INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
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SFS4Youth WORKING PAPER #9 NOVEMBER 2025

Implications of increased urbanization and consumer awareness on future food supplies in Tanzania

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Tanzania's food system faces increasing pressure from rapid urbanization, population growth, and shifting consumer preferences toward more nutritious and diverse diets. This study analyzes how these macro trends will affect national food supply needs by 2050 and identifies key policy entry points to ensure an efficient, sustainable, and equitable food system transformation.

Using census data (2012–2022) and the National Panel Survey (2020/21), combined with two international healthy diet benchmarks – the EAT-*Lancet* Reference Diet (ELRD) and the Hypothetical Micronutrient Adequate Diet (HMAD) – the report projects the required food supply volumes to provide all Tanzanians with healthy diets by 2050.

Tanzania's population is projected to more than double, from 59.8 million in 2020/21 to 138.1 million by 2050, with the share of urban residents rising from 34.5% to 55.4%. This demographic shift implies that a relatively smaller rural workforce will need to feed a much larger and more urban population, requiring higher productivity and stronger rural-urban linkages.

Current diets in Tanzania are heavily dominated by cereals and sugar products and contain too few fruits, dairy products, and eggs (according to both healthy diet references) combined with insufficient amounts of vegetables (according to ELRD) as well as meat and fish products (according to HMAD). To assure a heathy diet for all by 2050, the supplies and consumption of food from these food groups must expand substantially. This not only requires that total annual food supplies increase from 24 million tons to 52 million tons (under ELRD) or 62 million tons (under HMAD), but certainly also that its composition change dramatically: vegetables by roughly 3 times of current supply; oils by 4 times; fruits by 5 times; dairy by 8 times; eggs by 10 times (under ELRD) and 37 times (under HMAD), and meat and fish by 4 and 8 times (under HMAD), respectively. In contrast, cereal and sugar production can remain stable or even decrease slightly without compromising nutritional adequacy.

Meeting these targets requires significant productivity gains. For key commodities such as milk, oranges, sunflower oil, tomatoes, and beans, yield improvements of 2-10 times current levels are needed, though still within feasible global productivity frontiers. Addressing post-harvest losses (PHL) and expanding processing, cold storage, and urban agriculture are possibly also critical avenues to reduce waste and improve food availability. From an environmental viewpoint, the study urges the adoption of sustainable intensification practices and climate-smart livestock management, with emphasis on reducing emissions per unit of output, diversifying protein sources toward fish and poultry, and improving logistics and market inclusion for smallholders.

In policy terms, the report highlights alignment between its findings and Tanzania's Agriculture Master Plan (2024), noting that 12 of the 20 government-prioritized commodities (e.g., banana, avocado, tomatoes, sunflower, beans, and dairy) are also essential for future healthy diets. However, important food items such as eggs, onions, leafy vegetables, mangoes, and oranges remain underemphasized and deserve greater policy focus. The agenda on PHL, though formally acknowledged, is also inadequately mainstreamed into Tanzania's broader agricultural policy framework.

In conclusion, achieving healthy diets for all Tanzanians by 2050 will require, in addition to raising nutrition awareness and improving economic affordability among the population:

- A more than doubling of total food supplies with major shifts toward nutrient-rich foods,
- Substantial agricultural productivity and efficiency gains,
- A stronger emphasis on reducing PHL and strengthening urban food systems, and
- A coordinated policy focus on nutrition-sensitive and environmentally sustainable production.

EXECUTIVE SUMMARY (SWAHILI)

Mfumo wa chakula wa Tanzania unakabiliwa na mabadiliko makubwa yanayotokana na ukuaji wa miji, ongezeko la idadi ya watu, na mabadiliko ya matakwa ya walaji kuelekea ulaji wa lishe bora yenye mchang-anyiko mpana wa vyakula. Utafiti huu unachambua jinsi mwenendo huu utakavyoathiri mahitaji ya chakula kufikia mwaka 2050. Pia unalenga kubainisha maeneo muhimu ya sera ili kuhakikisha mabadiliko ya mfumo wa chakula yanakuwa yenye ufanisi, yanayoakisi utunzaji wa mazingira, uendelevu na usawa.

Kwa kutumia takwimu za sensa za mwaka 2022; takwimu za Utafiti wa Ufuatiliaji wa Kaya (NPS) wa mwaka 2020/21; na viwango vya kimataifa vya lishe bora—EAT-Lancet Reference Diet (ELRD) na Hypothetical Mi-cronutrient Adequate Diet (HMAD); ripoti hii inakadiria kiasi cha chakula kinachohitajika ili Watanzania wote wapate lishe bora ifikapo mwaka 2050.

Ifikapo mwaka 2050, idadi ya Watanzania inatarajiwa kuongezeka kwa zaidi ya mara mbili, kutoka milioni 59.8 mwaka 2020/21 hadi milioni 138.1. Vilevile, sehemu ya watu wanaoishi mijini itaongezeka kutoka 34.5% hadi 55.4%. Hali hii ina maana kuwa idadi ndogo ya watu wanaoishi vijijini italazimika kulisha idadi kubwa ya watu waishio mijini, hivyo kuhitaji ongezeko kubwa la uzalishaji pamoja na uimarishaji wa mifumo inayounganisha vijiji na miji.

Takwimu zinaonyesha kuwa kwa sasa, ulaji wa chakula nchini Tanzania unatokana na nafaka na bidhaa za sukari, huku matunda, maziwa na mayai yakitumiwa kwa kiwango cha chini (kwa mujibu wa viwango vyote vya lishe bora). Pia kuna upungufu wa utumiaji wa mboga za majani (kwa ELRD) pamoja na nyama na samaki (kwa HMAD). Hivyo, kuhakikisha watu wote wanapata lishe bora ifikapo 2050, uzalishaji na upatikanaji wa vyakula vya makundi haya lazima uongezeke kwa kiasi kikubwa.

Mageuzi haya yatahitaji ongezeko la upatikanaji wa chakula kutoka tani milioni 24 hadi tani milioni 52 (kwa ELRD) au tani milioni 62 (kwa HMAD). Bidhaa zinazohitaji kuongezeka zaidi ni:-

- Mboga za majani — ongezeko la mara 3
- Mafuta ya kupikia — ongezeko la mara 4
- Matunda — ongezeko la mara 5
- Bidhaa za maziwa — ongezeko la mara 8
- Mayai — ongezeko la mara 10 (ELRD) na mara 37 (HMAD)
- Nyama na samaki — ongezeko la mara 4 (ELRD) na mara 8 (HMAD)

Kwa upande mwingine, uzalishaji wa nafaka na sukari unaweza kubaki kama ulivyo au kupungua kidogo bila kuathiri lishe bora.

Kufikia malengo haya kutahitajika ongezeko kubwa la tija. Kwa mazao kama maziwa, machungwa, mafuta ya alizeti, nyanya na maharage, mavuno yanahitaji kuongezeka mara 2 hadi 10 ya kiwango cha sasa (tafiti zinaonyesha kuwa tija ya viwango hivi tayari inapatikana katika nchi nyingine duniani). Hatua nyingine muhimu ni pamoja na kupunguza upotevu wa chakula baada ya mavuno, kuongeza uchakataji wa mazao, kuwekeza kwenye maghala ya baridi, na kuimarisha kilimo cha mijini.

Kwa upande wa mazingira, utafiti unapendekeza matumizi ya mbinu za kilimo endelevu, ufugaji rafiki kwa tabia nchi, kupunguza uzalishaji wa gesi kwa kila kitengo cha uzalishaji, kuongeza matumizi ya vyakula vyenye protini kama samaki na kuku vinayozalishwa kwa kutoa gesi kigogo, na kuboresha miundombinu ya usafirishaji na masoko ili kuhakikisha wakulima wadogo wananufaika.

Kisera, ripoti hii inalingana na Mpango Mkuu wa Kilimo wa Tanzania (2024), ambapo kati ya mazao 20 yaliyopewa kipaumbele, 12 (kama ndizi, parachichi, nyanya, alizeti, maharage na maziwa) yanaelekeza katika ripoti hii kuwa ni muhimu kwa lishe bora ifikapo 2050.

Hata hivyo, bidhaa muhimu kama mayai, vitunguu, mboga za majani, maembe na machungwa hazijapewa uzito wa kutosha katika mpango huo, hivyo zinahitaji kuzingatiwa zaidi katika sera za kilimo. Aidha, ajenda ya kupunguza upotevu baada ya mavuno, ingawa inatajwa rasmi, bado haijapewa kipaumbele cha kutosha ndani ya sera kubwa za kilimo.

Kwa ujumla, pamoja na kuelimisha jamii kuhusu lishe bora na kufanya upatikanaji wa chakula chenye virutubisho kuwa nafuu kwa kila Mtanzania, ili kuhakikisha Watanzania wote wanapata lishe bora ifikapo mwaka 2050 kunahitajika:

- Uzalishaji wa chakula kuongezeka zaidi ya mara mbili, kwa mkazo katika vyakula vyenye virutubisho vingi.
- Kuongezwa kwa tija na ufanisi katika uzalishaji.
- Kutilia mkazo kupunguza upotevu wa chakula baada ya mavuno na kuimarisha mifumo ya chakula mijini.
- Kuimarisha sera zinazolenga uzalishaji wa chakula chenye virutubisho na kinacholinda mazingira.

INTRODUCTION

While there is general agreement that our food systems are failing us (Global Panel 2016; Béné et al. 2019a; von Braun et al. 2021), different perspectives exist on the exact nature of this failure. Béné et al. (2019a) identify four main narratives, which can be summarized as the system's inability to feed future populations with healthy diets in a socially just and environmentally sustainable way. At the same time, food systems are undergoing rapid and structural changes at an ever-increasing pace (von Braun et al. 2021). "Traditional" food systems were mainly local with short supply chains between smallholder farmers and local markets, where basic staples were sold with little value addition. In contrast, "modern" food systems range from local to global, with possibly longer supply chains connecting industrial food producers, processors, and retailers, while serving international markets and supermarkets with a wide variety of unprocessed and processed foods (Ericksen 2008).

Apart from attenuating or neutral effects, most of the ongoing and future drivers affecting the functioning of food systems carry multiple risks that could aggravate the degree of failure (von Braun et al. 2021). For example, the expected growth in household incomes will increase overall demand for food (including more nutritious and animal-source foods), which will not only widen the yield and nutrient gaps of current food production but will also increase its environmental footprint. Likewise, the intensification and homogenization of agricultural production may certainly help to feed a growing population but will contribute to the deterioration of soils and agroecological conditions (Béné et al. 2019b).

