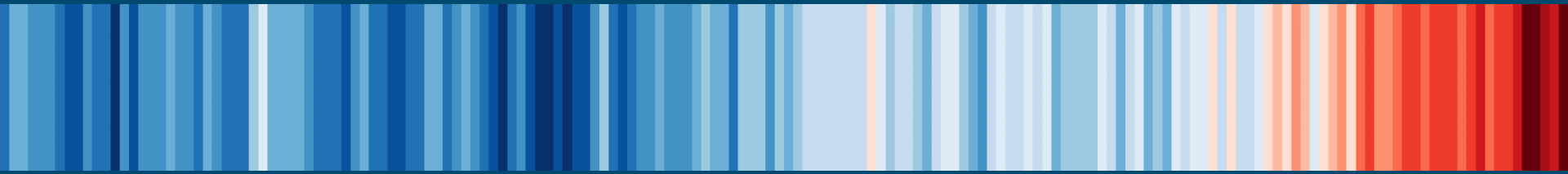
HEIDELBERG UNIVERSITY HOSPITAL

HEIDELBERG INSTITUTE OF GLOBAL HEALTH

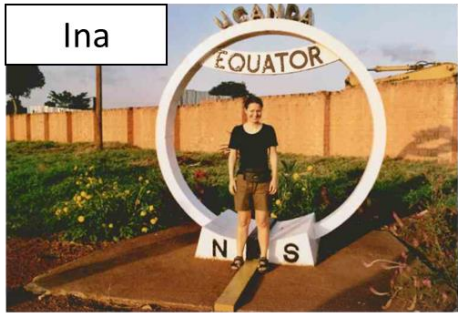
Solutions for climate change mitigation and health co-benefits



Ina Danquah
Data Science Initiative-Africa (DSI-A)
Durban, July 18th, 2023

UK HD

Ina



2001 ijgd

2016-2018 CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN

2010-2019 DIfE German Institute of Human Nutrition Potsdam-Rehbruecke

2013-2016 LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

2001-2007 Universität Potsdam UNIVERSITY OF GHANA

2007-2010 KATH CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN

Course outline

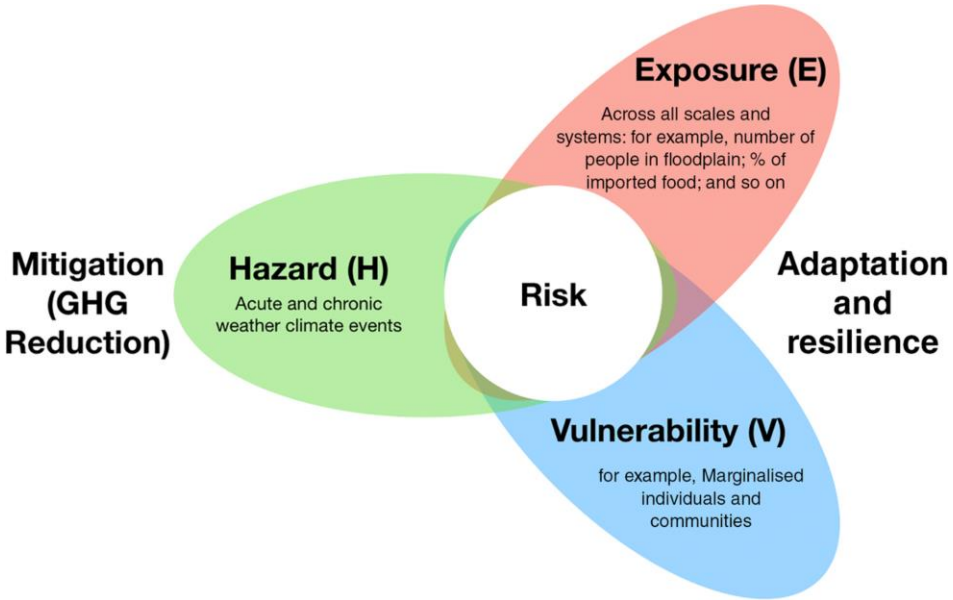
Week 1

Concepts of climate change and weather; public databases
Concepts of footprints (LCA); public databases
Remote sensing – terms and concepts
Remote sensing – techniques and approaches
Concepts and indicators of food systems (dashboard, diet quality indicators)

Week 2

Methodological challenges and solutions – identify climate change impacts on health
Derive solutions for climate change adaptation (MEGA, optimization modelling)
Derive solutions for climate change mitigation (sustainable diets)
Own project work
Remote sensing – software, data, image analysis

Course outline



Week 2

Methodological challenges and solutions – identify climate change impacts on health

Derive solutions for climate change adaptation (MEGA, optimization modelling)

Derive solutions for climate change mitigation (sustainable diets)

Own project work

Remote sensing – software, data, image analysis

IPCC, 2018

Learning objectives

- Familiarize with the concept of sustainable diets
- Consolidate knowledge about methods to identify the sustainability of diets
- Understanding approaches to design context-specific sustainable diets
- Applying the socio-ecological model for the implementation of sustainable diets

Literature

- FAO (2010) Sustainable diets and biodiversity: directions and solutions for policy, research and action.
- Schulze M and Hoffmann K. Methodological approaches to study dietary patterns in relation to risk of coronary heart disease and stroke. BJN 2006; 95: 860-869
- Seconda L *et al.* Development and validation of an individual sustainable diet index in the NutriNet-Santé study cohort. BJN 2019; 121: 1166-1177
- Willett W *et al.* Food in the Anthropocene. The EAT-*Lancet* Commission on healthy diets from sustainable food systems. Lancet 2019; 393: 447-492
- van Dooren C *et al.* A review of the use of linear programming to optimize diets, nutritiously, economically and environmentally. Fron Nutr 2018; 5: 48

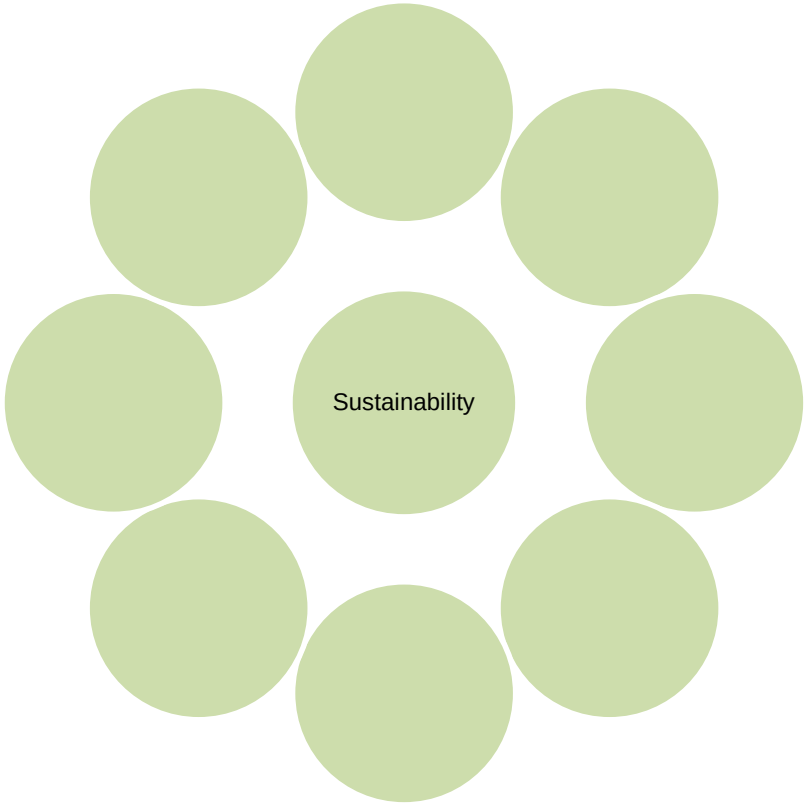
What are sustainable diets?

Definition of the Food and Agriculture Organization (FAO)

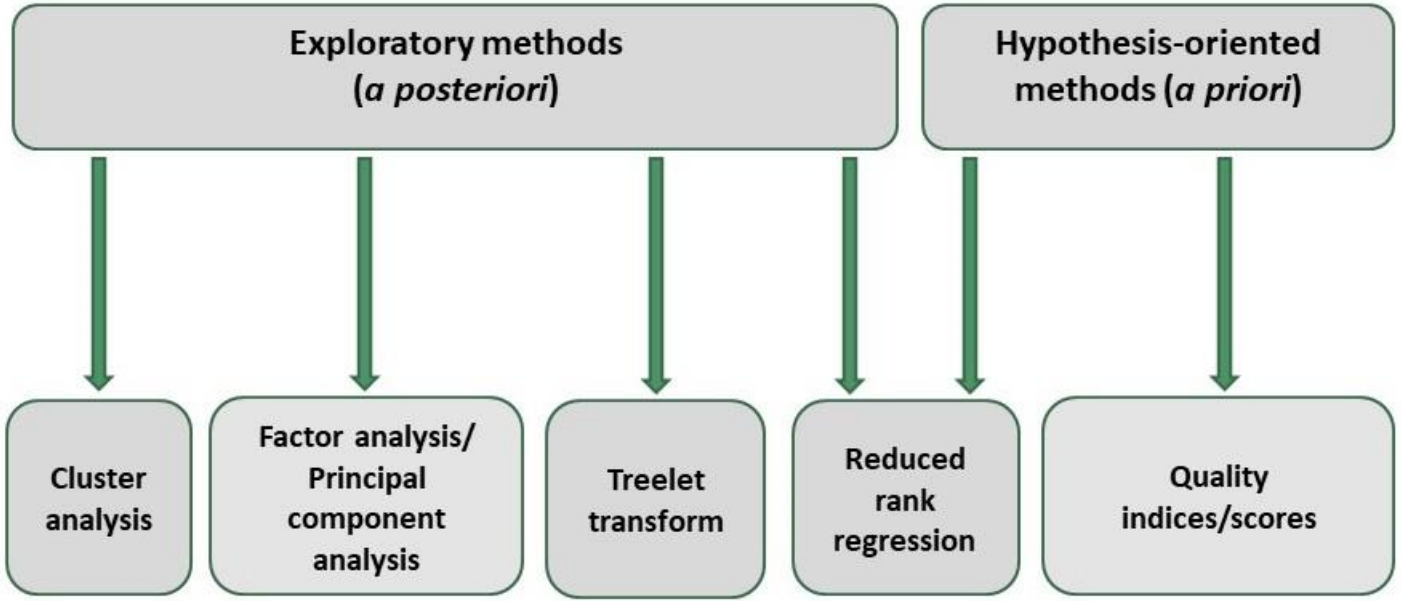
"Sustainable Diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources."

