Optimization modelling for sustainable diets

(Practical Example)

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What is a sustainable healthy diet?

- Definition by FAO and WHO: Sustainable healthy diets are dietary patterns that:
- promote all dimensions of individuals' health and wellbeing (nutritional adequacy);
- have low environmental pressure and impact;
- are accessible, affordable, safe and equitable; and
- are culturally acceptable.

How does a sustainable healthy diet look like?

- Defining healthy and sustainable food patterns is complex.
- What should be taken into account?
- Should be based on a systematic investigation and sound data on each dimension.
- Dependent on the availability and accuracy of data on food characteristics.

Approaches towards more sustainable diets

1. Evaluate the sustainability characteristics of hypothetical diets.

- Starts with a theoretical diet (e.g., EAT-Lancet diet) and compares it with current diet or recommendations

- **Advantages:**
- No need for individual food consumption data

- **Limitations:**

- No consideration of cultural acceptability
- Diet designed based on predetermined assumptions –does not ensure improvement in sustainability dimensions, verified a posterior
- No consideration of other diets that could be more sustainable

Approaches towards more sustainable diets

2. Evaluate the sustainability characteristics of existing diets.

- Looks at the variability of impacts of self-selected diets and classifies individuals into groups based on different levels of nutritional quality or environmental impact.

- **Advantages:**
- Better consideration of cultural acceptability
- Better understanding of trade-offs between sustainability dimensions

- **Limitations:**

- Requires food consumption data at the individual level
- Improvement of one sustainability dimension does not ensure improvement of others

Approaches towards more sustainable diets

3. Identify existing positive deviants (multi-criteria approach)

- Selects individuals whose diet combines several positive characteristics (e.g., in terms of environmental impact and nutritional quality) and compare their diet to the general population's diet.

- **Advantages:**
- Greater consideration of cultural acceptability, as these diets are actually consumed

- **Limitations:**

- Magnitude of improvements might be small and might not be perfectly adequate
- Improvement in one characteristic (e.g., GHGE) does not ensure improvement in others (e.g., water consumption)

Approaches towards more sustainable diets

4. Design more sustainable diets with constrained optimization (multi-criteria approach)

- A mathematical technique that finds the optimal combination of decision variables (i.e., foods available) for a population, a subpopulation, or an individual that fulfils a set of constraints (e.g., nutritional requirements), while minimizing or maximizing an objective function (e.g., total deviation from observed diet, total GHG)

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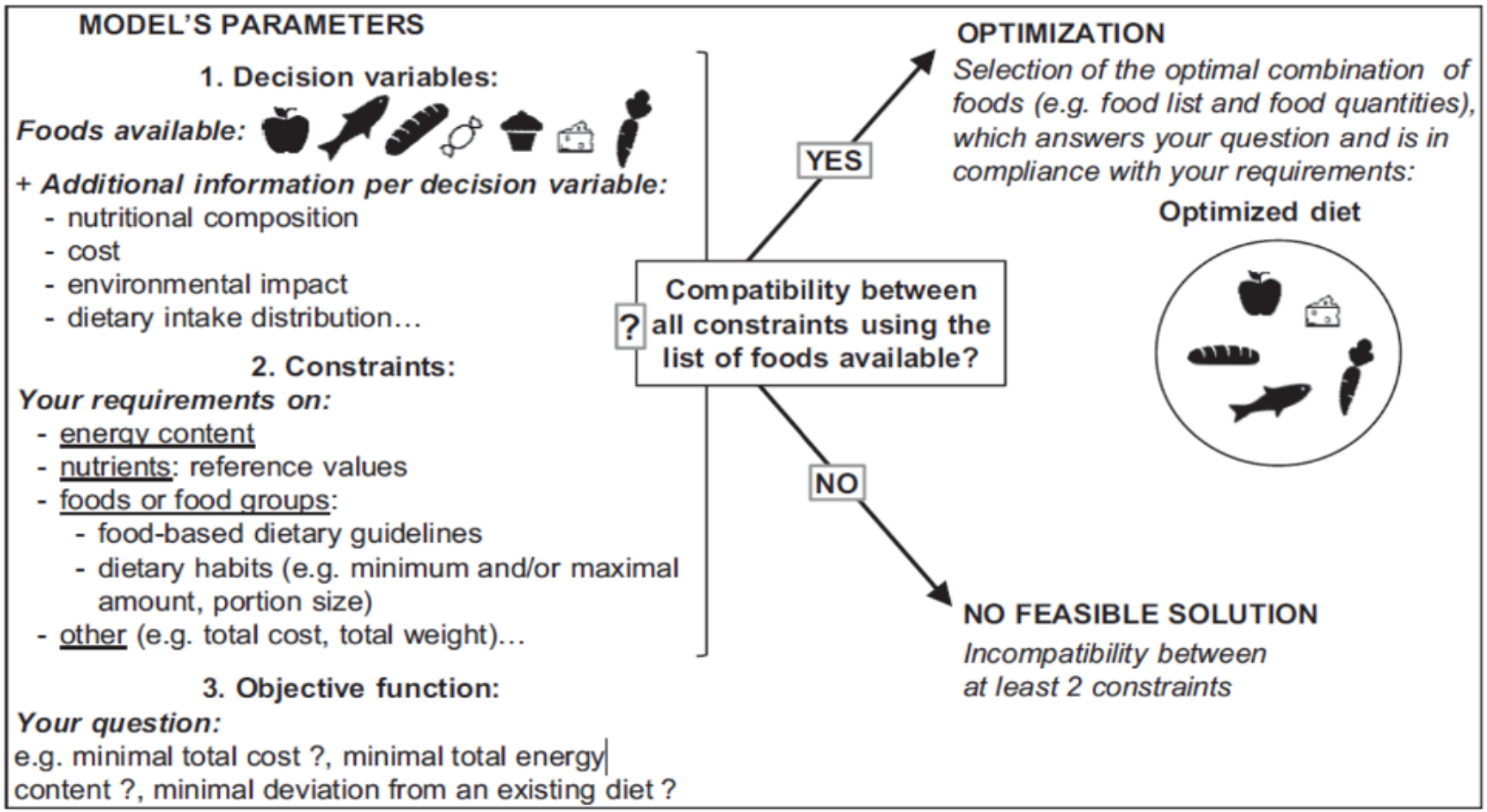
What is diet optimization?



