PREFALIM

TRANSITIONS TOWARDS CARBON-NEUTRAL FOOD SYSTEMS

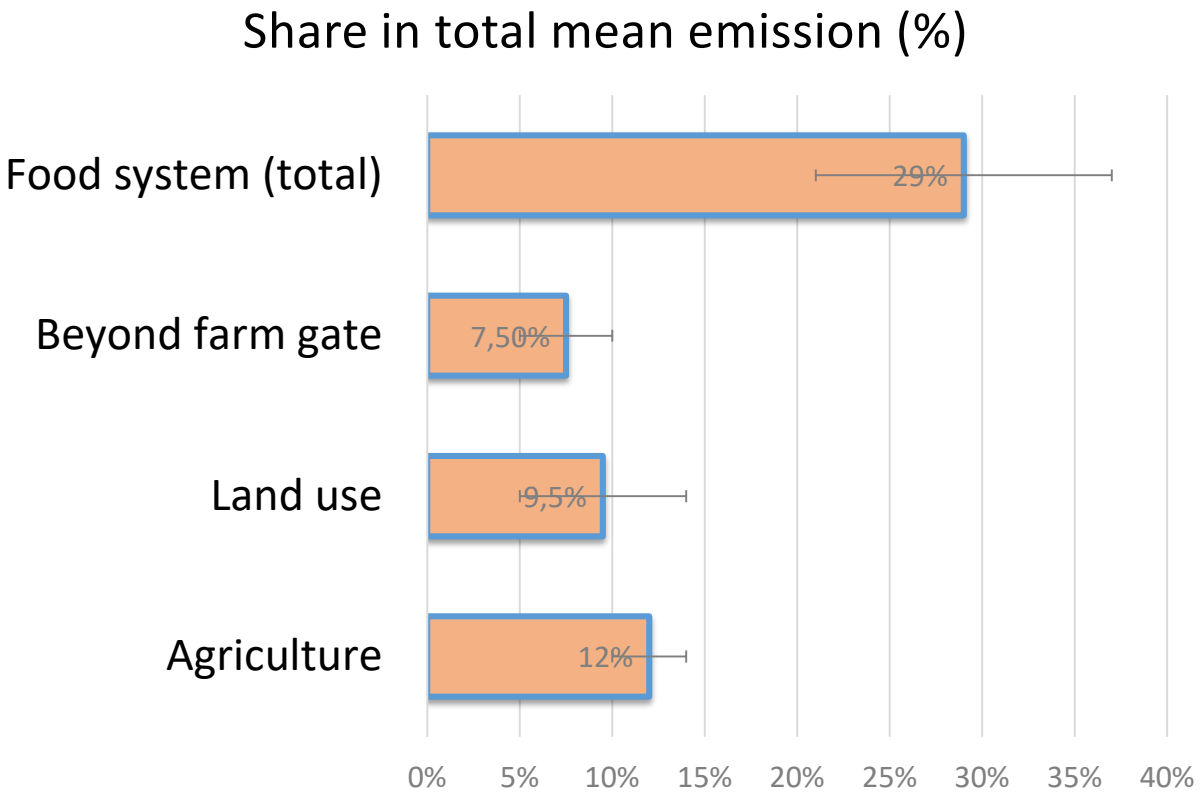
PREFERENCES, CONSUMER WELFARE & PUBLIC POLICIES

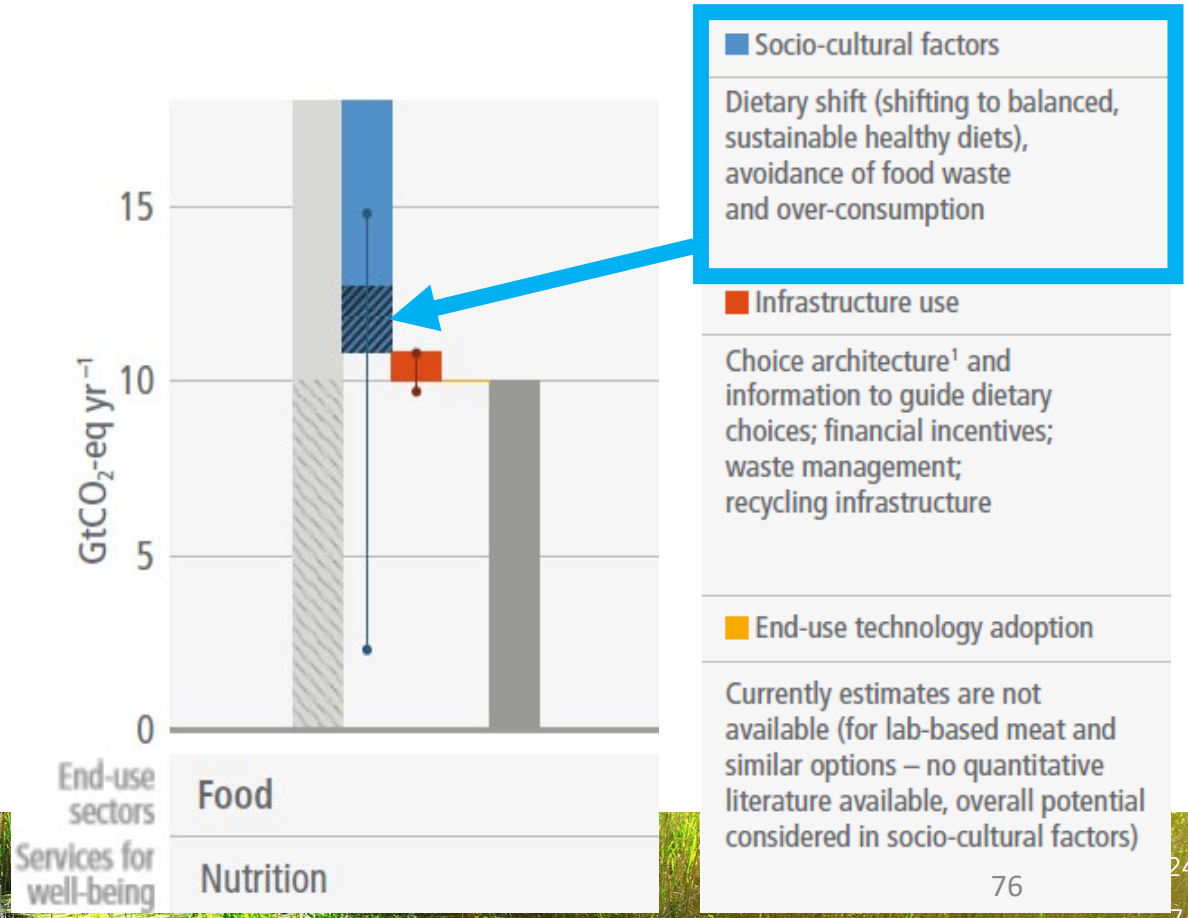
PROJECT OVERVIEW

JOURNÉES ANNUELLES 2024

Scientific context

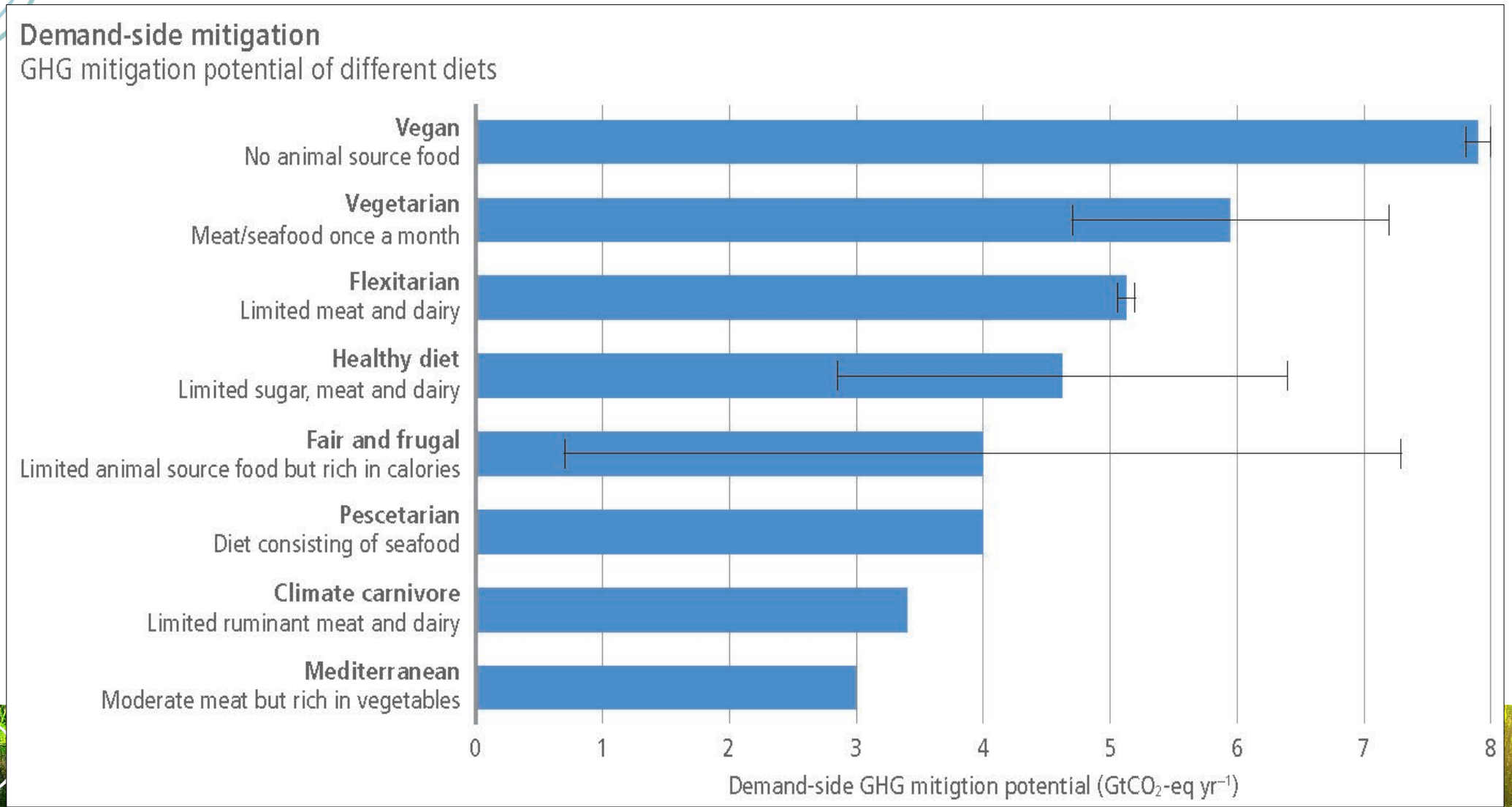
- Food systems emit **21-37%** of total anthropogenic GHG emissions (IPCC 2022)
- Average estimated *potential* of food-demand mitigation by 2050: -44% of current emissions (IPCC 2023)