FAO, 2010

Dimensions of sustainability



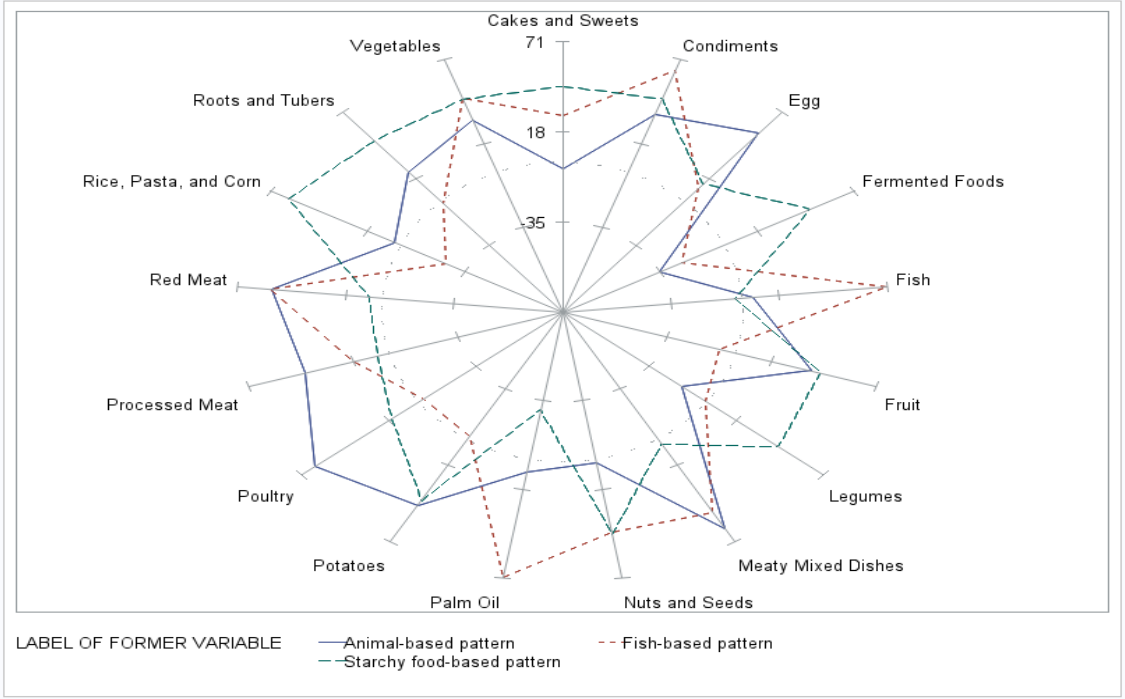
Methods to identify the sustainability of diets



Schulze & Hoffman, 2006

Methods to identify the sustainability of diets

Example 1 – Compare exploratory patterns (PCA) with recommendations



Weil et al., 2023 under review

Methods to identify the sustainability of diets

Example 2 – Construct a multi-component Sustainable Diet Score

SDI component	Chosen indicator	Data	Result
Healthfulness	Global Diet Quality Score (GDQS)	AFPQ	Healthfulness score
Climate-friendliness	Carbon footprint of each food item	RODAM Study (Ghana)	Climate-friendliness score
Affordability	Local food prices weighted against educational level and settlement type	Market data + AFPQ	Affordability score
Cultural appropriateness	Ratio natural to processed food	AFPQ food items	Cultural appropriateness score
			Sum of the 4 subscores = SDI

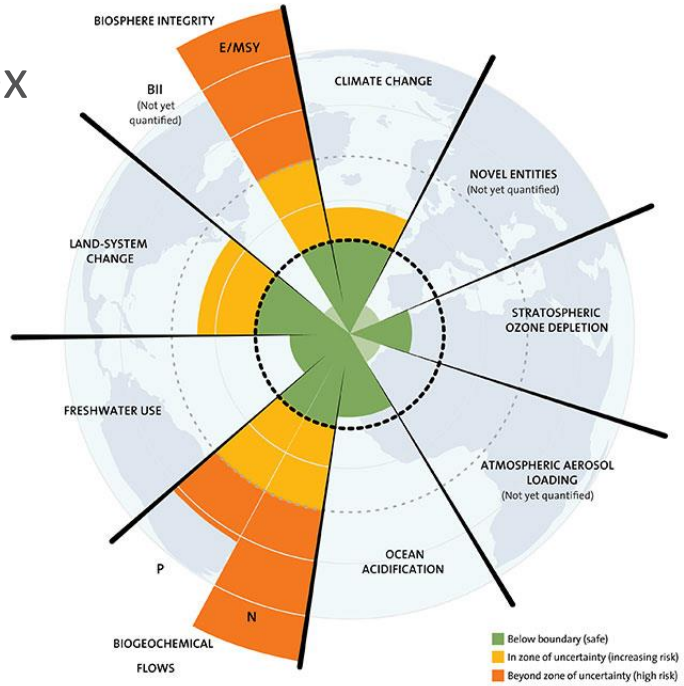
Yalikun Y et al., 2023 under review

Methods to identify the sustainability of diets

Example 3 – Construct an evidence-based index (EAT-Lancet Planetary Health Diet)

- Meta-analysis for diet-disease-associations
- Define Planetary Boundaries
- Consider food system for feasibility
- Formulate strategies for implementation

→ Safe operating space



Willett W et al., Lancet 2018

The Planetary Health Diet

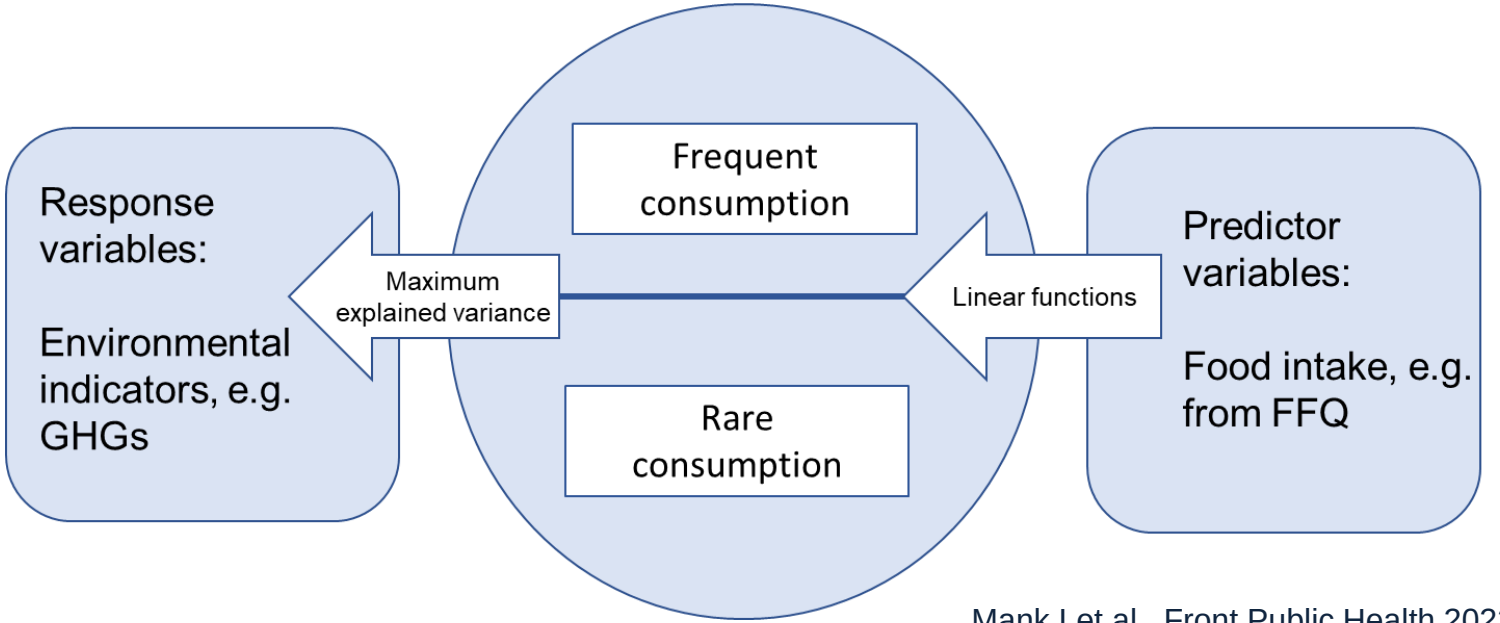
	Macronutrient intake grams per day (possible range)	Caloric intake kcal per day
Whole grains		
Rice, wheat, corn and other	232	811
Tubers or starchy vegetables		
Potatoes and cassava	50 (0–100)	39
Vegetables		
All vegetables	300 (200–600)	78
Fruits		
All fruits	200 (100–300)	126
Dairy foods		
Whole milk or equivalents	250 (0–500)	153
Protein sources		
Beef, lamb and pork	14 (0–28)	30
Chicken and other poultry	29 (0–58)	62
Eggs	13 (0–25)	19
Fish	28 (0–100)	40
Legumes	75 (0–100)	284
Nuts	50 (0–75)	291
Added fats		
Unsaturated oils	40 (20–80)	354
Saturated oils	11.8 (0-11.8)	96
Added sugars		
All sugars	31 (0–31)	120

