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Prototyping climate-smart agricultural landscapes: a generic modelling framework and application in a tropical island

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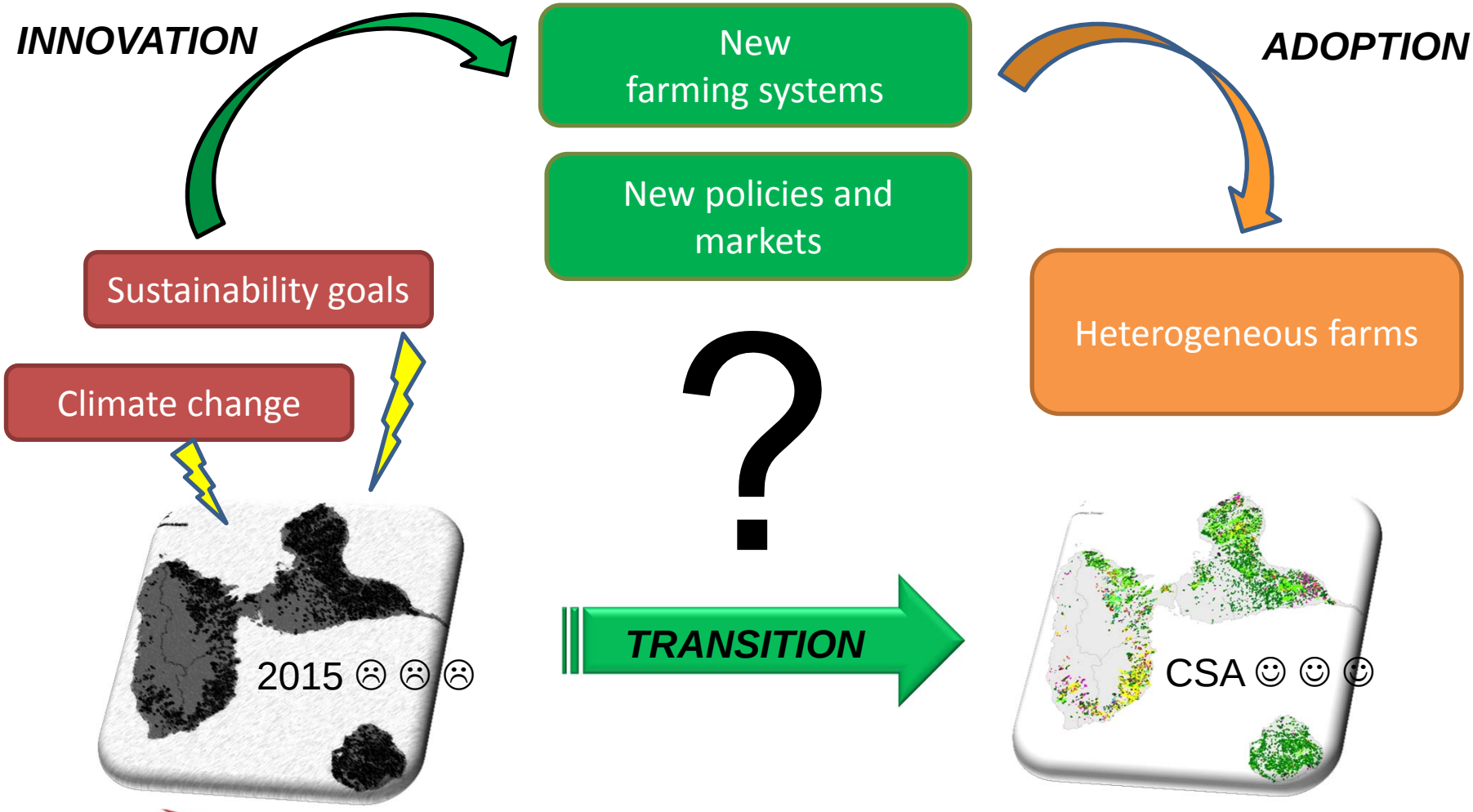
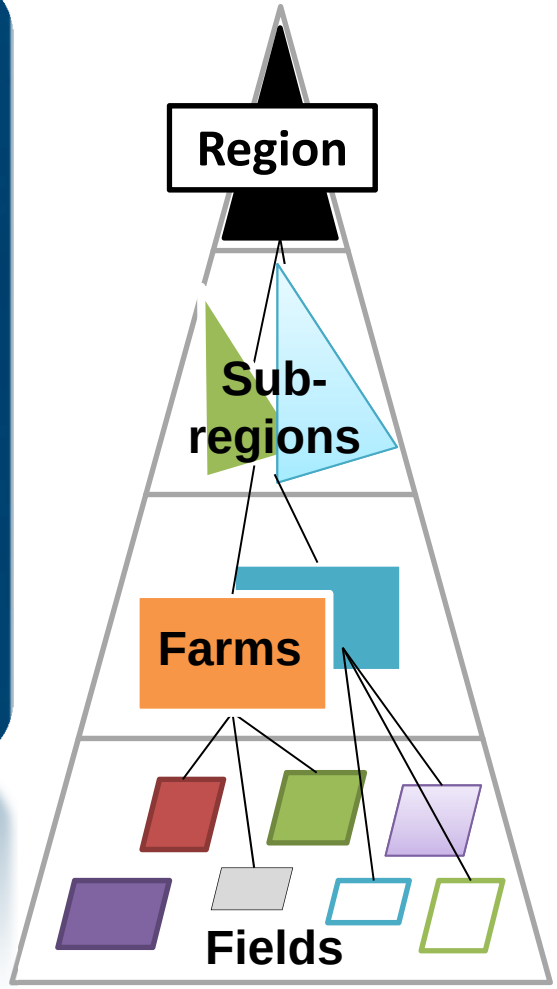
The challenge of transition to CSA landscapes



