Breads from African Climate-Resilient Crops for Improving Diets and Food Security

Martijn Noort and Stefano Renzetti, Wageningen Food & Biobased Research

ICBC24, 24 April 2024, Nantes, France

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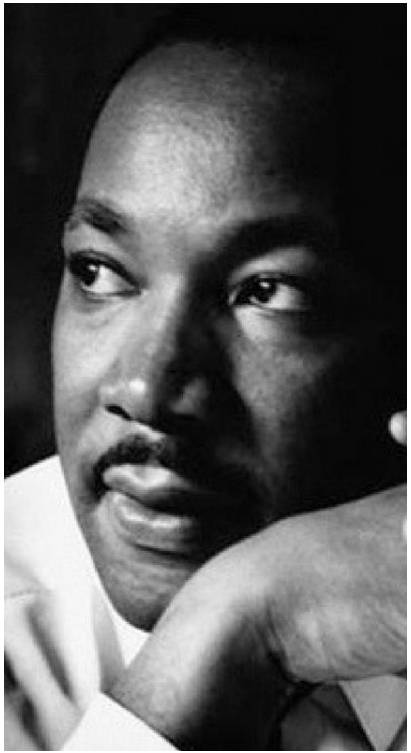
Ending hunger in 2030 (SDG2)

There is no evidence to doubt that hunger can be avoided by human action.

"Why should there be hunger and deprivation in any land, in any city, at any table, when man has the resources and the scientific know-how to provide all mankind with the basic necessities of life? There is no deficit in human resources. The deficit is in human will."

— Martin Luther King Jr. (1964)



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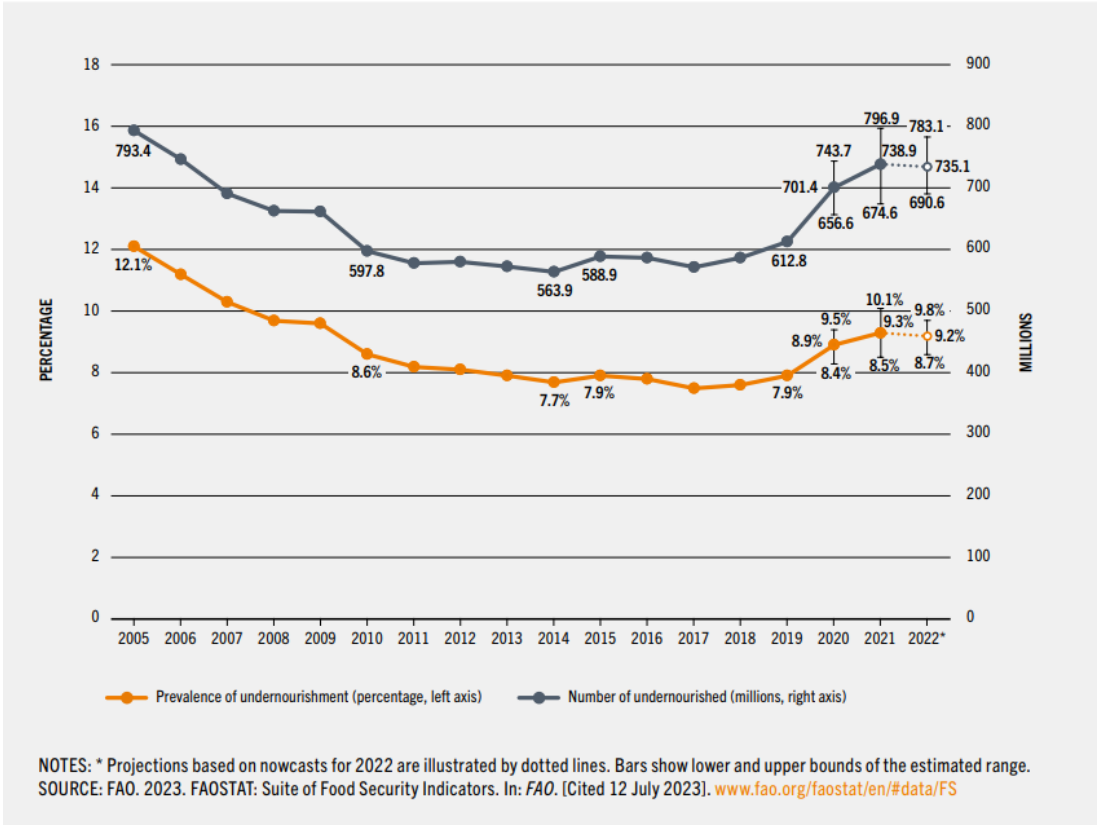
Ending hunger in 2030 (SDG2)

However, hunger rises, and in 2021:

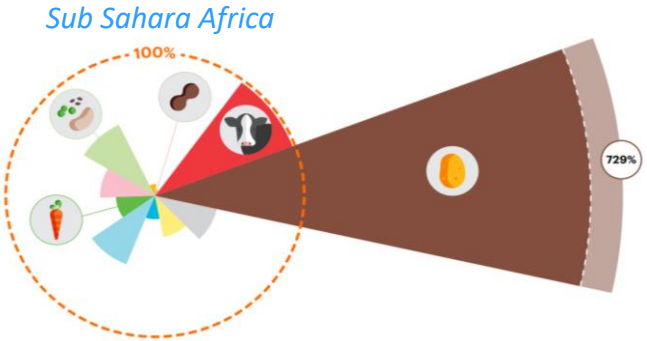
- Almost 750 million people – or **10%** - were **undernourished**
- More than 3.1 billion people in the world – or **42%** – were **unable to afford a healthy diet**