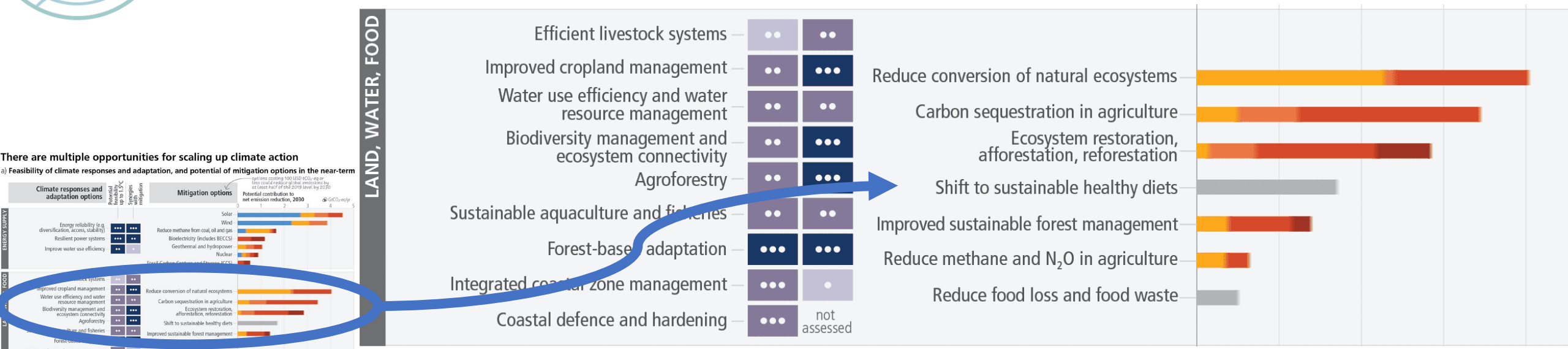
Scientific context

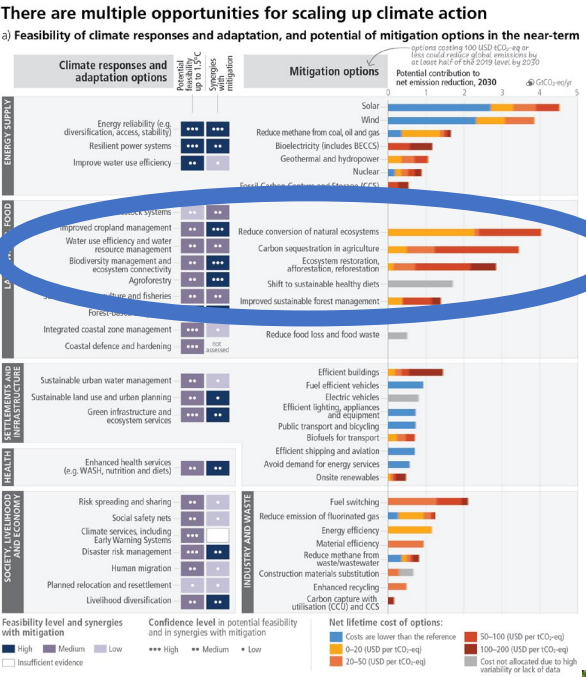
Although the potential of sustainable diets is well-identified (IPCC 2023)…



Research question

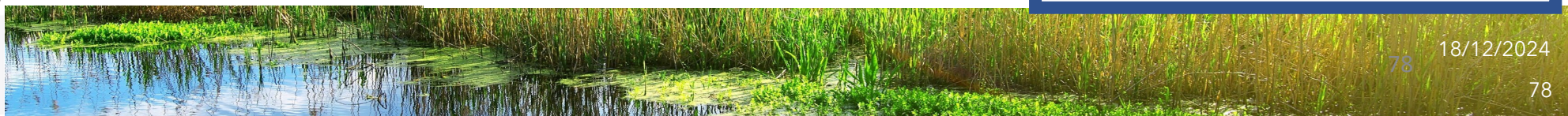
… less is known about the potential of demand-side public policies





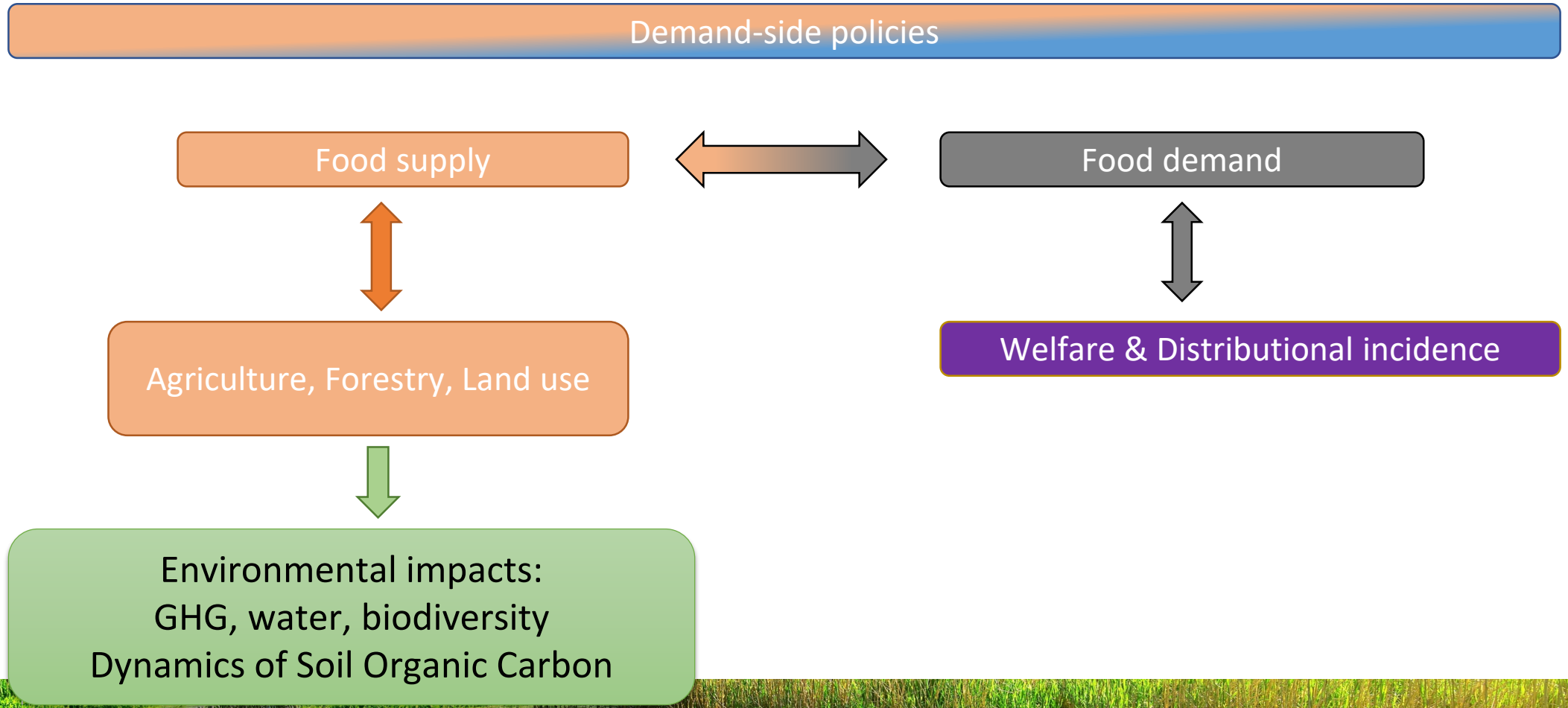
Net lifetime cost of options:

- Costs are lower than the reference
- 0–20 (USD per tCO_2-eq)
- 20–50 (USD per tCO_2-eq)
- 50–100 (USD per tCO_2-eq)
- 100–200 (USD per tCO_2-eq)
- Cost not allocated due to high variability or lack of data



Research question

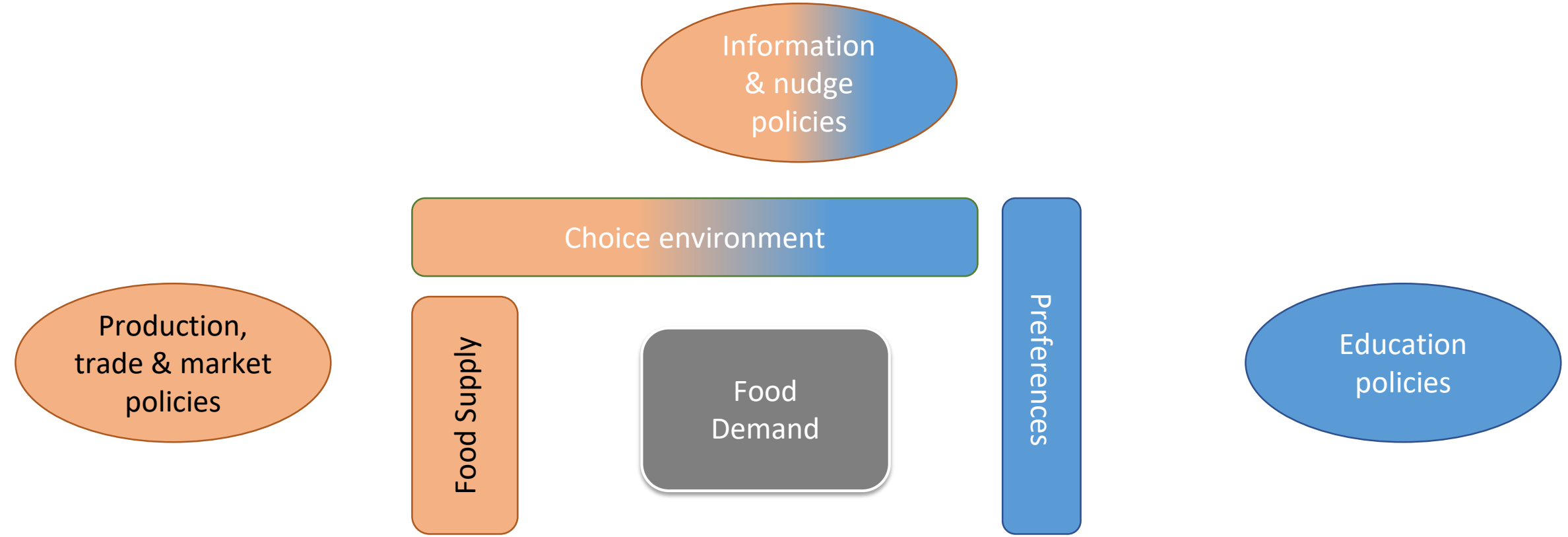
What is the potential of **demand-side public policies** for **carbon-neutral food systems?**