- 1 glass of milk per day
- 1 hamburger per week
- 2 servings of poultry per week
- 2 eggs per week
- 2 servings of fish per week
- 2-3 servings of legumes per day
- 1-2 servings of nuts/seeds per day
- Total fat max. 35% of energy
- <1 softdrink per day

Willett W et al., Lancet 2018

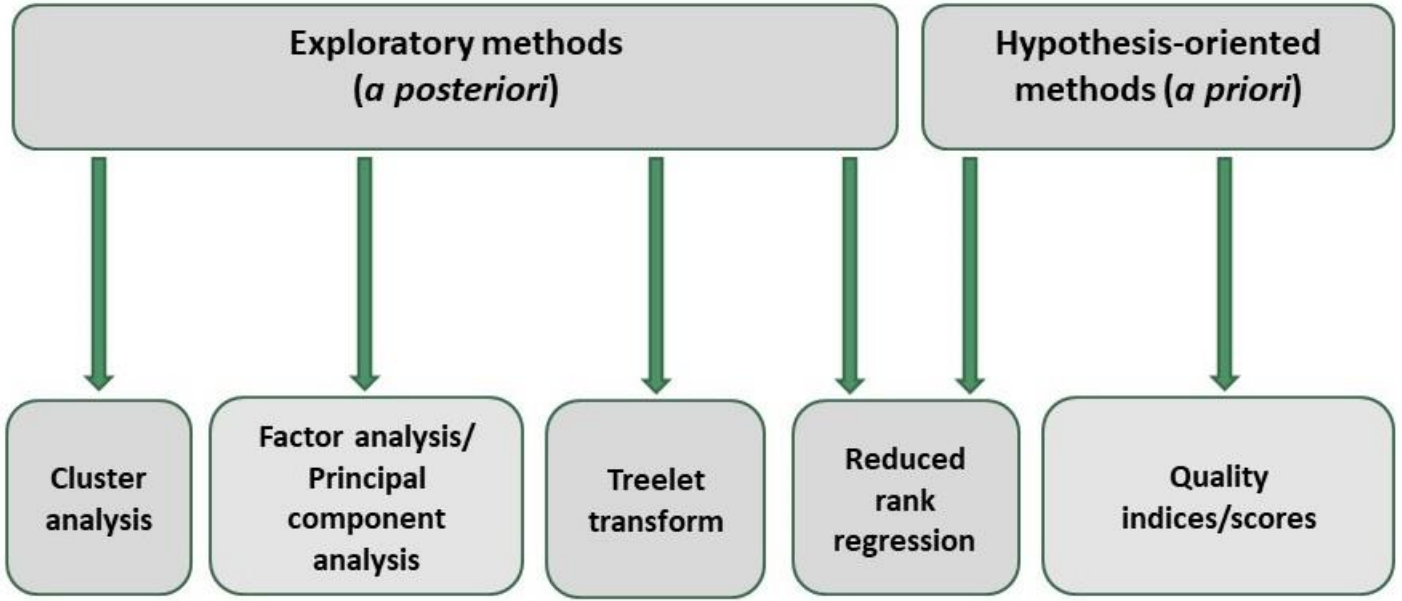
Methods to identify the sustainability of diets

Example 4 – Maximum explained variance in sustainability (hybrid)



Mank I et al., Front Public Health 2022

Methods to identify the sustainability of diets



Schulze & Hoffman, 2006

Which method is it?

Based on the FAO's definition of sustainable diets, our index includes seven indicators categorised into four standardised sub-indexes, respectively, environmental, nutritional, economic and sociocultural. The index (range: 4–20) was obtained by summing the sub-indexes.

Seconda L et al., Br J Nutr 2019

Which method is it?

Four patterns were identified. Respondents were found to consider “mountain products” a fundamental commodity with reference to all related categories of food (cheese, meat, honey, fruits and vegetables) and believed that all stages of the supply chain should be carried out in mountain areas. All of the four patterns also reported a positive perception of mountain products, and they associated mountain foodstuffs with various key concepts, such as sustainable development (32.6%), local traditions and specialities (49.1%) and health (18.3%).

Bonadonna A et al., Sustainability 2022

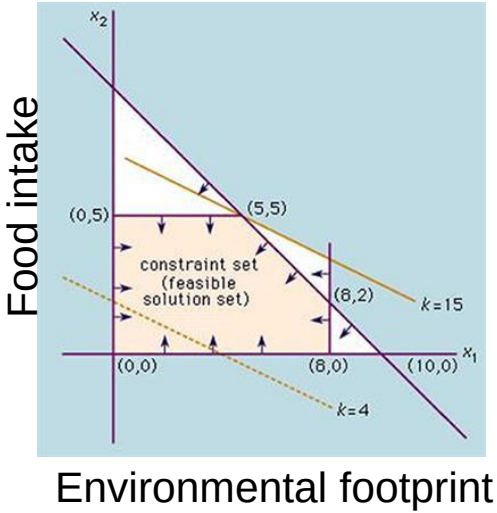
Which method is it?

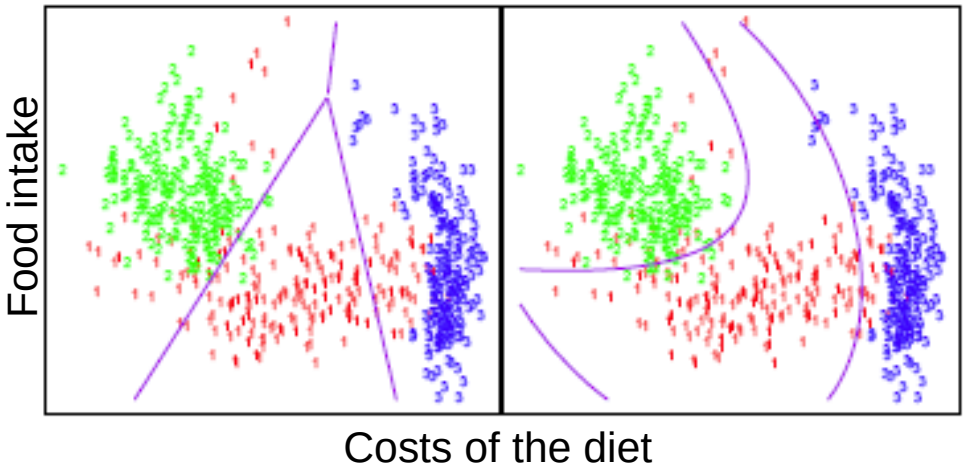
We developed a food-based metric incorporating a more comprehensive list of food groups than most existing diet metrics, and a simple means of scoring consumed amounts.

Bromage S et al., J Nutr 2021

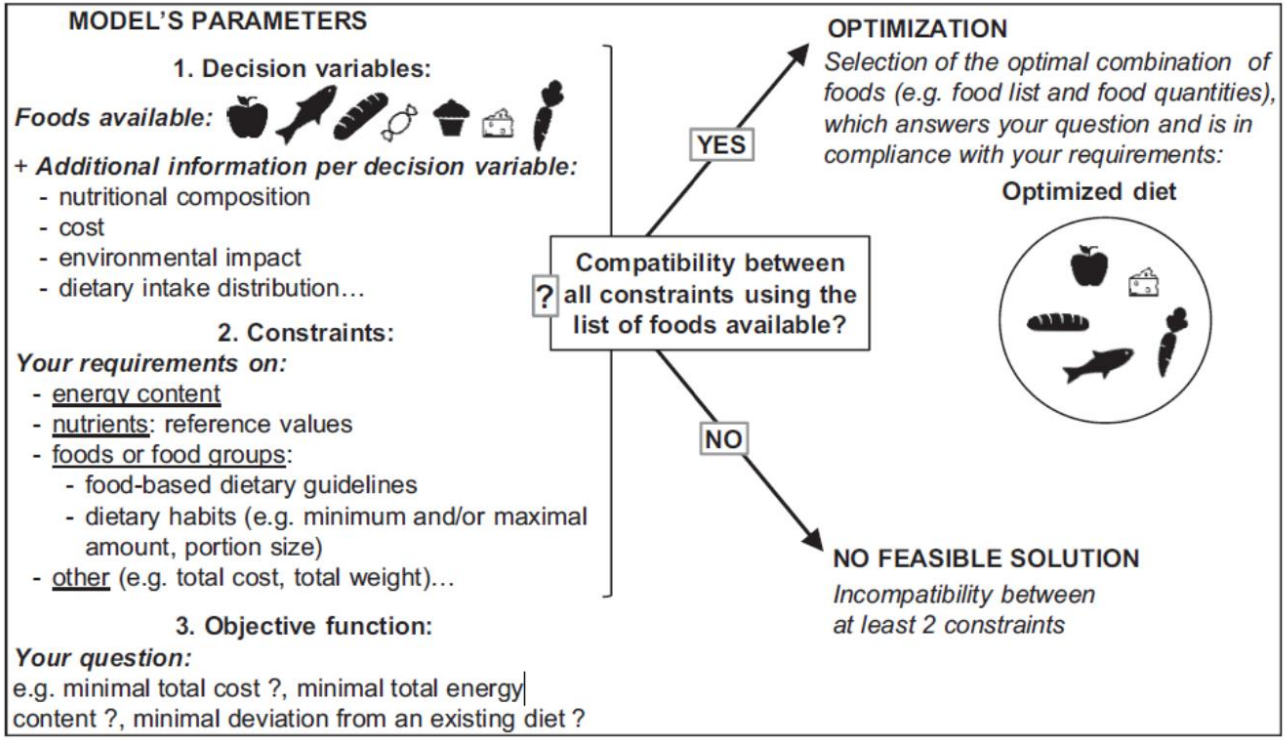
Approaches to design sustainable diets

Quantitative → optimization modelling → prototype





What is diet optimization?