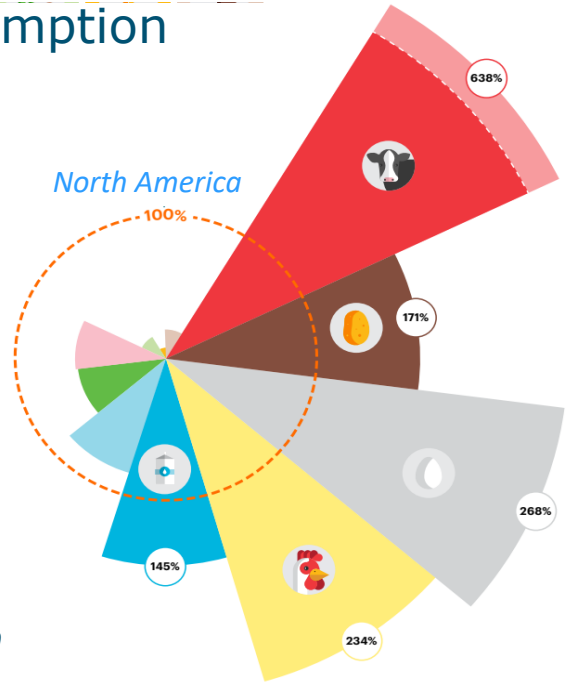


FAO, SOFI 2023, doi.org/10.4060/cc6550en

Concerted actions required

- Sustainably Intensify production
- Reduce food waste and loss (at least -50%)
- Substantial change in diets: enhanced consumption of wholegrain cereals, pulses and nuts !





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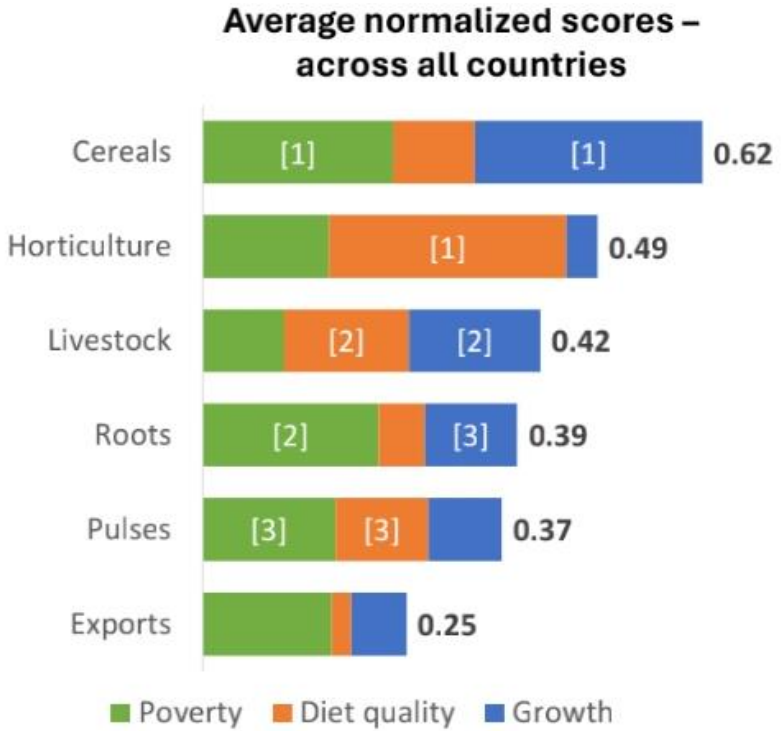
EAT Lancet, 2019

Cereal Grains matter

- What is the effect of different food chains on food system outcomes?
- IFPRIs Rural Investment and Policy Analysis model (RIAPA) for 16 SSA countries
- No single value chain is most effective in achieving all outcomes
- Cereals have most impact against poverty and for economic growth: **more value addition in chain**