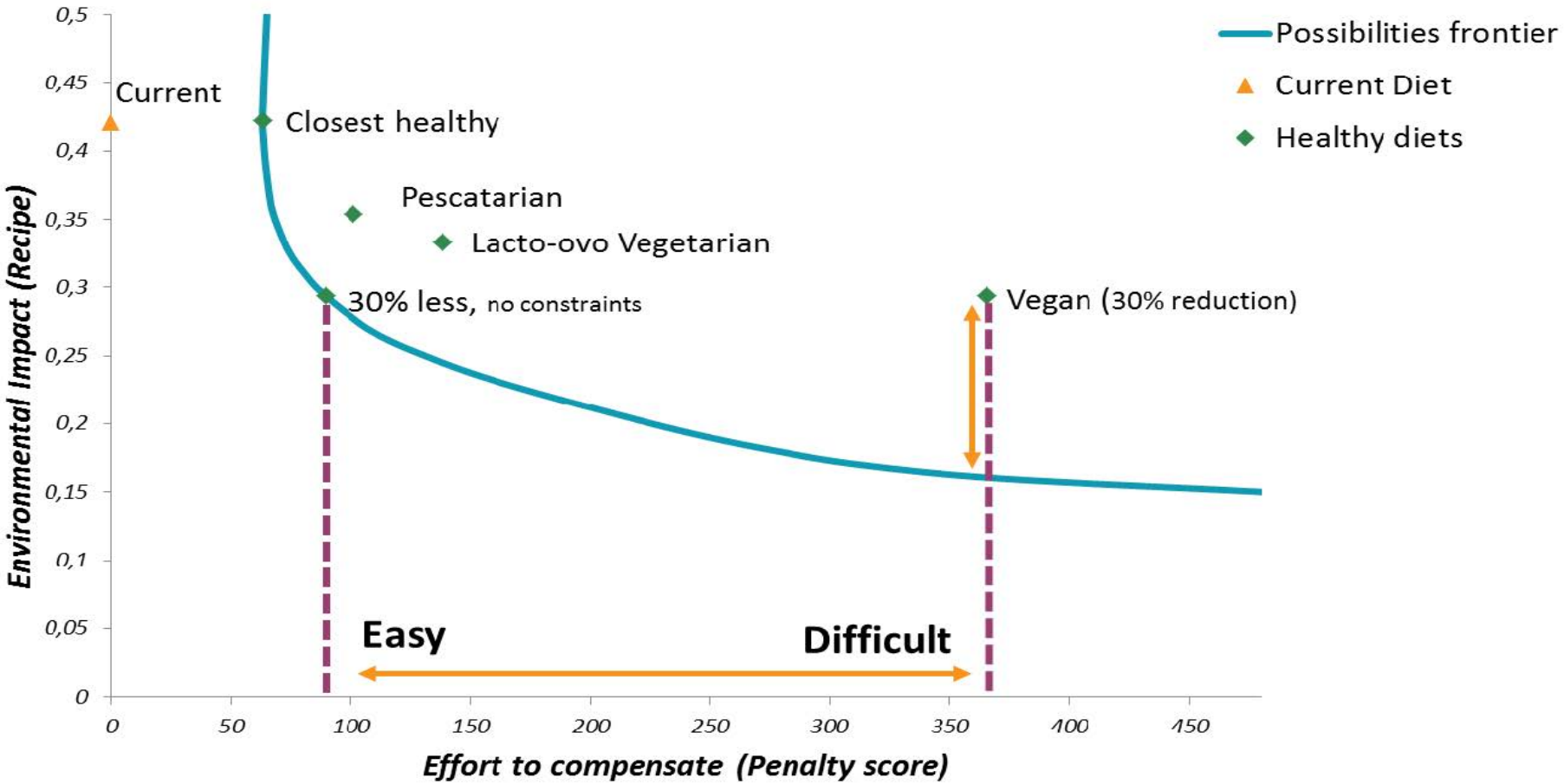
Source: Gazan et al. (2018)

Advantages and Limitations for Diet Optimization

- **Advantages:**
  1. Simultaneous application of constraints to ensure nutritional adequacy and other aspects of sustainability
  2. Allows integration of bioavailability of nutrients and coproduction links with sophisticated models
  3. Help identify trade-offs by studying constraints that are difficult to fulfil or incompatible with other constraints

- **Limitations:**
  1. Can lead to no or unrealistic solution when constraints are too severe or incompatible
  2. Difficult to include cultural acceptability (proxy: deviation from current diet)
  3. Sensitive to starting a diet, or menu items
  4. Data intensive
  5. Difficult to interpret and explain changes

