Fruit and Vegetables for Sustainable Healthy Diets

# Improving Fruit and Vegetable Consumption and Production in Tanzania: An Evaluation of the FRESH end-to-end approach

## Study Protocol

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**List of Abbreviations**

| | |
|---|---|
| FAO | Food and Agriculture Organization |
| FE | Food environment |
| FFQ | Food frequency questionnaire |
| FIES | Food Insecurity Experiences Scale |
| FRESH | Fruit and Vegetables for Sustainable Healthy Diets |
| F&V | Fruit and vegetables |
| GAP | Good agricultural practices |
| IPM | Integrated pest management |
| LMICs | Low- and middle-income countries |
| RCP | Relative caloric price |
| WHO | World Health Organization |
| WRA | Woman of reproductive age |

# Summary

In Tanzania, poor diets, especially low fruit and vegetables (F&V) intake, contribute to poor nutritional status and non-communicable diseases mortality and morbidity. The FRESH project implemented in Northern Tanzania uses a holistic approach to address supply, demand, and food environment (FE) barriers to F&V production and intake. The approach starts from understanding F&V intake, barriers to increasing it, and ways to influence consumer behaviour, and works back through the value chain to improve vegetable biodiversity and seed systems, safe and sustainable vegetable production, and FEs. This comprehensive approach recognizes the complexity of food systems and the need for coordinated change to transform diets.

This study aims to: (1) evaluate the changes over time in production of vegetables and F&V intake among farmers and non-farmer households; and (2) assess the impact of the FRESH approach on vegetable production and F&V intake among farmer and non-farmer households and individuals within them. We hypothesize that the FRESH holistic approach will increase availability, accessibility, affordability, and desirability of F&V. These changes are expected to positively influence consumer behaviour and lead to higher F&V intake and improved diet quality. Additionally, we hypothesize broader benefits on women's time use, household expenditures, and nutritional status.

The study uses a longitudinal cluster-randomised controlled trial design. It will take place in 33 villages in 14 wards with FRESH supply activities across five districts in Arusha and Kilimanjaro region. Villages will be randomly assigned to one of three intervention groups: control, supply, or supply+demand+FE. All households with WRA (15-49 years) and adolescents (10-14 years) will be invited to participate in the study. ~2,800 households (~940 per group) will be invited to participate in the study.

Household surveys (baseline Oct-Nov 2023, follow-up Oct-Nov 2024) will collect information on household characteristics, women's empowerment, water and food security, agricultural production, drivers of food choice, F&V knowledge, anthropometry, and women's diet. Village questionnaires will collect community-level information. Lastly, a FE census will be conducted within the participating villages to sample markets and retailers for a FE survey (bi-monthly between baseline and follow-up).

The study will generate evidence on the effectiveness of the FRESH end-to-end approach (and the interventions within it) in improving vegetable production and F&V intake. The findings will help inform programs and policies related to diet, nutrition, food systems, and public health in Tanzania.

# 1. Introduction

## 1.1 Background

Poor diets are a primary cause of malnutrition and the leading cause of disease worldwide (Afshin et al., 2019; FAO et al., 2020; Global Panel on Agriculture and Food Systems for Nutrition, 2016). Improving diets, including increasing fruit and vegetable (F&V) intake, could save one in five lives annually (Afshin et al., 2019). Micronutrients are essential for health; those obtained from F&Vs have a lower environmental footprint than those obtained from other foods making F&Vs essential to healthy and sustainable diets. Globally, F&V intake is far below recommended levels (Willett et al., 2019). However, the extent and nature of the problem is poorly understood due to insufficient dietary data, especially in low- and middle-income countries (LMICs). Increasing F&V intake will require starting with consumers, understanding dietary patterns, and addressing desirability, accessibility, affordability, and availability barriers through cost-effective solutions using an end-to-end approach.

Even when F&V are accessible and affordable, intake is too low (Ruel et al., 2004) highlighting the role of desirability in F&V intake. Context- and population-specific, cost-effective multi-channel behavioural and experiential approaches (Varman et al., 2021) and policy changes are needed to improve F&V desirability. Cost-effectiveness may be optimized by targeting programs and policies towards those whose preferences are most malleable (e.g., young children (Ventura & Worobey, 2013) and adolescents (Viner et al., 2015)) and/or influential (e.g., women (Quisumbing et al., 2020)).

Improving accessibility necessitates bringing consumers and the foods they desire closer together. This can be accomplished in several ways such as increasing home production of F&Vs (Olney et al., 2015) or altering the physical food environment.