Optimization – Advantages and limitations

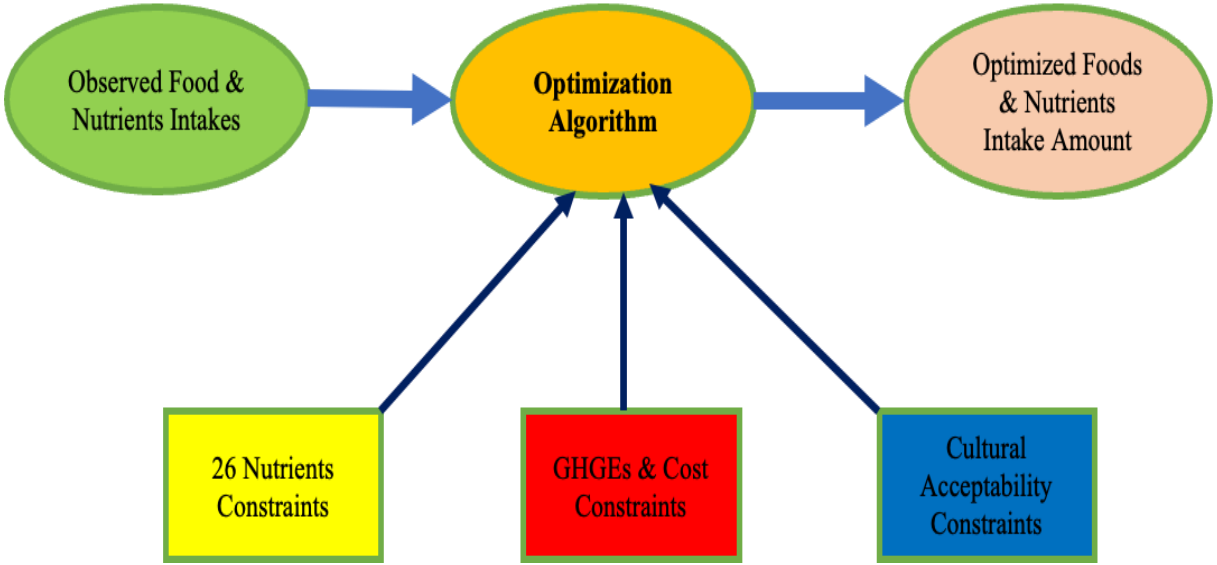
Advantages

- Simultaneous application of constraints to ensure nutritional adequacy and other aspects of sustainability
- Help identify trade-offs by studying constraints that are difficult to fulfil or incompatible with other constraints

Limitations

- Can lead to no or unrealistic solution when constraints are too severe or incompatible
- Difficult to include cultural acceptability (proxy: deviation from current diet)
- Sensitive to starting diet, menu items
- Difficult to interpret and explain changes

Optimization – Example: urban Ghana



Kallah-Dagadu G et al., 2023 in preparation

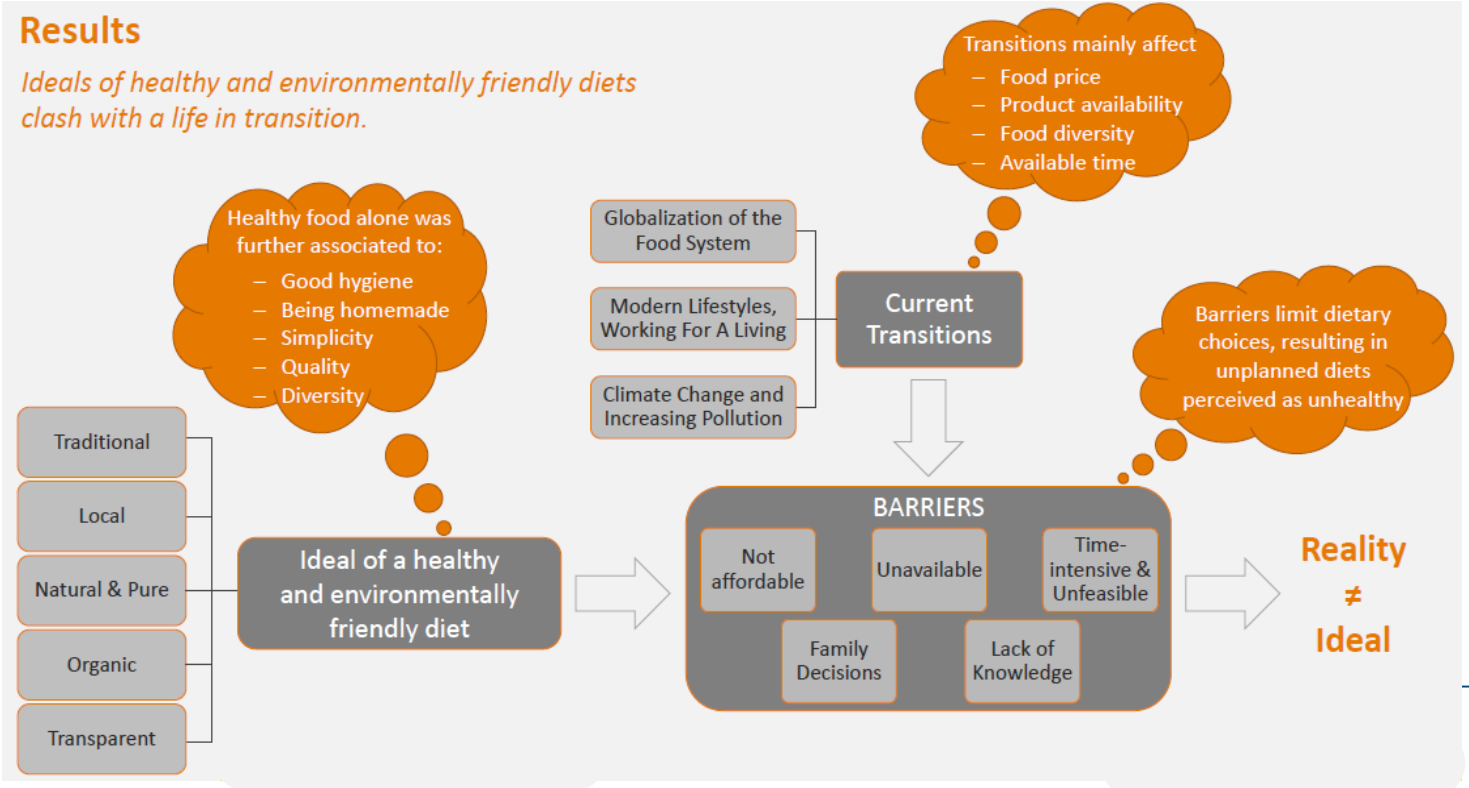
Optimization – Example: urban Ghana

Food Group	Starting diet women (g)	Starting diet men (g)	Optimized diet women (g)	Optimized diet men (g)
Cakes and Sweets	14.5	12.8	7	5.5
Coffee Tea	100	100	36	46
Condiments	60.7	64.8	29	30
Dairy Products	30.0	42.1	10	10
Eggs	12.9	5.0	2	2
Fermented Maize products	120.0	120	70	68
Fish and Seafood	87.0	83.7	55	50
Fruits	120.0	130	94	104
Legumes	44.2	69.3	15	31
Margarine	4.5	2.57	12	7
Meat mixed dishes	64.3	64.3	10	10
Nuts and Seeds	4.7	4.67	1.3	1.3
Olive Oil	0.2	1.21	0.02	0.12
Other Oils	3.8	3.99	11	2
Palm Oil	1.5	1.47	10	9
Potatoes	13.3	16.7	1.3	1.6
Poultry	10.0	12.5	5	5
Processed Meat	11.7	11.7	0.2	1.2
Red Meat	26.7	47.9	10	12
Rice & Pasta	163.0	182	136	147
Soft Drinks & Juices	33.8	55.0	27	48