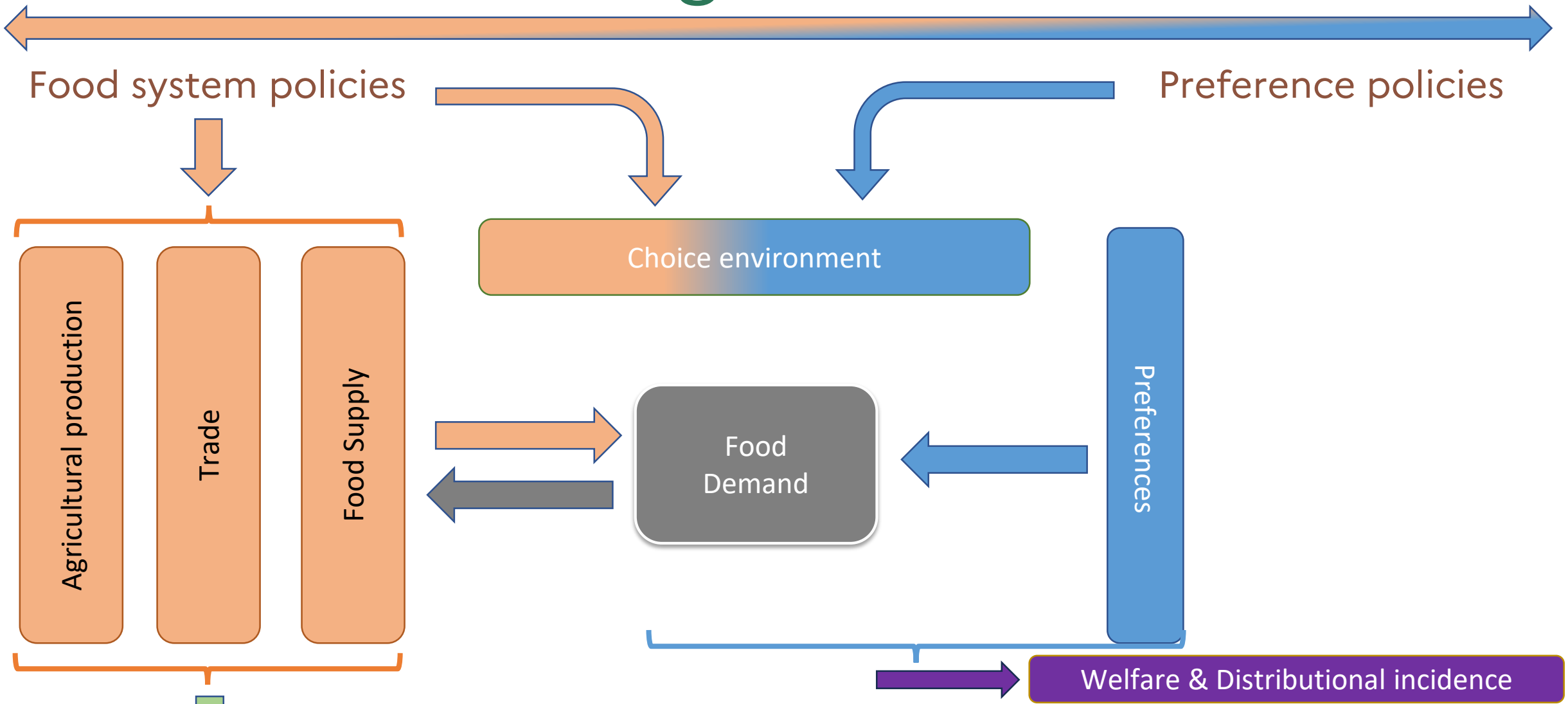
Demand-side policies

Food system policies

Preference policies



The issue of integration



Environmental impacts: GHG, water, biodiversity (ERC Flora); Dynamics of SOC

Interdisciplinary consortium

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CARBONE ET ÉCOSYSTÈMES CONTINENTAUX

Trade and production economics

Anne-Célia Disdier, Christophe Gouel, Carl Gaigné

Environmental sciences

Carole Dalin, Julia Le Noë

Coordination
Fabrice Etilé, Anne-Célia Disdier

Consumer economics
Céline Bonnet, Fabrice Etilé, Laurent Muller, Benjamin Ouvrard, Rafael Schütz