More than 3 billion people cannot afford a healthy diet (Hirvonen et al., 2020). Often, F&V are among the least affordable foods (FAO et al., 2020). On the demand side, affordability of F&Vs can be increased with social assistance programs (e.g., school-feeding programs or cash-based transfers), or through providing fair wages for workers. On the supply side, increasing availability is essential to reducing cost of F&Vs and accommodating increased intake. The gap between F&V supply and demand is projected to remain large globally, especially in sub-Saharan Africa (Mason-D'Croz et al., 2019). To provide enough vegetables for healthy diets production likely needs to increase by 75% by 2050 in addition to reducing postharvest losses, estimated at 30-50%. To attain this, system-wide improvements are needed such as improving farmer access to and use of quality seed of resilient cultivars, irrigation, safe pest management technologies and appropriate post-harvest handling (e.g., cold chains, shorter supply chains). Lastly, institutional or socio-economic constraints on marginalized groups (such as unequal pay or zero-hours contracts) should be removed so F&V sector jobs are safe and profitable.

## 1.2 Statement of the problem

The EAT-Lancet report (Willett et al., 2019) demonstrated the need to transform global diets through reduced consumption of unhealthy foods such as sugar and red meats and increased consumption of healthy foods such as F&Vs. Solutions for improving diet quality, in part by increasing F&V intake, are urgently needed. These solutions will need to be multifaceted and interconnected. FRESH will use a

holistic end-to-end approach to address these challenges in Northern Tanzania. The approach starts from F&V intake and understanding barriers to increasing F&V intake and how to influence consumer behaviour and works back through the value chain to address how this can be improved through improving vegetable biodiversity and seed systems, safe and sustainable vegetable production, and food environments. This approach recognizes the complexity of food systems and the need for coordinated change in many parts of the food system in order to transform diets.

In this study, we will examine changes over time in production of vegetables, household consumption, and dietary intake along with associated outcomes such as women's time use, household expenditures and more. In addition, we will assess the impact of the FRESH end-to-end approach and interventions within it in improving vegetable production and F&V intake.

### 1.3 Rationale

In Tanzania, both undernutrition and overnutrition are major public health concerns, with almost a third of Tanzanian children under 5 years stunted and almost a third of women of reproductive age either overweight or obese (Ministry of Health, Community Development, Gender et al., 2016; Ministry of Health (MoH) [Tanzania Mainland] et al., 2023). Suboptimal diet is associated with a range of non-communicable diseases (NCD) and is a major contributor to NCD mortality globally (Afshin et al., 2019). One of the nutritional risk factors of poor health and nutrition status is low F&V intake. Specifically, in Tanzania a survey conducted in 2012 showed that almost all Tanzanians (>95%) had insufficient F&V (Ministry of Health and Social Welfare & National Institute for Medical Resarch, 2012).

Under the leadership of the Prime Minister's office, Tanzania developed an ambitious action plan (National Multisectoral Nutrition Action Plan 2016–2021 and 2021/22 – 2025/26) to reduce multiple burdens of malnutrition associated with both deficiency and excess and imbalance. The overall goal is to scale up high-impact interventions among the most vulnerable people (infants, children under five years of age, adolescent girls, women of reproductive age, including pregnant and lactating women) as well as other population groups (early childhood, middle childhood, adult males, and the elderly). The plan focuses on maternal, infant, young child and adolescent nutrition; micronutrient deficiencies; acute malnutrition and diet-related NCDs; interventions across sectors; nutrition governance; and nutrition information systems (*2022 Global Nutrition Report: Stronger Commitments for Greater Action*, n.d.). The FRESH multisectoral end-to-end approach fits well within this plan and aims to address dietary quality by improving F&V intake. Evidence related to the effectiveness of the FRESH approach and its components will be useful for informing future programs and policies in Tanzania. The FRESH project is also fits well with the Government's Second Agricultural Sector Development Programme (ASDP-II) and its focus on increasing agricultural production, improving incomes of smallholder farmers (particularly supporting farming as a business), and ensuring adequate food security for all Tanzanians.

## 2. Methodology

### 2.1 Study location and duration

The proposed study will take place in five districts: two districts in Arusha Region (Arusha and Meru District Councils) and three districts in Kilimanjaro Region (Hai, Siha, and Moshi Rural District Councils) (**Figure 1**).