Confronted with this extending failure and culminating in the UN Food Systems Summit (UNFSS), a broad coalition of national governments, international organizations, civil society, the private sector, and scholars embarked on the ambitious agenda of transforming today's food systems (von Braun et al. 2021). This resulted in a call for paradigm shifts (Ruben et al. 2021), the expansion of food security frameworks from four to six pillars (Clapp et al. 2022), and the development of new definitions and food system frameworks to better understand, in a holistic and integrated manner, the multiple nonlinear linkages between drivers, activities, and outcomes to be able to assess trade-offs and inform policy design (Béné et al. 2019b; David-Benz et al. 2022; Ericksen 2008; FAO 2018; FS-TIP 2021; Global Panel 2016; HLPE 2017; Ingram 2011; Lawrence et al. 2015; Njuki et al. 2022; Pinstrup-Andersen and Watson 2011; Sobal, Kettel Khan, and Bisogni 1998; von Braun et al. 2021).

Inspecting key indicators from the food system dashboard, developed by the Global Alliance for Improved Nutrition and Johns Hopkins University (Fanzo et al. 2020),[1] Tanzania's food systems are indeed failing to provide healthy diets to its population: in 2022, 76% could not afford a healthy diet; 24% were undernourished; and 58% experienced moderate or severe food insecurity. One among several reasons relates to the significant level of food losses, estimated around 8% for cereals, 9% for vegetables and 17% for fruit. As a result, it is unsurprising to observe that 30% of children under the age of five years old are stunted and 27% of the adult population are suffering from raised blood pressure. These averages of course hide important spatial disparities, with urbanized areas being generally more food secure, partly due to socio-economic differences, but also allowing for the consumption of more unhealthy foods, especially in Dar es Salam, as compared to rural areas (Ameye 2023; Cockx, Colen, and De Weerdt 2018).

This research report aims to identify major food supply implications and potential entry points for a more efficient, nutritious, sustainable, and equitable transformation of Tanzania's food system. More specifically and inspired by Brouwer et al. (2021), this report on strategic knowledge generation of macro trends

[1] For a broad selection of indicators to assess Tanzania's food systems performance, see: https://www.foodsystemsdashboard.org/countries/tza.

in Tanzania's food system development first estimates the required volumes and composition of food supplies to meet the demands of an increasingly urban and more nutrition aware population. To operationalize this logic, we make use of a representative household food consumption survey combined with the latest census data to contextualize two international healthy diet references and project the corresponding food supply requirements to the year 2050. Then, by analyzing the required changes in future food supplies to assure a heathy diet for all Tanzanians by 2050, we identify corresponding challenges, trade-offs, and possible entry points in terms of logistics, environmental impact, and socio-economic implications – with special attention to the position of young small-holder farmers and agri-food entrepreneurs.

DATA

In 2022, Tanzania conducted its Sixth Population and Housing Census (PHC), exactly ten years after the previous round of 2012. Over this period, the total Tanzania population grew at an average annual growth rate of 3% from around 44.9 million in 2012 to 61.7 million people in 2022. For both census rounds, around 19% of the population is between 15 and 24 years and around 35% is between 15 and 35 years of age, which corresponds to the definition of youth employed by the United Nations and the 2007 National Youth Development Policy of Tanzania, respectively. Over this inter-census period, the urbanization rate of people living in private households has significantly increased from 33% in 2012 to 39% in 2022 in Tanzania Mainland and from 45% to 49% in Zanzibar. In regional terms, the population of the Katavi region has roughly doubled in the 2012-2022 period (which is equivalent to a 7% annual growth rate), while at the other end of the scale, the Kilimanjaro region accrued by slightly more than 1% (URT 2013, 2024a, 2024b).

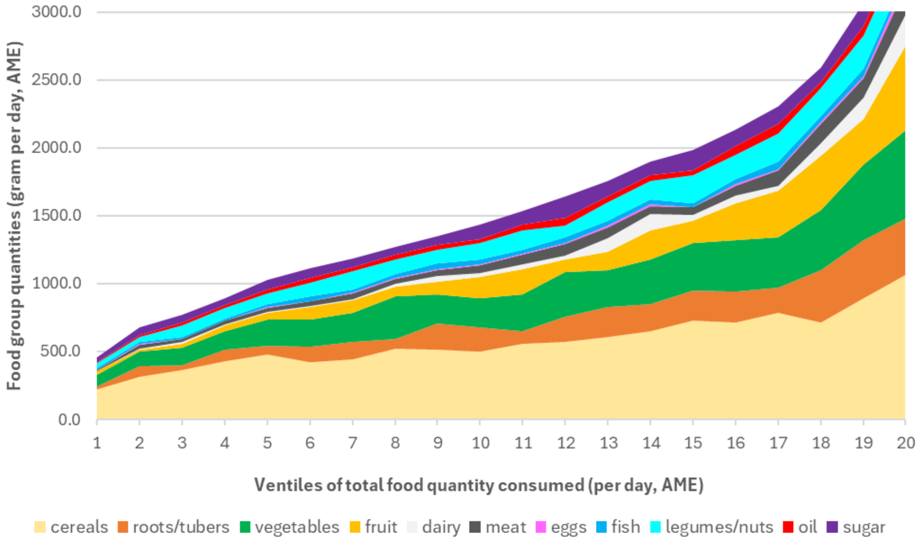
Next to the census data, this study relies on the fifth round (2020-2021) of the National Panel Survey (NPS5) launched in 2008 as part of the World Bank's Living Standards Measurement Survey– Integrated Surveys on Agriculture (LSMS-ISA). NPS5 followed a stratified, multi-stage cluster sampling design with four representative strata: Dar es Salaam, Other Urban Areas (Mainland), Rural Areas (Mainland), and Zanzibar. The total sample size of NPS5 covered 23,592 individuals in 4,709 households, of which 3,945 households had valid food consumption data to pursue the objectives of this study. This validated dataset covers daily metric food quantity estimates per adult male equivalent (AME)[2] for 57,502 individual transactions on 65 different food items. Indeed, given the number of outlier observations related to declarations on metric weights for purchases in non-metric measurement units, we relied on the corresponding food outlays combined with a set of standardized local food prices derived from food purchases in metric measurement units from the same survey. In contrast, for food obtained from own production or received as gifts in kind and recorded in non-metric measurement units, we relied on local metric conversion factors derived from metric weight declarations related to food transactions with only one unit. For the derivation of local standardized food prices and metric conversion factors, we used robust central tendency measures (such as the median value) while requiring a minimal number of observations. Given the importance of consuming food away from home (FAFH), especially in Dar es Salaam where almost three quarters of all households had at least one member eating full meals outside the household, we also introduced a household-specific FAFH allowance by using the ratio of total outlays spent on FAFH and

[2] In this analysis, AME is based on the energy requirements of men and women at different age intervals using a 30-year-old man with a physical activity level of 1.75 and a body mass of 60 kg as the reference (FAO 2001). While this approach helps to standardize food needs across individuals, it could not integrate the pregnancy and breastfeeding status of women at reproductive age (due to lacking data), nor does it account for changes in the composition of age groups over time.

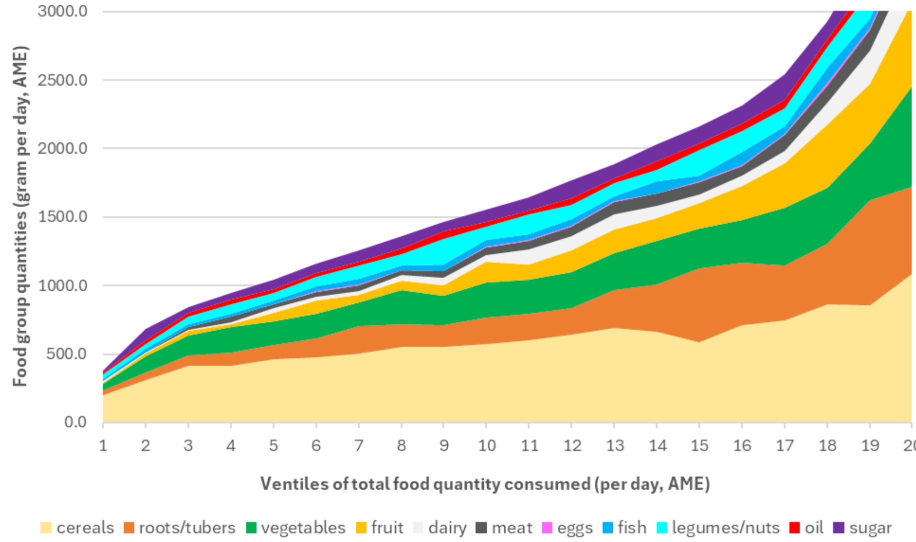
those spent on regular food purchases to estimate the corresponding FAFH quantities. Finally, the survey sampling weights were recalculated following the removal of households with outlier observations.

For increasing levels of total food intake, Figure 1 displays the average diet profile observed across eleven food groups (cereals, roots/tubers, vegetables, fruit, dairy, meat, eggs, fish, legumes/nuts, oil, and sugar) and each of the four analytical strata (see panel (a)-(d)). Ranging from 500 grams to more than 3,000 grams and with median consumption levels around 1,500 grams, the distribution of total daily food intake levels is roughly similar for Dar es Salaam and other urban areas in the country's mainland. In contrast, people in rural areas and especially the inhabitants of Zanzibar eat substantially less. Despite their similar size, diets in the capital city contain significantly less roots and tubers, slightly less dairy products, and a bit more vegetables, legumes and nuts, compared to the other urban areas. Except for cereals, roots, and tubers, the intake quantities of all other food groups are (substantially) lower among rural dwellers compared to their urban counterparts on Tanzania's mainland. Containing more fish, legumes and nuts, despite the much smaller daily food portion, the diet profile of Zanzibar is distinctly different from the other strata, which to some extent is not surprising given the island's biophysical conditions.

