Leveraging the opportunities of neglected and underutilized crops for nutrition and climate resilience

Summary

Katrin Glatzel, Cecilia C. Maina, Aimable Nyishimirente, Janosch Klemm, Matin Qaim

There is an urgent need to develop a holistic approach to agrifood systems, integrating food production, nutrition, health, and environmental outcomes. This is due to the severe state of global malnutrition, with >700 million people facing chronic hunger, 3 billion suffering from micronutrient deficiencies, and over 2 billion affected by overweight or obesity. Food demand is also projected to rise significantly, particularly in sub-Saharan Africa. At the same time, climate change and land degradation are reducing crop yields, exacerbating the food situation.

Addressing these challenges requires building resilient and sustainable agrifood systems that provide nutritious diets. Cultivating diverse, nutritious, and climate-resilient crops, such as neglected and underutilized crops (NUCs), offers a unique opportunity to address nutrition, health, and climate challenges in an integrated way. NUCs are often characterized by their limited geographic distribution, restricted use, and lack of broader adoption or support from policymakers, technology providers, donors, breeders, and extension services. NUCs are typically grown in Africa, Asia, and South America, where they have been part of traditional diets and used for various purposes for centuries. However, their significance has diminished over time due to a shift from traditionally grown crops to a few mainstream crops with larger international commercial potential. The global food systems' reliance on very few staple crops, particularly maize, rice, and wheat, poses significant risks in the face of production shocks caused by climate change and/or socioeconomic stressors. Monotonous consumption of only a few staple crops also fails to adequately nourish populations and ultimately leads to malnutrition. Leveraging nutrient-rich, locally adapted NUCs through value chain development can transform food systems, enhance diets, reduce malnutrition, and address poverty, food security, and vulnerability to climate change. However, various challenges are limiting the production and consumption of NUCs, hampering their adoption.

Nutritional benefits of NUCs

Many NUCs are a good source of macro- and micronutrients, providing a feasible option to complement mainstream crops in supplying healthy diets. Using different food composition tables and literature sources, we highlight different NUCs with high nutritional benefits, offering an opportunity to bridge the food and nutrition security gaps engendered by the strong observed focus on a narrow base of food resources in Africa.

Integrating and enhancing the productivity of nutrient-rich NUCs in African agrifood systems could help reduce the region's heavy reliance on food imports. Wider availability of NUCs would diversify dietary options to meet the recommended guidelines for a healthy diet (Box 1).

Box 1: Defining a healthy diet

According to the World Health Organization (WHO), a healthy diet prevents all forms of malnutrition and helps lower the risk of noncommunicable diseases such as diabetes, heart disease, stroke, and cancer. The composition of such a diet varies depending on local conditions.

- The recommended daily energy intake is around 2500 calories for men and 2000 calories for women. These calories should be in balance with the daily energy expended by the human body.
- Daily consumption of fruits and vegetables (at least 400 grams per day), legumes, nuts, and whole grains.
- Daily protein intake of at least 5 to 35 percent of total daily energy intake.
- Daily fat intake of at most 30 percent of total energy consumption, mostly from (poly)unsaturated fats and avoiding industrially processed fats. Saturated fats should account for less than 10 percent and trans-fats for less than 1 percent of daily energy intake.
- Daily carbohydrate intake should account for 45-65 percent of daily energy intake.
- Free sugars should account for less than 10 percent of daily energy intake, with an ideal target of less than 5 percent.
- Daily dietary fiber should be at least between 14 and 34 grams.
- A healthy diet should also contain minerals (e.g., iron, sodium, zinc, iodine, and magnesium) and vitamins (A, B-complex, C, D, E, and K).
- Salt intake should be less than 5 grams per day equivalent to less than 2g of sodium. The salt should be iodized.

Several neglected **cereals and grains** are rich sources of energy, protein, and minerals, but this potential continues to be underexploited. Many African governments have prioritized the productivity of mainstream cereals like maize, rice, and wheat in recent decades but this has failed to fill the persistent food supply gaps, and most African countries remain net importers of these cereals. In comparison, dryland cereals, such as millets, teff, fonio, and sorghum, which are more adapted to local agroecological conditions, provide commensurable energy and some of them contain more protein, minerals, and dietary fiber. For example, Amaranth grains (14.7g/100g), teff (13.3g/100g), and buckwheat (13.25g/100g), contain more **protein** than wheat (12g/100g), maize (9.7g/100g), and rice (7g/100g). Important to note, teff, fonio, millets, and amaranth, **are gluten-free**, making them attractive options for consumers affected by celiac disease. Fonio, pearl millet, amaranth grain, and red sorghum are exceptionally rich in mineral nutrients like **iron and magnesium**. In regions with favorable agroecological conditions, increasing the uptake of these neglected cereals can significantly complement the limited capacity of maize, rice, and wheat to provide adequate and diverse nutrients.