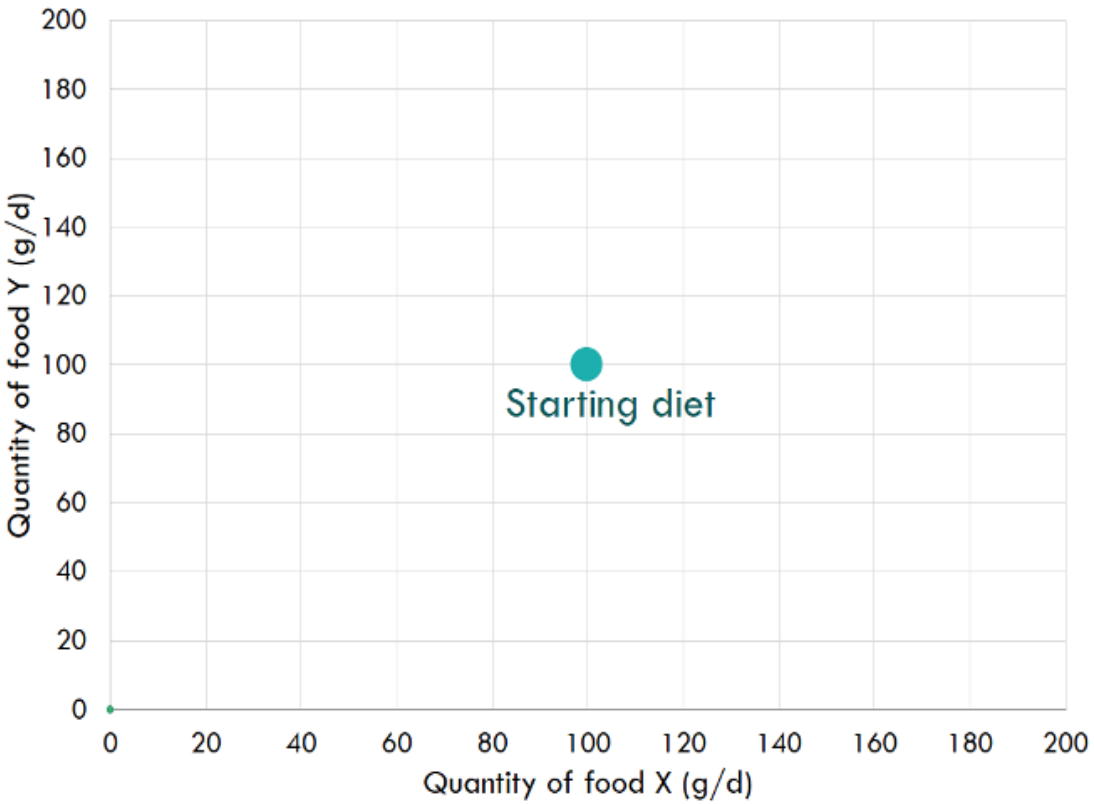
How Optimization works



Source: Blonk Sustainability Tools (2022)

How to find an optimized diet?

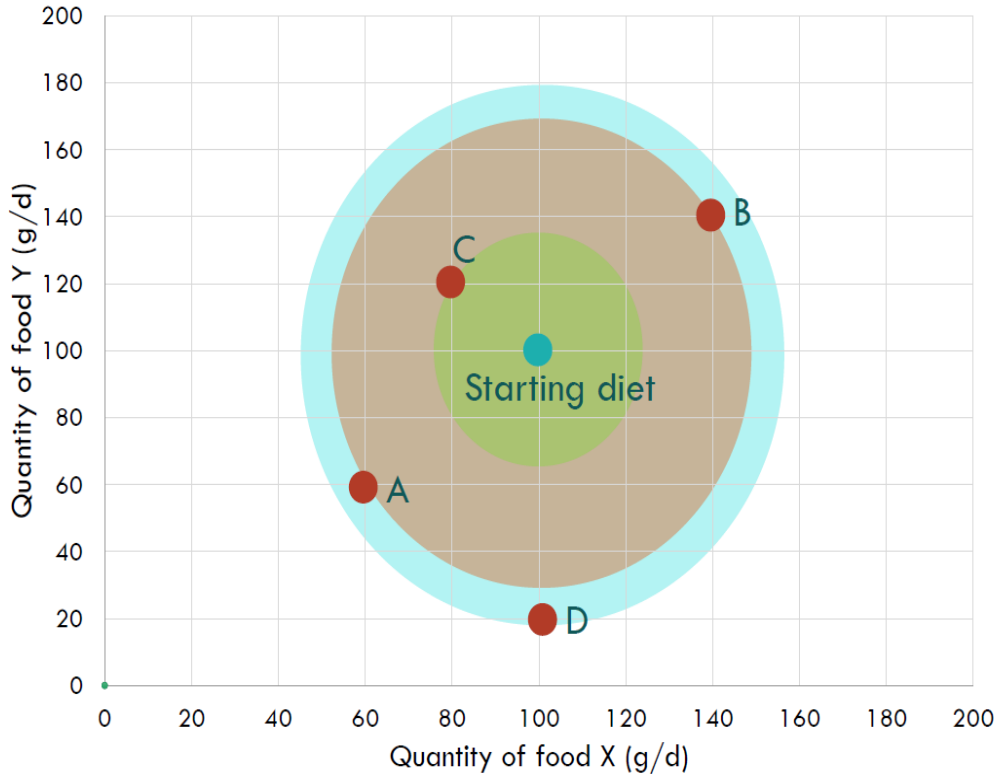
A (starting) diet is just a description of amounts per day of each food: for example100 grams of X, 100 grams of Y



Source: Blonk Sustainability Tools (2022)

How to find an optimized diet?

We can measure the similarity (distance) between diets by drawing circles where a diet is the center



Diet	X	Y	Distance
Starting diet	100	100	
A	60	60	Orange
B	140	140	Orange
C	80	120	Green
D	100	20	Blue

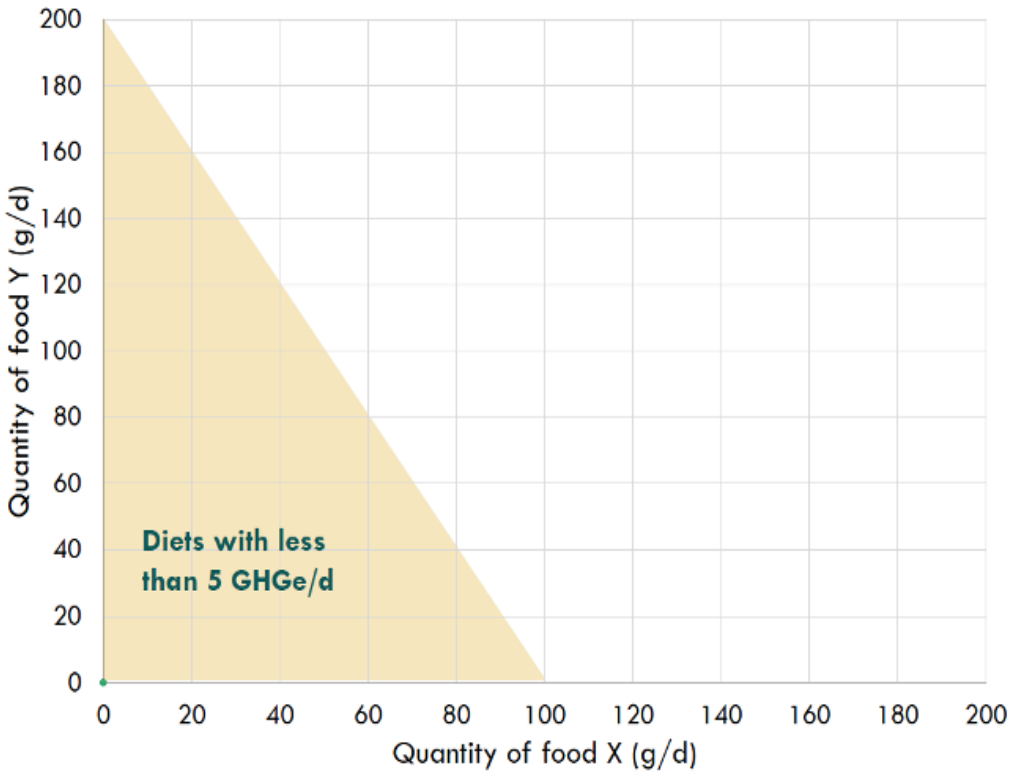
Green < Orange < Blue:

Diet C is the most similar to the starting diet
Diets A and B are equally similar
Diet D is the most different

Source: Blonk Sustainability Tools (2022)

How to find an optimized diet?

To choose we need to know which diets satisfy the nutritional and **environmental** requirements



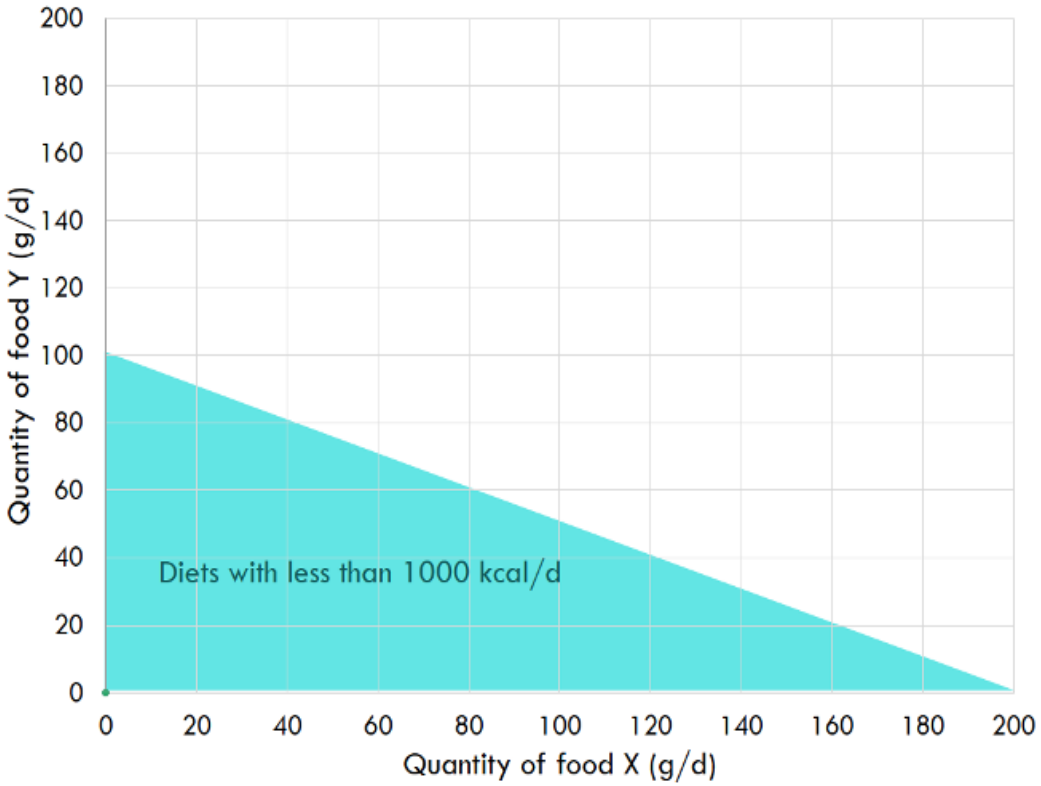
Property/g	X	Y
Calories	5	10
GHGe	**0.050**	**0.025**

Requirements	Min	Max
Calories	500	1000
GHGe	**0**	**5**

Source: Blonk Sustainability Tools (2022)

How to find an optimized diet?

To choose we need to know which diets satisfy the **nutritional** and environmental requirements



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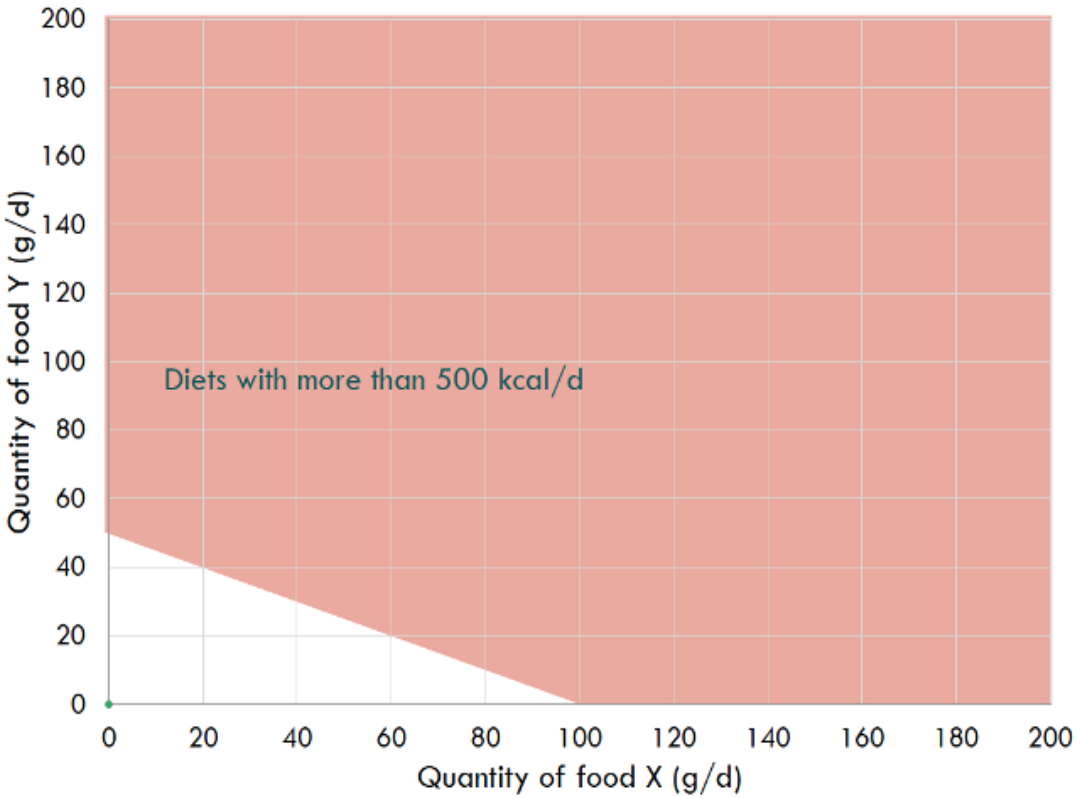