Fourteen wards with FRESH supply activities be selected to participate in the study: 6 wards in Arusha Region (2 wards in Arusha District Council and 4 wards in Meru District Council) and 8 wards in Kilimanjaro region (1 wards in Hai District Council, 2 wards in Siha District Council, and 5 wards in Moshi Rural District Council). Within the selected wards, a total of 33 villages will be randomly selected to participate in the study. For the food environment assessment component of the study (described below), market questionnaires will be conducted in a slightly expanded area, including 10 additional wards within the 5 study districts, and 1 ward in the Moshi urban district. This expanded area will ensure that main markets utilized by study villages for fruit and vegetable purchases can be studied.

The project is planned for two years, June 2023 to June 2025 and will involve a minimum of two rounds of data collection (one in 2023 and one in 2024). Depending on funding, the study will be extended by six years and collect up to six additional survey rounds.

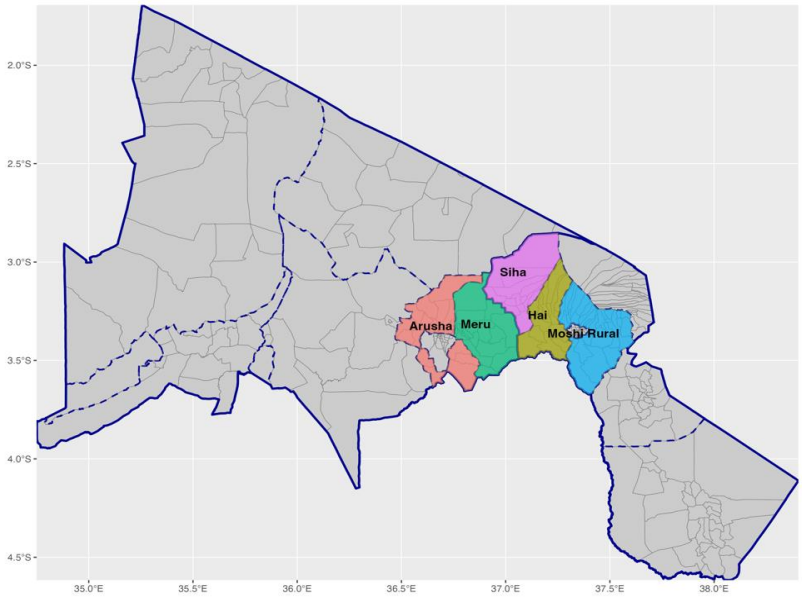


**Figure 1** Districts in the Arusha and Kilimanjaro Regions where the study will take place

## 2.2 Study design

The objective of this study is to evaluate (1) the changes over time in production of vegetables and dietary intake of F&V, and (2) the impact of supply (i.e., increased production of vegetables and post-harvest processes for F&V), demand (i.e., increased demand for F&V), and food environment (i.e., increased accessibility, affordability, and promotion of F&V) interventions (alone or in combination) on production of vegetables and dietary intake of F&V.

We will use a longitudinal cluster-randomised controlled trial design with a minimum of two survey rounds (baseline and first follow-up) (**Figure 2**) and up to six additional surveys rounds, depending on funding. This study will take place in 14 wards in which FRESH supply activities are expected to be implemented ("supply wards" hereafter). From the 63 villages within these wards, 33 villages will be selected assigned to one of three intervention groups: control, supply, or supply+demand+FE. Seventeen villages with supply activities will be randomly assigned to supply or supply+demand+FE and 16 villages will be randomly selected from the remaining villages to participate in the study. Randomization will be stratified

by village size. The 33 villages will be randomly assigned to one of three intervention groups: control (n=10 villages), supply (n=11 villages), or supply+demand+FE (n=12 villages) (Figure 2). Within all 33 villages, all households that meet the inclusion criteria specified below, i.e., with at least one WRA (15-49 years of age) and at least one adolescent (10-14 years of age) will be invited to participate in the study. If more than one WRA and only one adolescent live in the household, we will enrol the mother-child pair, i.e., the WRA and her biological child. If the WRA has more than one biological child 10-14 years of age, they will be listed in alphabetical order, and one will be randomly selected. If the adolescent is not the biological child of the WRA, they will not be interviewed. Approximately ~940 households per intervention group will be invited for a total of ~2,800 households.