There are also several neglected **roots and tubers (RTs)**, which are rich sources of energy, vitamins, and minerals, offering complementary food security options alongside mainstream staples. NUCs such as orange- and yellow-fleshed sweet potatoes, apart from being energy-dense, provide additional nutritional benefits such as **vitamin A and C, iron, zinc, and calcium**. Orange-fleshed sweet potato, in particular, is a rich source of beta-carotene, with up to 791 mcg of vitamin A Retinol Activity Equivalents (RAE) per 100g. This makes it a crucial food option for addressing vitamin A deficiency – a leading cause of immune dysfunction and blindness in Africa. Cocoyam (532mg/100g) is a rich source of potassium. Taro (4.1g/100g) and water yam (9.7g/100g) provide rich sources of **dietary fiber**, adequate consumption of which is crucial for digestive health, heart health, and regulation of blood glucose and cholesterol.

Many neglected **legumes, nuts, and seeds** contain high levels of protein, healthy fat, dietary fiber, and vitamins, providing additional options to staples like kidney beans and soybean. For instance, the **protein share** in edible portions of lentils, African locust bean, cowpea, chickpea, pigeon pea, and Bambara groundnuts is around **20 percent**, indicating their potential to contribute to addressing the persistent protein supply gaps in Africa. Other protein-rich but neglected legumes include Hausa groundnut and Lima bean. Alongside legumes, several neglected nuts (e.g., cashew nuts) and seeds (pumpkin seeds) are also rich in **protein**, accounting to upwards of 15 percent of their edible portions. Leveraging these

food options for enhanced protein consumption is beneficial for physical and cognitive development, maintaining a healthy body and skeletal mass, regulating metabolic functions, and strengthening the immune system. Moreover, Fava bean, mung bean, chickpeas, and pigeon peas, are richer in **vitamin A** than soybean, groundnut, and kidney beans. A 100g portion of Bambara groundnuts (28.9g/100g), chickpeas (25.2g/100g), and pigeon peas (21g/100g) provides a **dietary fiber** content that exceeds the WHO-recommended daily minimum intake of 14 grams by more than 50 percent. Furthermore, Marama beans and Bambara groundnuts are rich in **polyunsaturated fatty** acids, the consumption of which enhances heart and blood vessel functions and prevents the risk of heart disease and obesity.

Various underutilized **vegetables and fruits** provide adequate vitamins, minerals, and dietary fiber. Traditional vegetables like moringa leaves (1640 mcg/100g), spider plant leaves (531 mcg/100g), amaranth leaves (451 mcg/100g), cassava leaves (574 mcg/100g), jute mallow (275 mcg/100g), and sweet potato leaves (285 mcg/100g) contain high amounts of **vitamin A**. Other NUCs in this group, such as okra fruit and its leaves, African eggplant, and black nightshade provide superior content of **dietary fiber** when compared to mainstream vegetables like cabbage, tomatoes, and carrots. Moreover, underutilized crops like African pear/Safou, gingerbread plum, and egusi are rich in **edible fat**, providing a readily accessible energy source with no processing requirements. Wild watermelon contains Ca, Fe, Mg, P, many vitamins, and carotenoids, including lycopene. Baobab is rich in Fe, Ca, K, vitamin C, and many other micronutrients that enhance its biological properties, including antimicrobial, anti-malarial, anti-diarrheal, anti-anemia, anti-asthma, antiviral, antioxidant, and anti-inflammatory properties, among others. Greater uptake of these crops could contribute to sufficient consumption of micronutrients, which are essential for physical growth, immune function, cognitive health, and disease prevention.

While scientists, governments, and development partners increasingly recognize the nutritional benefits of NUCs for healthy diets, their uptake remains minimal. There is an urgent need for policy innovation to incentivize greater uptake of NUCs among producers and consumers. This is particularly crucial for enhancing the consumption of micronutrients in Africa, where micronutrient deficiency is especially prevalent.

Climate resilience, ecological adaptation, and biodiversity benefits of NUCs

Food systems in Africa and other LMIC regions are heavily impacted by climate change, resulting in lower crop yields, shorter growing seasons, increased water stress and reduced nutritional quality of crops. Increasing the adoption of NUCs offers a sustainable solution, as many of these crops are well adapted to marginal environments and contribute to biodiversity and food security.