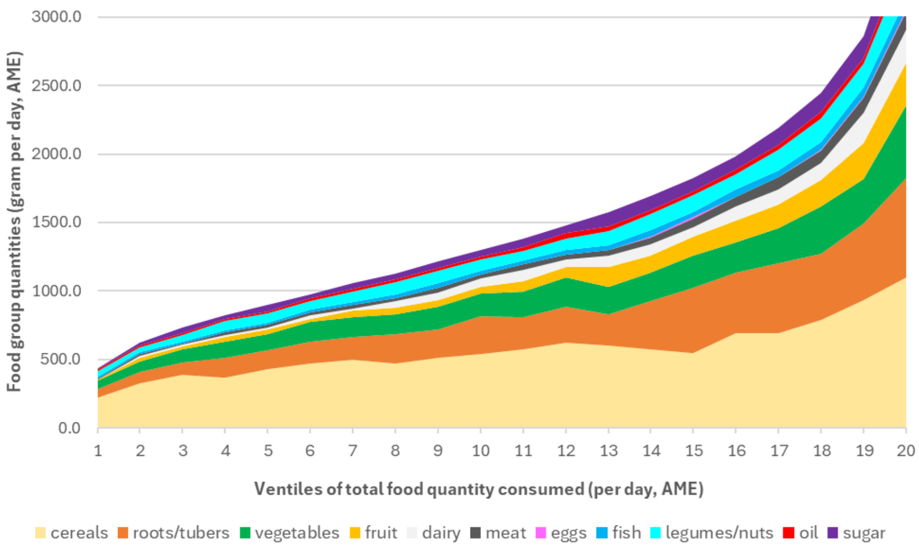
Figure 1: Diet composition by food group and total portion size, Tanzania (2020/21)



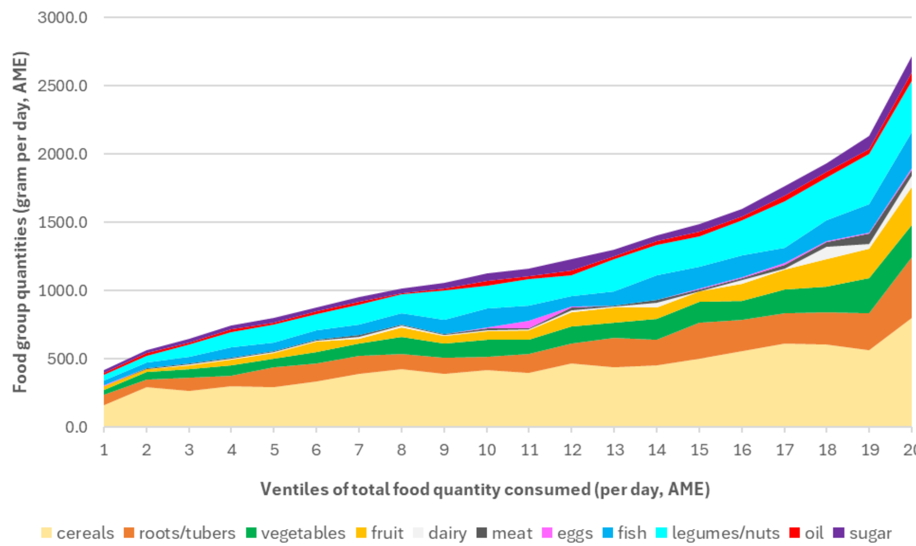
Panel (a): Dar es Salaam



Panel (b): Other urban areas



Panel (c): Rural areas



Panel (d): Zanzibar

Source: Authors based on NPS (2020/21).

METHODS

The methodology to estimate the food supply requirements in support of healthy diet consumption by all Tanzanian people in 2050 basically consists of two components. The first aims to account for the expected demographic growth between 2020/21 and 2050, while the second involves a procedure to specify and adapt international healthy reference diets to the Tanzanian context.

Demographic projection to 2050

To estimate the required food supplies by 2050, it is essential to know how the population distribution is likely to change between the survey year and the projection year. To obtain this information, intercensal region- and area-specific growth rates are first derived based on the 2012 and 2022 census rounds (URT 2013, 2024a, 2024b), after which they are used to interpolate and extrapolate the population figures of 2020/21 and 2050, respectively. More specifically, Equation (1) derives the growth rate g for each region r = 1…31 and area a = {urban, rural}, where pop_{2012} and pop_{2022} refer to the total population counted by each of the respective national census rounds.

$$g^{r,a} = \left[\left(pop^{\,r,a}_{\,2022} \big/ pop^{\,r,a}_{\,2012} \right)^{1/10} \right] - 1 \tag{1}$$

Following Equation (2a) and (2b), these growth rates are then used to estimate the population distribution in 2020/21 and 2050, denoted by $pop_{2020/21}$ and pop_{2050}, respectively.[3] To account for longer-term trends in fertility, mortality and migration, the region- and area-specific population estimates of 2050 are further calibrated using the demographic projections for urban and rural areas of Tanzania as estimated by UN-DESA (2018) and denoted by $unpop_{2050}$. This calibration entails a proportional correction based on the latter estimates combined with the area-specific population totals obtained by taking the sum of all regional population projections using the region- and area-specific growth rates obtained in Equation (1).

$$pop^{\,r,a}_{\,2020/21} = pop^{\,r,a}_{\,2012}\,(1 + g^{r,a})^{9} \tag{2a}$$

$$pop^{\,r,a}_{\,2050} = \left[pop^{\,r,a}_{\,2012}\,(1 + g^{r,a})^{38}\right] \left(unpop^{\,a}_{\,2050} \Big/ \textstyle\sum_r \left[pop^{\,r,a}_{\,2012}\,(1 + g^{r,a})^{38}\right] \right) \tag{2b}$$

Based on these inter- and extrapolations, the sampling weights W, associated with the enumeration areas of the NPS survey within each region r and area a, are adjusted (W_{adj}) for the 2020/21 period and projected (W_{pro}) for 2050, following Equation (3a) and (3b).

$$W^{\,r,a}_{\,adj} = W^{r,a} \left[pop^{\,r,a}_{\,2020/21} \Big/ \textstyle\sum_{r,a} W^{r,a} \right] \tag{3a}$$

$$W^{\,r,a}_{\,pro} = W^{r,a} \left[pop^{\,r,a}_{\,2050} \Big/ \textstyle\sum_{r,a} W^{r,a} \right] \tag{3b}$$

While absorbing some of the longer-term demographic trends, the geographically sensitive proportional adjustment and projection of the initial NPS sampling weights do not account for subnational trends in fertility, mortality and migration, nor can they reflect any substantial or administrative fluctuation that has

[3] The mid-point of the NPS survey period as well as the timing of the projected period have been assumed around August 2021 and August 2050, respectively, thus being 9 and 38 years after the implementation of the 2012 census round.

occurred in between or after both census rounds, such as a large influx of people following a crisis or conflict, a natural promotion to city status based on reaching a certain population threshold, or a political decision to relabel certain areas as urban or rural.

Contextualization of international healthy reference diets

The second component of the methodology involves a scaling of intra food group patterns observed in the Tanzanian diet to match the required absolute corresponding quantities as indicated by international reference diets. For each food group and each analytical stratum, the method basically aims to extract the typical consumption pattern of those people whose food group consumption level is close to the target quantities set by the reference diets. The general idea is to adhere to the generic prescriptions of healthy diet consumption while at the same time selecting individual food items that are not uncommon to most Tanzanians living in each of the four analytical strata of the NPS survey.

This study relies on two international healthy reference diets, which are the EAT-*Lancet* Reference Diet (hereafter: ELRD) developed by Willett et al. (2019), and the Hypothetical Micronutrient Adequate Diet (hereafter: HMAD) proposed as an alternative by Beal, Ortenzi, and Fanzo (2023). Whereas ELRD has the ambition to be healthy for both people and planet, the main perspective adopted by HMAD is to assure micronutrient adequacy, especially regarding six micronutrients that are globally scarce (i.e., calcium, iron, zinc, folate, vitamin B12, and vitamin A). This assessment resulted in adding three new food groups, specifying subcomponents of existing food groups, and revising target macronutrient intake quantities (Beal, Ortenzi, and Fanzo 2023).

The first three columns of Table 1 present the daily macronutrient intake proposed by ELRD and HMAD across several food groups. Compared to ELRD, HMAD assigns more weight to tubers and starchy vegetables (+131 grams (g)) and to various animal-source food (ASF) categories (+163 g) – resulting in a daily food portion that is 260 g bigger (i.e., 1584 g for HMAD against 1324 g for ELRD). The argument behind the higher weight assigned to ASF is that a sufficient intake of micronutrients (especially vitamin B12, calcium, iron, and zinc) is challenging when sourced from other food groups (Beal, Ortenzi, and Fanzo 2023). By assigning a substantially higher weight to tubers and starchy vegetables, HMAD unintentionally introduces a component of resilience and flexibility to food security: in general, these food items are more resilient to erratic rainfall and have a larger harvesting window compared to many other food items. Despite its bigger daily portion size, HMAD contains substantially fewer kilocalories (i.e., 2227 kcal under HMAD against 2503 kcal under ELRD). In sum, HMAD is bigger, less energy dense, and overall tends to contain more micronutrients compared to ELRD.

Table 1: International healthy reference diets: initial and aggregated food groups

Food groups	Macronutrient intake (g/day)		Food groups for scaling	Macronutrient intake (g/day)	
	ELRD	HMAD		ELRD	HMAD
Whole grains	232.0	171.0	Cereals	232.0	239.0
Refined grains	.	68.0			
Tubers or starchy vegetables	50.0	181.0	Roots & tubers	50.0	181.0
Dark green vegetables	100.0	77.0	Vegetables	300.0	251.0
Red and orange vegetables	100.0	89.0			
Other vegetables	100.0	85.0			
All fruit	200.0	222.0	Fruit	200.0	222.0
Whole milk and derivatives	250.0	239.0	Dairy	250.0	239.0
Beef and lamb	7.0	7.0	Meat	43.0	84.0
Beef	.	19.0			
Pork	7.0	12.0			
Organs	.	6.0			
Chicken and other poultry	29.0	40.0			
Eggs	13.0	50.0	Eggs	13.0	50.0
Fish	28.0	39.0	Fish	28.0	124.0
Fresh fish	.	16.0			
Small dried fish	.	3.0			
Canned fish with bones	.	15.0			
Crustaceans	.	34.0			
Bivalves	.	17.0			
Dry beans, lentils, and peas	50.0	27.0	Legumes & nuts	125.0	113.0
Soy foods	25.0	61.0			
Peanuts	25.0	4.0			
Tree nuts	25.0	4.0			
Seeds	.	17.0			
Palm oil	6.8	7.0	Oils & fats	51.8	51.0
Unsaturated oils	40.0	40.0			
Dairy fats (included in milk)	0.0	0.0			
Lard or tallow	5.0	4.0			
All sweeteners	31.0	30.0	Sugar	31.0	30.0
Total macronutrient intake (g/day)	**1323.8**	**1584.0**	**Total**	**1323.8**	**1584.0**
Total caloric intake (kcal/day)	**2503.0**	**2227.0**	**Total**	**2503.0**	**2227.0**

Notes: ELRD and HMAD stand for EAT-*Lancet* Reference Diet and Hypothetical Micronutrient Adequate Diet, respectively.
Source: Authors based on Willett et al. (2019) and Beal, Ortenzi, and Fanzo (2023).