Within households, we will target WRA (15-49 years of age) given their critical role in activities like agriculture, food purchases, cooking for the family and feeding young children. Dietary practices are difficult to change (de Ridder et al., 2017). Thus, targeting interventions to key life-cycle stages important for habit formation should be prioritized. Some evidence suggests that dietary preferences are influenced in utero (Spahn et al., 2019) and solidified by age three (Ventura & Worobey, 2013). Evidence also shows that early habits persist into adulthood (Craigie et al., 2011; Lien et al., 2001). Influencing women's preferences and empowering them could improve all household members' diets especially their children's (Quisumbing et al., 2020) given their central role in food preparation. Many women are also involved in the production and selling of vegetables. Our demand creation and FE activities will be designed to influence foods that are available and prepared within households as well as selected outside of households and our supply side interventions will be influenced by the needs of farmers, including those of women.

In these same villages, a FE census will also be conducted, which will gather information on the location of all the food retail outlets servicing the villages, the type of outlet (e.g., open-air market, supermarket, retail shop, kiosk, mobile vendor, restaurant), and the variety of food groups they supply. This information will be used to assess physical accessibility to F&V in the study area. Together with key informants' inputs, it will also be used to inform a purposeful sampling of markets and other retail outlets to participate in bi-monthly follow-up surveys from baseline to the first follow-up. These bi-monthly follow-ups will assess year-round availability and cost of F&V, as well as other foods, and other vendor and product properties (e.g., food promotion, storage, safety).

In a sub-set of supply villages, in parallel to the baseline survey, a preliminary qualitative study consisting of in-depth interviews (30-35) and focus group discussions (5-7) will be conducted with a small sample of farmers, farm workers, market traders, and other food environment stakeholders engaged in F&V supply chains. This will capture communities' varied experiences and perspectives on how different models of F&V production are affecting livelihoods, income, food environments and diets and the different social, material, and structural barriers communities face. This initial exploratory work will feed into further qualitative lived experience research expected to take place alongside subsequent survey rounds, dependent on funding.

A second sub-study will be conducted among a subsample of respondents after the baseline survey. This mixed methods study will combine the quantitative data form the baseline with qualitative data consisting of 'shop-along' observations, participatory photo-elicitation interviews, and in-depth interviews with approximately 40 women. The objective of this sub-study is to gain a deeper understanding of consumer behaviours and food safety perceptions related to food environments (including understanding the role

of cultural and traditional factors), to help elucidate intervention opportunities, and to inform subsequent design of research questions.

Another sub-study will be conducted among a subsample of respondents from the baseline survey to assess the level of sustainability of vegetable farms. Sustainability, which is a holistic, complex, and multidimensional concept that encompasses three dimensions (economy, society, and environment), will be assessed using a matrix approach with different indicators. This survey is an essential step in achieving a good understanding of the farming practices in the areas and would help identify critical points to implement sustainable agricultural systems. The data generated will be used to generate recommendations for farmers in the areas that could contribute to achieving a sustainable production of vegetables in the area.

Lastly, a theory-driven process evaluation combining qualitative and quantitative data will be undertaken alongside the follow-up survey to generate meaningful and relevant data on operational and utilization aspects of the FRESH activities. This approach will enable to document the actual functioning of the FRESH activities, measure the level of exposure of the beneficiaries, and understand the perceived drivers of change, and investigate the barriers and facilitators to the adoption of FRESH activities. We will work closely with the partners implementing FRESH activities to identify key process indicators which will be embedded in the quantitative follow-up survey. Additional qualitative research will supplement the quantitative survey data collection to add richness, depth of understanding, and more nuanced perspectives both from implementers and program users. The feasibility for scaling-up the FRESH activities will also be explored.