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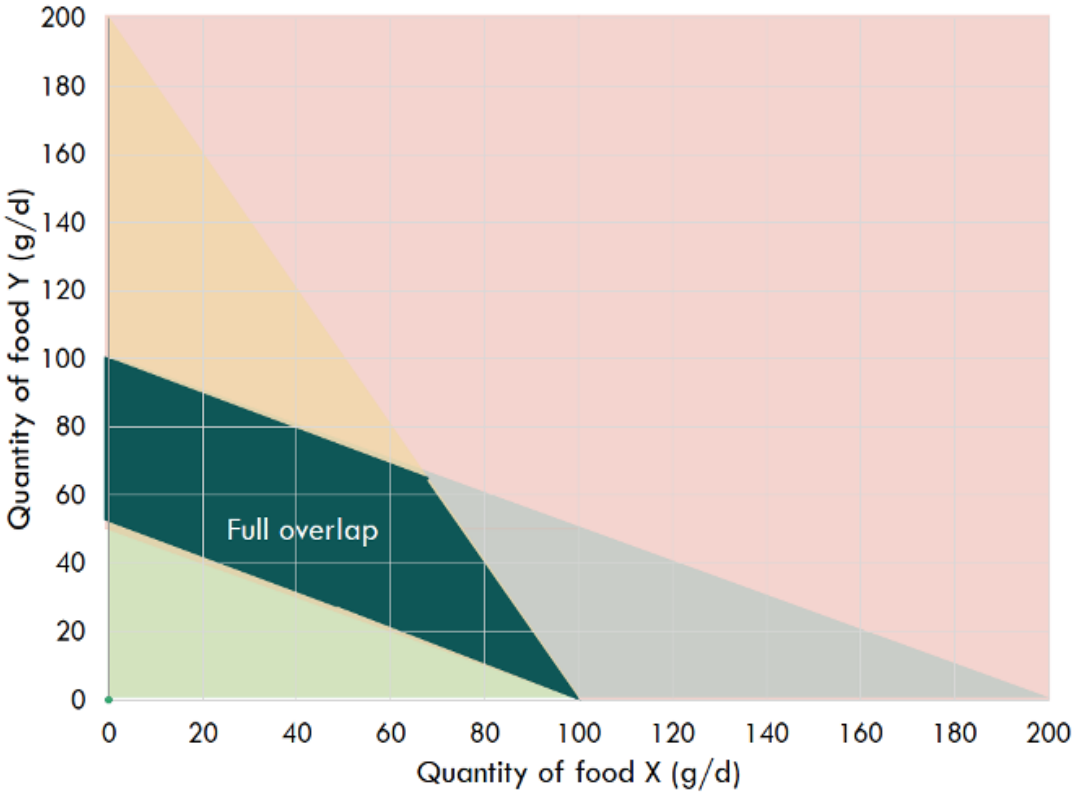

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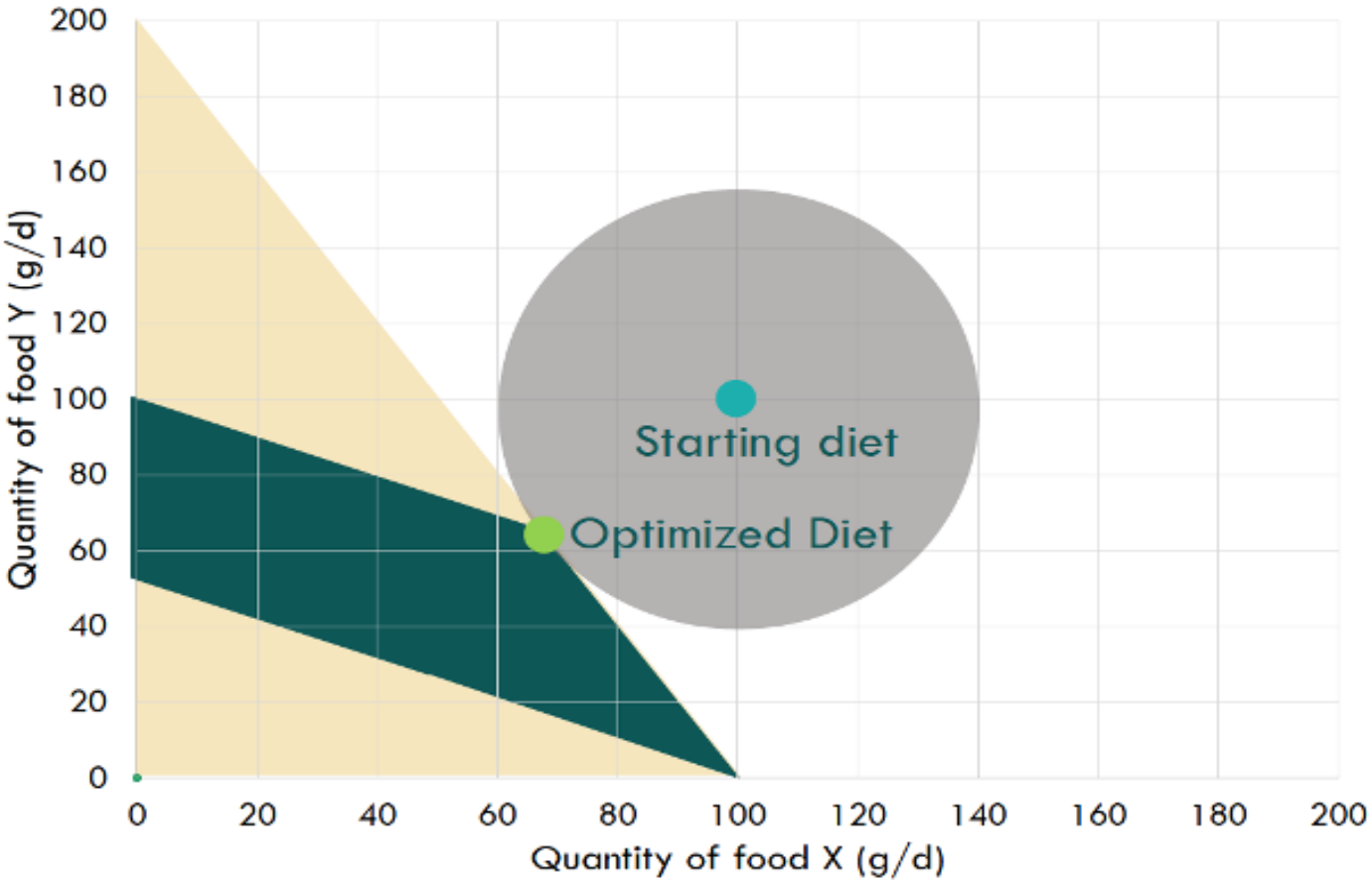
Requirements	Min	Max
Calories	500	1000
GHGe	0	5