The procedure to extract typical food group intake patterns and estimate required annual supplies for healthy diet consumption involves the following steps.

1. Aggregate the target macronutrient intake quantities set by ELRD and MHAD into broader categories based on the eleven food groups used for the computation of the Household Dietary Diversity Score (Swindale and Bilinsky 2006).[4] This aggregation is performed in the last three columns of Table 1. The reason for working with more aggregated food groups is both operational and functional: that is, to have enough observations for an accurate and representative scaling of observed consumption patterns based on food culture and availability. In addition, some food item descriptions of the NPS survey cannot be (easily) assigned to the more disaggregated food groups, such as "other domestic/wild meat products".

2. Identify in each stratum s = 1…4 and each food group g = 1…11 all households j whose sum of daily AME-adjusted macronutrient intakes *MI* across all food items i falls within a range of +/-10% of the target consumption level *TCL* set by the healthy reference diets d = {ELRD, MHAD}.[5] Equation (4) provides the mathematical equivalent for this condition.

$$\forall j \in (1-0.1)TCL_d^g \leq \sum_i MI_{ij}^{s,g} \leq (1+0.1)\, TCL_d^g \tag{4}$$

3. Compute the share of each food item i based on the *MI* observed for all households j that fulfill the condition in Equation (4), and multiply this share by the corresponding *TCL* to obtain the daily AME-adjusted required intake *RI* of food item i in stratum s as part of a contextualized healthy diet d. This can be written as in Equation (5).

$$RI_{d,i}^s = \left[\sum_j MI_{ij}^{s,g} \Big/ \sum_{ij} MI_{ij}^{s,g} \right] TCL_d^g \tag{5}$$

4. Annualize the *RI* and multiply by the number of *AME* in each stratum s using the projected population sampling weights for 2050 (as outlined above), before aggregating over all strata to find estimates of required annual supplies *RAS* of each food item i to be able to provide all Tanzanian people with a healthy and contextualized diet d. Equation (6) summarizes this final step.

$$RAS_{d,i} = 365 \sum_s \left(RI_{d,i}^s AME^s \right) \tag{6}$$

To discuss the implications and help identify potential entry points of food systems transformation, the required supplies of 2050 are compared with the 2020/21 food demand (i.e., the actual annual supplies). In this comparison, special attention will be devoted to differences in biophysical conditions, environmental impact, perishability, and processing level of the various food items. Most of this profiling information directly stems from the descriptions linked to the predefined food list of the NPS food consumption module. These profiles are important to guide future investments in production, transport, storage, cooling, and processing capacity, while pointing to import substitution opportunities and environmental concerns.

Apart from the immediate logistical and environmental implications, this study also inspects the shortfalls of current diets compared to the contextualized versions of the two reference diets – both in nutritional and monetary terms. To assess the extent by which current diets reflect healthy diets, Equation (7)

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[4] This score in fact consists of twelve food groups, but since no target quantities are set by ELRD and HMAD for the "miscellaneous" food group (covering condiments, coffee, and tea), this analysis will focus on eleven food groups.

[5] When less than 10 eligible households were found per stratum and food group, the national (instead of stratum-specific) food consumption pattern was imputed as derived following a similar procedure.

defines the food group adequacy rate *FGAR* for each household *j* as the share of *TCL* set for food group *g* by the reference diet *d* that is met by current consumption as estimated by the sum of *MI* across all food items *i* that belong to the same food group *g*. Similar to the notion of nutrient adequacy, the function *T(.)* concerns a truncation of all values above 100% to 100%.

$$FGAR_{d,j}^{g} = T\left(\left[\sum_i MI_{ij}^{g} \Big/ TCL_{d}^{g}\right]\right) \tag{7}$$

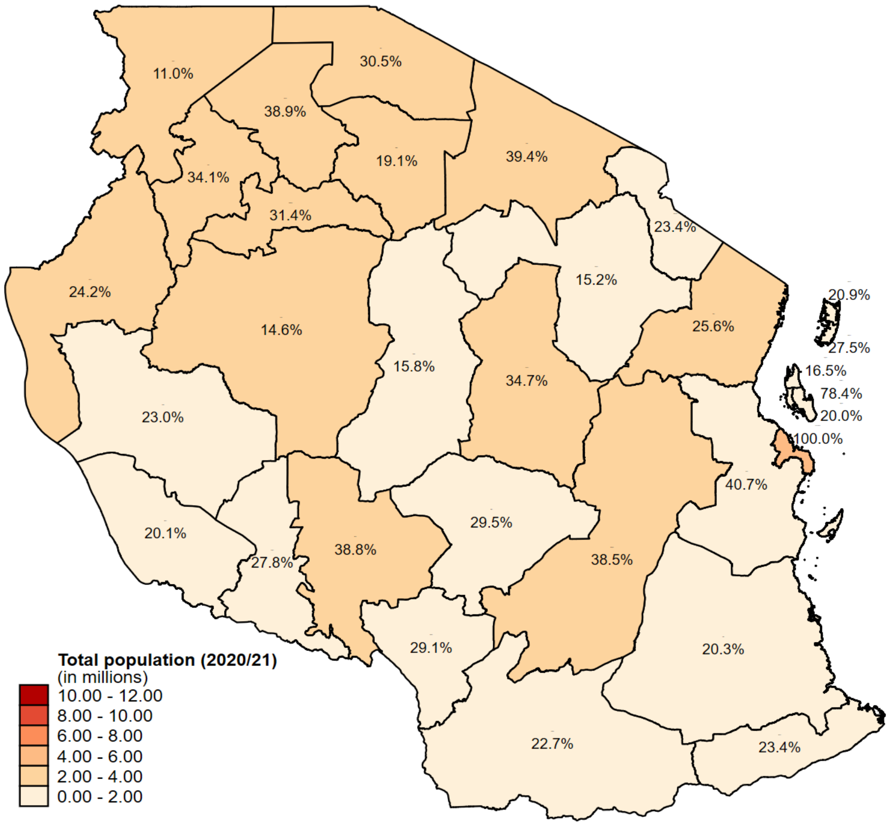
While the above procedure provides a workable method to contextualize international healthy reference diets at subnational level, the following shortcomings and characteristics are worth highlighting. First, the aggregation into eleven food groups ignores much of the granularity embodied in ELRD and HMAD, initially covering 21 and 30 food groups, respectively. Second, each stratum-specific food group consumption pattern is derived from households whose food group consumption level is around the TCL set by the international diets – irrespective of the consumption levels in other food groups. Third, the contextualized healthy diets do not necessarily reach full energy or nutrient adequacy, neither are they the most cost-effective combinations of food items. Fourth, the required annual supplies (RAS) reflect lower-bound estimates to strictly secure a healthy diet for all, without accommodating any excess supply to potentially cover higher food demands. Assessing the relative importance of these methodological features or how both reference diets perform in these respects, however, falls outside this country case study.

SIMULATION RESULTS

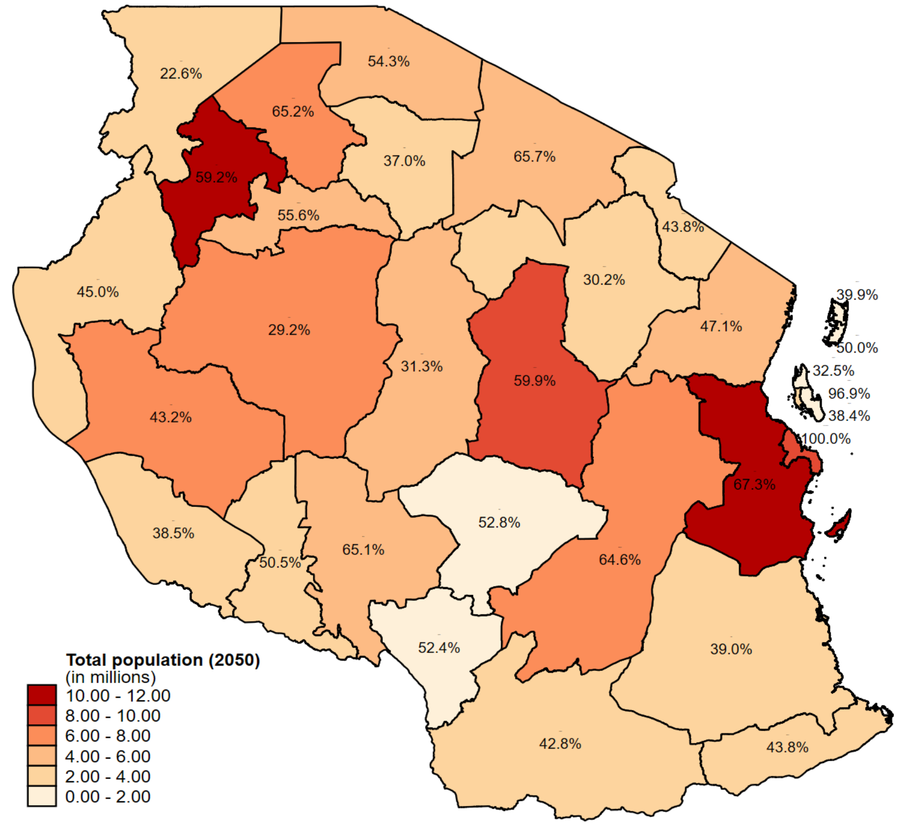
Expected demographic trends between 2020/21 and 2050

Following the methodology outlined above, Figure 2 indicates that the population of Tanzania is expected to more than double (that is, by a growth factor of 2.3), from 59.8 million to 138.1 million people, between 2020/21 and 2050. While the rural population will accrue by a growth factor of 1.6, the urban population is expected to almost quadruple over this 30-year period – thus pushing the urbanization rate from 34.5% in 2020/21 to 55.4% in 2050. Among the 31 regions of the country, the biggest absolute growth in total population is expected in Geita and in Pwani – growing from less than 4 million and less than 2 million people, respectively, to more than 10 million people. With an increase of 25% to 27% points, these two regions will also urbanize at a faster rate compared to the national average. While the combination of high demographic growth and high increases in urbanization rates also applies to Dodoma, Morogoro, and Mwanza, the demographic growth observed in Katavi and Tabora is expected to be less driven by increased urbanization. While the population totals following our methodology exceed the 2050 projections of the Tanzanian National Bureau of Statistics (estimated at 118.1 million), they are by construction fully in line with the UN projections and within the range estimated by the World Bank Group (i.e. between 120 and 141 million) (UN-DESA 2018; URT 2024c; WBG 2024).