- Cereal crops like fonio and finger millet are resilient to low-nutrient soils, water-scarce environments, and various pest infestations. Teff grows in areas with both drought and waterlogging conditions, and is resistant to important plant diseases and grain storage pests. Agrobiodiversity benefits of millets include enhancing soil structure, managing soil nutrients, contributing organic matter, preventing erosion, controlling pests, supporting pollinators and biological control organisms, and reducing reliance on chemical fertilizers.
- Roots and tubers such as taro and sweet potatoes are drought tolerant. Sweet potatoes can also be planted and harvested year-round.
- Legumes such as Bambara groundnut, cowpea and amaranth are adapted to water-scarce environments. Additionally, Bambara groundnut enhances biodiversity by fixing atmospheric nitrogen, while amaranth thrives in acidic soils and tolerates salinity stress.
- Vegetables such as African nightshade, African eggplant, bitter leaf, Ethiopian mustard, and jute mallow, are fairly resistant to droughts, floods, pests and diseases, and can be grown in shorter cycles than most mainstream crops.
- The drumstick tree provides ecosystem services such as improving soil fertility, stabilizing degraded land, sequestering carbon, and supporting biodiversity, while its resilience to drought and poor soils makes it valuable for agroforestry and environmental sustainability.

Constraints limiting the adoption of NUCs

Despite the numerous benefits, the potential of many NUCs remains untapped. This is largely because of various supply- and demand-side challenges. **Limited seed availability** causes farmers to rely on informal seed systems that are unreliable at supplying good-quality and early-germination seeds. **Insufficient funding for NUC-focused research** and development hinders the conservation, improvement, and sustainable use of their genetic resources. This contributes to challenges like seed dormancy (e.g., Bambara groundnut, okra, and African lettuce), late maturity in crops like pigeon pea, high vulnerability to certain pests and diseases gaining in importance through environmental change, and increased susceptibility to abiotic stressors such as heat and drought despite their inherent climate resilience. **Limited advancements in breeding, production, processing, and value addition** restrict NUCs' integration into value chains. Time-intensive manual harvest and post-harvest practices, such as for fonio and cassava, cause losses and reduce quality. Additionally, lengthy processing and the need to remove anti-nutritional factors (e.g., in Lima bean, fonio, and Bambara groundnut) diminish their appeal to producers and consumers. **Inadequate infrastructure and limited market access** hinder the commercialization of NUCs in Africa. Poor facilities for breeding, seed multiplication, and processing restrict their potential, while strong competition from mainstream staples reduces their market share and demand. Additionally, boom-and-bust cycles in NUCs' market demand undermine their long-term economic viability. **Institutional and knowledge gaps** contribute to the decline of NUCs. Governments often prioritize mainstream crops, leaving the promotion of NUCs to private initiatives and international organizations. Lack of extension services, seed promotion, and poor knowledge of seed conservation hampers the viability of NUCs, especially neglected vegetables like bitter leaf, African lettuce, jute mallow, and okra.

On the **demand** side, a key barrier to the adoption of NUCs is the need to adapt markets and consumer behavior. Consumer related challenges involve the low desirability of several NUCs, in addition to factors like availability, accessibility, and affordability. Individual nutrition behaviors are shaped by social, economic, and physical environments, along with public and private policies that influence dietary choices. Nutrition-centered social behavioral change (SBC) strategies are crucial for leveraging behavioral enablers and reducing adoption barriers. The socio-ecological model (SEM) highlights the complexity of nutrition-related decision-making, showing how effective SBC interventions can transform social, physical, market, and policy environments. Successful interventions require understanding of individual behavior within these contexts and engaging multiple influencers like family, peers, and healthcare workers. In the context of NUCs, shifting social norms and traditions, alongside interventions that disrupt habits and nudge desired behaviors, are essential. SBC integrates interpersonal communication, social change, community mobilization, and advocacy to promote and sustain impactful nutrition practices. Leveraging platforms like counseling, education, mobile phones, and mass media, SBC uses behavior change techniques such as providing instructions, demonstrating behaviors, sharing benefits, engaging credible sources, and restructuring environments. Effective SBC interventions are culturally and contextually tailored to reach diverse audiences. Valuable lessons from the boom and bust of NUCs like quinoa and teff can be learned on how to change behavior and create additional demand and supply, but also on how to foresee and avoid undesirable side-effects for smallholder producers.

