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Towards sustainable food systems in small islands: a WEF nexus approach

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1. Introduction

1.1. Context and related work

Small islands can be defined as territories surrounded by water, with a small surface area, limited resources and characterized by strong economic, climatic or demographic vulnerabilities.

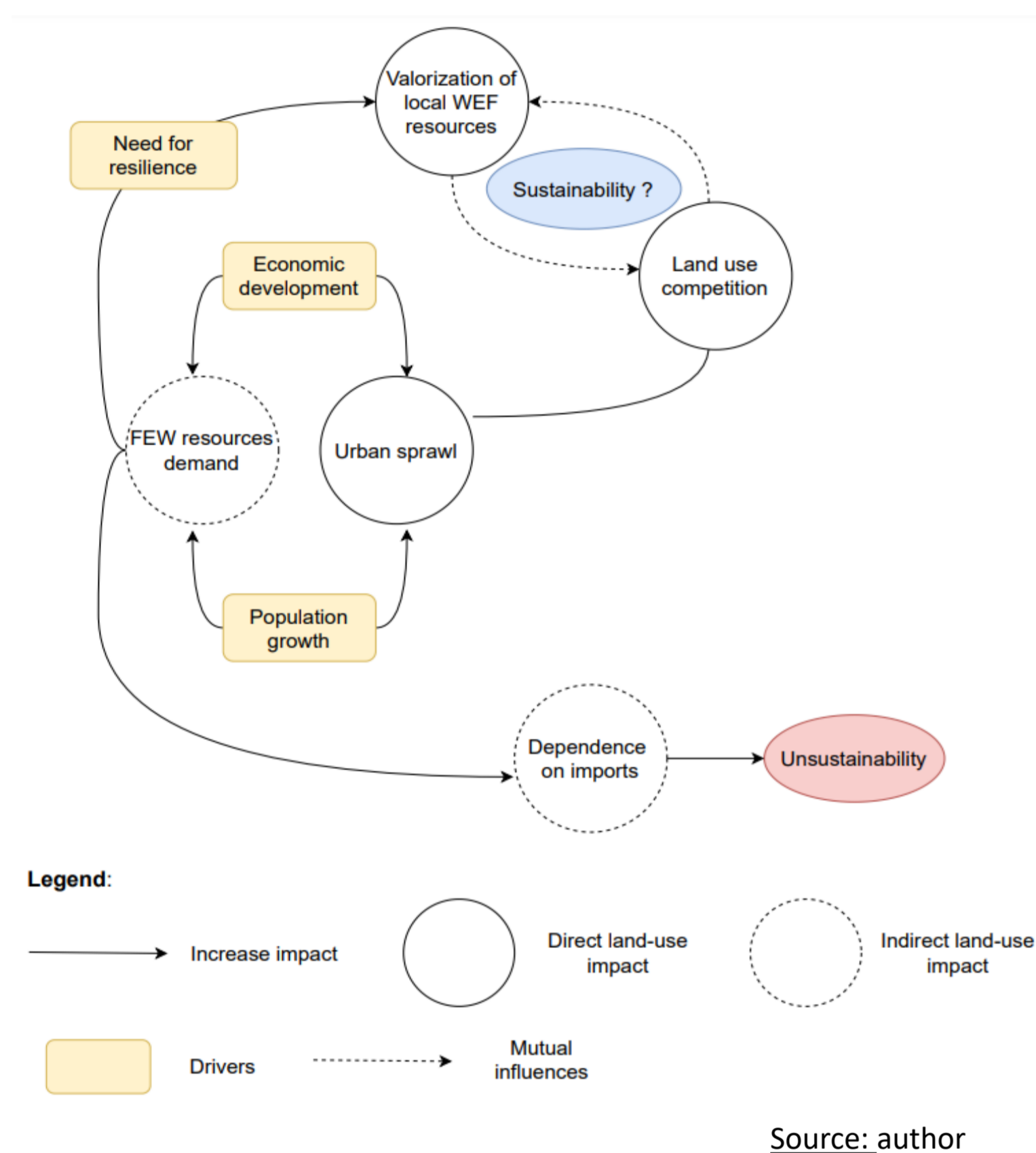
Need for resilience for these islands that implies a greater empowerment through the development of renewable energies, the development of local food systems and the improvement of water management.