Figure 2: Demographic trends, Tanzania (2020/21 and 2050)



Panel (a): 2020/21



Panel (b): 2050

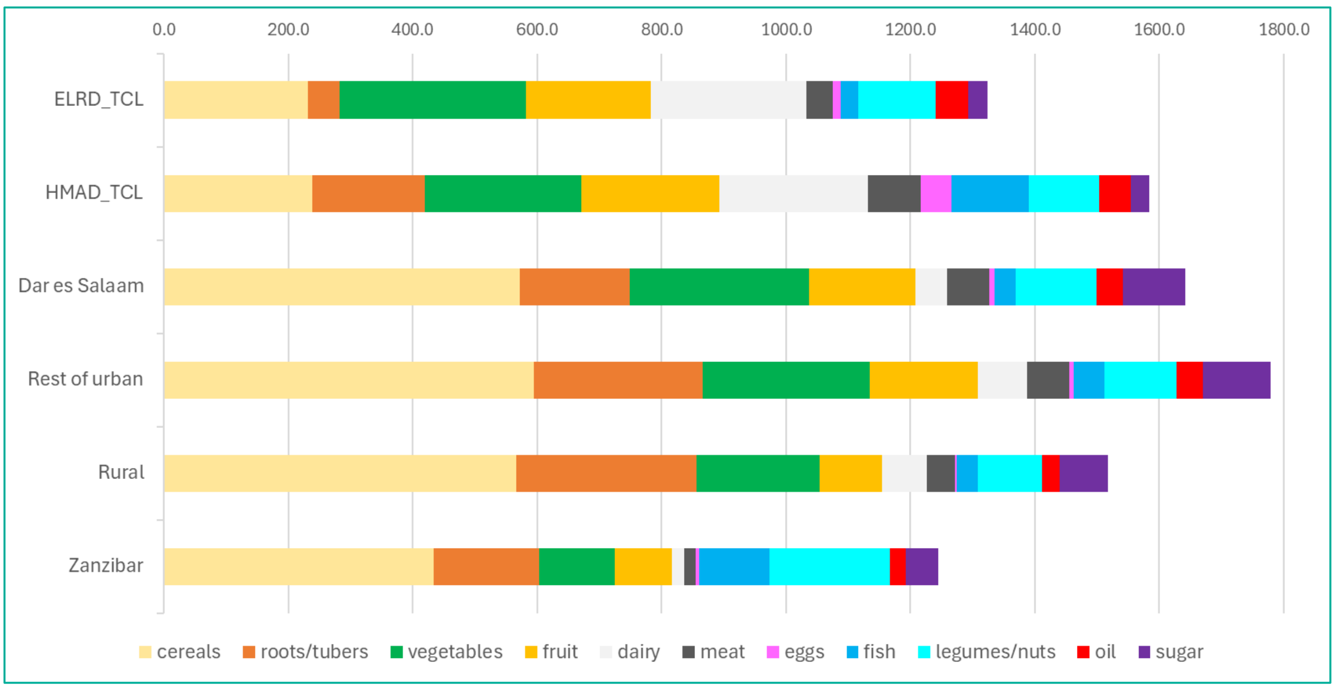
	Population (in millions) 2020/21	2050	Growth factor
Urban	20.6	76.5	3.7
Rural	39.1	61.5	1.6
Total	59.8	138.1	2.3
Urbanization rate	34.5%	55.4%	1.6

Note: Urbanization rates for each region are displayed as a percentage on the map.
Source: Authors based on PHC census data (2012 and 2022).

A comparison of current and healthy diets

Figure 3 displays the required and current intakes per AME for each of the eleven food groups. While the daily portion size of an average adult typically exceeds, or is close to, the required intakes of ELRD and HMAD (except for Zanzibar), none of the average diets in each of the four analytical strata resembles a healthy diet. Indeed, compared to the TCL set by ELRD and HMAD, the Tanzanian people on average consume too many cereals and sugar products while eating too few fruits, dairy products, and eggs. Using ELRD as the healthy diet reference implies that people also consume too many roots/tubers and too few vegetables. In contrast, if HMAD is chosen as the main reference, then people also eat too few meat and fish products. Intake gaps are most pronounced for dairy products, with the other urban areas (excluding Dar es Salaam) on the mainland performing best, but still only consuming one third of what is required. Fruit and vegetables gaps are also particularly high in rural areas and Zanzibar, where they range from 100 to 178 grams (except for the vegetables gap in rural areas under HMAD). The gap in fish consumption only applies to HMAD and ranges from 74 to 91 grams, while being negligible for Zanzibar. In relative terms, the gap in egg consumption is also substantial, especially under the HMAD requirements of 50 grams.

Figure 3: Required and current intakes (in grams/AME) per food group, Tanzania (2020/21)



Note: ELRD_TCL and HMAD_TCL refer to the target consumption levels defined by ELRD and HMAD, respectively.
Source: Authors based on NPS (2020/21), Willett et al. (2019) and Beal, Ortenzi, and Fanzo (2023).

Looking beyond average intake levels, Table 2 presents the FGAR for each food group, healthy diet, and analytical stratum, following the methodology outlined above. Consistent with the previous observations, all adequacy rates related to cereal and sugar products exceed 85% except for sugar in rural areas where it is close to 65%. The latter observation, combined with an average intake level that is more than two times higher than what is required (that is, 78 grams versus 30 grams), implies that sugar is more of a luxury product in rural areas, especially compared to Zanzibar where the average intake amounts to only 52 grams and the FGAR levels around 85%. Other luxury products across all analytical strata involve fruit, meat, and fish (except for Zanzibar), which are clearly more consumed by food rich than by food poor households – as reflected by the relatively small average intake gap (Figure 3) combined with the relatively low adequacy rates (Table 2). For fruit and meat, adequacy rates range between 45% and 60% for capital and the other urban areas on the mainland, while being (substantially) lower than 42% in rural areas and Zanzibar. The adequacy rates for fish roughly fall in the same range as for meat, except for those related to Zanzibar which are approximately 30% points higher (given the much higher fish intake observed) and those related to HMAD which are substantially lower (given the distinctively higher fish requirements set by HMAD compared to ELRD). With FGAR (well) below 25%, both dairy and eggs are far from being adequately consumed, especially in Zanzibar regarding both food groups, in rural areas regarding eggs, and in Dar es Salaam regarding dairy products. In contrast, again by comparing average intake levels and FGAR, the consumption of vegetables as well as legumes/nuts appears to be more evenly distributed across households with different total food intake levels, which reflects the common nature of these food items across richer and poorer people's diets. Remarkably, people in Zanzibar eat less vegetables and more legumes/nuts than their counterparts on the mainland, which is also reflected in the corresponding FGAR – amounting at best to 46% for vegetables and to at least 81% for legumes/nuts. Zanzibar is also particular regarding roots/tubers, which appear to be more equally consumed between richer and poorer households while being more of a luxury product in the other analytical strata. Indeed, Zanzibar has the lowest average intake of roots/tubers (170 grams) but the highest FGAR regarding ELRD (83%).

Table 2: Food group adequacy rates (%), Tanzania (2020/21)

FGAR (%)	Dar es Salaam		Rest of urban		Rural		Zanzibar	
	ELRD	HMAD	ELRD	HMAD	ELRD	HMAD	ELRD	HMAD
Cereals	97.7	97.6	97.0	96.9	94.2	94.0	94.7	94.4
Roots/tubers	72.0	56.8	75.0	66.1	73.5	63.7	83.2	60.9
Vegetables	73.8	79.8	69.2	75.6	55.0	61.4	39.7	46.4
Fruit	51.2	48.7	47.1	45.0	31.9	30.2	33.4	31.3
Dairy	15.4	15.8	23.2	23.8	18.6	19.0	7.0	7.3
Meat	60.2	49.8	57.4	48.1	41.8	33.3	23.7	16.0
Eggs	24.7	12.0	18.0	9.6	10.4	4.6	6.4	4.2
Fish	58.4	25.4	63.6	32.5	51.6	23.0	89.0	65.4
Legumes/nuts	69.4	72.0	60.2	63.2	55.1	57.7	81.0	82.9
Oil	64.5	65.1	61.8	62.4	44.4	44.9	41.2	41.6
Sugar	92.7	93.0	85.3	85.5	64.6	64.9	84.7	85.5

Source: Authors based on NPS (2020/21), Willett et al. (2019) and Beal, Ortenzi, and Fanzo (2023).

Required changes in total annual food supplies

Table 3 compares the annual supplies of 2020/21 against the supplies needed to secure a healthy diet for all people in Tanzania by 2050. At the aggregate level and consistent with the expected demographic growth, total food supplies need to more than double by 2050, that is, from 24 million tons to 52 million tons to meet the ELRD requirements while the HMAD requirements imply an increase to 62 million tons. Knowing that the total population will become more urbanized by 2050, this doubling of required food supplies already implies that the overall food system in general and, particularly, in rural areas must become more productive.

More important, however, is that the composition of outputs of the country's food system must change dramatically. Indeed, the supplies of vegetables should increase by a factor of at least three; oil products by a factor higher than four; fruits by a factor of roughly five; dairy by a factor of more than eight (each time to secure the requirements of both healthy diet references); and eggs by a factor of roughly 10 (under ELRD) and 37 (under HMAD). In addition, if HMAD is the selected reference for healthy diets, then the supplies in meat and fish should respectively grow more than four- and eightfold as well.

