely to face the greatest challenges to F&V access and affordability.

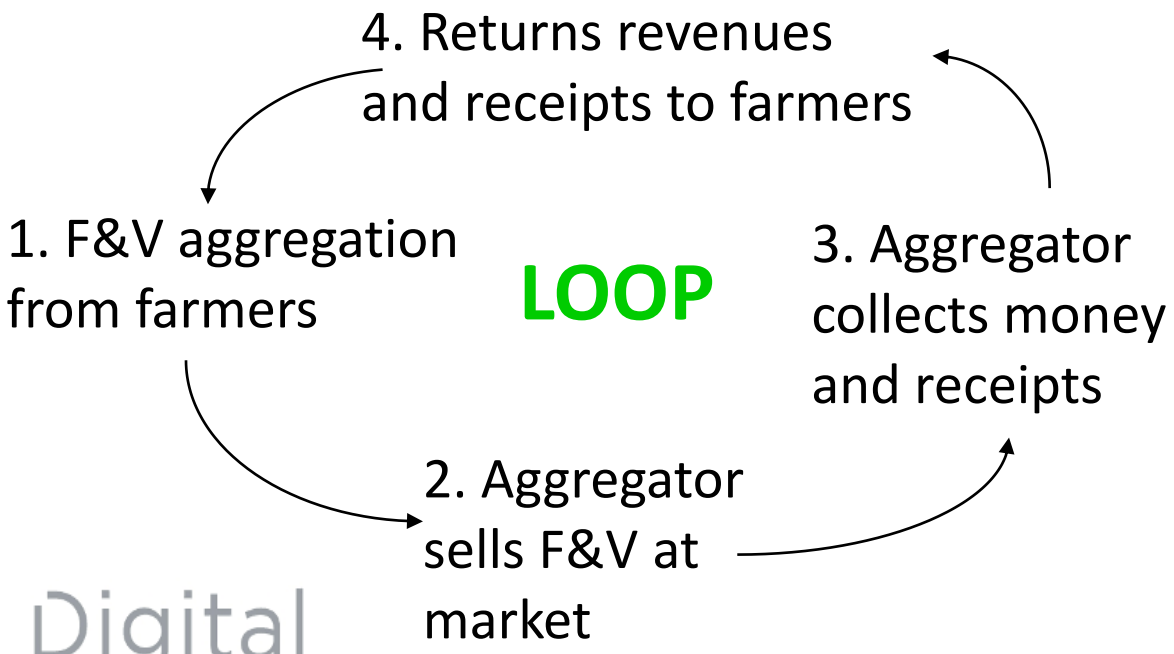

Green chilli in Ganj bazar, Muzaffarpur


Unloading oranges at Bazar Samiti, Patna


Bananas at Bazar Samiti, Patna

The LOOP aggregation scheme

LOOP: a mobile app-based aggregation service that has collected and sold the F&V supplies of over 28,000 farmers in Bihar, India

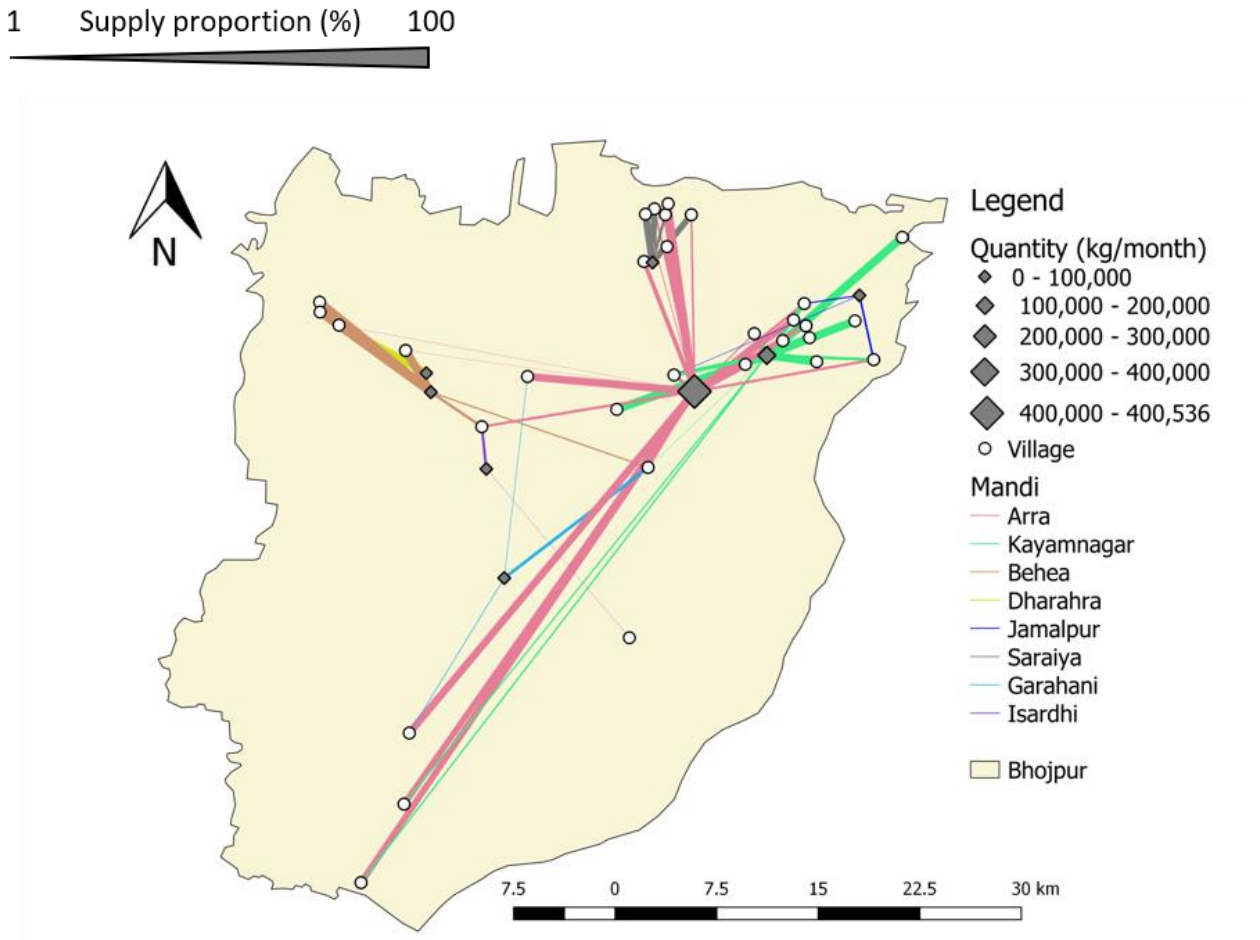


Key farmer-facing benefits:

- ✓ Cut transport costs (1.5 Rs/kg → 0.5-1 Rs/kg)
- ✓ Market access
- ✓ Increased bargaining power
- ✓ Time-savings

Problem definition

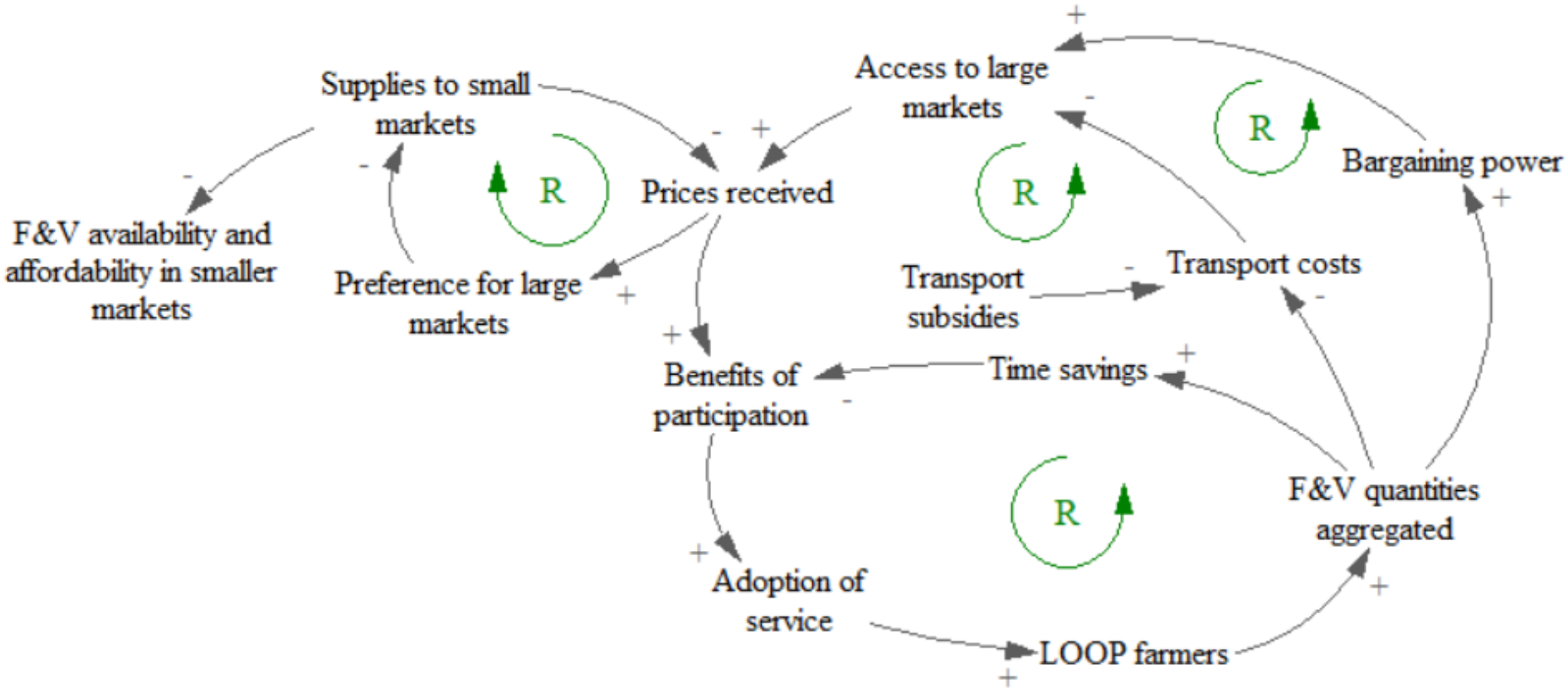
The combination of lower transport costs and access to higher capacity vehicles has contributed to **aggregation pathways clustering around large urban markets** (occasionally bypassing smaller rural markets)



Cooper et al (in review), Journal of Development Studies

Problem definition

1. Supplying LOOP removes the need for farmers to visit the market
2. Pooling helps to open up larger, wholesale-based markets
3. This reinforcing pattern may weaken supplies to smaller markets



Research aims

(i) Understand the current implications of the 'LOOP' aggregation scheme on the availability and affordability of fruits and vegetables (F&V) in nutritionally insecure markets in Bihar (and Jessore, Bangladesh)

(ii) Explore future scenarios to make the scheme more nutritionally sensitive in future