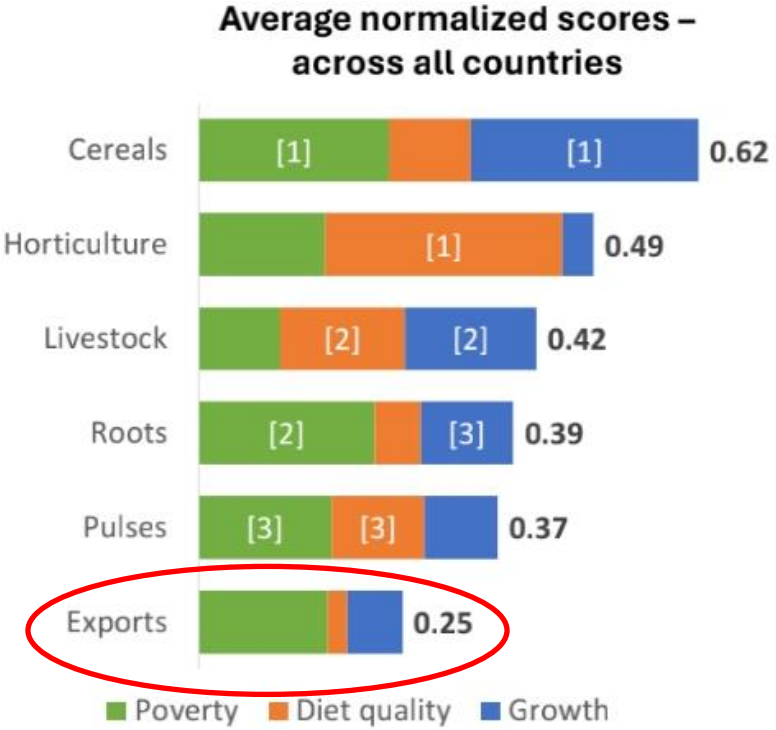
- Three development outcomes indicators
  - **Poverty**: %-pt. change in poverty per unit of agricultural GDP growth
  - **Diet quality**: % change in the ReDD* per unit of agricultural GDP growth
  - **Growth**: $ change in national GDP per $ increase in the targeted value chain

Diao, Pauw, Thurlow, IFPRI, 2024

Agri-export and domestic food security

- Agro-export promotion markedly alters the composition of output away from staple food items, further deteriorating the domestic availability of food and agricultural products - deteriorates food security in the exporting countries.
- Governments in developing countries should safeguard domestic food security, especially in urban areas, if they continue to implement agro-export orientation as a development strategy.

Aragie (2023)
https://doi.org/10.1016/j.worlddev.2023.106368



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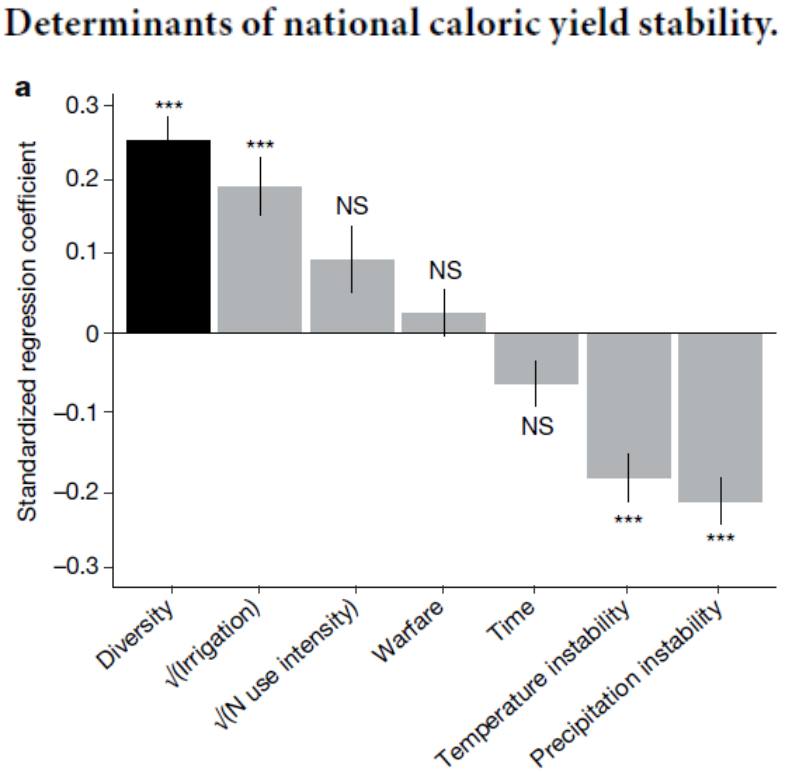
Crop diversity stabilizes yields

- Increasing food demand while facing climate change threatens the stability of food systems.
- Improve inputs and farming practices, irrigation and drought tolerant crops are important measures to improve.
- Greater diversity of crops at the national level strongly increases the year-to-year stability of the total national harvest of all crops combined.