Hence, the balance of food-energy and water resources within the Water-Energy-Food (WEF) nexus has been studied several times under different constraints accentuating tensions in the supply of these resources such as climate change, population growth or urbanization at different scales.

Our approach: Exploring the link between urbanization, local WEF resources and competition for land use in a spatially constrained territory.

2. Problem description and approach

2.1. Linking the approach to small island sustainability



1 Demographic growth and economic development are considered as the main drivers of the growth of the nexus.

2 Without environmental objectives, increased demand for WEF resources leads to a higher reliance on imports and then, to an unsustainable food system.

3 Conversely, in the quest for resilience, dependence on imports decreases in favor of local WEF resources.

2.2. Methodological framework

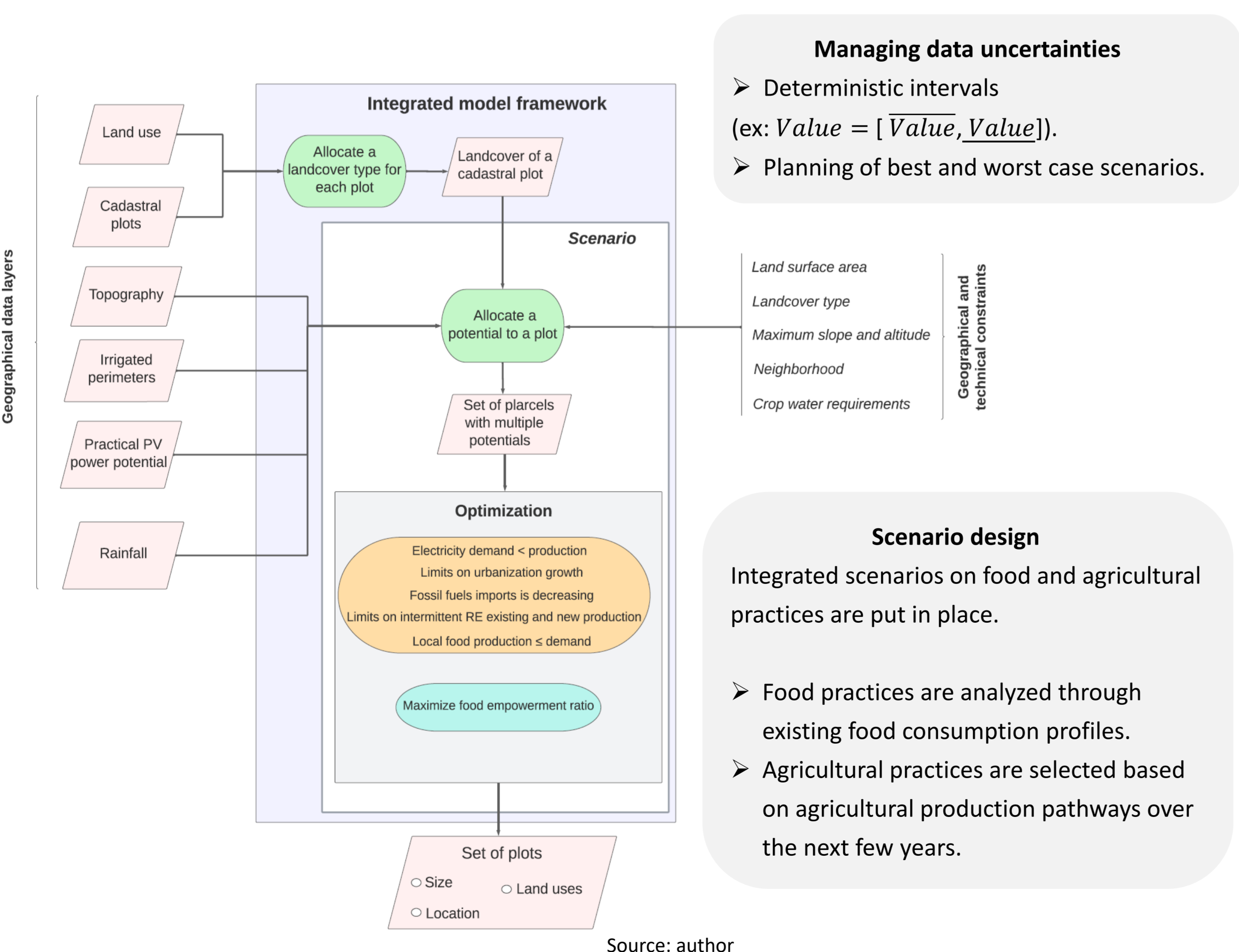
Contributions of a GIS based model :