Kallah-Dagadu G et al., 2023 in preparation

Approaches to design sustainable diets

Qualitative → pilot-test prototype



Fülbert H et al., 2023 under review

Approaches to design sustainable diets

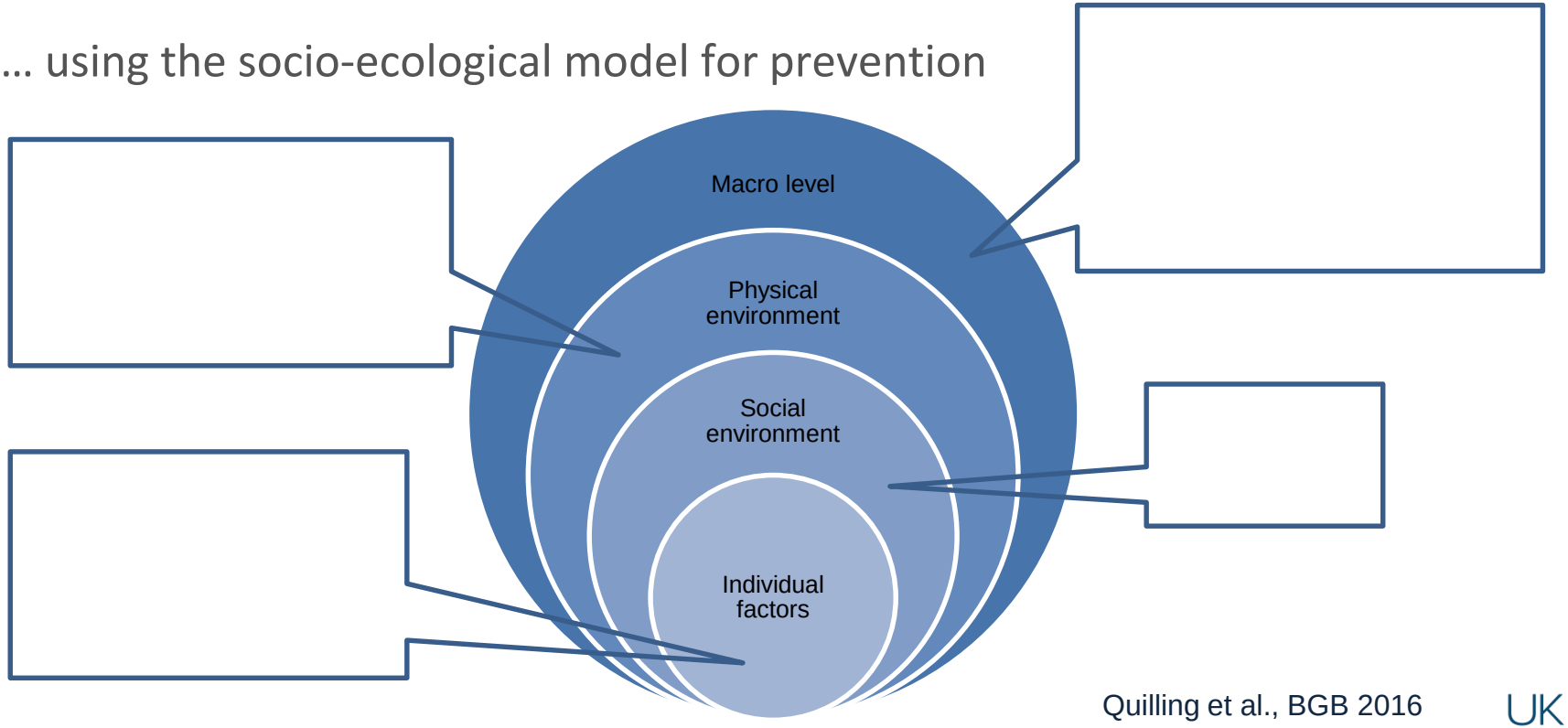
What is the current situation?

What are the possibilities and limitations?

Feasibility, acceptability, appropriateness, fidelity

Implementing sustainable diets

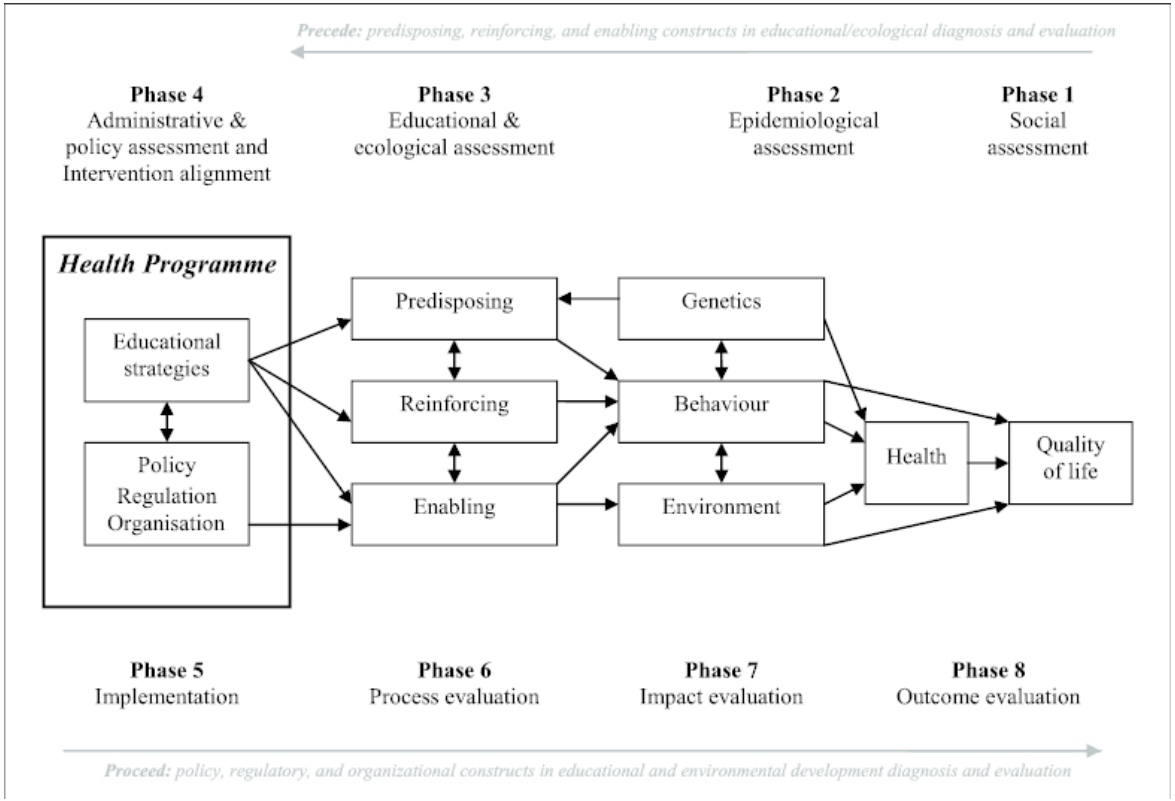
… using the socio-ecological model for prevention



Quilling et al., BGB 2016

Implementing sustainable diets – Phases

PRECEDE/
PROCEDE model



Green LW & Kreuter MW. New York: McGraw-Hill, 2005

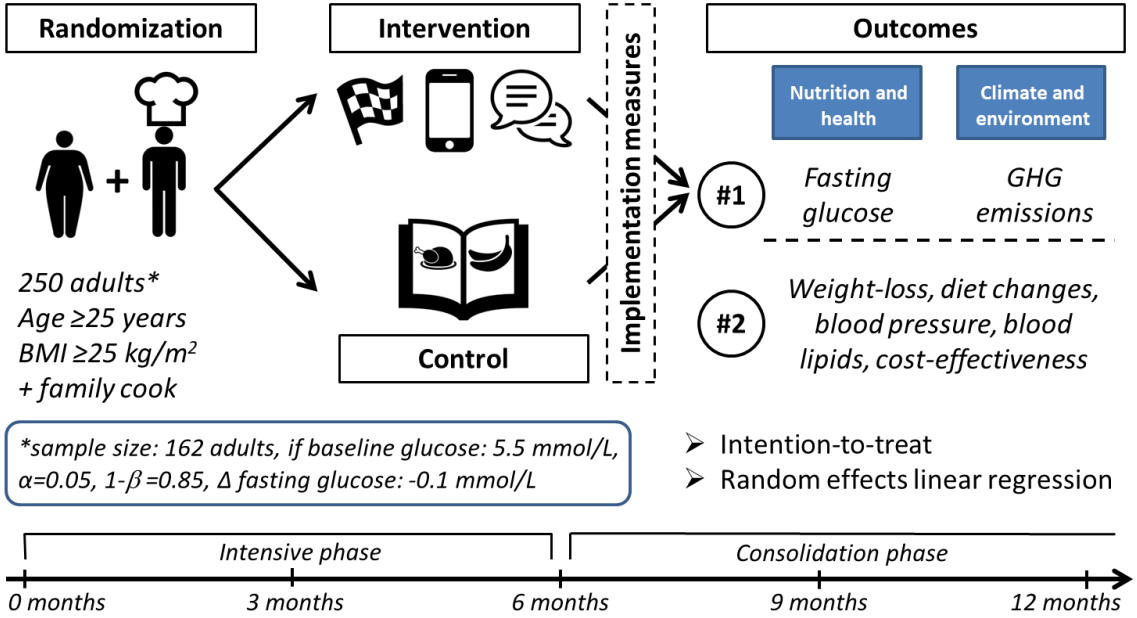
Implementing sustainable diets – Example

PRECEDE/PROCEDE model

- Phases 1 & 2: high prevalence of overweight and nutrition transition
- Phase 3: dietary habits characterized
- Phase 4: sustainable diets prototyped
- Phase 5: pilot-testing of sustainable diets
- Phase 6: implementation
- Phase 7: process evaluation
- Phase 8: impact evaluation
- Phase 9: results evaluation

Sustainable diets – Design

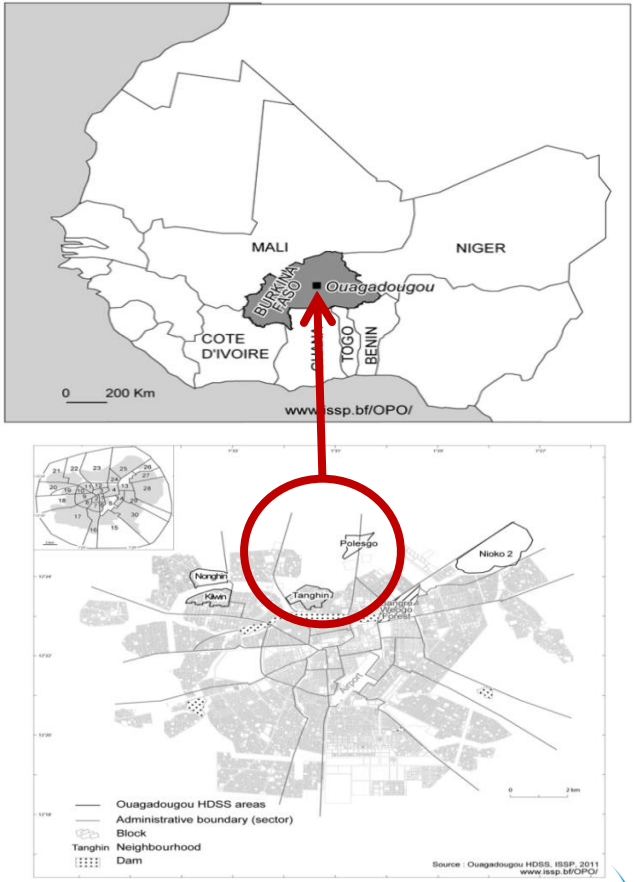
Sustainable lifestyle intervention for weight-loss and diabetes prevention among adults with overweight/obesity living on Ouagdougou