Welfare economics
Marc Fleurbaey, Craig Pesme, Stéphane Zuber

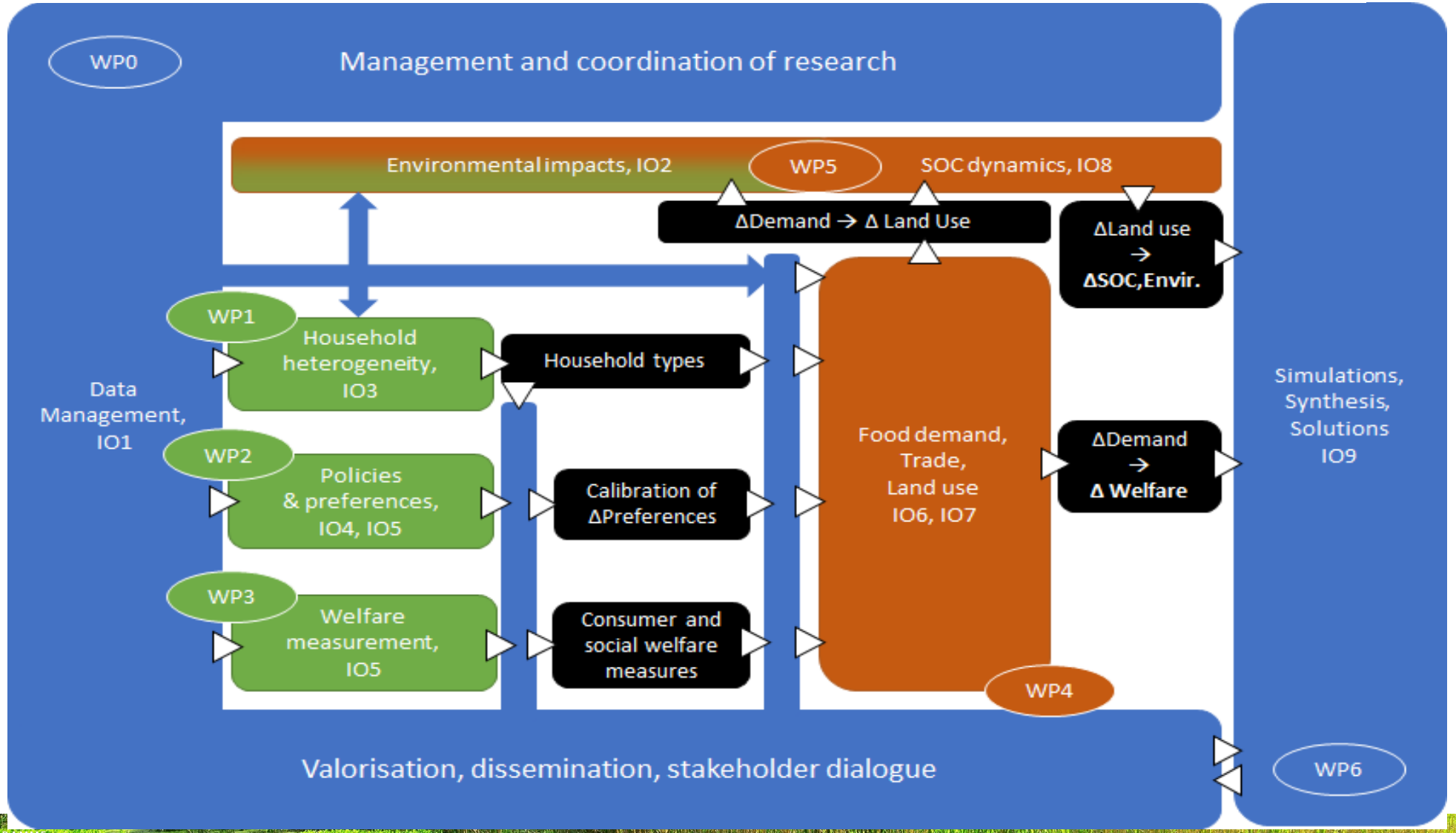
Sociology Marie Plessz

Two scientific objectives

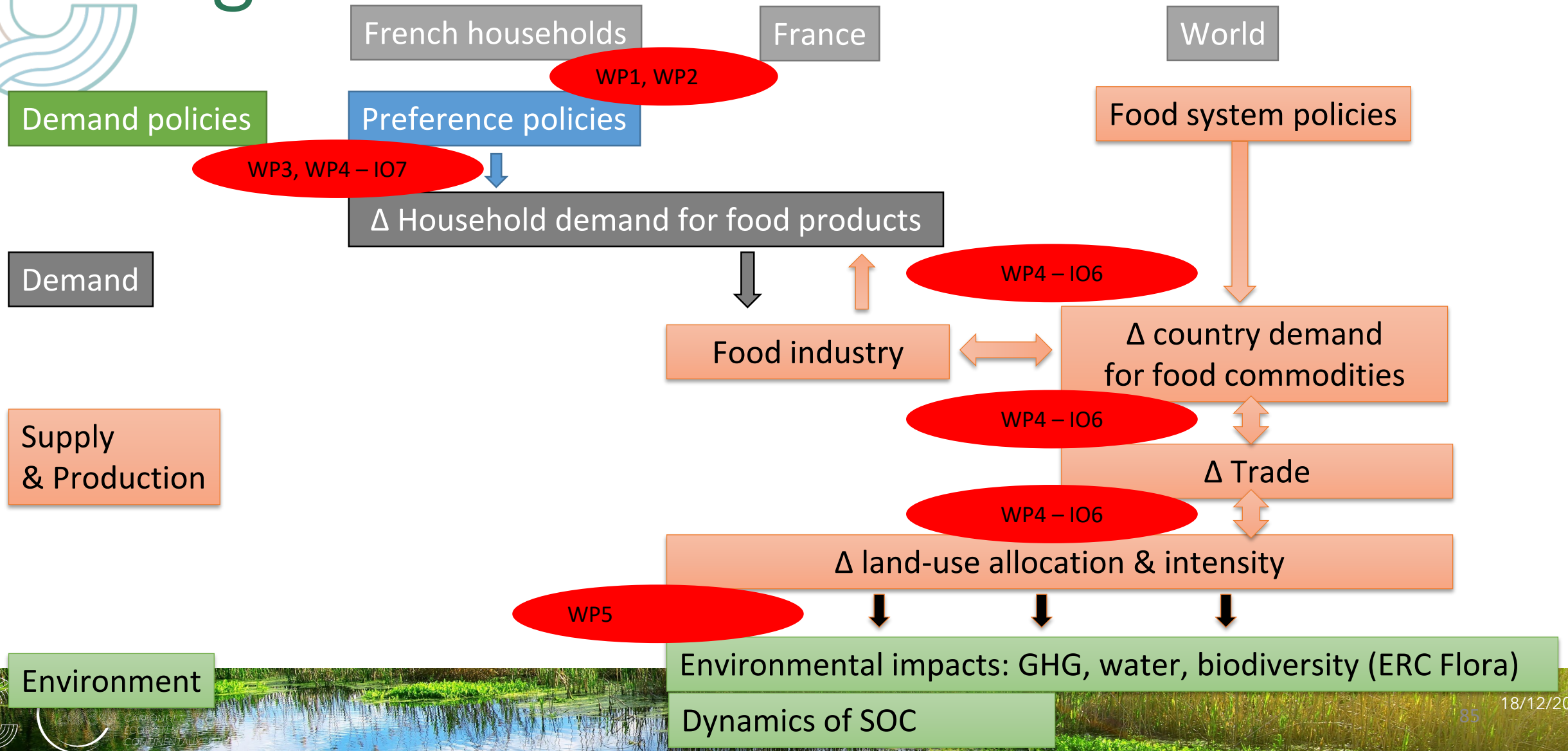
1. Evaluate the ability of public policies to alter consumer revealed preferences, to favor substitutions toward lower environmental-impact foods.

2. Provide ex ante evaluations of the impacts of policy scenarios on a wide range of economic and environmental outcomes.

PREFALIM: overall project structure



Integration



Main innovations

1. Identification of scenarios for preference changes from (1) experiences, (2) econometric analyses of ecological data.

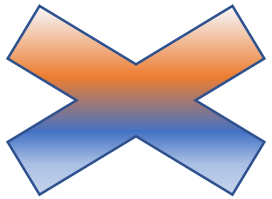
2. Quantification of policy-induced variations in consumer welfare for policies affecting both prices and preferences.

3. Coupling of French household food demand with food commodity supply.

4. Coupling of trade/agricultural production model with biogeochemical models.

Policy simulations (WP6)

Food system policies:
- Carbon tax at EU border
- Mirror clauses in trade agreements



Preference policies:
Information, nudge & Education/Boosts

- Benchmark values for carbon tax simulations will be aligned on the most recent evaluations of the social cost of carbon, by 2027

  ✓ Range of testable values, depending on assumptions regarding the discount rate etc… e.g. from US$40 per tCO2 to US$525 for a low discount rate (Tol, 2023),

  ✓ Average scenario with a price of about US$200-US$250.

Expected policy outcomes

- Expected policy outcomes:

  - ✓ Document the potential welfare losses and distributional effects of tax/trade policies under various scenarios regarding changes in consumer preferences.

  - ✓ Document more precisely the C- and environmental impacts of demand policies, by modelling the entire food chain, from farm to fork.

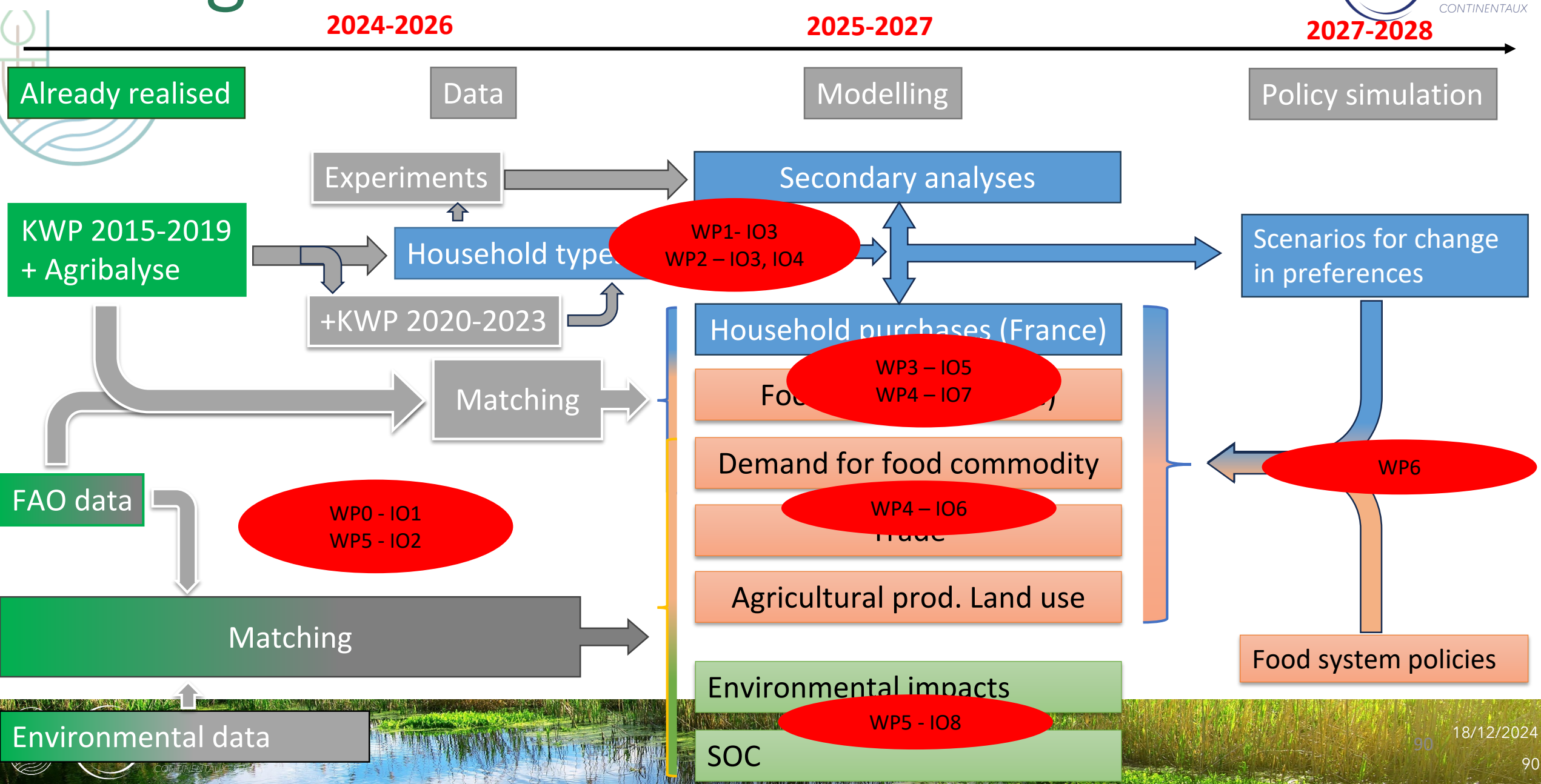
  - ✓ Best case scenario for what can be achieved through changes in consumer preferences.

Timing

Work Packages	Task	2024	2025		2026		2027		2028		2029
		S2	S1	S2	S1	S2	S1	S2	S1	S2	S1
WP0 - Management & coordination (F. Etilé & A-C. Disdier)	***0.1*** *Supervision & monitoring*										
	0.2 *Data management (IO1)*										
	0.3 *Valorisation & dissemination*										
WP1 - Household heterogeneity (M. Plessz)	***1.1*** *Heterogeneity in envir. concerns (IO3)*										
	1.2 *Dynamics of envir. concerns (IO3)*										
WP2 - Public policies and preferences (L. Muller)	***2.1*** *Experimental evaluations (IO4)*										
	2.2 *Achievable change in pref. (I04, I03)*										
WP3 - Welfare measurement (M. Fleurbaey)	***3.1*** *Tractable measures (IO5)*										
	3.2 *Sensitivity analyses (IO5)*										
WP4 - Modelling food demand, trade and production (C. Gouel)	***4.1*** *Global model (IO6)*										
	4.2 *Detailed model for France (IO7)*										
WP5 - Carbon & environmental impacts of production (C. Dalin)	***5.1*** *Production → Environment (IO2, IO8)*										
	5.2 *SOC dynamics (IO8)*										
WP6 - Solutions (A-C. Disdier & F. Etilé)	***6.1*** *Simulations, synthesis & solutions (I09)*										

Orange areas indicate periods dedicated to management and valorisation,
Blue areas indicate periods where preliminary works will be undertaken (literature review, model and experimental design, etc.),
Green areas indicates periods where data works will be undertaken (collection, harmonization, linkage),
Black areas indicate periods where primary scientific results will be produced (data analysis, modelling), Grey areas indicate periods where the different models are combined to prepare data simulation.
Yellow areas indicate periods where results are disseminated, feedbacks from scientific are received and technical reports are written.

Timing


2024-2026
2025-2027
2027-2028
Already realised
Data
Modelling
Policy simulation
Experiments
Secondary analyses
KWP 2015-2019
+ Agribalyse
Household type
WP1- IO3
WP2 – IO3, IO4
Scenarios for change in preferences
+KWP 2020-2023
Household purchases (France)
Matching
WP3 – IO5
WP4 – IO7
Demand for food commodity
WP6
FAO data
WP0 - IO1
WP5 - IO2
WP4 – IO6
Agricultural prod. Land use
Matching
Environmental impacts
Food system policies
WP5 - IO8
Environmental data
SOC

Governance & dissemination

- ✓ **External Scientific Advisory Board (ESAB):** Vincent Aussilloux, Pierre Barré, Maël Ginsburger, Louis-Georges Soler.

- ✓ **Policy briefs**, and a **final policy report**, will be disseminated and send to administrations and agencies,

- ✓ **Conferences (joint with other projects)** also **open** to selected representatives from NGOs (e.g. RAC), the food industry (e.g. Danone, Mars), farmers unions, and representatives from administrations and governmental agencies (ADEME, Ministry of Agriculture, Ministère de la Transition Ecologique).

- ✓ **Site WEB (en 2025)**

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Integration - details

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Integration – Data – details Kantar WorldPanel

KANTAR WORLDPANEL

- Scanner purchase data collected in continuous time from a representative sample of N=20,000 households:
  - inc. sociodemographic information, income etc.
  - attitudinal surveys in 2015, 2019, 2023 to measure environmental concerns = our measure of true preferences.