Source: Blonk Sustainability Tools (2022)

How to find an optimized diet?

The optimized diet (green dot) is the most similar to the starting diet (blue dot) which fulfils all requirements.



Source:

Blonk Sustainability Tools (2022)

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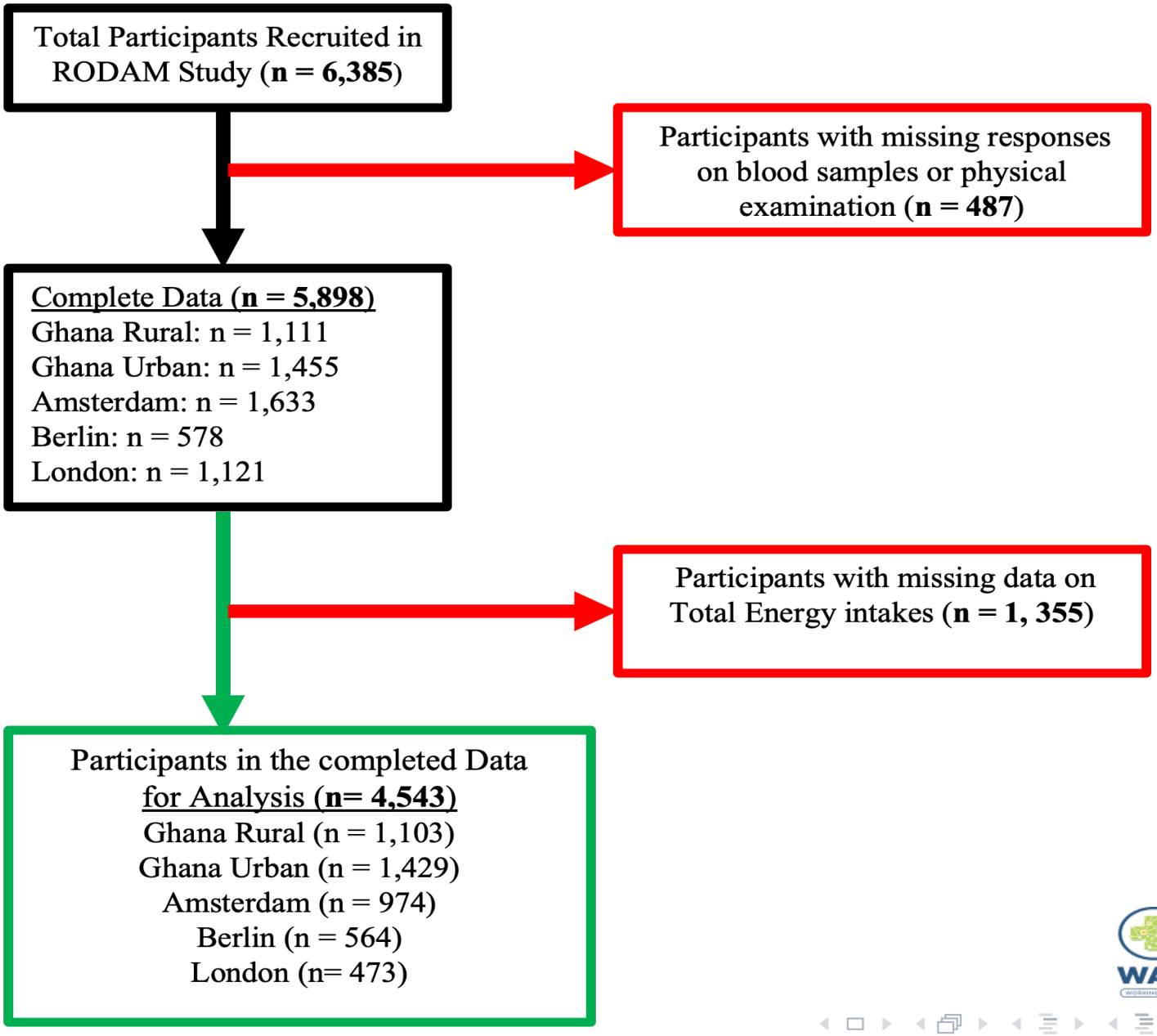
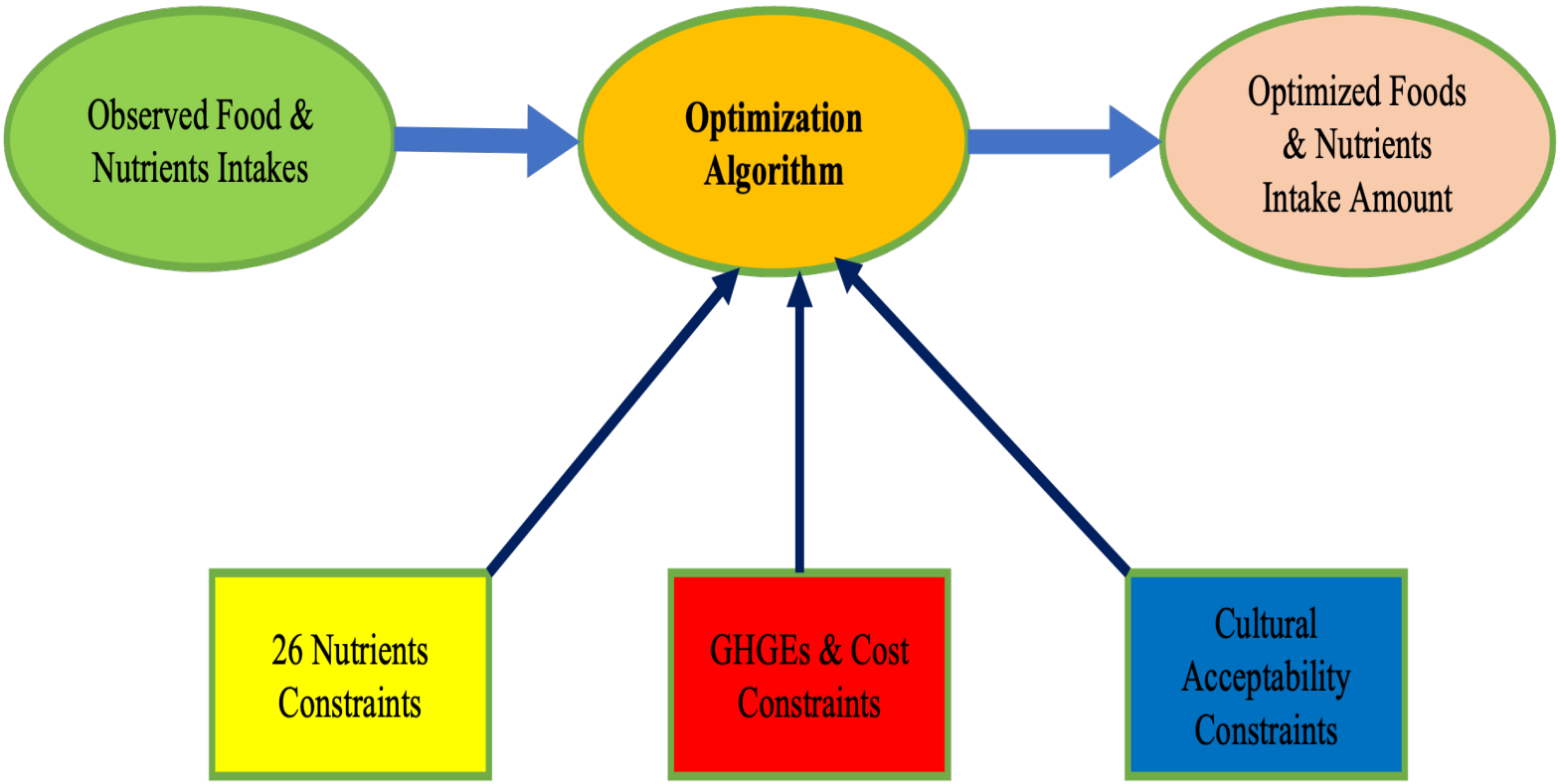
Optimization of sustainable diets for Ghanaian migrants