Table 3: Current and required annual supplies per food group, Tanzania (2020/21 and 2050)

Food group	Type	Current annual supplies (in tons, 2020/21)	ELRD		HMAD	
			Annual supplies (in tons, 2050)	Growth factor	Annual supplies (in tons, 2050)	Growth factor
Roots/tubers	unprocessed	3,838,973	1,677,372	0.4	6,496,741	1.7
	processed	499,075	276,846	0.6	577,527	1.2
	total	4,338,048	1,954,218	0.5	7,074,268	1.6
Sugar	sugar	1,264,506	1,211,615	1.0	1,172,531	0.9
	total	1,264,506	1,211,615	1.0	1,172,531	0.9
Cereals	unprocessed	618,079	421,880	0.7	345,502	0.6
	processed	8,464,217	8,634,650	1.0	8,985,693	1.1
	total	9,082,296	9,056,530	1.0	9,331,195	1.0
Fish	unprocessed	395,062	575,012	1.5	3,338,362	8.5
	processed	180,892	519,349	2.9	1,508,098	8.3
	total	575,954	1,094,361	1.9	4,846,460	8.4
Meat	small ruminants & pork	195,128	226,907	1.2	410,780	2.1
	poultry	211,187	337,798	1.6	627,624	3.0
	large ruminants	366,364	1,115,923	3.0	2,244,682	6.1
	total	772,679	1,680,628	2.2	3,283,086	4.2
Legumes/nuts	processed	213,552	553,695	2.6	577,736	2.7
	unprocessed	1,462,816	4,331,849	3.0	3,838,796	2.6
	total	1,676,368	4,885,544	2.9	4,416,532	2.6
Vegetables	processed	68,927	212,208	3.1	219,076	3.2
	unprocessed	3,026,044	11,513,098	3.8	9,591,097	3.2
	total	3,094,971	11,725,306	3.8	9,810,173	3.2
Oil	oil	468,015	2,024,569	4.3	1,993,302	4.3
	total	468,015	2,024,569	4.3	1,993,302	4.3
Fruit	unprocessed	1,705,127	7,816,871	4.6	8,676,727	5.1
	total	1,705,127	7,816,871	4.6	8,676,727	5.1
Dairy	processed	359,659	1,614,978	4.5	1,823,785	5.1
	unprocessed	773,292	8,156,110	10.5	7,517,375	9.7
	total	1,132,951	9,771,088	8.6	9,341,160	8.2
Eggs	eggs	53,581	508,097	9.5	1,954,218	36.5
	total	53,581	508,097	9.5	1,954,218	36.5
Undefined		28,671	11,041	0.4	9,966	0.3
TOTAL		24,193,167	51,739,868	2.1	61,909,618	2.6

Note: The food groups in this table are ranked by the ELRD growth factor.
Source: Authors based on NPS (2020/21), Willett et al. (2019) and Beal, Ortenzi, and Fanzo (2023).

Table A1 annexed to this report provides more details on the required future supplies per food item. For example, the required increase in dairy products (responsible for critical micronutrients of calcium and vitamin B12) mainly involves fresh milk and cream/cheese/yoghurt, which should grow by a factor of around 10.1 and 4.8, respectively, as opposed to canned/powder milk, which appears negligible. Regarding fruit, the most important items are bananas, mangoes, avocados, and oranges, of which total annual supplies should amount to approximately 7 million tons by 2050, or an increase by a factor exceeding 4.7. The supply of cooking oil, which is the most important food item within the category of edible oil products, should increase more than fourfold between 2020/21 and 2050. Regarding vegetables, the main items concern tomatoes, green vegetables (like spinach), onions, cabbage, and carrots, of which total annual supplies should increase from around 3 million tons to almost 10 million (under HMAD) and almost 12 million tons (under ELRD). Finally, the main meat and fish items that should be part of future food supplies (mainly under the HMAD requirements), involve beef, chicken, *Dagaa* (fresh), and processed forms of fish and seafood (like dried, salted, and canned fish).

In contrast, the growth in supplies for the remaining food groups should be either in line with the expected population growth rate of 2.3 or could be even substantially lower. Demographic consistent growth is roughly required for supplies in legumes/nuts under both healthy diet references (ELRD and HMAD) and for meat and fish under ELRD. On the other hand, the 2020/21 supplies of sugar and cereal products are roughly sufficient to adequately nourish the population in 2050. Moreover, following the ELRD requirements, the 2020/21 supplies of roots/tubers may substantially decrease by a factor of 0.5 and still be sufficient as part of a healthy diet in 2050.

FOOD SUPPLY IMPLICATIONS AND POSSIBLE ENTRY POINTS

Given the significant changes required to supply healthy diets by 2050 predicted in this study, this section discusses key policy challenges and possible entry points for some of the subsectors that require substantial transformation. Without being exhaustive or holistic, this discussion considers several logistical, environmental, and socio-economic aspects.

Following the analysis above and inspecting Table A1 (in annex), future transformations of the country's food systems should focus on the following ten food items: eggs, fresh milk, bananas, mangoes, avocados, oranges, cooking oil, tomatoes, onions, and beans.[6] Based on FAOSTAT data, Table 4 presents the current and required yield rates to be achieved in Tanzania by 2050 to meet the supply requirements under ELRD for each of these items. It is important to highlight that the estimated required yield rates are solely based on an intensification strategy; that is, by keeping the current harvested areas (or number of animals) used to produce each food item constant while assuming no changes in soil health, climate and other biophysical conditions. Apart from excluding extensification, this simulation also does not consider any shifts in the allocation of agricultural land between crops, which might be advisable based on crops requiring less attention in future diets. Finally, not all future supplies should come from national production alone but could also be (partly) assured through imports from other countries with more favorable biophysical conditions or other comparative advantages.

Despite being upper-bound proxies, most required yield rates fall within the current technological frontier as proxied by countries with the highest two yield rates for each food item in 2021. This is certainly the case for milk, oranges, sunflower oil, tomatoes, and beans, where each time the required yield rate is far below the highest yield rates observed. For example, milk yield rates in Tanzania should almost triple

[6] Moreover, to meet the HMAD requirements by 2050, several meat and fish items should receive particular attention as well.

from 0.4 to 1.1 tons per cow, which is similar to what is observed in Libya and Mozambique, but still 10 times below the productivity levels achieved in Israel and Saudi Arabia. For eggs, the current annual yield rate should increase from 7.3 tons to 18.3 tons per 1,000 hens (or from one smaller egg every two days to one big egg every day), which is still substantially below the yield rates of the best performing countries Marocco and French Polynesia. In contrast, to meet the required increase in mango and onion supplies using the land currently assigned to both crops and without any imports, yield rates should increase (much) more than fourfold, which is close or beyond the yield rates of the best performing countries.

Despite the required increase in banana supplies by 2050 (as observed in Table A1), the required yield rate of 6.5 tons per hectare lies *below* the current rate of 10.2 tons per hectare, which (apart from possible data inaccuracies combined with minor export flows) points to important levels of post-harvest losses (PHL) related to this particular food item. While exact figures are lacking, PHL for the banana value chain are indeed high and typically estimated between 20% and 80% (URT 2019). In a similar vein, the required increases in productivity to supply healthy diets could be attenuated if complemented with increased imports. This is currently the case for cooking oil, of which 60% (mainly palm oil) is currently imported (HAPA 2022). In contrast, if yield rates of sunflower oil could increase sixfold, from 0.3 to 1.9 tons per hectare, and assuming no PHL, then most edible oil imports could be substituted by national production.

Table 4: Current and required yield rates for selected food items

Food group	Item	Tanzania		Other countries	
		Current yield rate (2021)	**Required yield rate** (2050)	**With required yield rate** (2021)	**With highest yield rate** (2021)
Eggs	Hen eggs in shell, fresh	7.3	18.3	Japan (18.3); Finland (18.4)	Morocco (27.7); French Polynesia (25.9)
Dairy	Raw milk of cattle	0.4	1.1	Libya (1.1); Mozambique (1.1)	Israel (13.6); Saudi Arabia (12.6)
Fruit	Avocados	.	.		El Salvador (42.6); Samoa (30.5)
	Bananas	10.2	6.5	CAR (6.1); Samoa (6.7)	Turkey (71.9); Puerto Rico (62.6)
	Mangoes	12.3	52.3	(beyond frontier)	Guyana (42.7); Samoa (34.9)
	Oranges	11.6	29.7	Paraguay (29.5); Honduras (30.4)	Guyana (62.2); Albania (53.0)
Oil	Sunflower-seed oil, crude	0.3	1.9	Mexico (1.9); Brazil (2.0)	Bosnia/Herzegovina (65.7); Iraq (34.7)
Vegeta-bles	Tomatoes	12.7	123.9	France (117.3); Kuwait (122.4)	Netherlands (475.7); Belgium (448.7)
	Onions and shallots, dry	10.9	72.9	Republic of Korea (85.4); USA (56.0)	Republic of Korea (85.4); USA (56.0)
Legumes/ nuts	Beans, dry	1.3	2.1	Syria (2.1); Yemen (2.2)	Tajikistan (7.1); Montenegro (6.3)

Note: All yield rates are annual and expressed in tons per hectare (for crops), tons per animal (for milk) and tons per 1,000 animals (for eggs). The required yield rates were also derived based on the current harvested areas (or number of animals) used for each food item and the required supplies in 2050 following the ELRD requirements. Given its value of 10 tons per hectare, the yield estimate of dry beans observed in Mali has been considered an outlier.

Source: Authors based on FAOSTAT, NPS (2020/21), and Willett et al. (2019).

As part of its vision to become a higher middle-income country by 2050, Tanzania has developed a comprehensive roadmap in 2024 to transform its crops, livestock and fisheries subsectors. Based on a detailed diagnostic and a consultative process, this Agriculture Master Plan (AMP) has defined 15 flagship development projects to address critical bottlenecks and identified 20 priority commodities to achieve the ambitious targets set for 2030 and 2050. The selection of priority crops follows from a discussion with key stakeholders based on available data and using four selection criteria: share of agricultural GDP, growth potential, smallholder focus, resilience and sustainability, and nutritional importance (URT 2024d).

Table 5 presents an overview of AMP's 20 priority commodities, including their targeted increase in yield rates by 2030/31 and their alignment with the selection criteria. The table also indicates whether the 20 selected commodities are important for future healthy diets (according to either ELRD or HMAD) as estimated by this study, and which food items are overlooked by AMP – respectively displayed in the last column and last row.

Of the 20 priority commodities set by AMP, twelve are also critical to meet the requirements of ELRD or HMAD by 2050 in that their supplies should increase by a rate higher than the expected demographic growth. These food items include banana, avocado, Irish potato, tomato, sunflower, kidney beans, pigeon peas, green gram, aquacultural products, poultry, red meat, and dairy. Three food items (Irish potato, aquacultural products, and poultry) are only critical as part of the HMAD reference diet because of its markedly higher weight given to roots & tubers, meat, and fish compared to ELRD. Following AMP (URT 2024d), most of the crops can be produced in large parts of Tanzania, but especially the northwestern part of the country is highly suitable for vegetal production. In contrast, most of the cattle to generate the required red meat and milk supplies can be found in the northcentral part of the country, while most chicken are located in the country's center as well as in the Ruvuma region in the South. In contrast, fish farming is mostly practiced along the continental lakes (Lake Malawi, Lake Rukwa, Lake Victoria, and Lake Tanganyika) located in the Southwestern part of the country as well as in Dar es Salaam and Zanzibar along the Indian Ocean.