Herrmann A et al., BMJ Open 2023

Sustainable diets – Setting

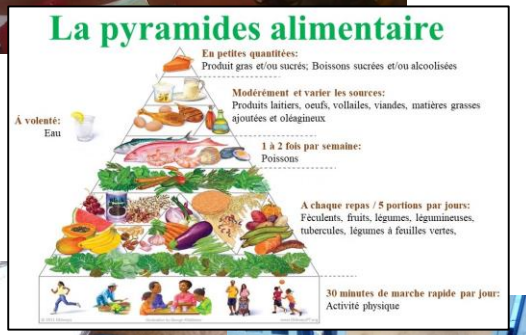
- Ouagadougou: urban HDSS
- 250 adults with BMI ≥25 kg/m^2 and the family cook
- men and women
- formal and informal settlements
- Household-based sampling



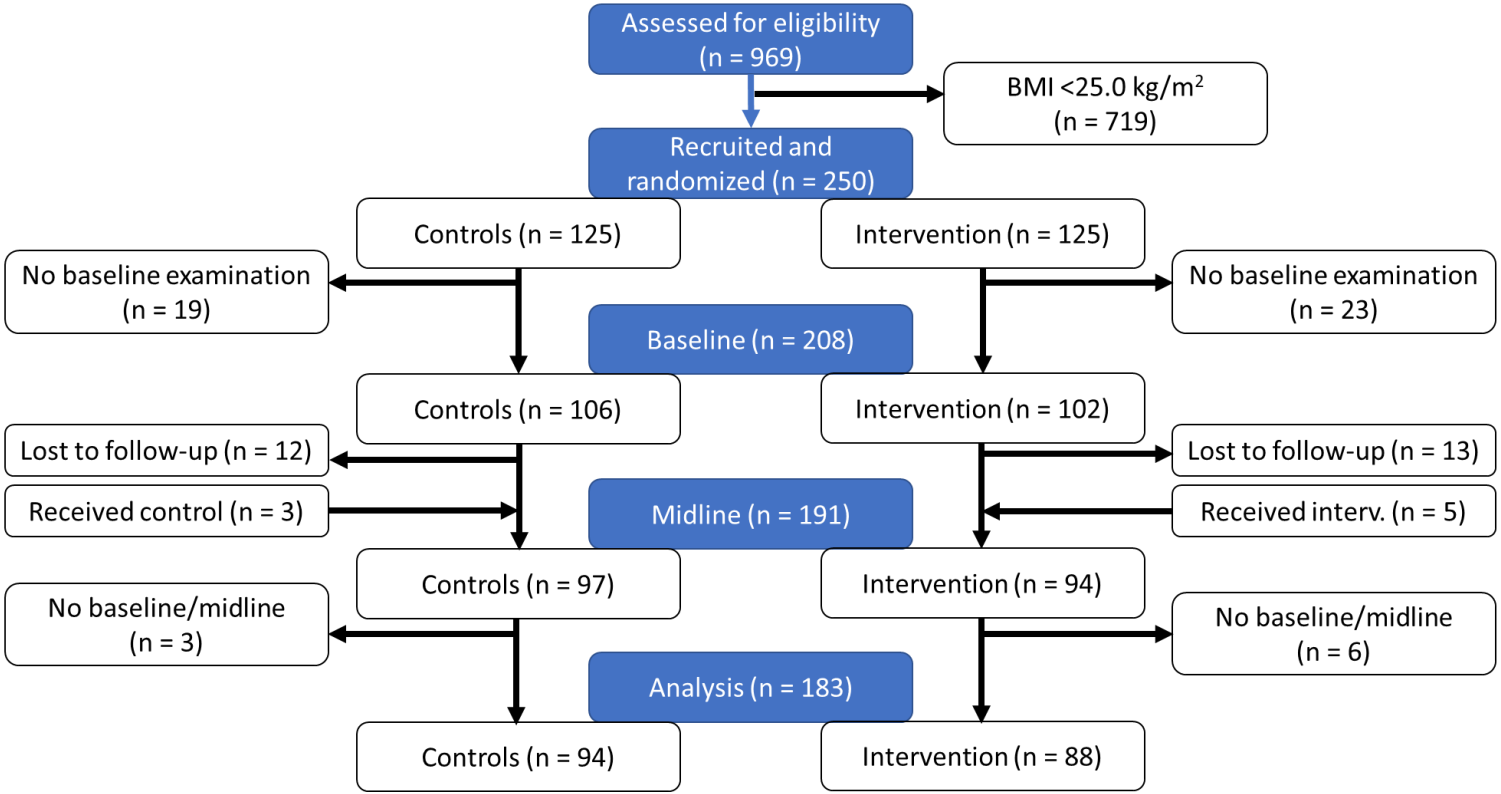
Ouagadougou HDSS 2011; Rossier et al. Int J Epidemiol 2012; Rossier et al. PLoS ONE 2014

Sustainable diets – Intervention

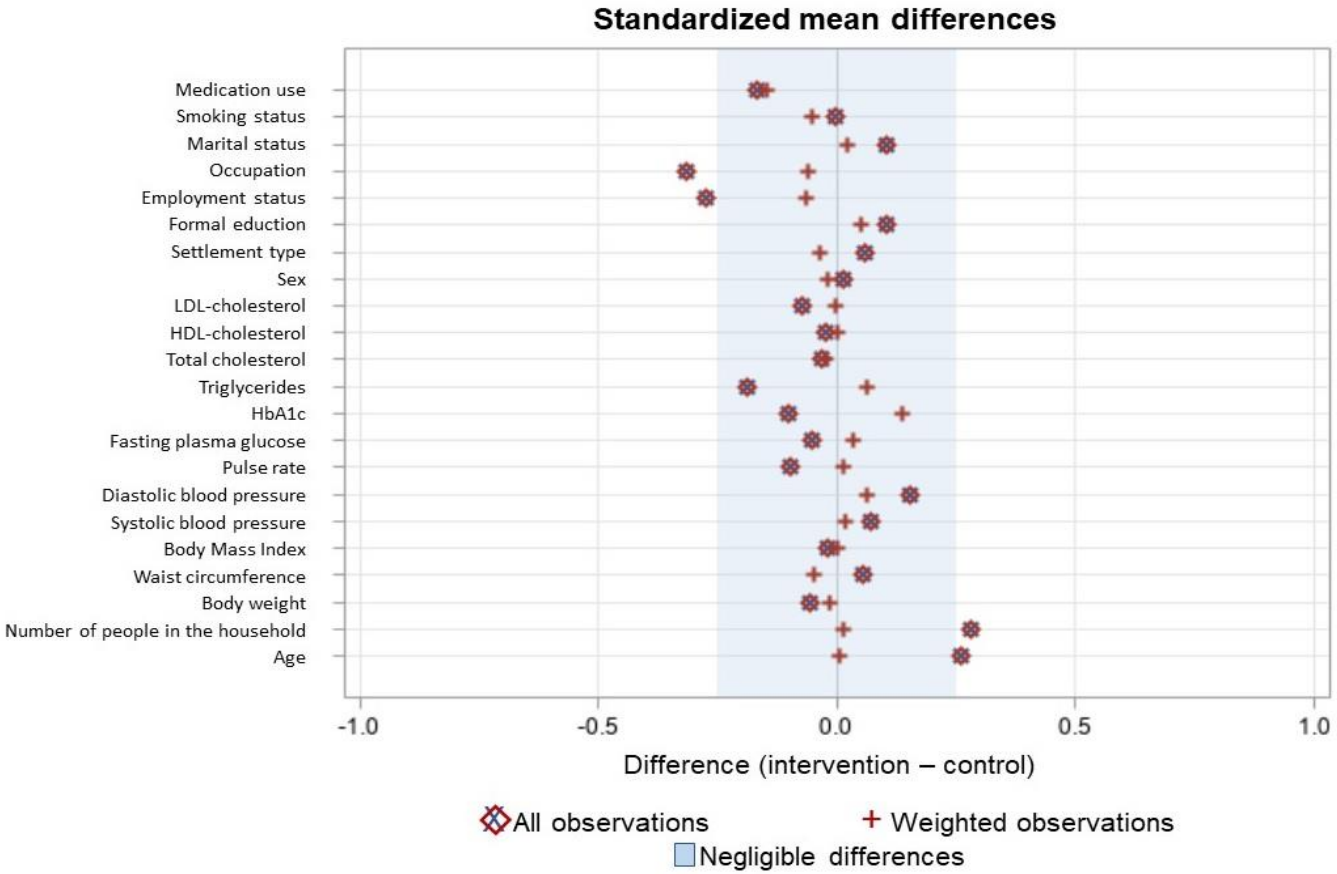
Steps for participant and data collection	Month of the study							
	0	1	2	3	4	5	6	12
Recruitment	x							
Check for eligibility criteria, including anthropometric measurements	x							
Oral and written study information and informed consent taking	x							
Sociodemographic and physical assessments	x						x	x
Socio-demographic questionnaire	x							
Global Physical Activity Questionnaire (GPAQ)	x						x	x
Anthropometric measurements • Height • Weight • Waist circumference	x						x	x
Cardio-metabolic measurements • Blood pressure • Resting heart rate • Fasting blood glucose • Oral glucose tolerance test • HbA1c • Blood Lipids: TG, Total-Chol, HDL	x						x	x
Dietary Assessments	x			x			x	x
24-hour dietary recall	xx			xx			xx	xx
Sustainble Diet Weight-Loss Intervention		x	x	x	x	x	x	
Standard counselling material (control group)		x						
Group counselling (intervention group)		x		x		x		
Guided market visit + cooking session (intervention group)					x			
Guided physical activity session (intervention group)		xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	