Across many African countries, local, regional, and international initiatives are shaping the role of NUCs in agrifood systems through seed genetic improvement, mapping NUCs' climate adaptation, and raising awareness about NUCs' nutrition benefits. There is a growing number of community-level seed initiatives contributing to the preservation of plant genetic resources, greater adoption of NUCs, climate change adaptation, and improved nutrition outcomes. By developing community seed banks, projects enhance farmers' resilience, improve access to diverse, locally adapted crops, and promote indigenous knowledge in plant management and nutrition. Successful examples include the Kiziba Community

Seed Bank in Uganda and the Seed Savers Network in Kenya. As a regional initiative, the African Orphan Crops Consortium (AOCC) is collaborating with the African Union to sequence, assemble, and annotate the genomes of 101 traditional African food crops to facilitate their genetic improvement and increase their productivity. The consortium aims to release improved varieties and cultivars of NUCs which are more accessible and profitable for African farmers to grow and easier for consumers to use. The Building Opportunities for Lesser-known Diversity in Edible Resources (BOLDER) Project by Crop Trust operates in Benin, Ghana, Tanzania, and Uganda, and collaborates with agricultural value chain experts to enhance the conservation, production, and consumption of lesser-known crops that are nutritious, robust, environment-friendly and important for local communities. The Vision for Adapted Crops and Soils (VACS) is a collaborative initiative by the US Department of State, FAO, and the African Union, aiming to foster more resilient food systems through climate-adapted crops and healthy soils. VACS has identified and mapped key neglected cereals, legumes, seeds and nuts, roots and tubers, and vegetables with large potential in a changing climate across different agroecologies on the African continent.

Country case studies on NUCs

We further highlight efforts in two African countries, Cameroon and Tanzania, to leverage the benefits of NUCs to improve resilience to climate challenges and tackle widespread malnutrition.

Cameroon's agricultural sector is critical for food security and exports but remains vulnerable to climate risks. Several NUCs are produced and consumed in Cameroon, including Bambara groundnut, cocoyam, taro, cassava, okra, plantain, African eggplant, African yam bean, broad bean, Kersting's groundnut, jute, moringa, cucurbitaceous crops, millet, sorghum, and sweet potato. Data show that the total output of most NUCs has stagnated or seen only a negligible increase in recent years.

Cameroon's seed system development is still in its infancy; the agricultural sector mostly relies on informal seed systems. Cameroon's seed sector mainly focuses on four crops, maize, rice, cassava, and sorghum, with slow progress in releasing new seed varieties. Producers of traditional and neglected crops largely depend on their own harvests for seed preservation. Nevertheless, Cameroon has made significant strides in reviving certain NUCs, such as cassava and plantain, through R&D initiatives, government programs, and partnerships. The African Center for Research on Banana and Plantain (CARBAP) has improved banana and plantain varieties and production technologies, contributing to Cameroon becoming Africa's top producer of plantains. Cameroon's Vision 2035 seeks to modernize the agricultural sector and intensify agricultural R&D, with positive implications for NUCs. Government projects like the Roots and Tubers Market-Driven Development Program and the Agriculture Investment and Market Development Project have enhanced cassava and sorghum yields, strengthened value chains, and improved smallholder livelihoods. Collaborations with initiatives like the Technologies for African Agricultural Transformation (TAAT) Program aim to enhance seed systems and productivity for both mainstream crops and NUCs. Additionally, the government is fostering partnerships with financial institutions and public-private collaborations to promote the production and consumption of NUCs.

Tanzania has rich arable land but still imports significant amounts of cereals and legumes and faces malnutrition challenges. Several nutritious NUCs are produced and consumed in Tanzania such as lablab bean, Bambara groundnut, buckwheat, sorghum, pearl millet, finger millet and safflower. Despite their nutritional value, these crops face significant challenges. Lablab beans in Tanzania struggle with flower drop, heat stress, pests, and diseases, limiting their production. Bambara groundnut is hindered by its reputation as "food for the poor" and lengthy preparation time, discouraging both farmers and consumers. While buckwheat and safflower production have increased, yield gains remain marginal, highlighting the need for efforts to boost productivity. Millets and sorghum experience fluctuating annual harvests, further complicating their reliable supply.

Tanzania's agri-food policy prioritizes major crops like maize, rice, beans, and sunflower, which make

up 71 percent of harvested field crop areas. The National Five-Year Development Plan (2021/22–2025/26) focuses on GDP growth and export revenues, leading farmers to neglect low-yielding NUCs. National seed policy frameworks do not currently recognize the role of NUCs, further limiting their development. Informal seed systems are dominant; most smallholder farmers rely on saved seeds. Policy initiatives such as the Quality Declared Seed (QDS) Regulation of 2020 legitimized a semi-formal seed system that allows smallholders and producer groups to produce and sell seeds locally at affordable prices, bolstering the inclusion of vegetatively propagated NUCs like sweet potatoes and cassava.