Aims of the research: an integrated model



→ Applying the approach to the prototyping of a scenario of CSA in Guadeloupe

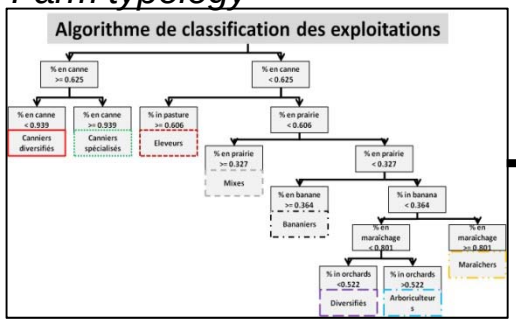
The MOSAICA model

Fields and soil database

Activities database

	A	B	C
1	ident	Agrumes	Ananas_Paillé
2	PRIX	700	1100
3	VAR_PRIX_P	0	0
4	VAR_PRIX_M	0	0
5	PRIMES	0	-100000
6	RDT	20	18.3
7	VAR_RDT	0.3	0.4
8	VAR_RDT_PL	0	0
9	VAR_RDT_M	0	0
10	RICHESSE	0	0

Farm typology



(Chopin et al., 2015)

A bioeconomic model

Equations

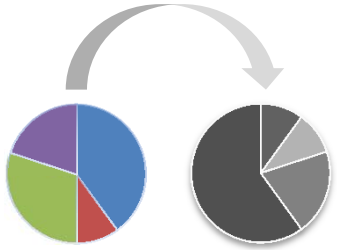
$$Ax \leq B \; ; \; x \geq 0$$

Function objective

$$MAX \sum_F \left(\sum_P X_a \left(\sum_A \bar{m}_a - \phi_F (Z_a) \right) \right)$$

Indicators

$$Gini = \frac{2 * \sum_{f=1}^{f} REV(f) * \mathrm{rank}(f)}{Nb_f * \sum_{E=1}^{e} REV(f)} - \frac{Nbf + 1}{Nbf}$$



(Chopin et al., submitted)

Climate change in tropical islands

- An increase in temperature, rainfall and intensity in extreme events (source: Meteo France)

- A critical issue because:
  - Small tropical island are more vulnerable to CC and markets fluctuations
  - Land availability is limited for ensuring food self-sufficiency
  - Hotspot of biodiversity

- Island = Archetype for transition?

A need in CSA landscapes in Guadeloupe

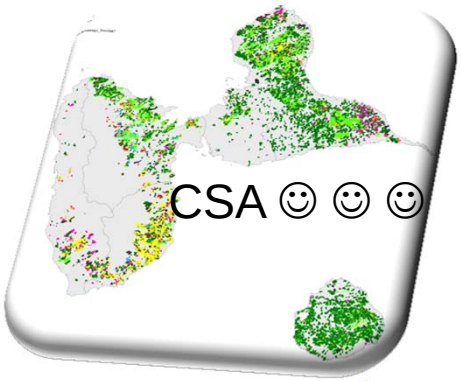
Scenario approach: transition to CSA through innovations at multiple level

- Development of energy crops on contaminated areas
- Organic waste recycling: Compost supply
- Development of agro-ecological farming systems for interior market
- Orientating economic incentives toward CSA

- Greening the electric mix
- Reduction of waste burning
- Increase in compost use in cropping syst.
- Reduction of pesticide use
- Reduction of chemical fertilizers

- Reduction of GHG
- Increase in food autonomy
- Adaptation to CC
- Preserving farmers' income