Sustainable diets – Flow chart 6 months

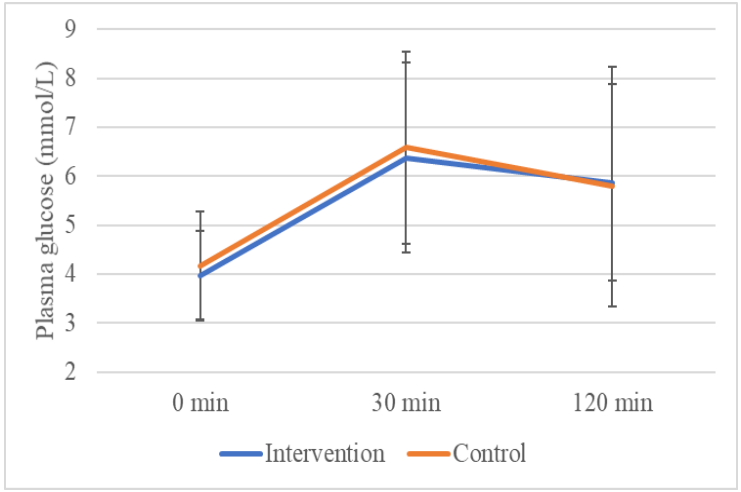


Baseline characteristics



Effects on primary outcomes after 6 months

Outcomes	Baseline	Midline	Adjusted differences (95% CIs) and p-values	
N	208	191	183	
Laboratory				
Fasting glucose (mmol/L)				
Intervention	5.03 ± 1.02	3.96 ± 0.91	**-0.339 (-0.620, -0.057)**	**0.019**
Control	5.08 ± 1.14	4.17 ± 1.10		
Glucose 30 min (mmol/L)				
Intervention	-	6.38 ± 1.95	-0.325 (-0.914, 0.264)	0.278
Control	-	6.58 ± 1.96		
Glucose 120 min (mmol/L)				
Intervention	-	5.87 ± 2.01	-0.068 (-0.719, 0.583)	0.837
Control	-	5.79 ± 2.45		
HbA1c (mmol/mol)				
Intervention	44.4 ± 11.4	42.7 ± 8.8	-0.100 (-2.670, 2.470)	0.939
Control	45.7 ± 13.3	42.8 ± 10.6		
HbA1c (%)				
Intervention	6.21 ± 1.05	6.05 ± 0.81	-0.009 (-0.244, 0.226)	0.939
Control	6.33 ± 1.22	6.07 ± 0.97		
Triglycerides (mmol/L)				
Intervention	0.87 (0.66-1.18)	1.00 (0.73, 1.40)	-0.051 (-0.324, 0.221)	0.710
Control	0.93 (0.68-1.44)	0.99 (0.66, 1.49)		
Total cholesterol (mmol/L)				
Intervention	4.49 (4.16-5.22)	4.61 (4.05, 5.35)	0.043 (-0.268, 0.353)	0.786
Control	4.48 (4.10-5.31)	4.43 (3.87, 5.36)		
HDL-cholesterol (mmol/L)				
Intervention	0.91 (0.70-1.15)	1.21 (0.93, 1.46)	0.090 (-0.110, 0.289)	0.374
Control	0.99 (0.79-1.21)	1.15 (1.01, 1.35)		
LDL-cholesterol (mmol/L)				
Intervention	4.07 (3.34-4.79)	3.89 (3.32, 4.67)	0.018 (-0.265, 0.301)	0.902
Control	3.94 (3.46-4.95)	3.97 (3.19, 4.74)		



Mean differences, their 95% confidence intervals (CIs), and p-values were calculated by linear regression and are adjusted for baseline values, age, number of people in the household, employment status, and occupation.

Effects on primary outcomes after 6 months

Outcomes	Baseline	Midline	Adjusted differences (95% CIs) and p-values	
N	208	191	183	
Anthropometry				
Weight (kg)				
Intervention	81.3 ± 12.9	81.0 ± 13.5	-0.765 (-2.178, 0.647)	0.286
Control	82.0 ± 14.6	81.9 ± 15.6		
BMI (kg/m^2)				
Intervention	29.7 ± 4.8	29.6 ± 5.2	-0.274 (-0.793, 0.244)	0.298
Control	29.7 ± 4.7	29.8 ± 5.0		
Waist (cm)				
Intervention	93.8 ± 9.9	94.5 ± 11.3	-1.661 (-4.289, 0.968)	0.214
Control	93.2 ± 11.3	94.8 ± 13.3		
Clinical				
Systolic BP (mmHg)				
Intervention	124 ± 21	123 ± 20	-0.836 (-4.958, 3.286)	0.689
Control	121 ± 17	122 ± 20		
Diastolic BP (mmHg)				
Intervention	88 ± 38	82 ± 14	1.429 (-3.137, 5.995)	0.538
Control	83 ± 11	80 ± 16		
Pulse rate (beats/min)				
Intervention	81 ± 11	80 ± 10	-1.767 (-4.424, 0.890)	0.191
Control	82 ± 11	83 ± 11		

Effects on changes in primary outcomes

Outcomes	Crude mean changes (95% CIs) Midline – Baseline	Adjusted mean differences in changes (95% CIs) and p-values	
Laboratory			
ΔFasting glucose (mmol/L)			
Intervention (n=88)	-1.06 (-1.64, -0.48)	**-0.36 (-0.71, -0.01)**	**0.046**
Control (n=94)	-0.79 (-1.03, -0.56)		
ΔHbA1c (mmol/mol)			
Intervention (n=88)	-1.83 (-7.76, 4.10)	0.73 (-2.92, 4.39)	0.692
Control (n=94)	-2.55 (-4.98, -0.11)		
ΔHbA1c (%)			
Intervention (n=88)	-0.17 (-0.71, 0.38)	0.07 (-0.27, 0.40)	0.692
Control (n=94)	-0.23 (-0.46, -0.01)		
ΔTriglycerides (mmol/L)			
Intervention (n=88)	0.18 (-3.44, 3.80)	1.11 (-1.12, 3.34)	0.328
Control (n=94)	-0.92 (-2.41, 0.56)		
ΔTotal cholesterol (mmol/L)			
Intervention (n=88)	0.07 (-1.57, 1.71)	0.50 (-0.51, 1.52)	0.329
Control (n=94)	-0.48 (-1.16, 0.19)		
ΔHDL-cholesterol (mmol/L)			
Intervention (n=88)	0.35 (0.02, 0.68)	0.09 (-0.11, 0.29)	0.396
Control (n=94)	0.22 (0.09, 0.36)		
ΔLDL-cholesterol (mmol/L)			
Intervention (n=88)	-0.20 (-0.70, 0.30)	0.06 (-0.24, 0.35)	0.711
Control (n=94)	-0.20 (-0.41, 0.00)		

Effects on changes in primary outcomes

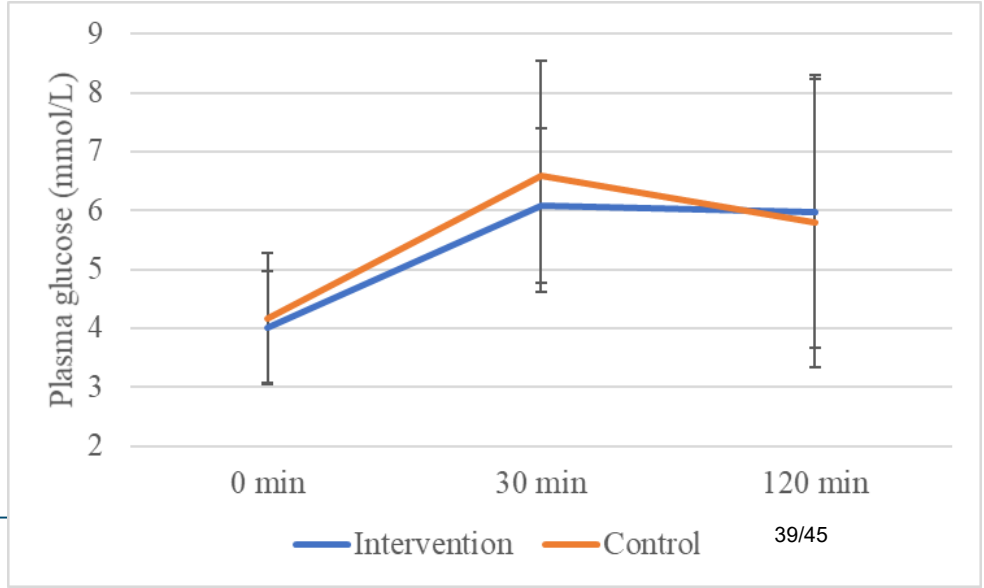
Outcomes	Crude mean changes (95% CIs) Midline – Baseline	Adjusted mean differences in changes (95% CIs) and p-values Intervention effects	
Anthropometry			
ΔWeight (kg)			
Intervention (n=88)	-0.38 (-2.71, 1.96)	-0.75 (-2.16, 0.66)	0.293
Control (n=94)	0.10 (-0.86, 1.06)		
ΔBMI (kg/m^2)			
Intervention (n=88)	-0.14 (-1.00, 0.72)	-0.28 (-0.79, 0.24)	0.298
Control (n=94)	0.03 (-0.32, 0.39)		
ΔWaist (cm)			
Intervention (n=88)	0.74 (-3.79, 5.27)	-1.81 (-4.52, 0.91)	0.191
Control (n=94)	1.91 (0.05, 3.77)		
Clinical			
ΔSystolic BP (mmHg)			
Intervention (n=88)	-1.21 (-8.22, 5.80)	-1.02 (-5.31, 3.26)	0.637
Control (n=94)	-0.01 (-2.88, 2.87)		
ΔDiastolic BP (mmHg)			
Intervention (n=88)	-6.23 (-21.59, 9.13)	-3.18 (-12.64, 6.28)	0.508
Control (n=94)	-3.25 (-9.54, 3.05)		
ΔPulse rate (beats/min)			
Intervention (n=88)	-0.47 (-5.62, 4.67)	-1.04 (-4.21, 2.12)	0.517
Control (n=94)	0.98 (-1.13, 3.09)		