Civil society organizations and international NGOs are taking the lead in efforts to revive NUCs in Tanzania. The Tanzania Alliance for Biodiversity (TABIO) advocates the recognition of farm-saved seeds, promoting agrobiodiversity through seed fairs, policy dialogues, and community seed banks. Campaigns like *Seed is Life* and *My Food is African* emphasize seed sovereignty and traditional foods. The Consumption of Resilient Orphan Crops for Products for Healthier Diets (CROPS4HD) Project led by SWISSAID, FiBL, and the Alliance for Food Sovereignty in Africa (AFSA) revives NUCs by improving nutrition, seed access, and farmers' livelihoods. It promotes twelve neglected crops, including Bambara nuts, finger millet, pumpkin, and African indigenous vegetables, develops value chains for processed NUCs products, and highlights NUCs-based food recipes to fight malnutrition. Other initiatives, such as Kilimo Endelevu, support seed banks, while the AFRICA RISING Project by USAID and several CGIAR Centers uses a farmer-to-farmer training approach to scale improved farming technologies for target crops, including traditional vegetables. The BOLDER project by the Crop Trust focuses on conserving crops like Bambara groundnut through participatory breeding and partnerships. The Nelson Mandela African Institution of Science and Technology (NM-AIST) operates a gene bank to conserve neglected legume germplasm and collaborates with farmers to boost seed productivity. The World Vegetable Center promotes indigenous African vegetables, enhancing yields and food security through participatory breeding and conservation efforts.

Policy recommendations

More needs to be done to leverage the opportunities of NUCs for improving nutrition and enhancing climate resilience. This paper presents a set of policy recommendations to help policymakers and their partners harness the potential of NUCs, including developing innovative and culturally adaptive strategies to increase their consumption:

1. Increased investment and multilateral collaborations in R&D and seed systems are crucial to improve NUCs breeding, production, processing, seed availability, pest resilience, and post-harvest efficiency through modernized methods and gene banks. Genomic techniques hold potential to accelerate breeding progress in NUCs and should be harnessed alongside traditional breeding methods.
2. Development of infrastructure, including breeding stations, processing facilities, and value chain networks, is essential to enhance economic viability and improve market access for NUCs.
3. Addressing institutional and knowledge gaps for NUCs requires integrating them into policies, reallocating resources, fostering public-private partnerships, enhancing training and education, and promoting awareness through on-farm demonstrations and extension services.
4. Social behavior change strategies are essential for addressing consumer behavior by integrating interpersonal communication, social change, community mobilization, mass media, and advocacy to promote and sustain impactful nutrition practices and raise awareness of the nutritional and environmental benefits of NUCs.
5. Utilizing market and trade opportunities like the African Continental Free Trade Area (AfCFTA) can enhance regional trade of NUCs, encouraging economic growth and resilience.
6. Empowering smallholder farmers through access to funding, technology, and training is critical for scaling up NUCs production.
7. Private sector and community initiatives should be encouraged, such as local innovations that enhance NUCs production efficiency, awareness campaigns, training programs, and efforts that

increase the visibility of NUCs locally and globally by showcasing their versatility and benefits.

8. Leverage international collaborations and campaigns, such as FAO's "Year of Millets" and initiatives like the Vision for Adapted Crops and Soils (VACS), to promote awareness, enhance productivity, and improve market access for NUCs. Support capacity-building programs for producers and invest in global outreach efforts, including social media campaigns and recipe demonstrations, to increase demand and foster sustainable development of NUCs.
9. Expand international markets for NUCs by enhancing their global visibility through strategic partnerships with retail markets and food processors. Leveraging the growing demand for health-conscious products such as fonio and teff in global markets presents a significant opportunity to boost income for farmers in regions like West Africa and Ethiopia. These efforts should include targeted marketing campaigns, trade facilitation, and capacity-building initiatives for producers to meet international quality standards.
10. Lessons from other crops: Insights from the quinoa boom in Latin America and teff in Ethiopia underscore the importance of ensuring that scaling efforts for NUCs are sustainable and benefit smallholder farmers and rural communities. Learning from these experiences can guide strategies for broader NUCs development.

The full ZEF Working Paper and list of references are available at:
https://www.zef.de/publications/zef-publications/zef-working-papers.html

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