Unsurprisingly, the four cash crops identified by AMP (cotton, cashew, sisal, and coffee) are not immediate priorities to assure healthy diets following the methodology of this study. However, investing in these cash crop subsectors might be a valid strategy to increase people's income and purchasing power and thereby increase their access to nutritious diets indirectly. A similar reasoning applies to the fodder subsector, of which the support does not directly lead to higher supplies of nutritious food, but only indirectly in terms of assuring enough animal feed for the meat and dairy subsectors to develop, especially under the HMAD requirements. More importantly, the selection of spices/cloves, cassava, maize, paddy, sorghum, wheat, sesame, and soyabeans as AMP priority crops is not supported by the findings of this study, given that these energy-dense food items (except for spices) are already sufficiently consumed by Tanzanian households or less preferred than other items in the same food group. The latter observation might be the case for sesame and soyabeans, which are not even listed in the predefined food list of the NPS survey. While these eight food items are less important from a purely nutritional perspective, unlike what the "better diet" criterion would suggest, their inclusion in AMP might result from considerations beyond nutrition, as reflected in the other selection criteria.

Table 5: Agricultural Master Plan's 20 prioritized commodities

		Yield		Selection criteria					Priority for healthy diets by 2050
		Current (2022/23)	Target (2030/31)	Share in Ag. GDP	High growth potential	Smallholder focus	Resilience & sustainability	Better diets	
Horticulture	1A. Fruit: Banana	10.4	16.0	11.9%	V	V		V	ELRD/HMAD
	1B. Fruit: Avocado	6.0	9.0						ELRD/HMAD
	2. Spices: Cloves	1.2	1.9	0.2%	V	V	V	V	No priority
	3A. Vegetables: Cassava	6.4	9.7						No priority
	3B. Vegetables: Irish potato	8.4	14.8	6.2%	V	V		V	HMAD
	3C. Vegetables: Tomatoes	12.7	42.7						ELRD/HMAD
Cash crops	4. Cotton	0.7	1.1	2.4%	V	V			No priority
	5. Cashew	0.3	0.5	1.3%	V	V			No priority
	6. Sisal	0.8	1.4	0.2%	V	V			No priority
	7. Coffee	0.3	0.4	1.0%	V	V			No priority
Cereals	8. Maize	1.6	2.3	7.5%	V	V	V	V	No priority
	9. Paddy	2.9	5.0	7.8%	V	V	V	V	No priority
	10. Sorghum	1.0	1.5	2.4%	V		V	V	No priority
	11. Wheat	1.4	2.0	0.3%	V		V	V	No priority
Oilseeds	12. Sunflower seeds	1.1	1.6	1.1%	V	V	V	V	ELRD/HMAD
	13. Sesame	0.7	1.0	1.0%	V	V	V	V	No priority
Pulses/beans	14. Soyabeans	1.2	1.7	0.2%	V	V	V	V	No priority
	15A. Kidney beans	1.3	2.2						ELRD/HMAD
	15B. Pigeon peas	1.1	1.8	1.0%	V	V	V	V	ELRD/HMAD
	15C. Green gram	0.5	0.8						ELRD/HMAD
Animal protein	16. Aquaculture	2.0	1.5	<0.1%	V	V	V	V	HMAD
	17. Poultry	0.8	2.5	6.1%	V	V	V	V	HMAD
	18. Red meat	0.1	0.2	11.1%		V			ELRD/HMAD
	19. Dairy	0.4	0.6	7.6%	V	V	V	V	ELRD/HMAD
	20. Fodder	10.0	20.0	<0.1%	V	V	V		No priority
Other items for healthy diets by 2050	Eggs								ELRD/HMAD
	Mangoes								ELRD/HMAD
	Oranges								ELRD/HMAD
	Onions								ELRD/HMAD
	Cabbage/Chiness/Spinach								ELRD/HMAD

Note: If the growth factor in annual required supplies exceeds the demographic growth factor of 2.9 between 2020/21 and 2050, the corresponding food item is considered a priority food item (ELRD or HMAD). In other cases, the food item is not a priority.
Source: Authors based on URT (2024d), NPS (2020/21), Willett et al. (2019), Beal, Ortenzi, and Fanzo (2023).

Another type of mismatch concerns the priority food items identified by this study, which are *not* selected by AMP. These involve eggs, mangoes, oranges, onions, and several leafy vegetables, such as cabbage and chiness/spinach. While being considered by AMP within the consolidated poultry subsector, there is not a lot of attention dedicated to eggs in particular, and certainly not in light of the spectacular increase in supplies needed. The two fruit items (mango and orange) and two vegetable types (onion and leafy vegetables) are not even mentioned in the AMP document of 2024. Given their importance in current and future diets, more attention could be devoted to these food items in upcoming revisions of selected priority crops.

Reviewing the list of priority food items and increasing their agricultural productivity should of course be done by considering the ecological footprint of several competing options. In general, the required yield rates derived by the simulation conducted in this study should best be pursued by adhering to the principles of sustainable intensification as defined by the Earth system's safe operating space, which accounts for GHG emissions, land expansion, biodiversity, fertilizer recycling, and water management (Rockström et al. 2017). For example, cattle are among the highest GHG emitters (Cheng et al. 2022; Clark et al. 2019; FAO 2021; Tubiello et al. 2014). While both traditional and improved systems emit comparable levels of methane from enteric fermentation and manure management, the emission intensity per unit of output varies greatly. In traditional systems, milk production for example generates between 20.3 and 28.8 kg CO_2 equivalent per kg of fat and protein, whereas under improved production systems, emissions are significantly lower – ranging from 1.9 to 2.2 kg CO_2 equivalent per kg (FAO 2019). In other words, to meet the required annual supplies of almost 10 million tons of milk and between 1.1 and 2.2 million tons of beef by 2050, efforts must focus on reducing emissions per unit of output, which includes improving feed quality to enhance digestibility and reduce methane emissions, controlling animal diseases, and investing in better genetics and reproductive efficiency. From a socio-economic viewpoint, given that livestock is central to their livelihoods, such climate-smart interventions should not exclude pastoralist communities living in the arid and semi-arid regions of the country (URT 2015). While the Tanzanian Livestock Master Plan had projected a 77 percent increase in total milk production over a period of five years, this target is still far below the required increase by a factor of 5 as recommended by WHO (from a current intake of 40 liters per person per year to a recommended 200 liters) and certainly below the required eightfold increase by 2050 as simulated in this study. In contrast, despite low productivity rates, milk production already exceeds current demand, which in turn points to the need for public awareness campaigns to shift consumer behavior toward higher milk intake (URT 2017).

In a similar vein, several studies show that while plant-based proteins have a better environmental profile, the lifecycle environmental impacts of animal proteins can vary widely, with eggs, dairy, non-trawling fish, non-recirculating aquaculture, poultry, and pork performing much better than trawling fish, recirculating aquaculture, and red meat. As such, the same nutritional outcomes may be obtained by introducing certain environmental-smart substitutions among the required simulated annual supplies (Clark et al. 2019; Tilman and Clark 2014; Deprá et al. 2022). In line with this observation, the Fisheries Sector Master Plan (URT 2022) emphasizes the importance of the aquaculture sector in boosting the supply of proteins. Given the marked difference in required annual fish supplies by 2050 following ELRD and HMAD requirements (that is, 1.1 versus 4.8 million tons), this substitution option may represent an important lever to reconcile healthy diets and environmental sustainability. Yet, without effective regulatory oversight, this strategy of aquacultural expansion may carry environmental and public health risks, including overfishing, the outbreak of fish diseases and antimicrobial resistance (Eklöf et al. 2006; Ottinger et al. 2016; Paul and Vogl 2011; Primavera 2006).

Apart from addressing possible mismatches in priority food crops and increasing their agricultural output, two other strategies could be put forward to help supply more healthy food to Tanzanian households in an environmentally sustainable way. To culminate into solid recommendations, each of these strategies, however, requires more contextual data and in-depth investigation.

The first involves increased commercialization and the reduction of PHL along the entire food supply chain. While accurate and contextualized data are largely missing, especially in fruit and vegetable value chains (Ambuko et al. 2025), PHL in Tanzania are estimated to be at around 40%, with substantial variation depending on crop type and geographical area (URT 2019). Undeniably, PHL not only represent a direct waste of land, water, labor and capital resources, but these high loss levels are also staggering considering the food security and nutrition challenges of the country. In addition, climate change might further exacerbate the level of PHL given the negative impact of changing temperature, rainfall, humidity, and extreme weather events on storage and processing activities (Stathers, Lamboll, and Mvumi 2013; Ndiritu and Ruhinduka 2019). More in general, the rural-urban food supply linkages in Tanzania remain poorly developed, with storage, processing and transport infrastructure being mostly inadequate and its organization being informal or not adapted to equitably include small producers, traders and processors. In addition, the biggest food processing companies in Tanzania focus on value chains which are less critical to future healthy diets, such as sugar and cereals, while most of the domestic food items procured through supermarkets might remain inaccessible to poorer consumers (Wenban-Smith, Faße, and Grote 2016).

Despite the explicit acknowledgement of issues related to commercialization and PHL by the Tanzania government, as reflected in the National Post-harvest Management Strategy for the 2019-2029 period (URT 2019), the focus of most agricultural policies and development programs remains on agricultural production with the PHL agenda being only poorly integrated in the overall policy framework (Rutta 2024). In the 2024 AMP document, however, two flagship projects could directly help reduce PHL. The first relates to the development of warehouses and processing infrastructure, especially targeted at cashew, sisal, chicken, fish, dairy and packaging (Flagship 9), while the second focuses on increasing cold chain and export capacity and mainly involves red meat, poultry, dairy, fish, and horticultural products (Flagship 10) (URT 2024d). Given the prevailing budget constraints in general, considerable attention should also be devoted to raising awareness and sharing information on low-cost tools and technologies to abate PHL along the entire value chains (Teutsch 2019). While modern technologies, like solar-powered cold storage units or the ones listed under Flagship 9 and 10, might be promising under certain conditions, they are certainly no panacea given the high investment costs and limited financial resources of most farmers and other actors in the value chain (Rutta 2022).

The second strategy to sustainably supply more nutritious foods to Tanzania's growing cities is to invest in and create the right policy environment for "urban agriculture" (which in itself remains a poorly defined concept). By shortening the distance between production and consumption centers, the logistical burdens linked to storage, processing and marketing of nutritious foods, especially those with higher perishability rates, could be attenuated. In addition, the reduction in transport costs and corresponding CO2 emissions has direct beneficial effects on food affordability and climate mitigation, while providing environmental services to cities and developing a more circular economy through nutrient recycling (Lee-Smith 2010; Magigi 2013). While urban agriculture is becoming more important and recognized as an economic activity in Tanzania (Lee-Smith 2010), more context-specific analyses are however needed to design and implement the right policies. In Dar es Salaam for example, where urban agriculture is more competitive and lucrative compared to Moshi, the main issue involves access to land and water while technical and marketing skills are the major constraints in the latter city (Schmidt, Magigi, and Godfrey 2015). Similarly, in terms of food retail and processing infrastructure, there are huge differences between Mwanza, Arusha, and Dar es Salaam, with the former city being at an early stage of development, while Arusha has made substantial progress in food processing capacity (especially given its relatively small size) and Dar es Salaam stands out regarding retail as manifest in the countless supermarkets opening constantly (Ijumba et al. 2015). In addition to the need for more contextualized studies on urban agriculture, special attention should be devoted to making policies more pro-poor while recognizing that the overall positive effect of urban agriculture on dietary diversity might be moderate (Lee-Smith 2010; Sangwan and Tasciotti 2023).