Sensitivity analyis – weight-loss

Weight-loss	Total (n = 182)	Control (n = 94)	Intervention (n = 88)
Achieved any weight-loss	50.0%	51.1%	48.9%
Achieved weight-loss goal (≥ 2.5 kg)	23.1%	26.6%	19.3%

<u>Effect on fasting glucose at midline</u>
Adjusted difference (mmol/L):
-0.65 (-1.31, 0.001); p = 0.051

<u>Effect on change in fasting glucose</u>
Adjusted difference in change (mmol/L):
-0.37 (-0.82, 0.07); p = 0.099



Summary and conclusion

- Lower fasting glucose (-0.34 mmol/L) and stronger reduction in fasting glucose (-0.36 mmol/L) in intervention group than in controls
- No differences in weight-loss between the groups (Hawthorne effect)
- Results similar in sensitivity analysis; with slight improvements in 30min glucose value

➢ Sustainable diet intervention improves fasting glucose and this is indpenedent of weight-loss

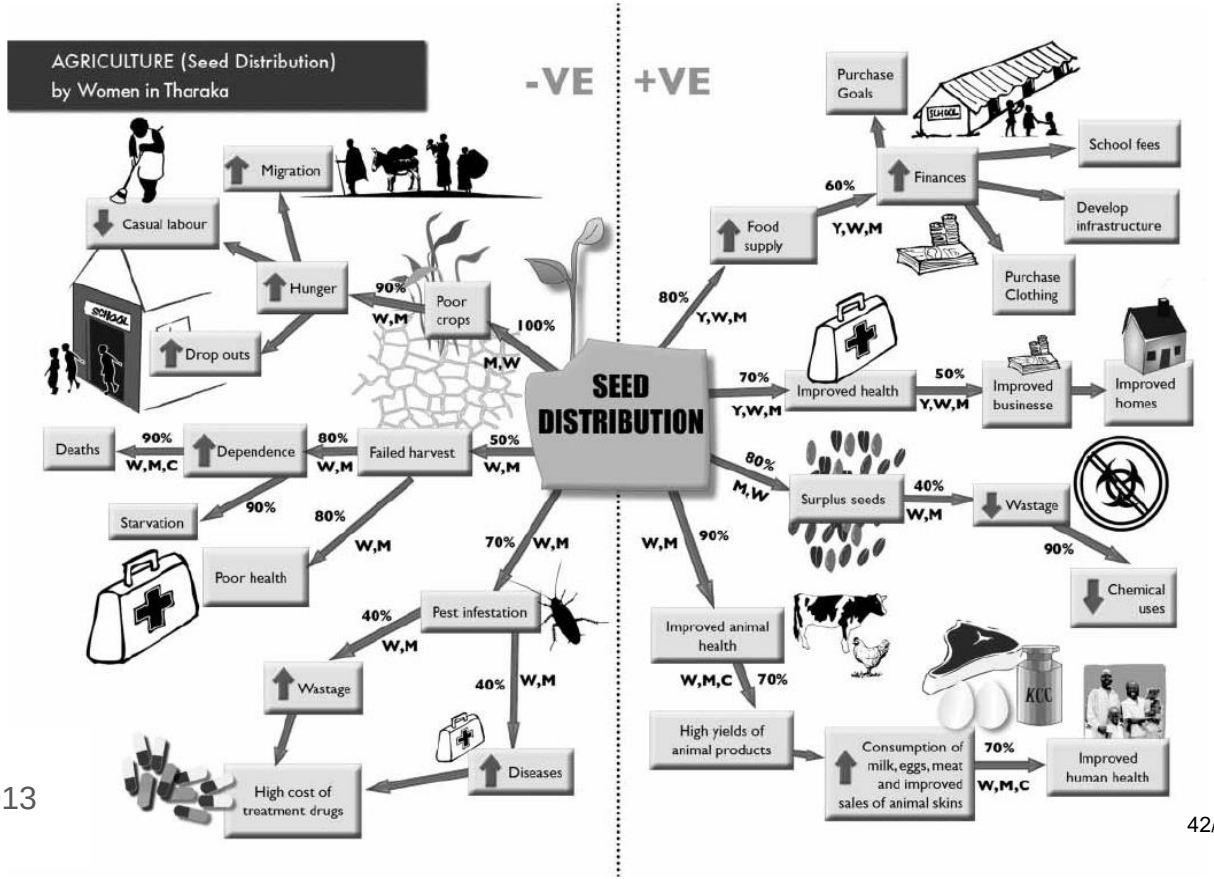
Outlook

- Per protocol analysis

- Effects on dietary changes
- Effects on environmental outcomes
- Cost-effectiveness

- Impact mapping

Impact mapping – example

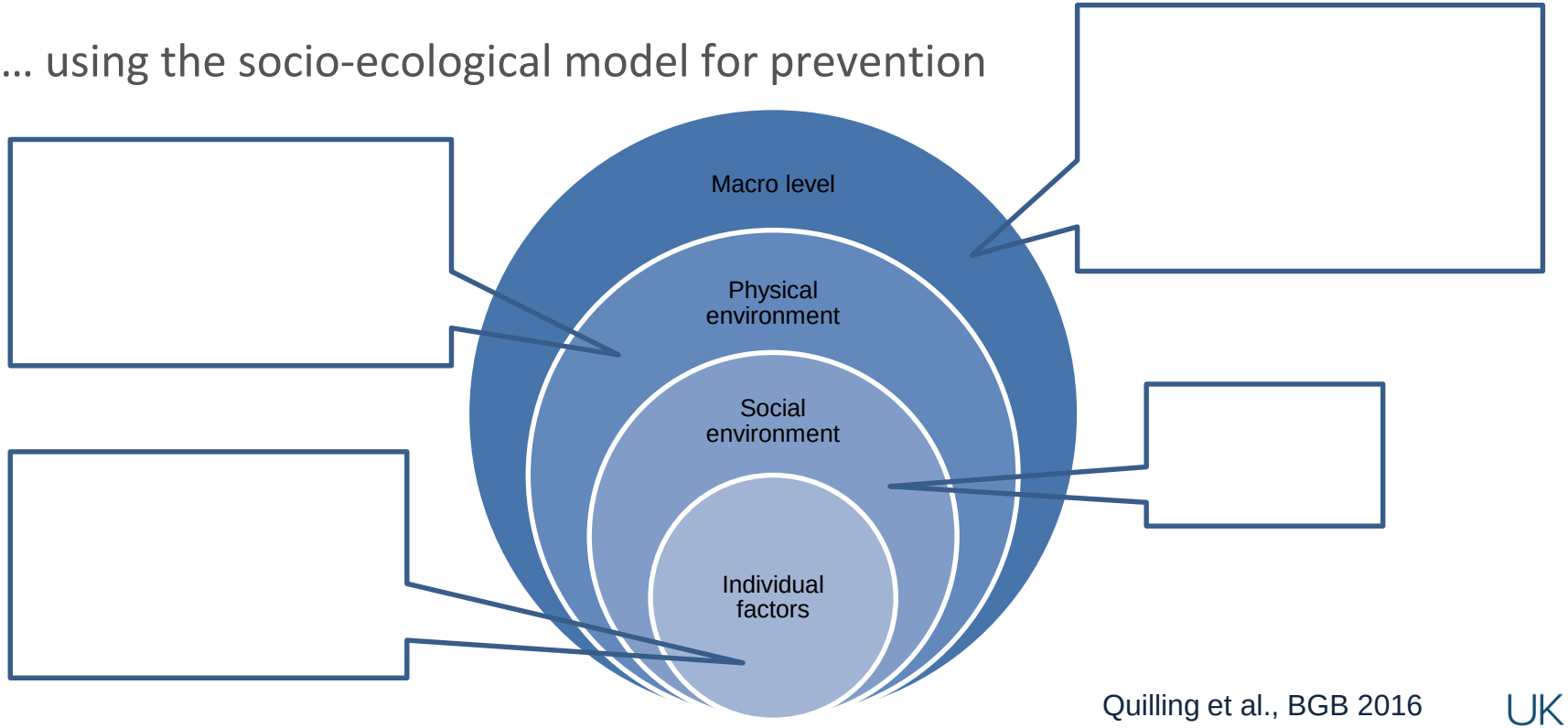


Kariuki J & Njuki J.
Development in Practice 2013

Merci beaucoup!

What was our approach?

… using the socio-ecological model for prevention



Quilling et al., BGB 2016

Summary

- FAO concept of sustainable diets: multi-dimensional
- Methods to identify sustainability of diets: data-driven, hypothesis-based, hybrid
- Approaches to design sustainable diets: optimization modelling, qualitative design research
- Socio-ecological model for the implementation of sustainable diets: consider the system!