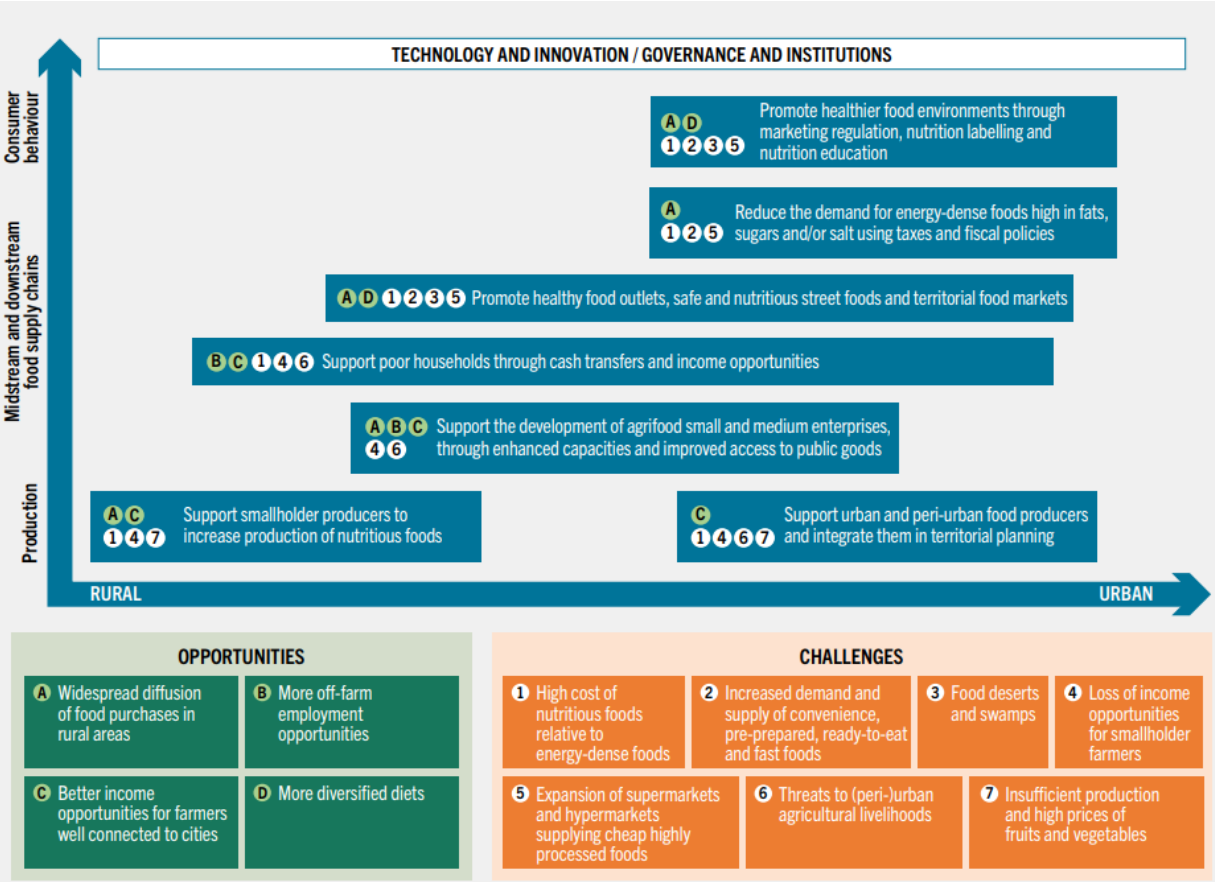


Renard & Tilman (2019) doi.org/10.1038/s41586-019-1316-y

Food security and urbanization

- Rapid urbanization
- Healthy diets even more closely related to income
- It's not about availability but affordability
- **Challenge and opportunity!**

FAO, SOFI 2023, doi.org/10.4060/cc6550en



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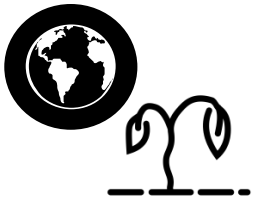
CHIPS
CHICKEN
GOD'S GRACE

Background

Africa is increasingly dependent on imported wheat, while traditional crops are underutilized.

This makes populations increasingly vulnerable for disruptions in (global) food supply chains, as currently shown by the wheat and fertilizer crisis*.



Due to climate changes, yields in Africa are expected to decrease substantially.

There is an urge for a shift to more Climate Resilient Crop (CRC) production and consumption.

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** Zhang et al (2023) https://doi.org/10.1038/s41598-023-43883-4*

What are Climate Resilient Crops?

CRCs are resistant to high temperatures and drought:

- Cereals: e.g., sorghum, fonio, teff and finger millet,
- Pseudocereals: e.g. amaranth,
- Roots and tubers: e.g. cassava and sweet potato,
- Pulses: e.g. phaseolus beans, cowpeas, chickpeas, pigeon peas and Bambara groundnuts
- Oilseed legumes: soya beans and peanuts.

Widely grown across SSA, many are indigenous to SSA

Why are Climate Resilient Crops underutilized?

Traditional staples based on CRCs are home- or fresh-cooked

(post) colonial staples like breads, fried snacks etc. are increasingly consumed and are more convenient (e.g. packed).

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Food System Approach

SOCIO-ECONOMIC DRIVERS

- Markets: agrofood and consumer market
- Science and technology
- Standardi-zation
- Policies and legislation

FOOD SYSTEM ACTIVITIES

- Enabling environment
- Food environment

FOOD SUPPLY SYSTEM

- Agricultural production
- Trade
- Food processing and transformation
- Food market
- Food consumption

- Business services
- Consumer characteristics

ENVIRONMENTAL DRIVERS

- Climate
- Water
- Soils
- Minerals
- Biodiversity

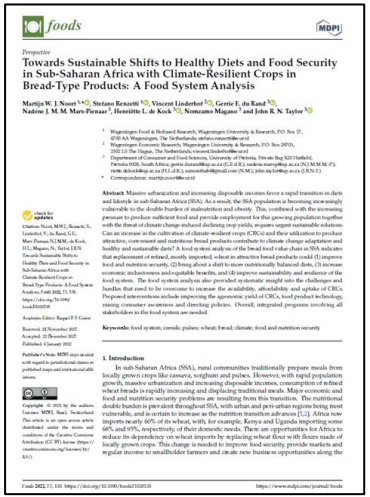
FOOD SYSTEM OUTCOMES

- Socio-economic outcomes

FOOD AND NUTRITION SECURITY

- Food accessibility
- Safe and healthy diets
- Food availability

- Environmental outcomes


foods

Perspective

Towards Sustainable Shifts to Healthy Diets and Food Security in Sub-Saharan Africa with Climate-Resilient Crops in Bread-Type Products: A Food System Analysis