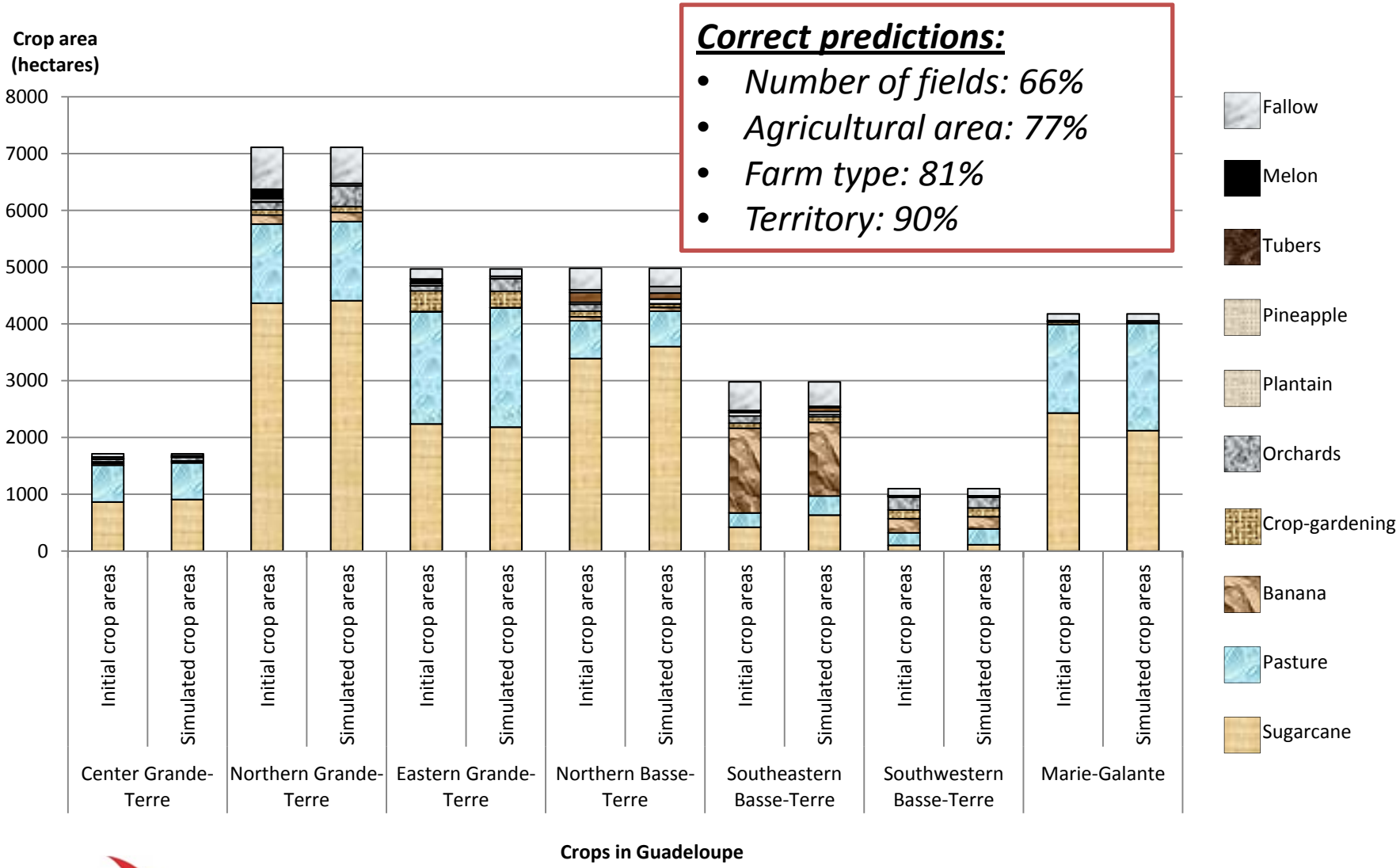
Will this scenario lead to a CSA?



Scenarization with the MOSAICA model

Scenario parameters	« Tendency » scenario 2040	« Adaptation » scenario 2040
All activities	CC affects yields and SOM	CC affects yields and SOM
New activities	NO	Crop-energy agro-ecology Horticulture agro-ecology
New agricultural policies	NO	AES compost + pesticide-free Reallocation of susbisidies amount per hectare