- The study seeks to identify the optimal combination of food groups and intake frequencies to achieve nutritious, climate-friendly, culturally appropriate, and affordable dietary patterns for Ghanaian adults living in rural Ghana, urban Ghana, and three European cities.
- Specific Objectives:
  1. Identifying optimal nutritious dietary patterns for the five study sites without any constraints on the GHG emissions and costs, that are culturally acceptable.
  2. Identifying optimal nutritious and climate-friendly (GHG-emissions) dietary patterns that are culturally acceptable for the five study sites without cost constraints.
  3. Identifying optimal nutritious dietary patterns, when considering climate-friendly, and costs (affordability) as constraints for the five study sites, that are culturally acceptable.

Study Population

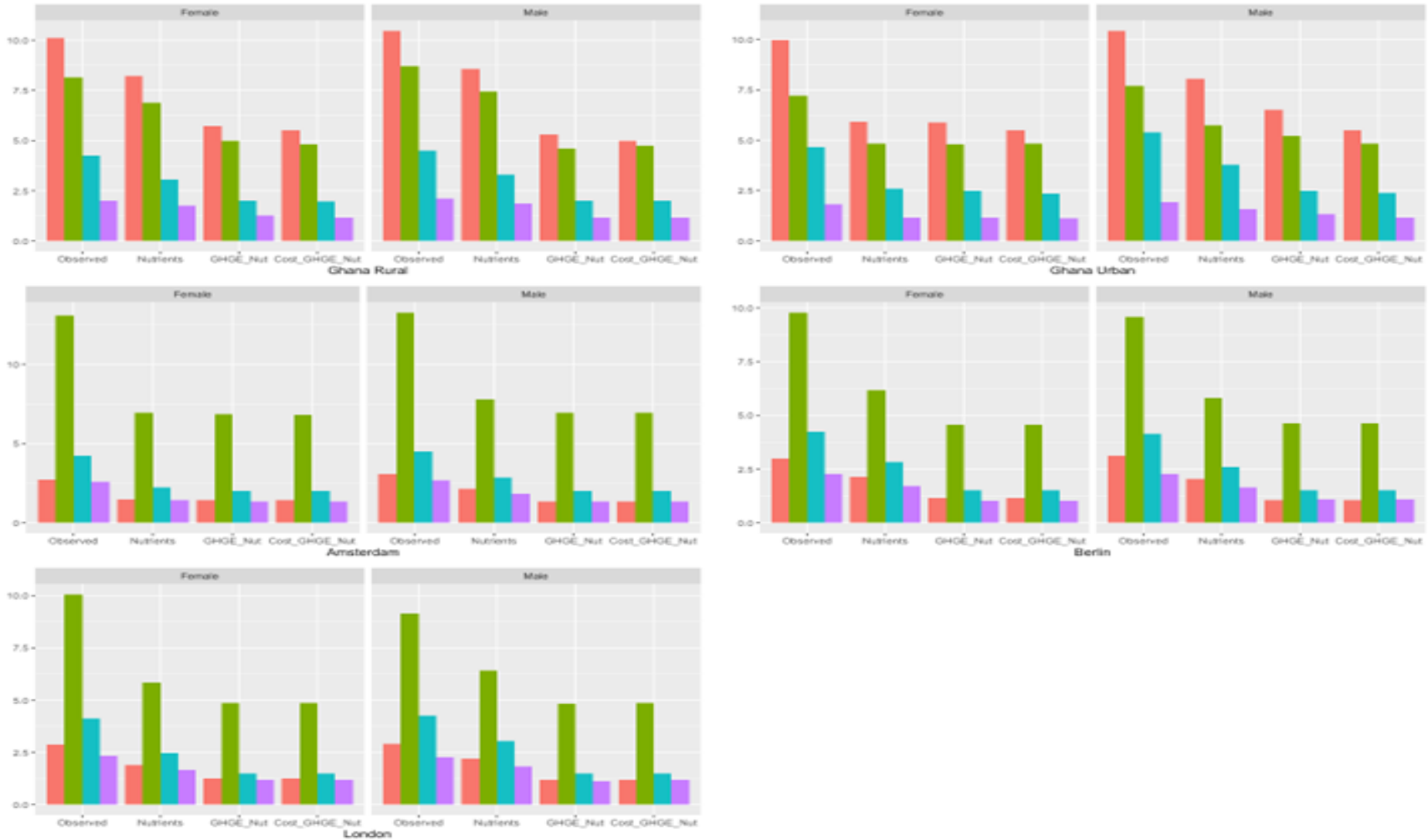


Optimization Model



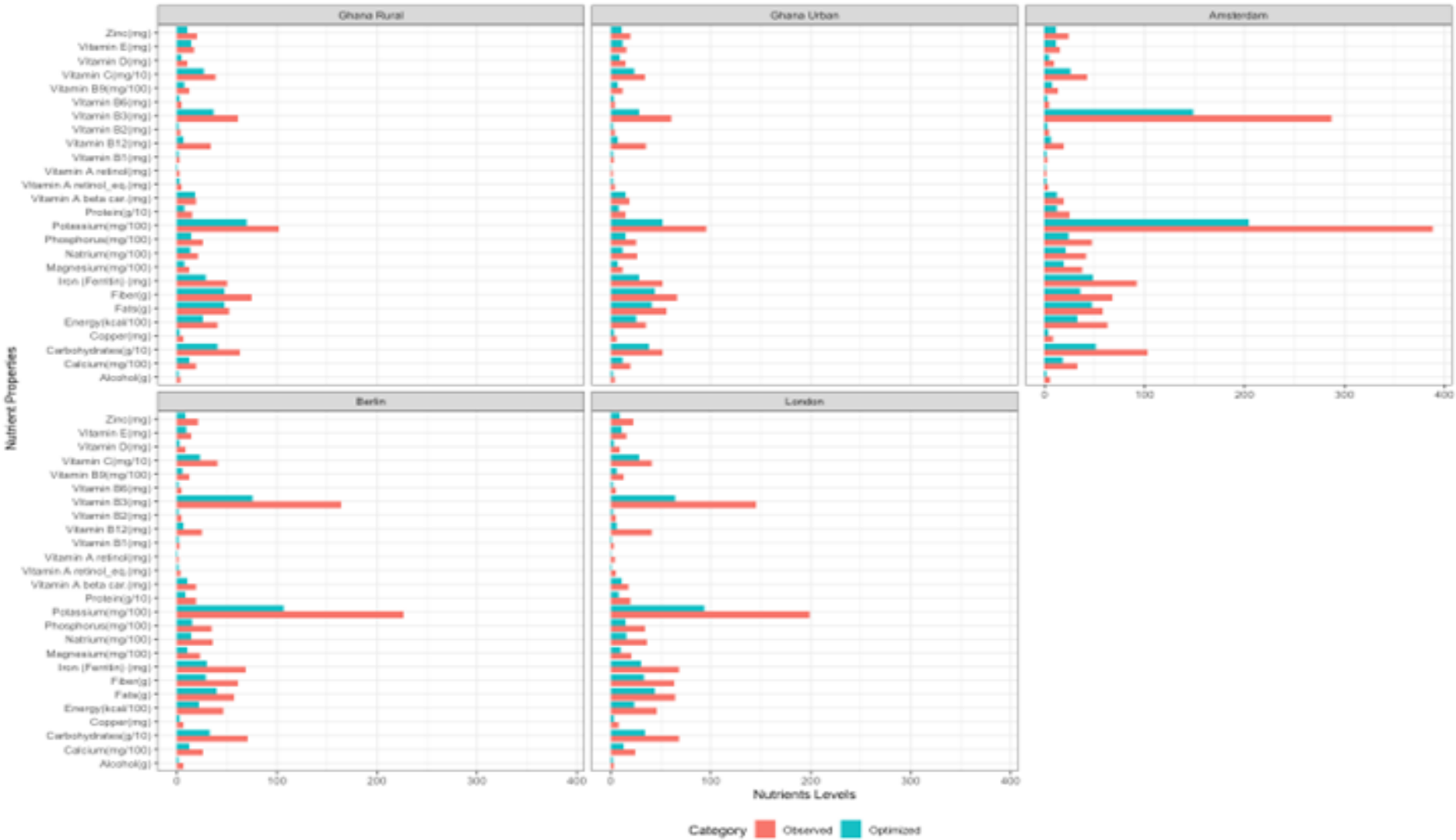
Flowchart for Optimization Algorithm of the consumed diets.

Results



Summary of the results illustrating the differences in cost, energy use, GHGEs, and weight after three subsequent cycles

Results



Comparison of the observed and optimized 26 nutrient properties for the five sites