Martijn W. J. Noort [1,*], Stefano Renzetti [2], Vincent Linderhof [2], Gerrie E. du Rand [3], Nadine J. M. M. Marx-Pienaar [3], Henriëtte L. de Kock [4], Nomzamo Magano [3] and John R. N. Taylor [3]

Abstract: Massive urbanization and increasing disposable incomes favor a rapid transition in diets and lifestyle in sub-Saharan Africa (SSA). As a result, the SSA population is becoming increasingly vulnerable to the double burden of malnutrition and obesity. This, combined with the increasing pressure to produce sufficient food and provide employment for this growing population together with the threat of climate change-induced declining crop yields, requires urgent sustainable solutions. Can an increase in the cultivation of climate-resilient crops (CRCs) and their utilization to produce attractive, convenient and nutritious bread products contribute to climate change adaptation and healthy and sustainable diets? A food system analysis of the bread food value chain in SSA indicates that replacement of refined, mostly imported, wheat in attractive bread products could (1) improve food and nutrition security, (2) bring about a shift to more nutritionally balanced diets, (3) increase economic inclusiveness and equitable benefits, and (4) improve sustainability and resilience of the food system. The food system analysis also provided systematic insight into the challenges and hurdles that need to be overcome to increase the availability, affordability and uptake of CRCs. Proposed interventions include improving the agronomic yield of CRCs, food product technology, raising consumer awareness and directing policies. Overall, integrated prognosis involving all stakeholders in the food system are needed.

Keywords: food system; cereals; pulses; wheat; bread; climate; food and nutrition security

1. Introduction

In sub-Saharan Africa (SSA), rural communities traditionally prepare meals from locally grown crops like cassava, sorghum and pulses. However, with rapid population growth, massive urbanization and increasing disposable incomes, consumption of refined wheat breads is rapidly increasing and displacing traditional meals. Major economic and food and nutrition security problems are resulting from this transition. The nutritional double burden is prevalent throughout SSA, with urban and peri-urban regions being most vulnerable, and is certain to increase as the nutrition transition advances [1,2]. Africa now imports nearly 60% of its wheat, with, for example, Kenya and Uganda importing some 68% and 95%, respectively, of their domestic needs. There are opportunities for Africa to reduce its dependency on wheat imports by replacing wheat flour with flours made of locally grown crops. This change is needed to improve food security, provide markets and regular income to smallholder farmers and create new business opportunities along the

Foods 2022, 11, 135. https://doi.org/10.3390/foods11020135 https://www.mdpi.com/journal/foods

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Figure adapted from Van Berkum et al (2018)
Noort, Renzetti et al (2022) Foods 11, 135. https://doi.org/10.3390/foods11020135

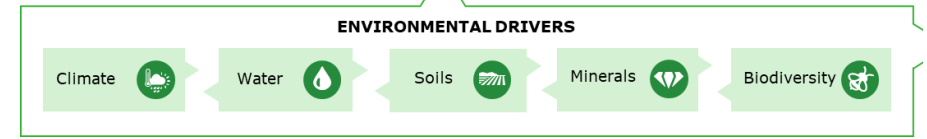
Climate resilience

Wheat, rice, maize

Moderate resistant to high temperatures

Poor drought tolerance

Maize productivity in SSA is predicted to decline by 18–30% by 2050



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Sorghum, millets, cow pea (pulses), cassava

Highly resistant to high temperatures and/or very drought tolerant

Deeper rooting prevents soil degradation

Pulses fix atmospheric nitrogen: improve cereal yield with crop rotation

Heterogeneity enhances ecological resilience and biodiversity

Nutritional value

Nutrient	Unit/ 100 g	Refined wheat flour	Degermed maize flour	Sorghum flour	Cassava flour	Cowpeas whole
Water	g	13.4	12.0	12.4	12.0	12.0
Energy	kJ	1510	1512	1377	1455	1406
Carbohydrates	g	72.5	78.0	73.1*	83.0	40.7*
Sugars	g	0.31	0	2.53	3.71	6.90
Proteins	g	11.98	8.00	10.2*	2.96	23.9*
Lysine	g	0.231	No data	0.229	0.096	1.591
Lipids	g	1.66	2.00	3.46	0.61	1.26
Dietary fiber	g	2.40	2.00	10.5*	3.92	20.6*
Folate, total	µg	33	No data	20	59	633
Calcium	mg	15	0	13	35	110
Iron	mg	0.90	0	3.36	0.59	8.27
Zinc	mg	0.85	No data	1.67	0.74	3.37