- 2015-2019 *already* acquired => acquisition of 2020-2023 data (70k€),

- Standardized nomenclature and harmonized procedures developed by Céline Bonnet and her team at TSE, including matching with Agribalyse data, which provides GHG emissions for more than 2,000 generic food products.

- Data that can be disseminated for comparisons with estimates from other sources (see previous research project on alcohol price regulation):
  - Aggregate consumption statistics by household types and food groups,

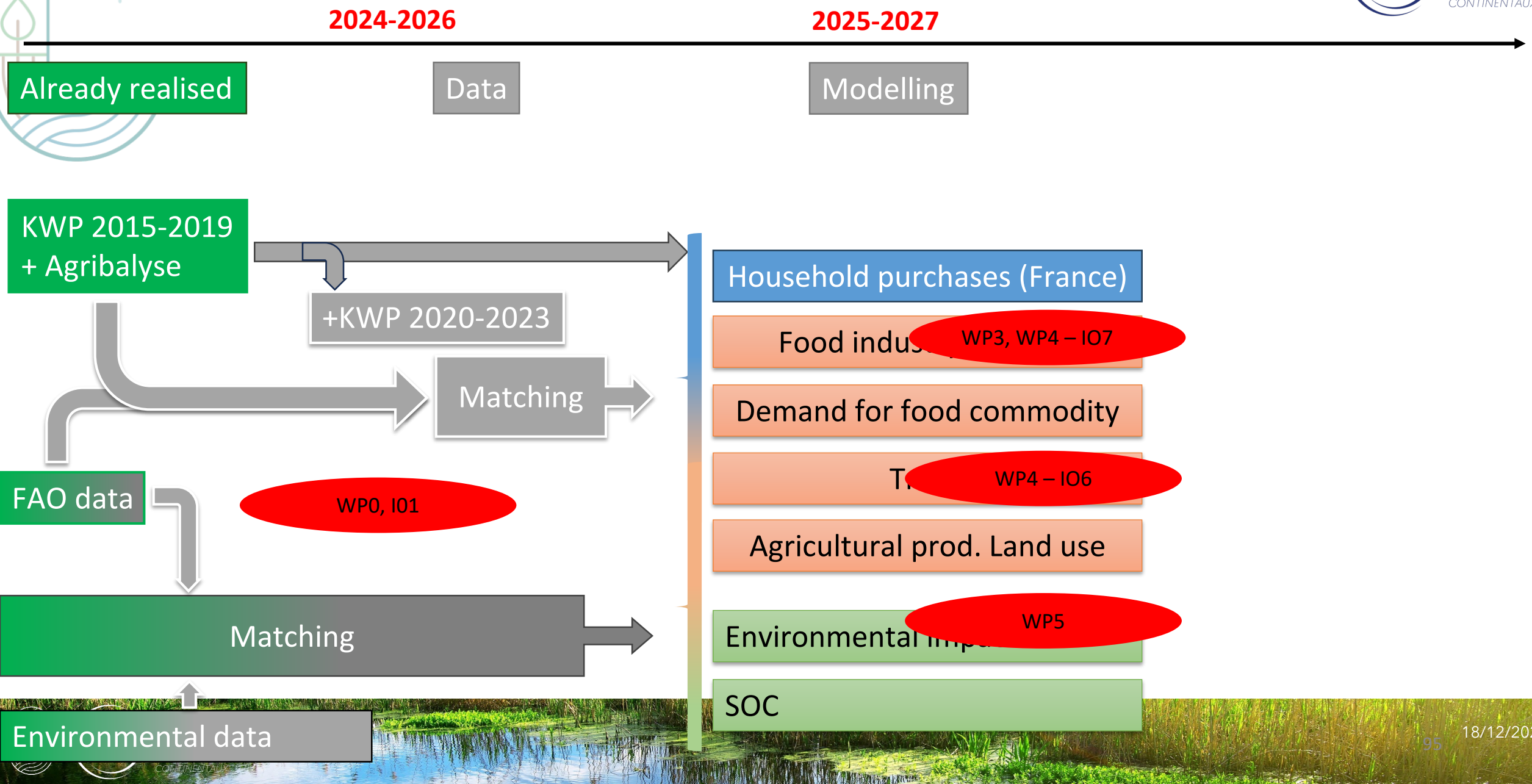
Integration – Data – details FAO & biophysical models

- Output: **GHG emissions and environmental impacts of food supply in France (both domestic and imported)**

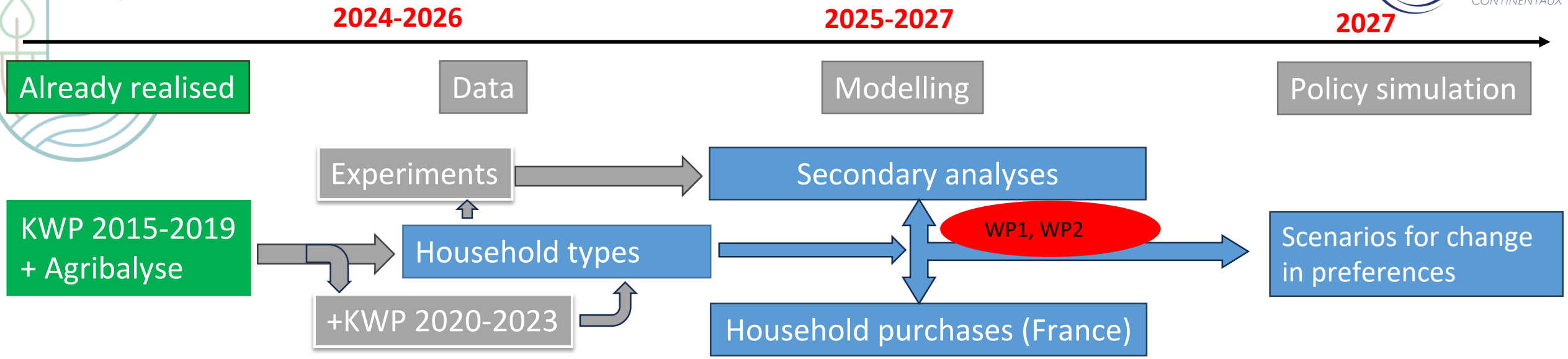
=> Innovations: finer spatial resolution (30'), updated data (2020), several sources of emissions & better account for C-stock, assignment to FAO food commodities, will also be produced for other FAO countries.

- Inputs:
  - FAOSTAT: Country-level information on agricultural production, and trade and supply of food commodities Christophe Gouel (I06: trade & agricultural production) and Carole Dalin (I02, I08: environmental impacts) have already combined FAO emissions, trade & production data with model estimates. Now collaborating to further improve these models.
  - Sources for GHG emissions and emissions factors:
    - Land use change: OSCAR bookkeeping model (for the world baseline)
    - Pre-farmgate, on-farm, post-farm gate: synthetic fertilizer production, synthetic fertilizers/manure application, enteric fermentation, rice methane, manure management, energy use in transport, waste -- Dalin et al., FAOSTAT & EXIOBASE.
    - Land use change France: specific modelling of SOC dynamics for France by Julia Le Noë, using the LUCCA model and data from FAO, Eurostat, Agricultural and Forestry Statistics National Geographic Institute to establish the baseline.

Integration - Workflow



Integration - Workflow



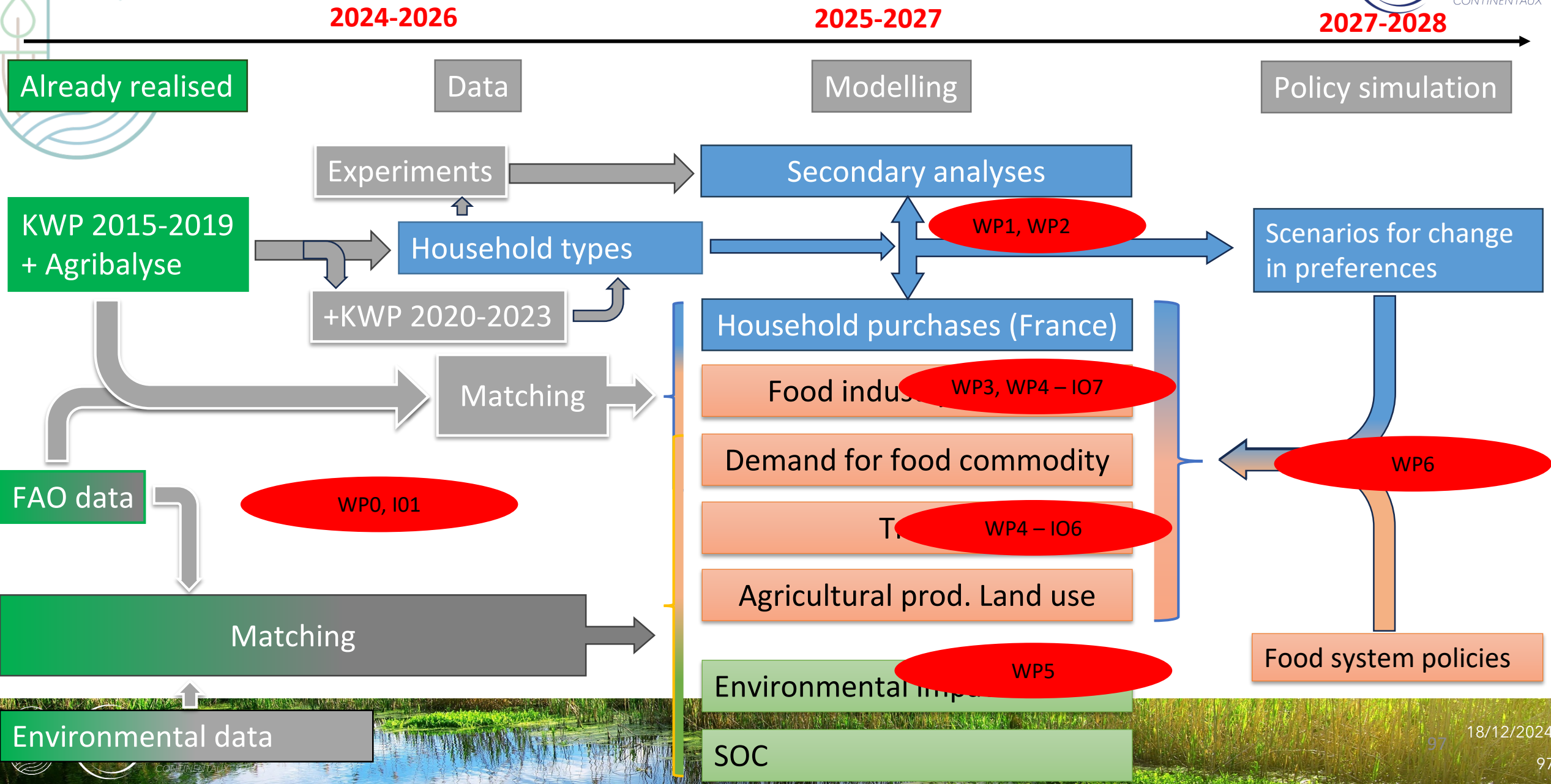
- Economic experiment => test policies: policy-mix carbon tax + labelling, boosts.

$$e(p,u;x) = \left(\sum_{i \in N} x_i p_i^{1-\theta_0} u^{\xi_i} \right)^{\frac{1}{1-\theta_0}}$$

- Use of a common workhorse demand model:
  - Estimation of demand functions on KWP data, by household types (environmental concerns) and by subperiods (<2020, COVID, Inflation)
  - Use of experimental data (DCE-like designs) to estimate CES demand model for estimating the impact of treatments on revealed preferences.