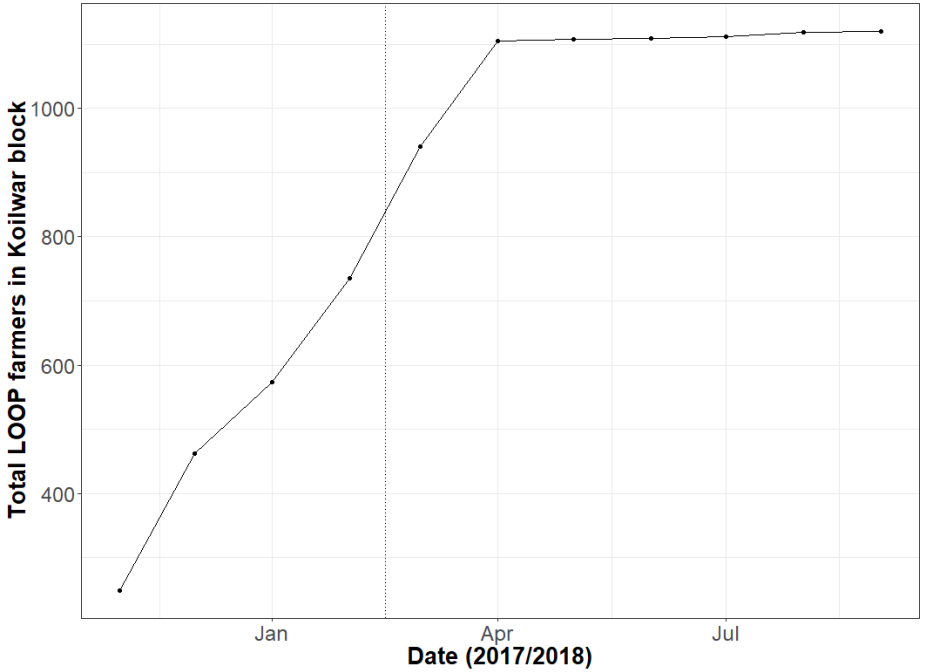
(iii) Evaluate the (nutrition-based) trade-offs resulting from the scenarios at multiple points along the value chain.

Data sources

1. Spatial group model building (SGMB): involving stakeholders in model conceptualisation, formulation, analysis, evaluation and decision-making (Mumba *et al.* 2017); using the participatory GIS tool 'LayerStack' (Rich *et al.* 2018)

2. LOOP dashboard data: real-time market transaction data covering LOOP supply quantities, F&V types, prices and associated meta-data

3. Household survey data: 360 farming household surveys on production and marketing habits



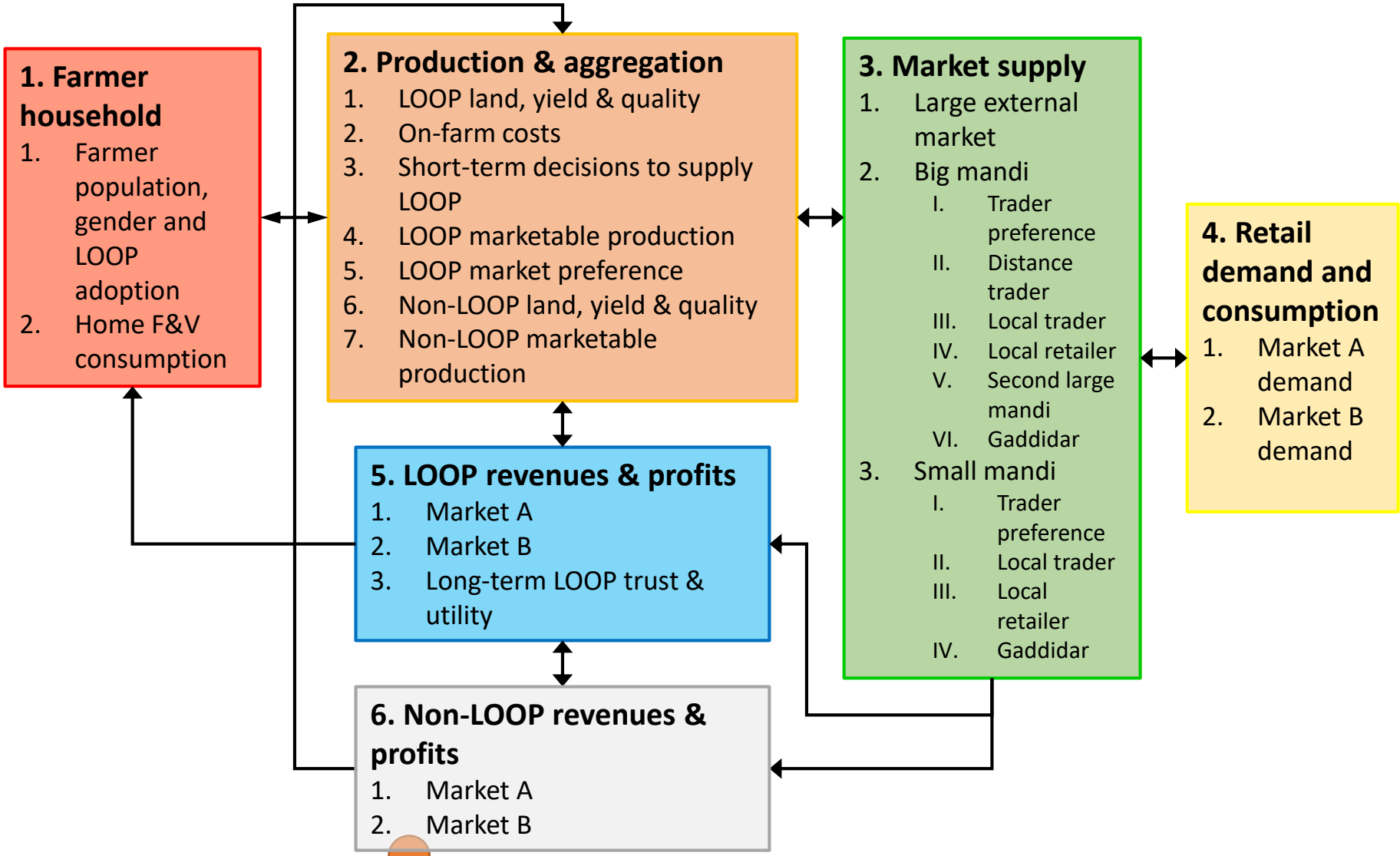
Example: the total number of farmers registered to LOOP in Koilwar block, Bihar