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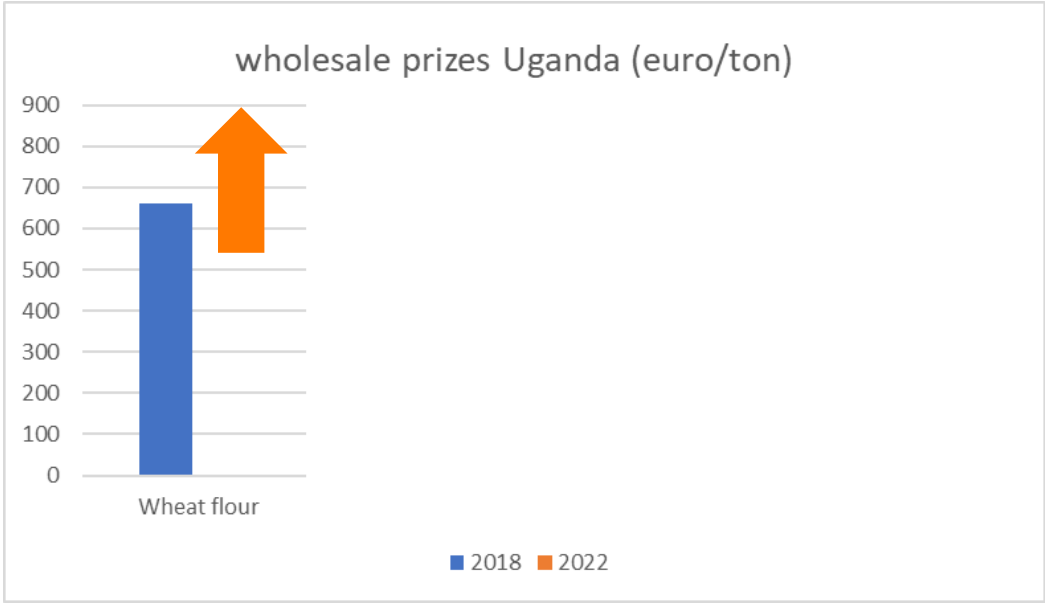
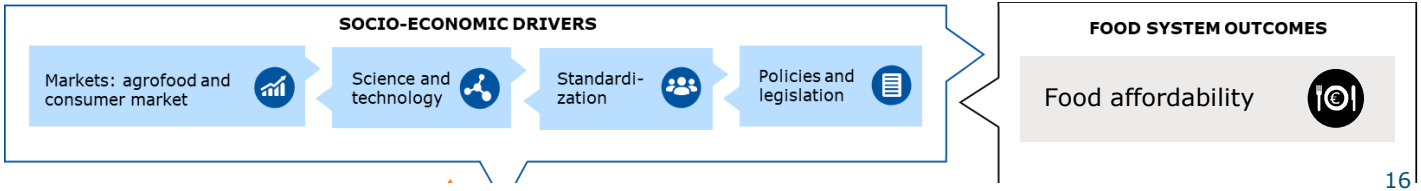
** Measured data, Nikinmaa et al 2022 https://doi.org/10.3390/foods11193049*

Food prices and food affordability

- Dependency on imported wheat makes SSA vulnarable for food price volatility and disruptions
- Wheat is relatively cheap and local crops can't always compete costwise
- **Replacing wheat by mix crops economically feasible**





Adding-value to Climate-Resilient Crops

Food processing and transformation

- Various processing technologies offer potential to improve properties and for adding value to CRCs with (low tech) solutions:

- Cowpea roasting and dry-heating for flavour improvement and flour functionalization

- Extrusion of cassava and cowpea flours to produce functional ingredients

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Renzetti et al., 2022. *doi.org/10.3390/foods11111554*

Kesselly, Mugabi and Byaruhanga, 2022 a, b, c

Bioprocessing CRCs

Food processing and transformation

Mild processing by microbial fermentation and/or enzymes:

- Improve functional properties of sorghum
- Reduce the beany flavor of cowpeas
- Improve digestibility / reduce anti-nutritional factors
- Integrate in- or advance traditional fermentations

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Dankwa et al 2021, doi.org/10.3390/foods10123095
Nikinmaa et al 2022 https://doi.org/10.3390/foods11193049

Formulation of leavened pan breads

Based on the outcomes of the Food System Analysis potential for mixing of CRCs was studied to fully replace wheat:

- Functionality: combining their physico-chemical properties.
- Balancing their nutritional value.
- Balancing their cost.
- Mixture of cereal (sorghum), root/tuber (cassava) and pulse (cowpea)

Check our poster **P2-29** with formulation principles:

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Renzetti et al 2023
doi.org/10.3390/foods12040689

Formulation of leavened pan breads

Ingredients	Dough with low cowpea content grams	Dough with high cowpea content grams
CRCs flours mixture	*1000 of which*	*1000 of which*
Sorghum flour	457	274
Cassava flour	457	457
Cowpea flour	87	270
Dry yeast	50	50
Salt	23	23
Rapeseed oil	37	37
Sucrose	37	37
Psyllium flour	73	73
Water	1087	1087
Total	*2308*	*2308*

- Handable dough instead of GF batter. Breads with soft and cohesive texture
- Not comparable to white wheat bread, however, attractive and nutritious breads

Versatile to change ratios of ingredients or to include other crops like millets etc.