- ✓ Competitions for land use in a context of local WEF resources use
- ✓ Land use constraints

Contributions of a robust optimization model :

- ✓ Modeling of the growth of the nexus
- ✓ Identifying of thresholds and limits linked to food self-sufficiency process
- ✓ Managing data uncertainties

Proposed modelling : Integrated GIS and robust optimization framework as a decision-support tool



Managing data uncertainties

- Deterministic intervals (ex: $Value = [Value, Value]$).
- Planning of best and worst case scenarios.

Scenario design

Integrated scenarios on food and agricultural practices are put in place.

- Food practices are analyzed through existing food consumption profiles.
- Agricultural practices are selected based on agricultural production pathways over the next few years.

1.2. Contributions

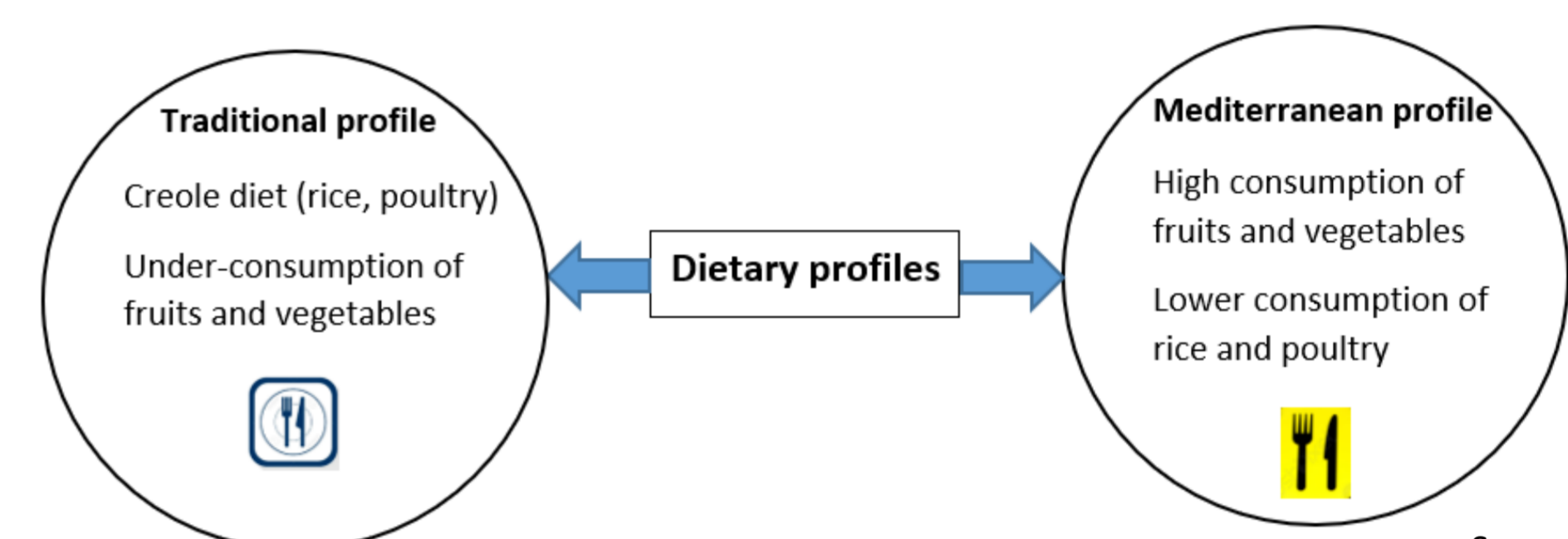
- ✓ Sustainability of food systems in small islands is explored through the study of reciprocal influences between WEF resource empowerment and land use competition for several scenarios of food and agricultural practices.
- ✓ Building of food and agricultural practices scenarios based on various consumption patterns and agricultural pathways on the island to visualize the impact on food systems sustainability within a WEF nexus approach.
- ✓ Development of a GIS-based optimization model satisfying constraints linked to the growth of the WEF nexus (increased demand for WEF resources).