Survey enumeration in Muzaffarpur, Bihar

Model characteristics and outline

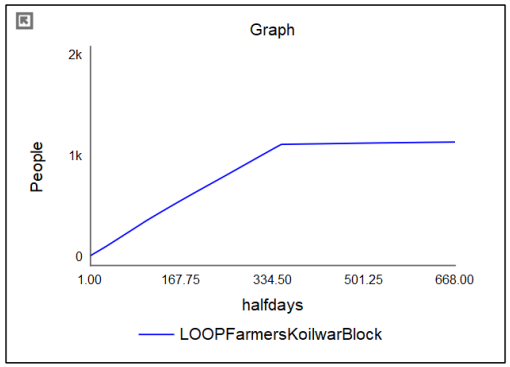
- **Temporal horizon:** October 1st 2017 – September 30th 2021
  - Parameterisation: October 1st 2017 – February 28th 2018
  - Performance analysis: March 1st 2018 – August 31st 2018
- **Temporal resolution:** half-day (i.e. morning and afternoon)
- **Spatial dimensions:** Koilwar block in Bhojpur district, Bihar state, India.
  - Farming households ≈ 12,100
  - Two major urban markets supplied (hereafter 'big market'): Arra and Kayamnagar (individual daily capacity >100 tonnes F&V).
  - Up to 5 smaller markets supplied by the aggregation scheme (individual capacities 5-15 tonnes/day)