Definition of scenarios regarding variations in preference parameters (x_i, θ_0) :

Integration - Workflow



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Preferences

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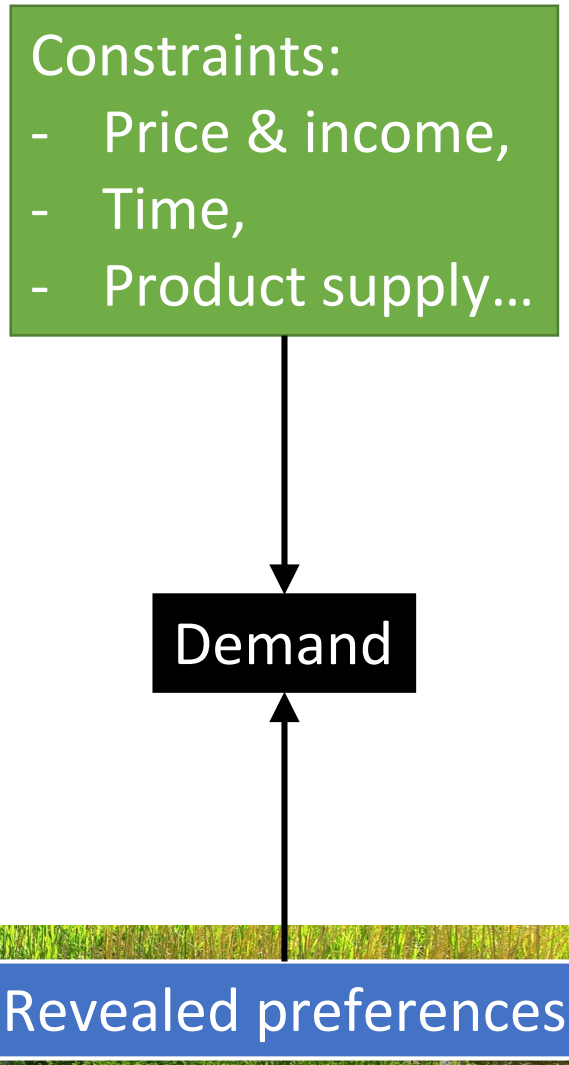
Clarification of the term 'preferences'

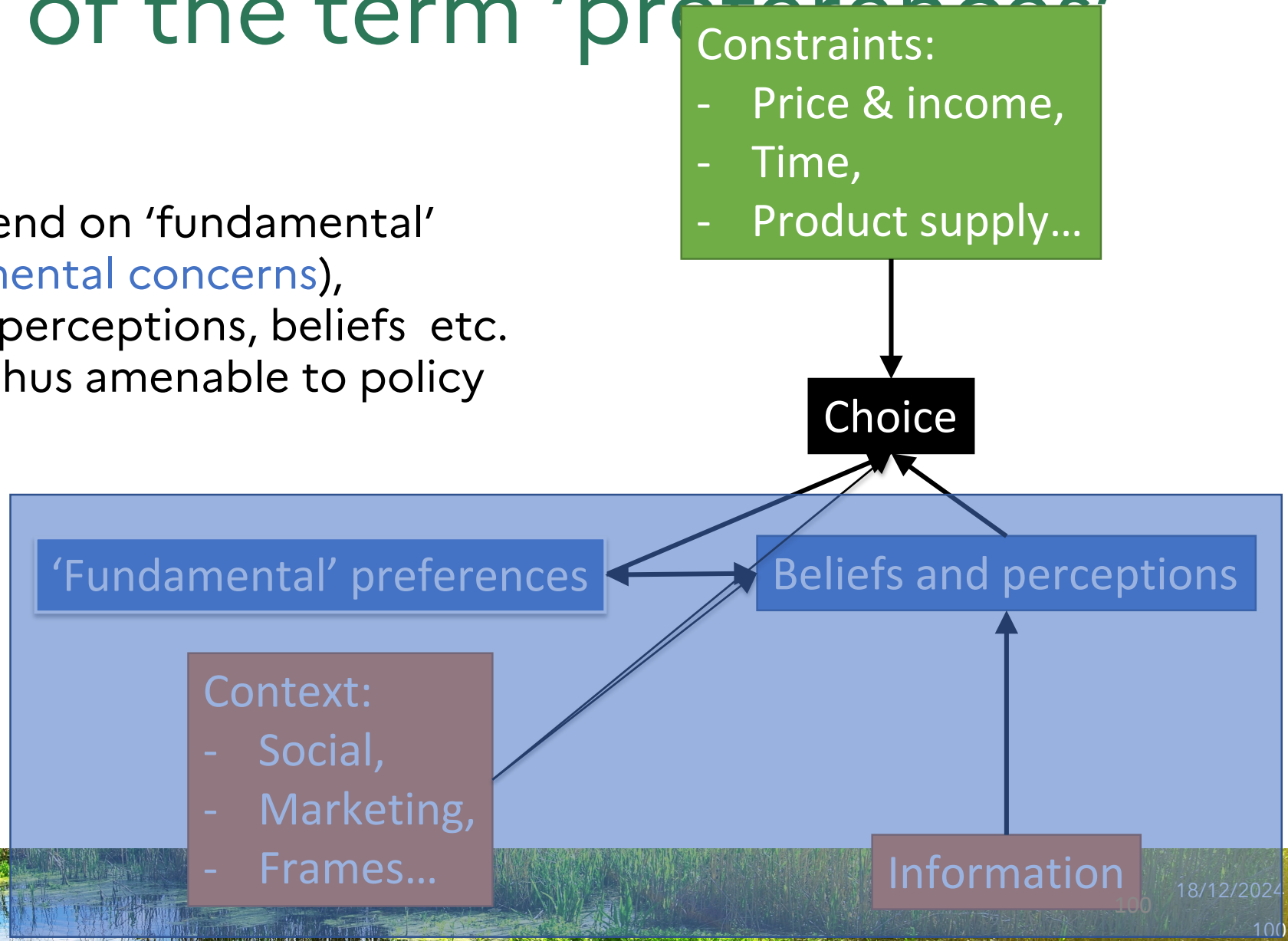
- ***Revealed preferences*** are inferred from observed choices, by fitting econometric models of demand
- These models are derived from a utility maximization problem
- These models yield **measures of variations in consumer welfare when prices or preferences change**.

- In all quantitative modelling of food demand, we will use the same econometric model to ensure the integration between modelling steps: results obtained in one step will be re-usable in another step.



Clarification of the term 'preferences'

- Revealed preferences depend on 'fundamental' preferences (e.g., environmental concerns), contextual factors, (noisy) perceptions, beliefs etc.
- Revealed preferences are thus amenable to policy interventions.



Clarification of the term 'preferences'

- Formally:

$$e(p,u;x) = \left(\sum_{i\in N} x_i p_i^{1-\theta_0} u^{\xi_i}\right)^{\frac{1}{1-\theta_0}}$$

$$\begin{matrix} Max_{\boldsymbol{c}} U(\boldsymbol{c};\boldsymbol{\Omega}) \\ \boldsymbol{p}'\boldsymbol{c} = e \end{matrix} \Rightarrow \boldsymbol{c} = q(\boldsymbol{p}, \boldsymbol{e}; \boldsymbol{\Omega}) \Rightarrow \boldsymbol{\Omega}\text{: preferences as revealed by choices}$$

- Revealed preferences are functions of true preferences (θ_0), and other factors (choice context, (mis-)information, cognitive and perception biases: γ) that are considered as harmful for the subject's well-being/autonomy: $\Omega = \omega(\theta_0, \gamma)$.

- People have brown revealed preferences for two reasons:
  1. They truly have brow preferences and 'biases' don't offset that: $\theta_0 = \theta^B$
  2. They truly have green preferences but are 'biased' towards green preferences: $\theta_0 = \theta^G$ and γ is such that $\omega(\theta^G, \gamma) = \Omega^B$

- Ideally we would like everyone to have true green preferences and no bias $\Omega = \omega(\theta^G, 0)$

Clarification of the term 'preferences'

- In practice, we want to identify four types of households:

Bias → True preferences ↓	Bias	No bias
Brown	T1	T2
Green	T3	T4

Primary focus/assumption: all consumers are biased.

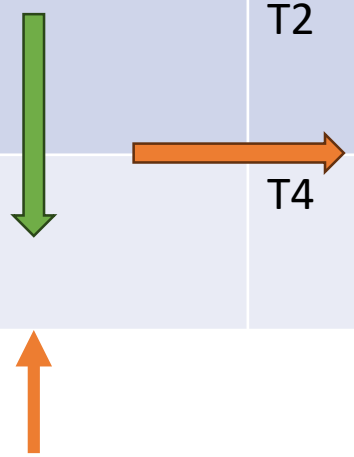
- The Kantar WorldPanel 'lifestyle' questionnaire can be used to identify true green consumers, assuming that answers are sincere.

- But it is more difficult to identify the extent to which they are biased:
  - Question on impulsivity
  - No question on information…
  - Hundreds of biases reported in the literature

Clarification of the term ‘preferences’

- We can then work on two types of changes:

Bias → True preferences ↓	Bias	No bias
Brown	T1	T2
Green	T3	T4



- Transition from T1 to T3: consumers becoming (or not) greener over time, e.g. cohort effects, diffusion of specific norms => investigate this by looking at dynamics and heterogeneity over 2011-2019 (2023).