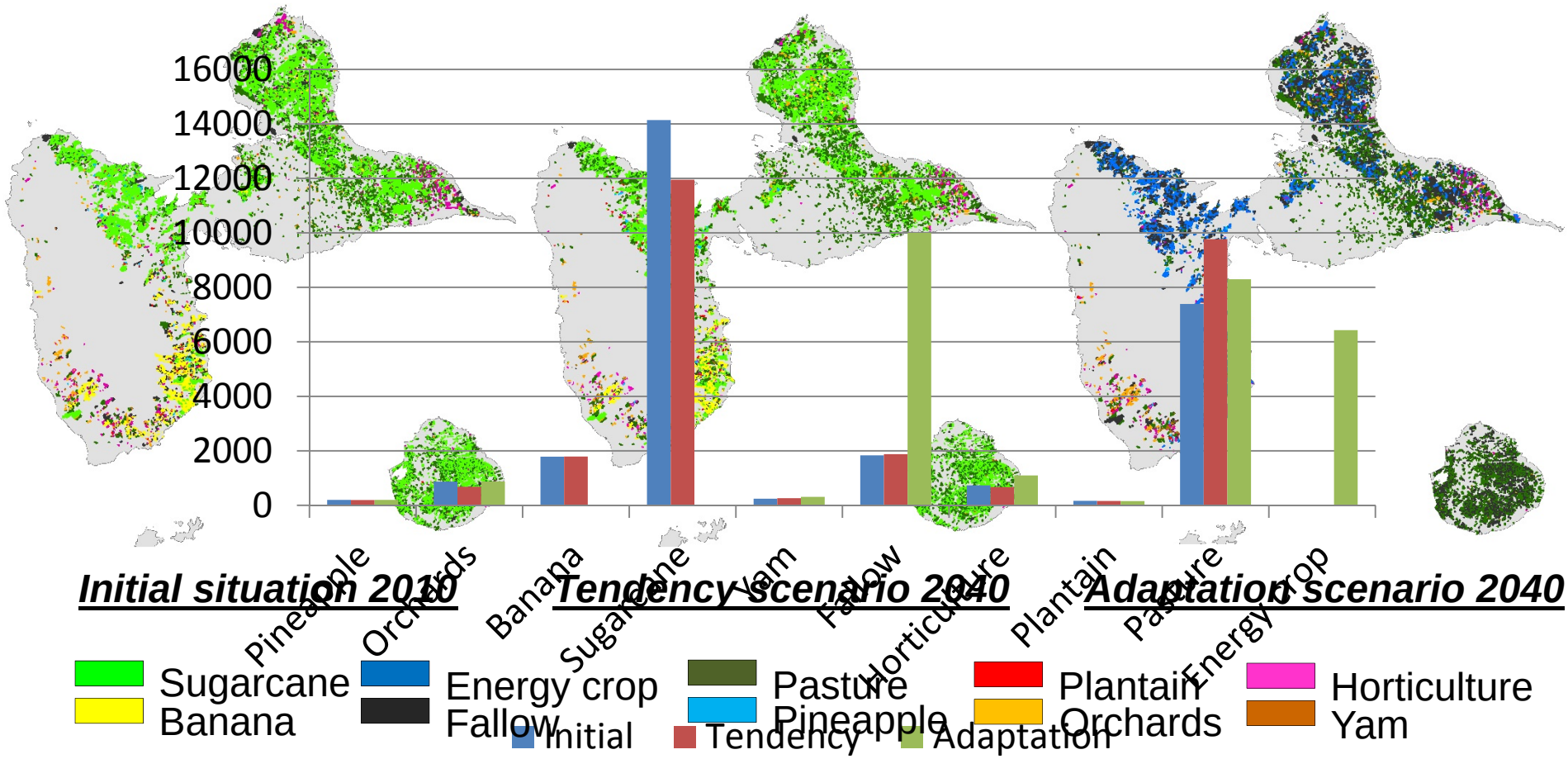
Model calibration



Correct predictions:

- *Number of fields: 66%*
- *Agricultural area: 77%*
- *Farm type: 81%*
- *Territory: 90%*

Simulation of landscapes evolution



→ Agricultural landscapes are greatly changed by the « adaptation » scenario

Balance of landscape GHG emissions

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CSA could make it possible to reduce GHG emission:

- ✓ -170% of GHG Emissions from Agriculture and Forest
- ✓ -10% of GHG Emissions from the overall Guadeloupe

Impacts on other sustainability issues

Indicators	Units	*Initial situation*	*Tendency scenario*	*Adaptation scenario*
Mean farmers' income	€/ha/year	*3510*	*3110*	*4940*
Energy self-sufficiency from biomass	%	*3%*	*3%*	*13%*
Food self-sufficiency	%	*15%*	*15%*	*17%*
Proportion of rivers potentially polluted	%	*39%*	*36%*	*8%*
Total amount of subsidies (first + second pillar of CAP)	M€ /year	*75*	*63*	*61*

→ Our « adaptation » scenario is climate smart ☺

Conclusions

- ✓ **A promising methodology for designing CSA landscapes:**
  - ✓ Useful to think about how a more climate smart and sustainable future could be
  - ✓ Explicitly represent complexity in agroecoystsems across scales
  - ✓ Ability to quantify scenarios' impacts in a spatially explicit way
  - ✓ Integrating knowledge and models from different discipline

- ❑ **What does it remains to do?**
  - ❑ Testing a combination of crop and livestock management systems adapted to CC
  - ❑ Dynamics of transition
  - ❑ Simulations to assess frontiers between sustainability goals