Model characteristics and outline

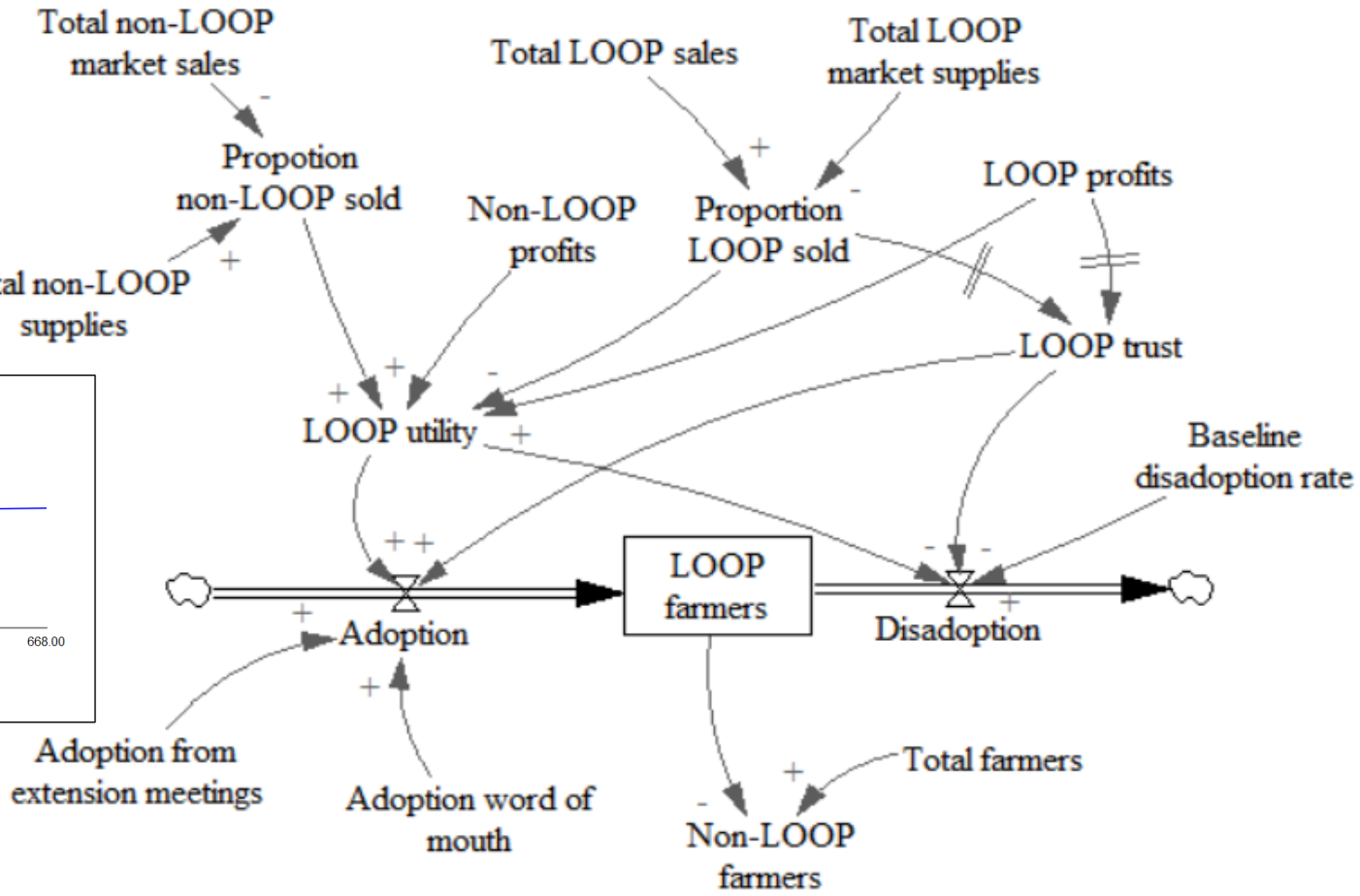


Two key stock and flow structures

1. LOOP adoption and disadoption

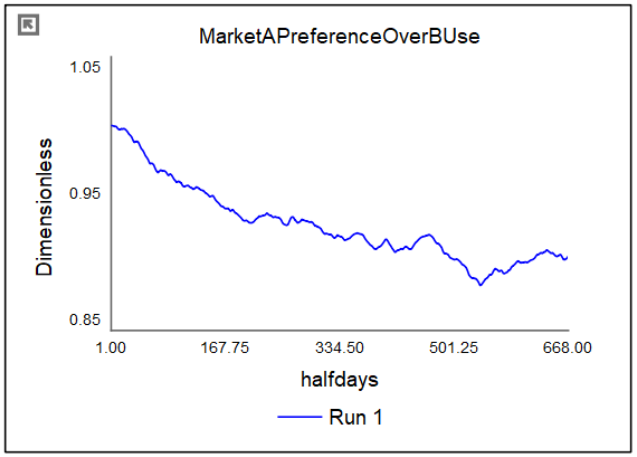


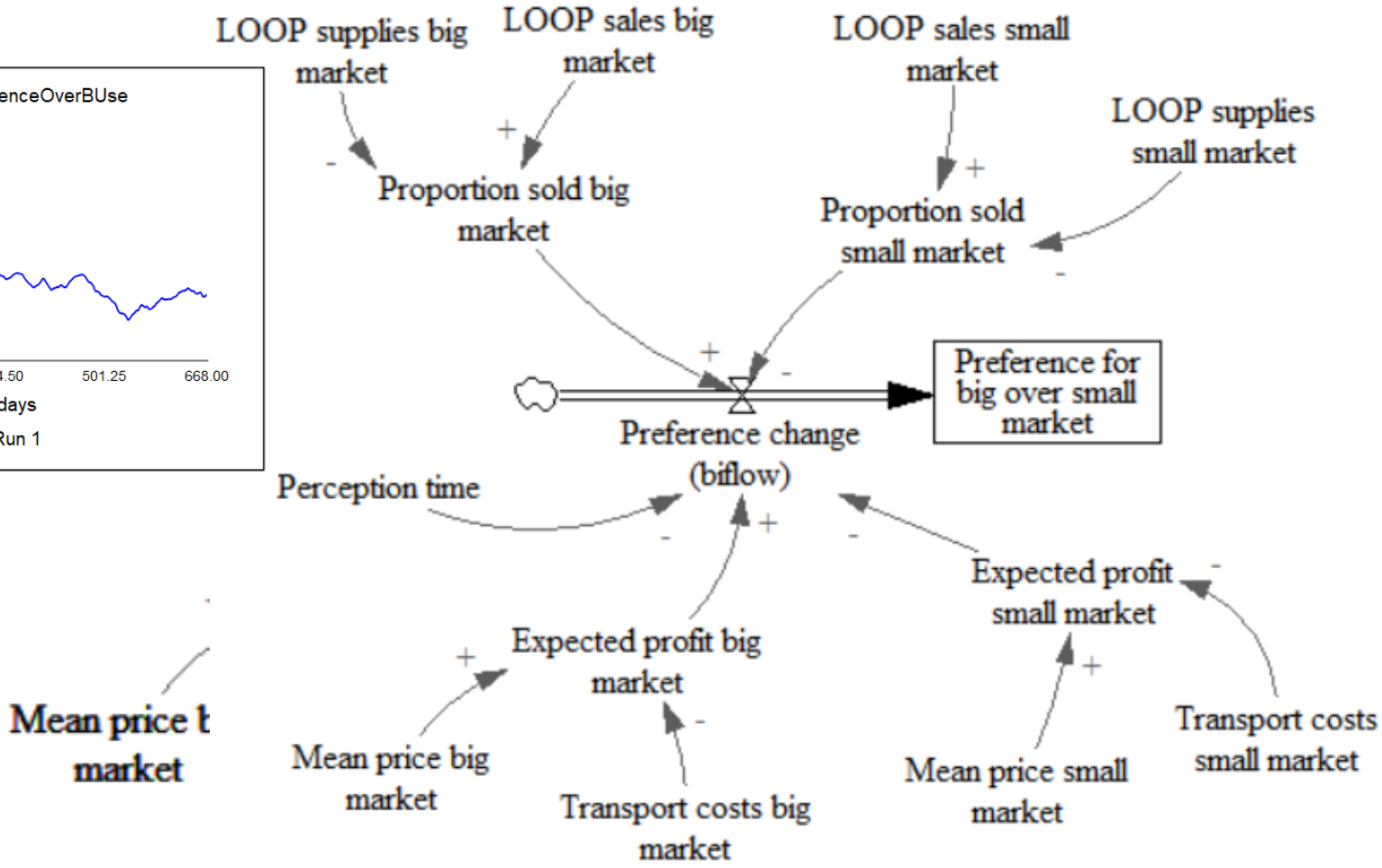
After Bass (1969) diffusion model



Two key stock and flow structures

2. Aggregation market choice

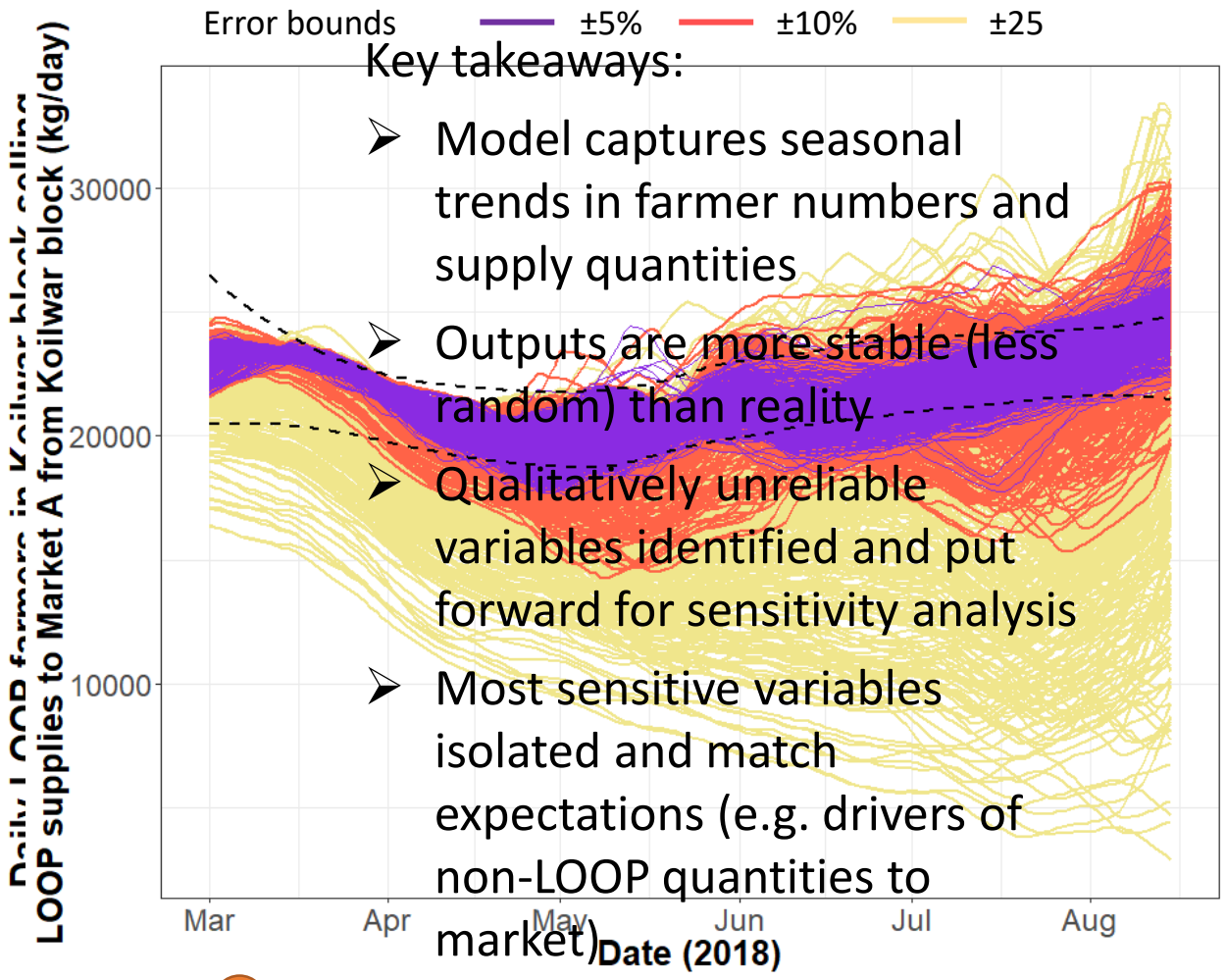




Model performance analysis

Four main tests conducted so far:

1. Assessment of parameter reliability (Chapman and Darby, 2016)
2. Pattern comparison
3. Extreme condition tests
4. Monte Carlo sensitivity analysis



Key takeaways:

- Model captures seasonal trends in farmer numbers and supply quantities
- Outputs are more stable (less random) than reality
- Qualitatively unreliable variables identified and put forward for sensitivity analysis
- Most sensitive variables isolated and match expectations (e.g. drivers of non-LOOP quantities to market)