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Renzetti et al 2023
doi.org/10.3390/foods12040689

Knowledge application in diverse markets

Informal bakeries &
street vendors

Artisanal bakeries

Industrial bakeries

CRC flour mix for informal bakeries

- CRC flour mix
- Simple in use
- 1-1 replacement of refined wheat flour

Sorghum flour (wholegrain)	42.5 %
Cassava flour	42.5 %
Cowpea flour (wholegrain)	8 %
Psyllium husk	7 %

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Chapati making with street-vendors in Kampala

Peter Arinaitwe, chapati-maker in Kasanvu Slum

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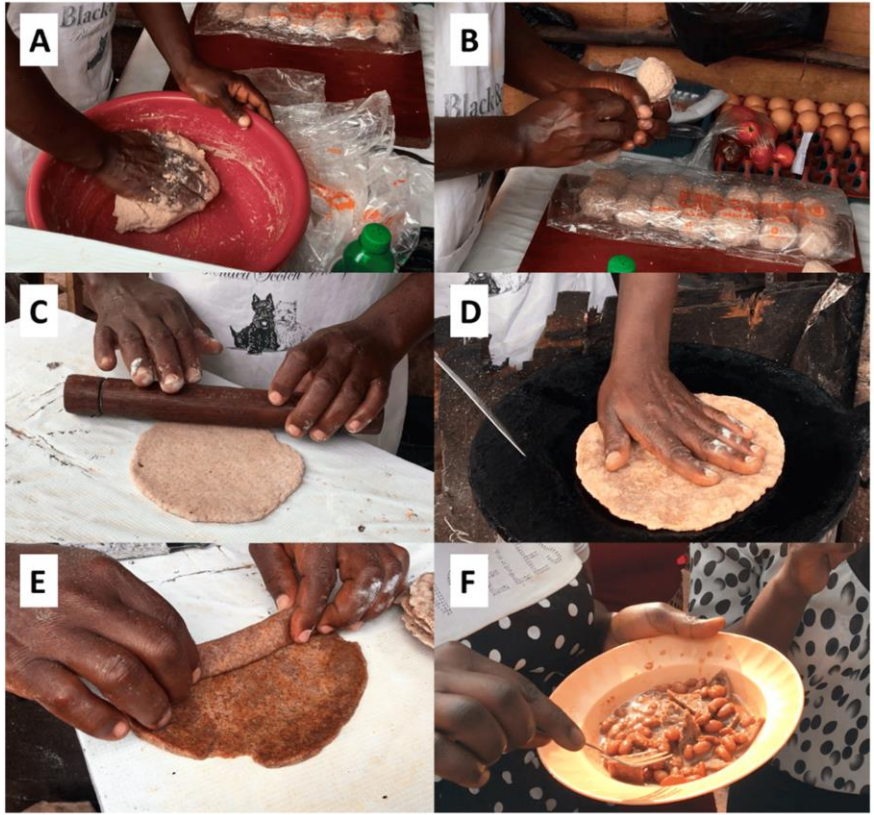
Chapati making with street-vendors in Kampala

CRC chapati flour mix	500	gram
Salt	10	gram
Sugar	17	gram
Water	489	gram
Vegetable oil: add a bit to dough and for frying		

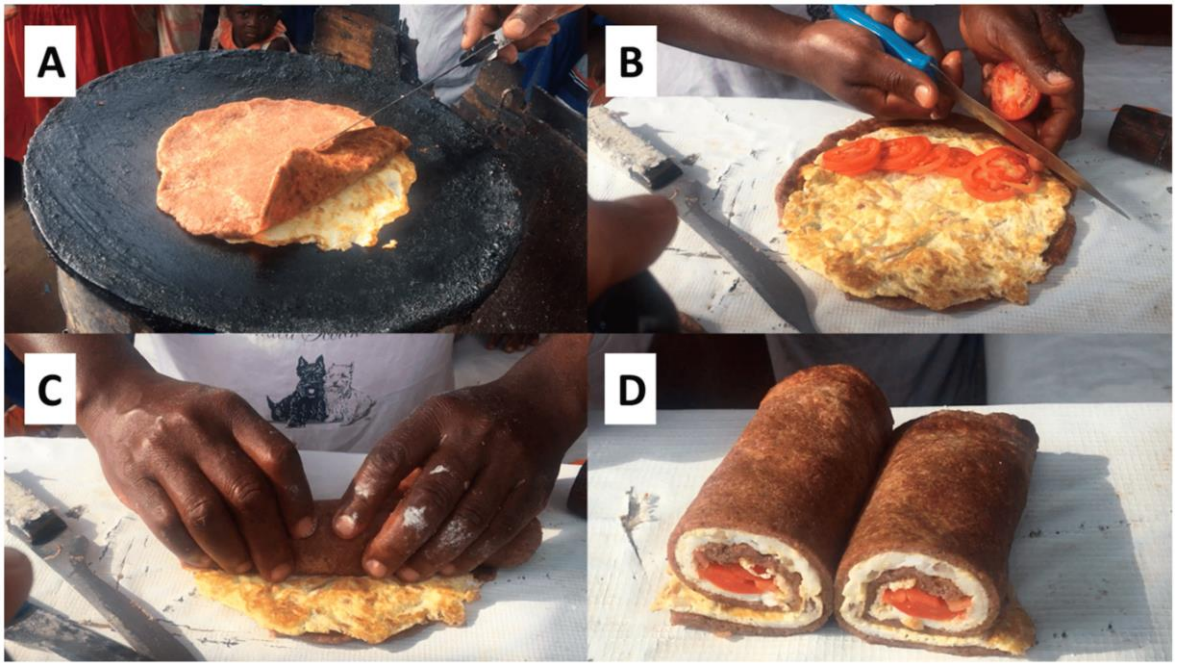
- Mixing, no kneading required
- Dough cohesive, bit more difficult to shape
- High quality texture, e.g. rollable
- "Kikomando" with beans