CONCLUSIONS

Based on specific procedures to account for population growth and to contextualize international reference diets, this study provides an overview of the changes in food supplies needed to secure a healthy diet for the Tanzanian population by 2050. While the demographic component is based on an extrapolation of intercensal region- and area-specific growth rates, the contextualization method stems from observed spatial food preferences with households whose consumption levels are near the food group targets defined by the EAT-*Lancet* Reference Diet (ELRD) and the Hypothetical Micronutrient Adequate Diet (HMAD). The input data used for this analysis involve the 2012 and 2022 census rounds combined with a household food consumption survey conducted in 2020/21 across the country's four analytical strata.

Comparing current and required annual food supplies for different food types, this study identifies the following main implications and potential policy entry points for a more efficient, nutritious, sustainable, and equitable transformation of the country's food system.

First, to provide Tanzania's population with healthy diets in 2050, total food supplies should more than double from 24 million tons per year in 2020/21 to 52 million tons per year under ELRD and to 62 million tons per year under HMAD. While this increase is much in line with the expected population growth rate, increased urbanization implies that relatively fewer (rural) people will be responsible for producing and supplying more food, which in turn requires that the overall food system should be organized more efficiently.

Second, the output of the country's food system should dramatically change in terms of composition, especially to be able to supply enough vegetables, oil products, fruit, dairy, and eggs (following the requirements of both reference diets) as well as sufficient amounts of meat and fish under HMAD. In contrast, the increase in supplies for the other food groups could either be in line with or markedly lower than the expected population growth rate. The latter especially applies to sugar and cereal products, of which the supplies in 2020/21 were almost sufficient to adequately nourish the population in 2050.

Third, while the required shifts in total agricultural output to secure healthy diets appear feasible for most food items under current optimal technological conditions, serious environmental challenges exist – especially with respect to ASF supplies. As a result, future policies of agricultural intensification to develop related subsectors should consider the overall impact on the environment and related use of natural resources. In addition, given the diverse environmental impacts of different ASF, several substitutions may be present to reach nutritious diets while minimizing environmental impacts.

Fourth, due to inadequate infrastructure and informal supply chain organization, the country also suffers from significant levels of PHL, particularly in fruit and vegetable value chains. Addressing these losses would not only increase vital supplies of nutritious food but also represent a more efficient use of limited natural and other resources. In addition, promoting urban agriculture might be another strategy to overcome logistical challenges, lower transport costs and GHG emissions, and increase the supply of nutritious food to rapidly growing cities.

Finally, while the Tanzania Agriculture Master Plan with its 20 priority commodities provides a solid policy foundation to guide future food system transformations, more attention could be devoted to eggs, mangoes, oranges, onions, and several leafy vegetables, given their importance in current and future diets. Further, despite being explicitly acknowledged as a critical issue, PHL remain insufficiently integrated in the overall policy framework. Regarding urban agriculture, more context-specific analyses are needed to account for differences in food retail, processing infrastructure, land availability, and private sector development among the major cities in Tanzania.

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ACKNOWLEDGMENTS

The authors are grateful to Monica Kauky for her research assistance on a previous version of this report. All errors remain the authors’ sole responsibility. The authors would also like to thank Pamela Stedman-Edwards and other members of IFPRI’s Communications and Public Affairs Division for copyediting and related publication services.

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ANNEX

Table A1: Current and required annual supplies per food item, Tanzania (2020/21 and 2050)

Food group	Item	Current annual supplies (in tons, 2020/21)	ELRD		HMAD	
			Annual supplies (in tons, 2050)	Growth factor	Annual supplies (in tons, 2050)	Growth factor
Roots/tubers	Yams/Cocoyams	141,284	0	0.0	128,587	0.9
	Other Starches	47,744	0	0.0	144,262	3.0
	Sweet Potatoes	1,121,664	381,255	0.3	1,383,530	1.2
	Cassava Fresh	691,700	259,471	0.4	1,499,963	2.2
	Cooking Bananas, Plantains	1,275,634	479,446	0.4	1,603,099	1.3
	Cassava Dry/Flour	499,075	276,846	0.6	577,527	1.2
	Irish Potatoes	560,946	557,200	1.0	1,737,299	3.1
Sugar	Cakes and Biscuits	8,867	997	0.1	1,912	0.2
	Sugarcane	377,340	71,084	0.2	61,146	0.2
	Buns	264,483	81,988	0.3	76,437	0.3
	Honey, Syrups, Jams, Marmalade, Jellies, Canned Fruits	56,878	39,522	0.7	33,533	0.6
	Sugar	554,096	1,012,918	1.8	996,589	1.8
	Sweets	2,842	5,106	1.8	2,914	1.0
Cereals	Barley Grain and Other Cereals	6,495	0	0.0	0	0.0
	Maize (Green, Cob)	304,694	95,745	0.3	96,972	0.3
	Other Cereal Products	26,939	11,041	0.4	9,966	0.4
	Rice (Paddy)	54,459	32,061	0.6	29,574	0.5
	Millet and Sorghum (Grain)	18,818	11,524	0.6	0	0.0
	Millet and Sorghum (Flour)	155,426	126,845	0.8	121,985	0.8
	Bread	239,183	212,109	0.9	175,777	0.7
	Maize (Flour)	5,141,615	4,990,902	1.0	5,309,934	1.0
	Rice (Husked)	2,598,506	2,883,717	1.1	2,854,767	1.1
	Maize (Grain)	233,613	282,550	1.2	218,956	0.9
	Wheat Flour	261,851	316,969	1.2	357,847	1.4
	Macaroni, Spaghetti	67,636	104,108	1.5	165,383	2.4
Fish	Packaged/Canned Fish	136	0	0.0	0	0.0
	Kolekole (Fresh)	15,156	16,452	1.1	287,024	18.9
	Tilapia (Fresh)	37,971	40,850	1.1	429,454	11.3
	Other Fresh Fish and Seafood	146,941	181,635	1.2	1,358,717	9.2
	Dagaa (Fresh)	194,994	336,076	1.7	1,263,166	6.5
	Dried/Salted/Canned Fish and Seafood (Incl. Dagaa)	180,756	519,349	2.9	1,508,098	8.3
Meat	Wild Birds and Insects	513	0	0.0	0	0.0
	Other Domestic/Wild Meat Products	1,219	0	0.0	0	0.0
	Other Poultry	6,683	0	0.0	0	0.0
	Goat Meat	150,152	148,141	1.0	180,604	1.2
	Chicken	204,505	337,798	1.7	627,624	3.1
	Pork (Including Sausages and Bacon)	44,976	78,766	1.8	230,176	5.1

Food group	Item	Current annual supplies (in tons, 2020/21)	ELRD		HMAD	
			Annual supplies (in tons, 2050)	Growth factor	Annual supplies (in tons, 2050)	Growth factor
	Beef (Including Minced Sausage)	366,364	1,115,923	3.0	2,244,682	6.1
Legumes/nuts	Seeds and Products from Nuts/Seeds (Excl. Cooking Oil)	3,645	0	0.0	6,532	1.8
	Coconuts (Mature/Immature)	407,992	876,493	2.1	690,225	1.7
	Cashew, Almonds and Other Nuts	17,120	39,217	2.3	69,148	4.0
	Groundnuts In Shell/Shelled	192,787	514,478	2.7	502,056	2.6
	Green Beans	264,816	714,875	2.7	636,537	2.4
	Other Beans, Lentils, and Pulses	660,679	2,119,569	3.2	1,968,368	3.0
	Peas	129,329	620,912	4.8	543,666	4.2
Vegetables	Canned, Dried, and Wild Vegetables	68,927	212,208	3.1	219,076	3.2
	Onions	387,466	1,334,356	3.4	1,226,849	3.2
	Other Green Vegetable	754,711	2,704,165	3.6	2,239,042	3.0
	Cabbage	226,980	850,342	3.7	577,444	2.5
	Tomatoes	1,144,722	4,533,959	4.0	3,846,197	3.4
	Carrots and Green Pepper, Other Vi-ungo	221,589	904,625	4.1	738,821	3.3
	Chiness/Spinach	290,575	1,185,652	4.1	962,743	3.3
Oil	Butter, Margarine, Ghee and Other Fat Products	8,398	8,763	1.0	8,321	1.0
	Cooking Oil	459,617	2,015,806	4.4	1,984,981	4.3
Fruit	Other Fruits	149,167	503,670	3.4	401,781	2.7
	Mangoes	505,944	1,898,532	3.8	2,020,322	4.0
	Lemon/Lime	93,693	405,171	4.3	339,783	3.6
	Ripe Bananas	462,682	2,211,768	4.8	2,574,990	5.6
	Orange/Tangerine	227,175	1,116,445	4.9	1,315,445	5.8
	Avocado	245,723	1,494,873	6.1	1,641,918	6.7
	Other Citrus Fruits	20,745	186,412	9.0	382,488	18.4
Dairy	Canned Milk/Milk Powder	1,303	0	0.0	0	0.0
	Milk Products (Like Cream, Cheese, Yoghurt, etc.)	358,356	1,614,978	4.5	1,823,785	5.1
	Fresh Milk	773,292	8,156,110	10.5	7,517,375	9.7
Eggs	Eggs	53,581	508,097	9.5	1,954,218	36.5
TOTAL		24,193,168	51,739,870	2.1	61,909,615	2.6

Note: The food groups and food items in this table are ranked by the ELRD growth factor.

Source: Authors based on NPS (2020/21), Willett et al. (2019) and Beal, Ortenzi, and Fanzo (2023).

This publication was prepared in the context of the Strengthening Food Systems to Promote Increased Value Chain Employment Opportunities for Youth partnership with the Mastercard Foundation. It is a five-year initiative running between 2022 and 2027 to gain insight into the latest trends and challenges in agrifood systems, and how addressing market inclusion and postharvest losses can enable dignified and fulfilling livelihoods for young women and men. The views expressed do not necessarily represent those of the Foundation, its staff, or its Board of Directors. This publication has not been independently peer reviewed. Any opinions expressed here belong to the author and are not necessarily representative of or endorsed by IFPRI.

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