1.3. Objective

Study the thresholds and limits to food self-sufficiency process beyond which the sustainability of food systems is no longer guaranteed within a WEF nexus approach (1) at an island scale such that (2) WEF-related and urban sprawl constraints are satisfied (3) at maximum food self-sufficiency ratio for a future horizon 2035.

3. RESULTS: Food self-sufficiency process in Réunion

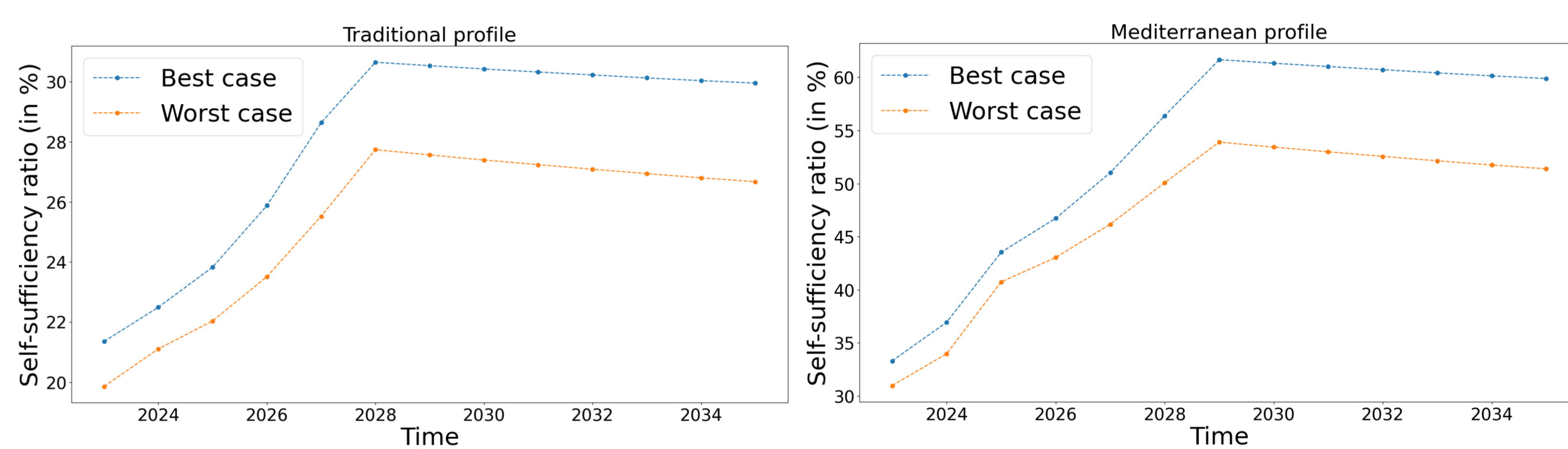
3.0. Food consumption profiles



Source: INSEE

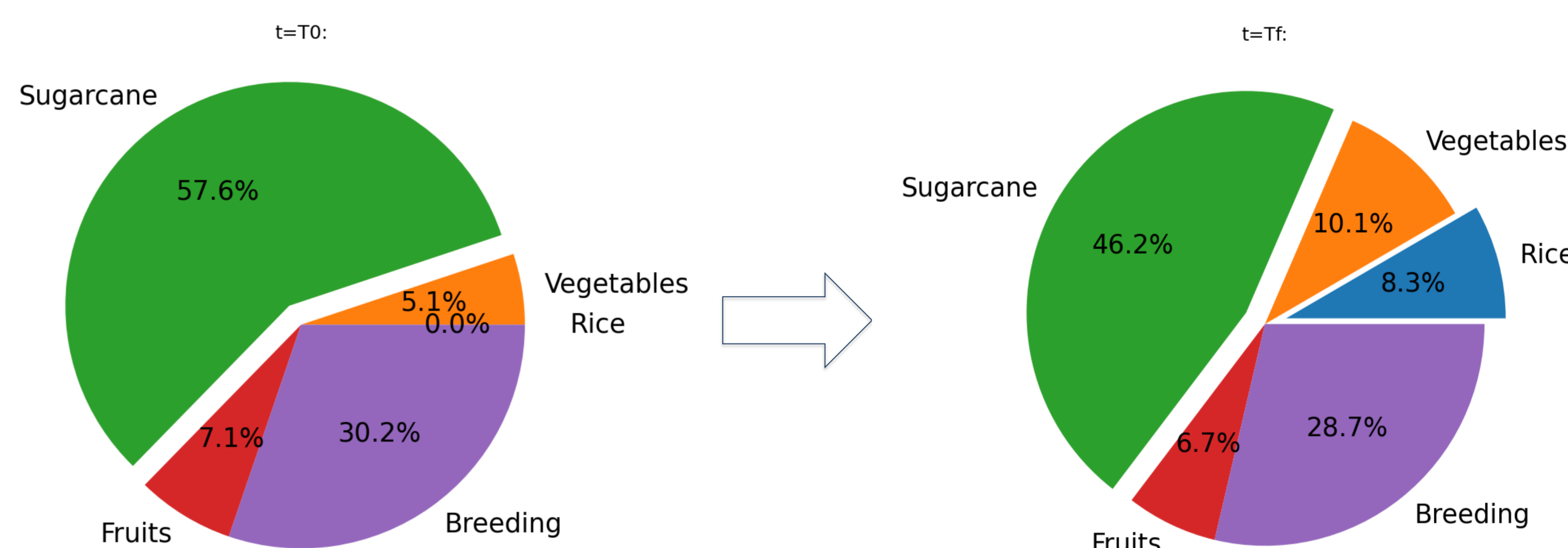
- 4 food groups selected for the analysis of food self-sufficiency process in Réunion:
 - Fruits, vegetables, poultry and rice
- Total reliance on rice imports (negligible local production)