Renzetti et al 2023 doi.org/10.3390/foods12040689

Chapati making with street vendor in Kampala

- Potential for commercial application in added-value convenient and nutritious street foods, such as “ROLEX”



- Initiate new supply chains based on flour-mix in 2kg bags

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Renzetti et al 2023 doi.org/10.3390/foods12040689

Acceptability
colour, texture,
flavour?

Product optimization and consumer studies in Uganda

- Consumer studies in Kampala with low-income consumers.
- Consumers have strong initial preferences (some prefer red sorghum, others white or wheat).
- White sorghum chapatis were highly liked although they clearly differ from the known taste and texture of wheat chapatis.
- High potential for viability, consumers have to familiarize with products.

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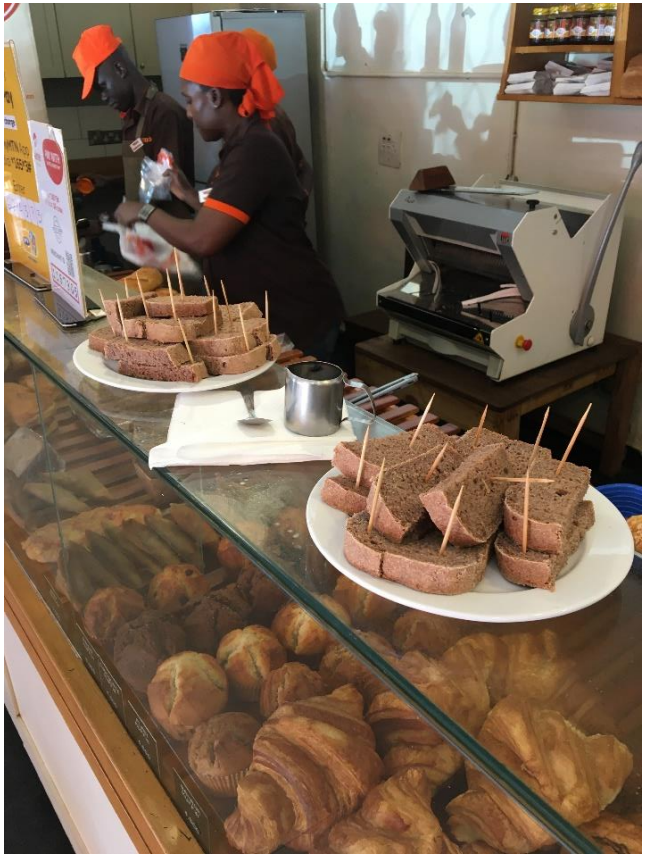
Unpublished results

Artisinal bakery in Uganda sccpy



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Artisinal bakery in Uganda

- Formal market example: Ugandan bakery serving high-income clientele.
- Bread based on white sorghum and cowpea varieties (wholegrain).
- Product has been introduced successfully as a healthy, wheat-free product.
- Product well received and profitable (67% margin on ingredients) at BBROOD, demand increasing.

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Application in industrial gluten-free bakery

- Functional properties of the African CRCs have been validated in practical conditions of an industrial gluten-free bakery.

- Upscaling and commercialization for the European market
- Ambition to set-up supply chains for export of African CRC ingredients

Insight supply chain Uganda

- We visited 10 companies in the local grain supply chain: agronomic extension services, input providers, aggregators, millers, bakeries and other consumer goods.
- Semi structured interviews to identify bottlenecks and opportunities for local crops: high cost of production and underdeveloped value chains.
- Clear potential and interest for e.g. white and red sorghum among all actors in chain

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Conclusions

- Climate resilient crops can provide valuable ingredients for healthy and attractive bread products
- Many commercial opportunities and new value chains for formal and informal businesses
- Opportunity to reduce Africa's dependency on imported wheat and create jobs and employment
- **Improve the resilience of SSA food system**

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There is momentum and renewed awareness...

- After decades of focus on cash-crops, African societies strive to enhance their food system resilience by improving their food self-sufficiency and enhance domestic crops.
    - However primary focus on agri-production
- We advocate for more focus on food processing of local produce, contribute to GDP, provide living incomes and healthy diets
- Promising processes should be scaled by local business networks:
    - Implementation & commercialization products
    - Incentivize supply chains for ingredients based on local crops
- Adjusting policies and making financial/economic environment conducive, e.g. rethinking protectionism

Thank you for your attention!

Download our report

Noort & Renzetti, 2023
https://doi.org/10.18174/583371

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