- Transition from T3 to T4 (or even T1 to T2): debiasing consumers => investigate this through experiments.

Assumption: all consumers are biased.

Clarification of the term 'preferences'

- Two empirical issues:

  - When working on the 'alignment' between revealed preferences and true preferences, we have to be cautious of not over-interpreting observed household choices as a direct measure of revealed preferences:
    - People can have a bad carbon footprint due to price or income constraints (or other constraints).

    ⇒Consumption of 'signalling' good is not a necessary condition for green preferences,
    - Avoid the reduction of green households to rich households.

  - The identification of 'revealed' preferences through the estimation of structural demand systems relies heavily on… the choice of a functional specification. Mis-specification biases:
    - Wrong functional form
    - Ignorance of other constraints on consumer choices (time)

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Kantar WorldPanel

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Kantar WorldPanel - Description

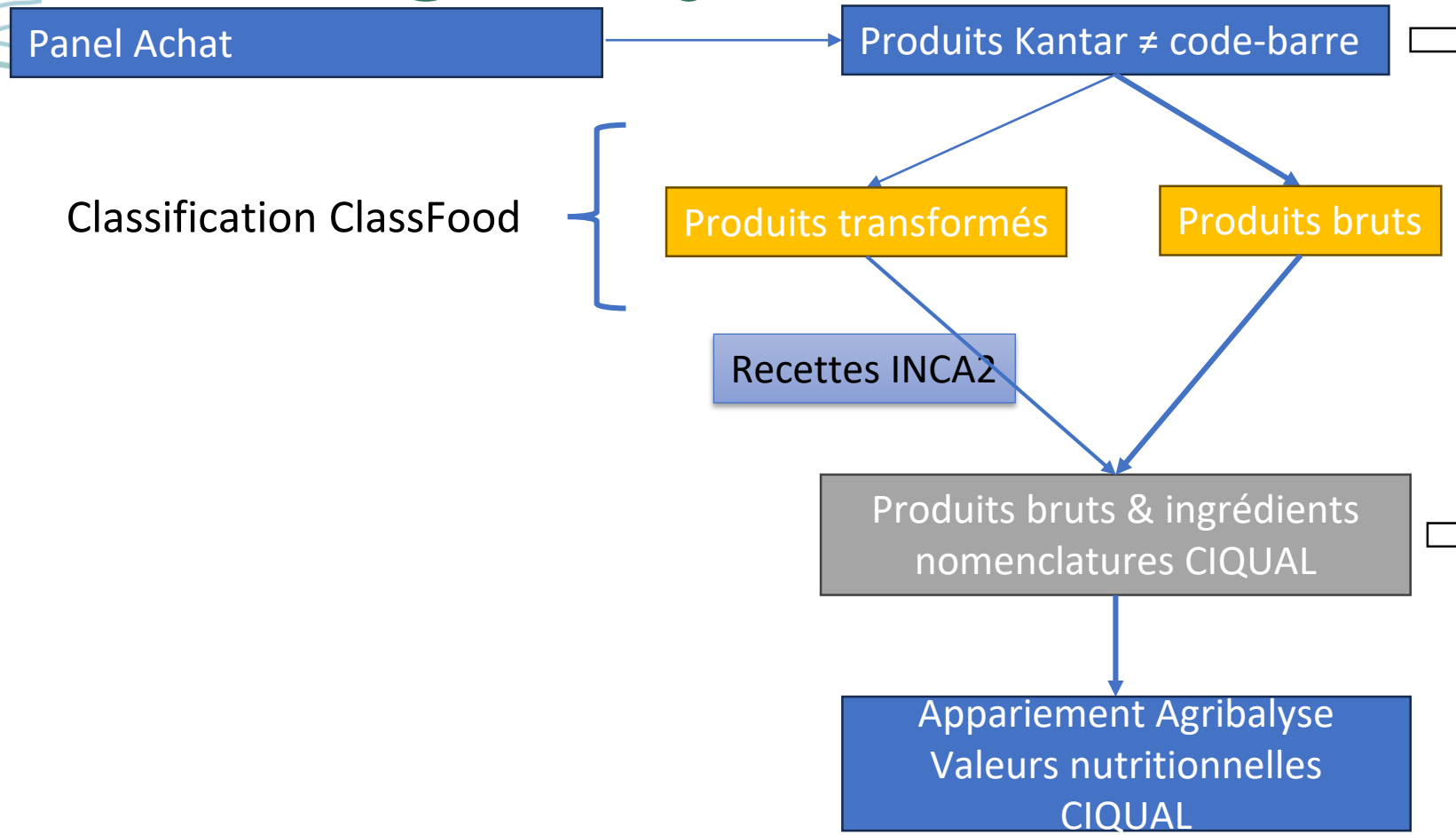
N >20,000 ménages
- Suivis en moyenne 4 ans
- Poids d'échantillonnage représentatif

Module socio-démographique annuel
- Unité d'observation = un **ménage**.
- Composition du ménage
- Caractéristiques des membres du ménage: âge, éducation, CSP, poids, taille
- Caractéristiques du ménage: revenu déclaré (en tranches), lieu de résidence, habitat…

Panel achat (N ~18 Millions en 2019)
- Unité d'observation = un achat par un **ménage** dans un magasin donné un jour donné.
- *Poids d'échantillonnage* pour rendre les achats représentatifs du marché.
- *Caractéristiques variables des achats*: volume, dépense => prix unitaire
- *Caractéristiques des produits*, fixes sur une année: marque, producteur, packaging, caractéristiques marketing différenciantes.

Modules styles de vie (2011, 2015, 2019)
- Unité d'observation: l'acheteur principal du **ménage**
- Questions sur les motivations guidant les comportements d'achats:
  - Recherche du plus bas prix, des promotions
  - Achats impulsifs
  - Prise en compte de l'environnement, de la santé, des labels, de l'étiquetage

Kantar WorldPanel – Appariement avec Agribalyse



Appariement compliqué avec Open Food Facts ou d'autres bases utilisant des code-barres

Ne contient pas des ingrédients ultra-transformés, type dextrose, amidon etc…

Bonnet et al. – disponible sur la plateforme ODALIM

Appariement Kantar WorldPanel – FAO

FAO: offre de commodités alimentaires (X)

Consommation (C)

Classification FAO/CPC
- Commodités plus ou moins transformées
- Ex: dextrose, breakfast cereals, corn

Kantar WorldPanel:
- Consommation finale à domicile
- Classification ClassFood

Industrie agro-alimentaire

Alimentation hors-domicile?

Approche comptable

$$T \times X_r + X_p = C_h + C_a$$

Généralisation?

Appariement Kantar WorldPanel – FAO

Matrice de transformation T pour les aliments transformés

- Données:
  1. Recettes INCA 3, incomplètes sur les additifs.
  2. Open Food Facts (OFF): qualité de l'information moyenne, mais contient des informations sur les additifs.
  3. CIQUAL.
- Algorithmes de calculs de recettes:
  - Anatole: calculateur sur ODALIM
  - PEFAP: algorithme open source

  ⇒Principe:

  (1) A partir d'un EAN, collecte de données d'ingrédients et de composition nutritionnelle sur OFF;

  (2) Matching avec les valeurs nutritionnelles CIQUAL;

  (3) reconstitution des parts volumiques par minimisation de la distance avec la composition nutritionnelle OFF

Appariement Kantar WorldPanel – FAO

Matrice de transformation Inputs-Outputs T pour les aliments transformés

- Enjeux méthodologiques:
  - Traitement des ingrédients dont la valeur nutritionnelle n'est pas dans CIQUAL (e.g. dextrose),
  - Correspondances nomenclatures: Ingrédients (OFF ou INCA 2) → FAO
  - Automatisation des appariements: Kantar (Code-produit, caractéristiques produits) → Open Food Facts (EAN, Ingrédients) → CIQUAL (Valeurs nutritionnelles)
    - Probable recours à du machine learning + utilisation de données adjacentes (AiMARK) déjà exploitées dans un projet antérieur (SODA-TAX).

Appariement Kantar WorldPanel – FAO

Alimentation hors-domicile:

- Données:
  1. Budgets de famille 2011 et 2017: dépenses pour les repas hors-domicile, mais rien sur la composition des repas,
  2. INCA 3: alimentation à domicile et hors-domicile – nomenclature spécifique,
  3. Comptabilité nationale (calage macroéconomique en volume et valeur?).
- Objectifs:
  1. Documenter les différences entre alimentation à domicile et hors-domicile par segments socio-économiques.
  2. Inférer des distributions statistiques (?) de consommation hors-domicile des items de ClassFood à partir de la consommation à domicile, par segments socio-économiques, et en respectant un calage au niveau macro-économique (données de comptabilité nationales, données FAO)

Appariement Kantar WorldPanel – FAO

Extensions:

- Gaspillage: $T \times X_r + X_p = C_h + C_a + Waste$

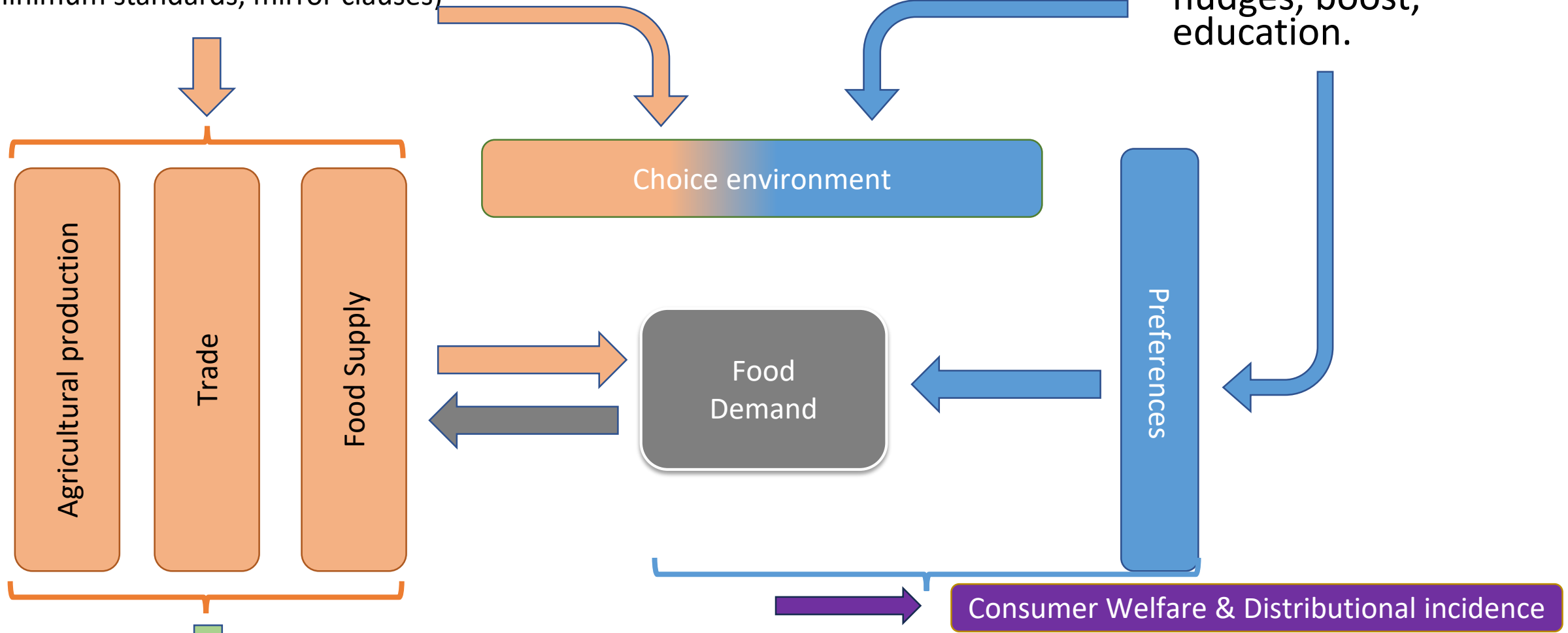
⇒Analyse de sensibilité

- Fonction de production plus flexible: $F(X_r, X_p, L, K; \theta) = C_h + C_a$

=> Calibration d'un modèle pour la couche intermédiaire IAA/Distributeur: Identification ?

Price regulations
(taxes, minimum price)
Quality regulations
(minimum standards, mirror clauses)

Preference policies: nudges, boost, education.



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Bio-geo-chemical modelling

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Environmental footprint

- ERC project FLORA ; Dalin + Gouel and Janssens :
  - Water footprint [FAO crop water requirements model; crop calendars, cropland & irrigation maps]
  - Biodiversity footprint based on land use [statistical model; PREDICTS database]
  - Climate Change: **gridded, crop-specific** GHG emissions modelling covering
    land cover change [BLUE model and MapSPAM data],
    enteric fermentation in ruminants [RUMINANT model and GLW data],
    rice cultivation [IPCC & Carlson/Gerber model],
    and nitrogen (N) fertiliser application (both synthetic N and manure N).

✦ circa 2000 including supply-side footprint (FAOSTAT trade); currently making **2020 update**

✦ **national** scale time-series **1986-2022** by Janssens et al. including N prod, energy, **transport** (cf. C. Gouel)

Environmental footp

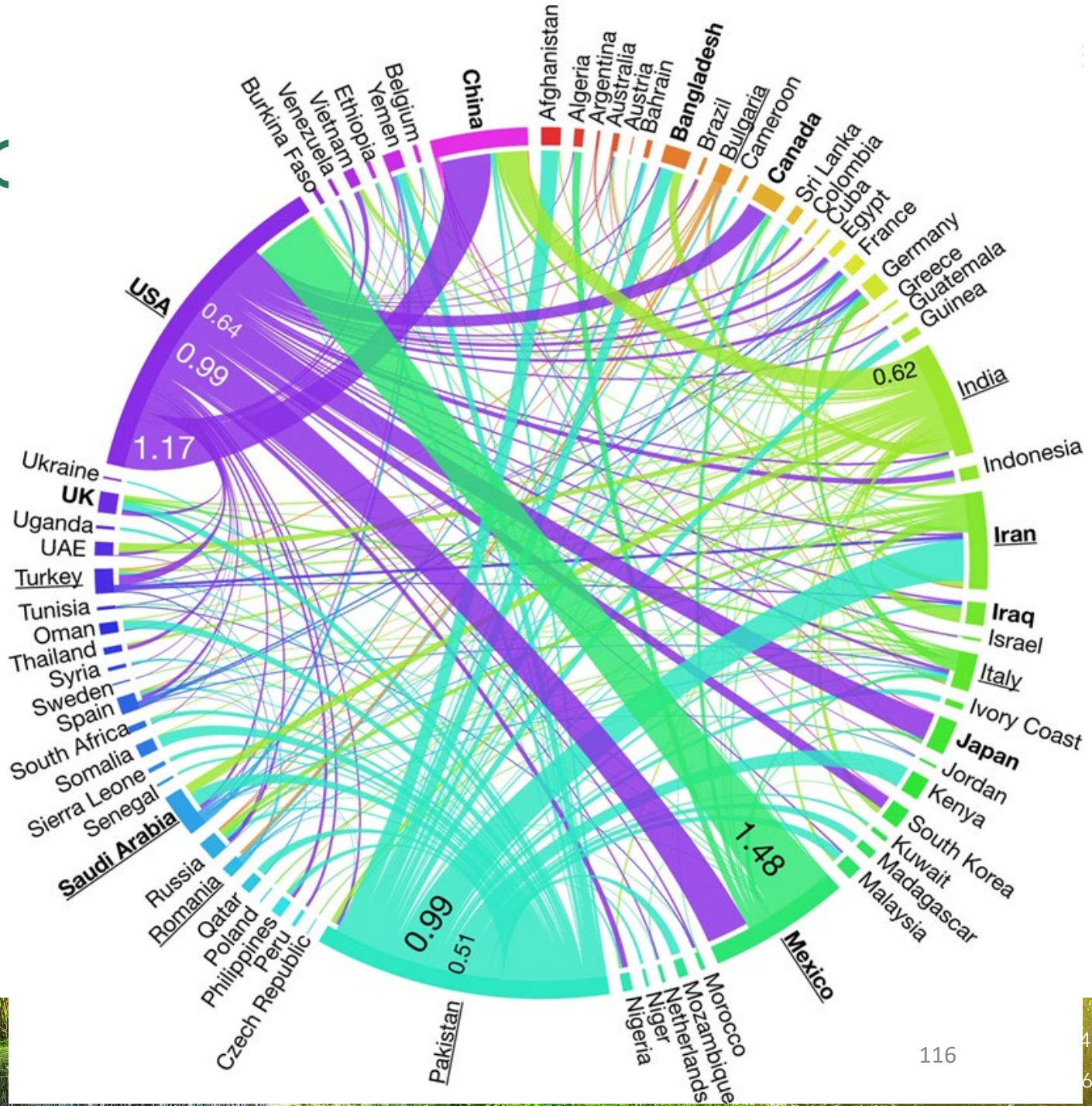
Example of output: GroundWater Depletion

(Dalin et al., Nature, 2017)

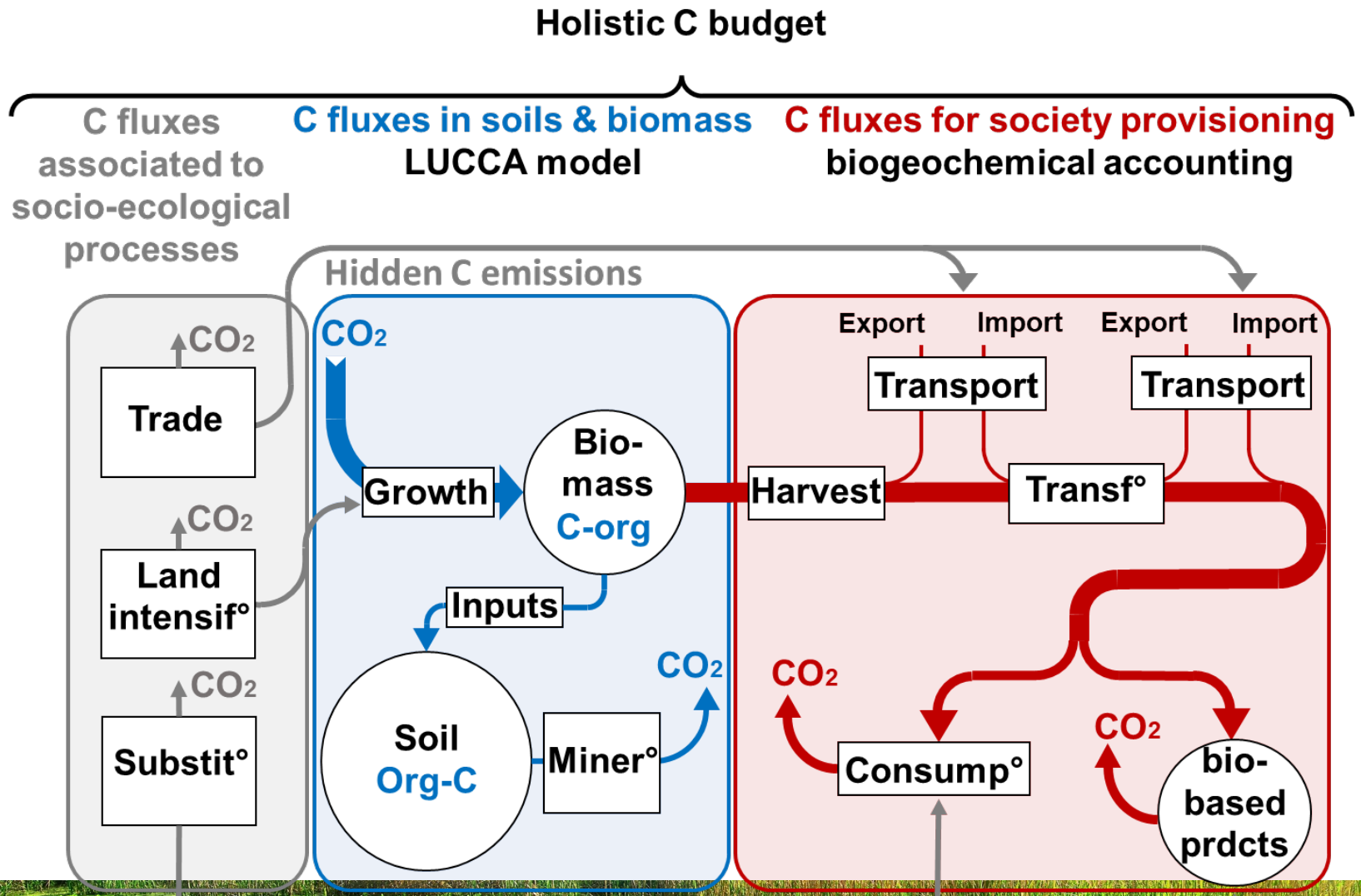
GWD = abstraction due to irrigation

- recharge

Unsustainable groundwater in food trade (km^3/year)



Soil Organic Carbon Dynamics



Available data