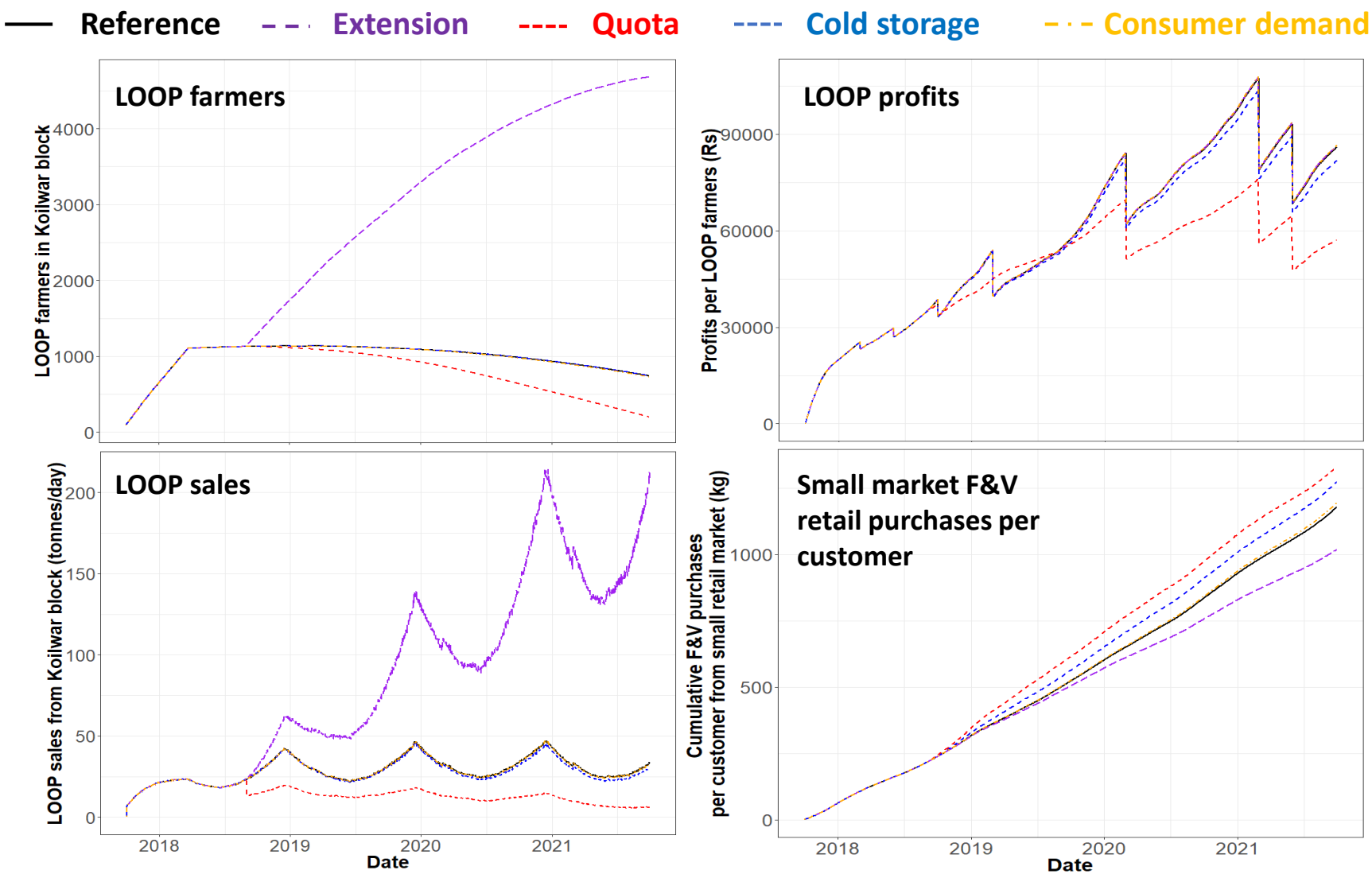
Scenario runs

- (i) What are the current LOOP scheme for the availability and affordability of F&V in smaller markets? (ii) How may the scheme be made more nutritionally sensitive in future? (iii) What are the wider trade-offs resulting from the scenarios.

Scenario names and descriptions:

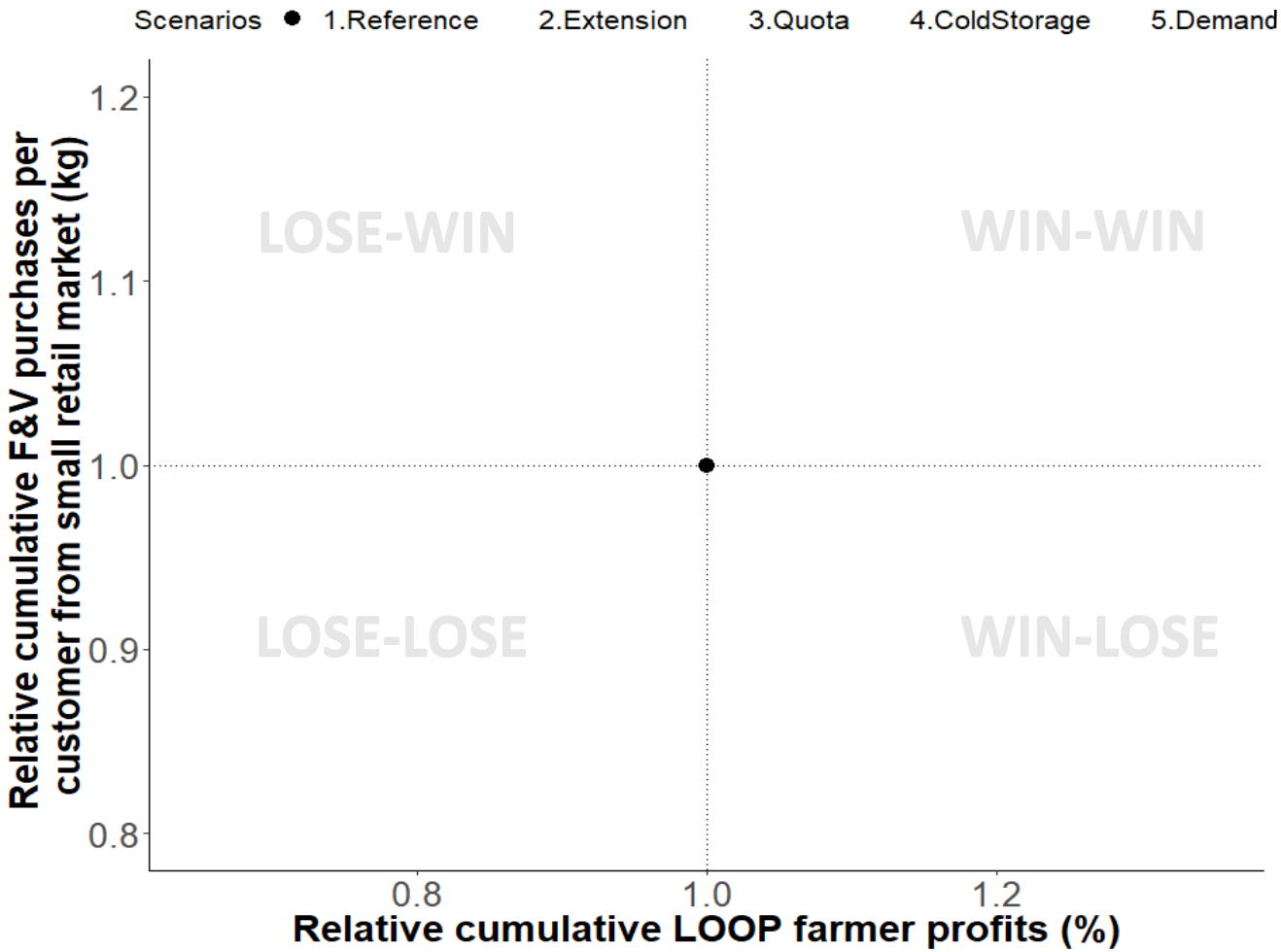
1. **"Reference":** model runs until end of August 2021 without any internal/external interventions.
2. **"Extension":** Effectiveness of extension efforts set at historical rate (i.e. same as when LOOP was actively expanding from October 2017-Feb 2018).
3. **"Quota":** 20% of LOOP supplies are sent to Market B.
4. "**Cold storage**": Traders may store F&V for up to 3 weeks, but pay rent to the government at 0.3 Rs/kg/day.
5. "**Reference consumer demand**": change in the baseline retail demand (i.e. pre-price adjustment) for F&V.