3.1. Food self-sufficiency ratio



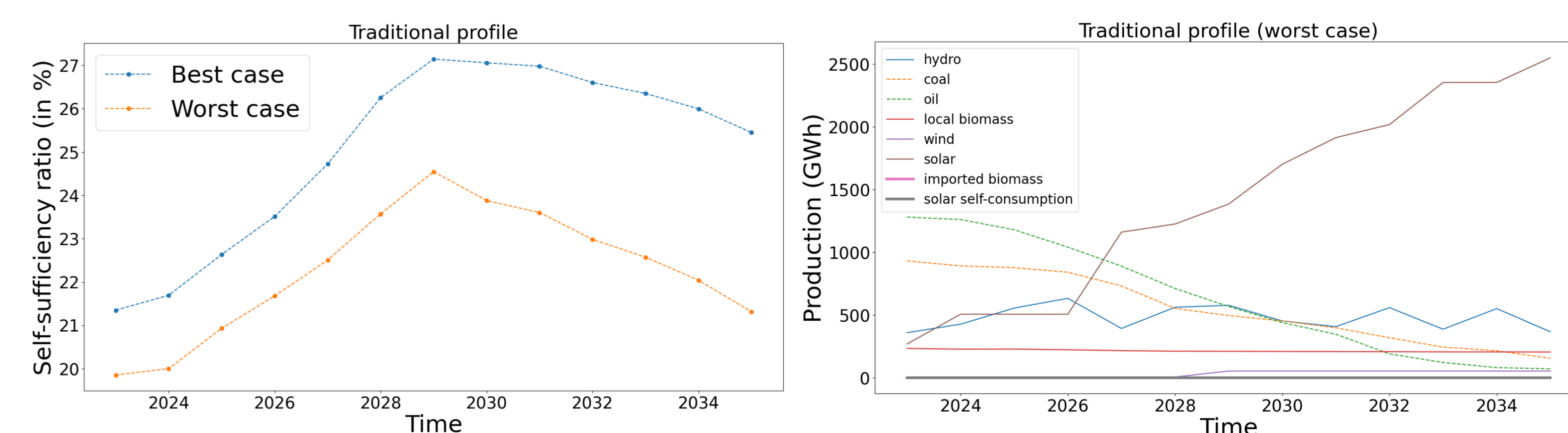
Source: author

3.2. Land use share in Réunion (Mediterranean profile)



Source: author

3.3. Influence of increasing the production threshold for intermittent RE (to 95 %)



Source: author

4. CONCLUSION

There are several ways of meeting the challenge of a greater food self-sufficiency in Réunion. On the production side, improving the region's sustainable food self-sufficiency process is based on developing the use of local resources for producing clean energy while saving as much space as possible, in particular through solar self-consumption and bioelectricity production. However, care must be taken to ensure that power grid regulation equipment is adapted to the development of decentralized production systems. On the demand side, the major lever towards a more sustainable food system lies in the change of eating habits towards locally produced food and high added-value crops.