Output timeseries

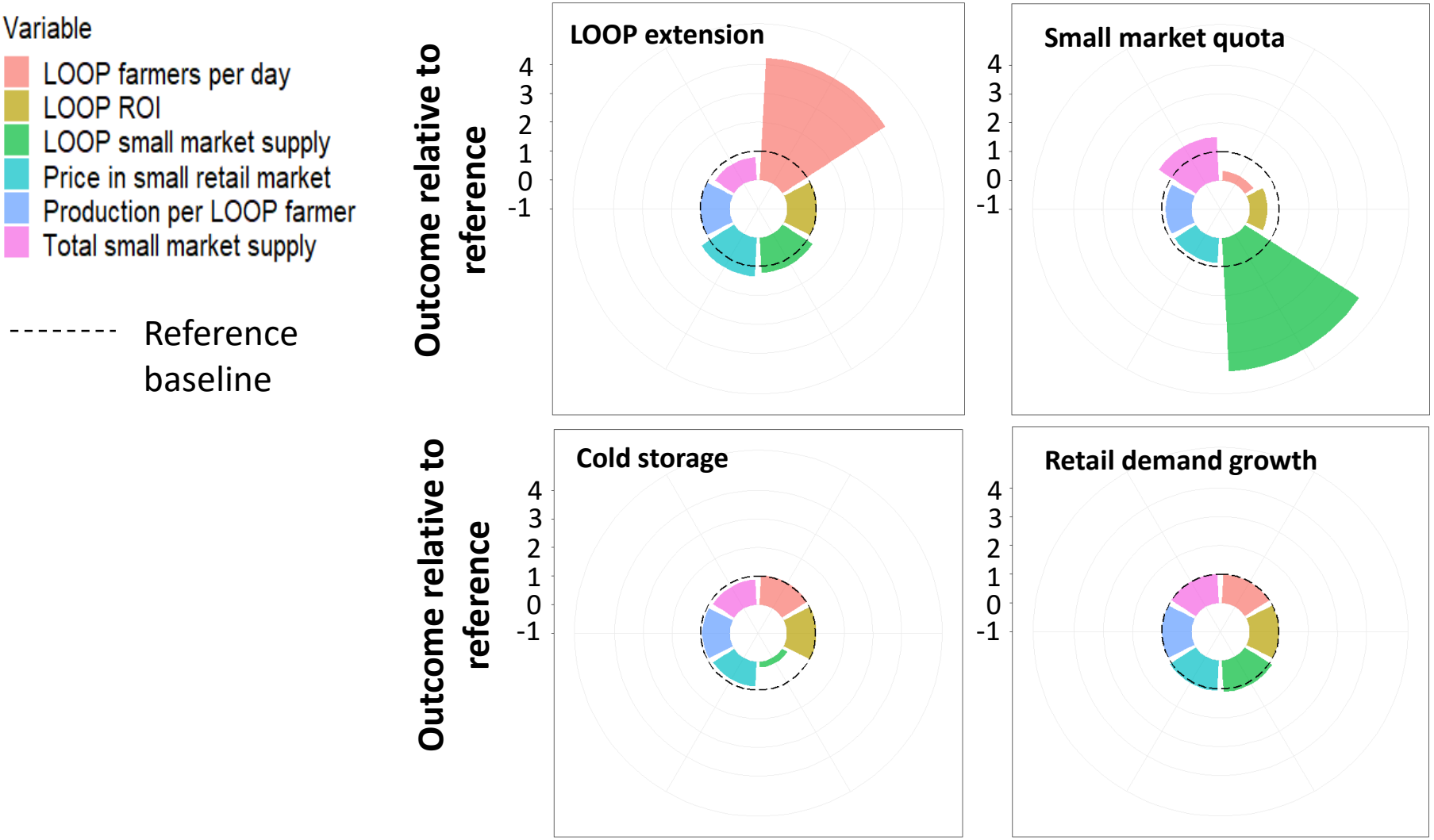


Nutrition-livelihood trade-offs

How do these scenarios plot on the trade-off space?



Wider trade-offs



Implications and next steps

- **Methodologically:** this approach probes trade-off spaces between various value chain outcomes to find pathways to 'win-win' futures.
  - Additional output dimensions could be added to explore pathways to 'win-win-win…' futures (e.g. the financial sustainability of the aggregation system).
  - Monte Carlo analysis could add uncertainty ranges to the trade-offs and trajectories, and better understand the interactions between scenarios (i.e. extension and subsidies)
- **Aggregation systems:** real potential to improve the availability and affordability of F&V in small, rural markets.
  - However, nutrition-facing benefits may come at the expense of producer-facing financial outcomes.
  - Likewise, changes in the wider enabling environment may compound these trade-offs (e.g. cold storage stabilising prices in smaller markets)

References

Chapman, A., Darby, S., 2016. Evaluating sustainable adaptation strategies for vulnerable mega-deltas using system dynamics modelling: Rice agriculture in the Mekong Delta's An Giang Province, Vietnam. Sci. Total Environ. 559, 326–338. https://doi.org/https://doi.org/10.1016/j.scitotenv.2016.02.162

FAO, WHO, 2014. Country Nutrition Paper: Bangladesh, in: International Conference on Nutrition 21 Years Later. Rome, Italy, p. 47.

Mumba, C., Skjerve, E., Rich, M., Rich, K., 2017. Application of system dynamics and participatory spatial group model building in animal health: A case study of East Coast Fever interventions in Lundazi and Monze districts of Zambia. PLoS One 12, 1–21. https://doi.org/10.1371/journal.pone.0189878

NSSO, 2013. Household Consumer Expenditure, NSS 68th Round Sch1.0 Type 1: July 2011—June 2012. New Delhi, India.

Rich, K.M., Rich, M., Dizyee, K., 2018. Participatory systems approaches for urban and peri-urban agriculture planning: The role of system dynamics and spatial group model building. Agric. Syst. 160, 110–123. https://doi.org/https://doi.org/10.1016/j.agsy.2016.09.022

Thank you for listening!

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