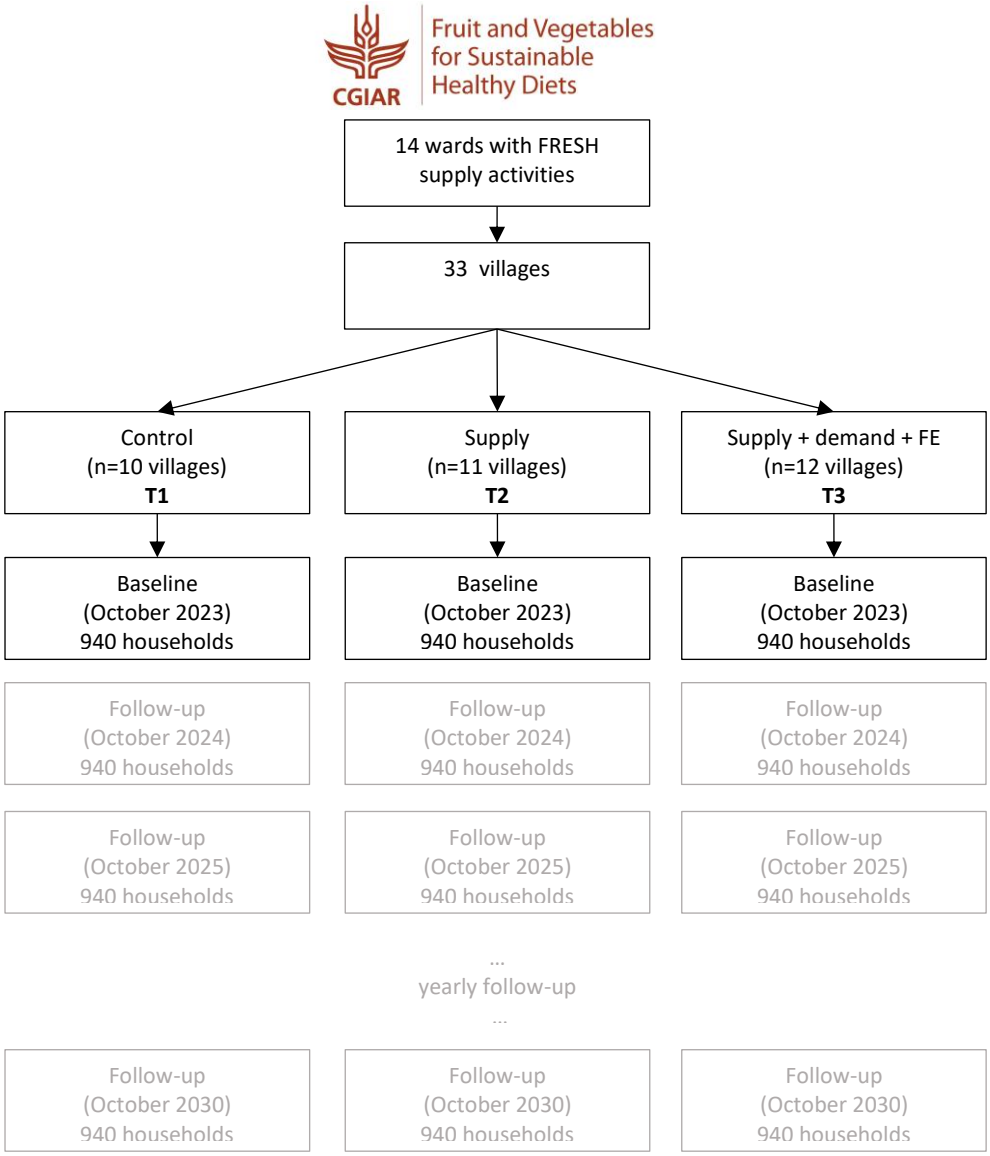


**Figure 2** Study design showing treatment and control groups, sample size, and timing of surveys. Boxes with dashed borders and grey text indicate surveys that will only be conducted if additional funding is available.

## 2.3 Objectives

### 2.3.1 Impact evaluation

The primary objectives of this study relate to (1) understanding the changes over time in production of vegetables and dietary intake of F&V among farmer and non-farmer households and among individuals within those households, and (2) understanding the impact of the FRESH end-to-end approach (and the interventions within it) on production of vegetables and dietary intake of F&V among farmer and non-farmer households and among individuals within those households. We will assess the individual impact of the FRESH supply interventions and the combined impacts of the FRESH supply, demand, and FE interventions. For detailed information on the specific research questions and group comparisons, see

**Table 1**. Given that the FRESH supply interventions focus only vegetables and not fruit, research questions on production pertain only to production of vegetables and not to production of fruit.

**Table 1** Research questions by objective and study group comparisons

| | **Groups compared** |
|---|---|
| **Objective 1** Assess the changes over time in production of vegetables and dietary intake of F&V among farmer and non-farmer households and among individuals within those households (by examining the change over time between baseline and follow-up within the control group) | |
| 1) What are the changes over time in production of vegetables? | Compare control group at follow-up to control group at baseline (T1 follow-up vs T1 baseline) |
| 2) What are changes over time in dietary intake of F&V? | Compare control group at follow-up to control group at baseline (T1 follow-up vs T1 baseline) |
| **Objective 2** Assess the impact of the FRESH interventions on production of vegetables and dietary intake of F&V among farmer and non-farmer households and among individuals within those households (by comparing the change over time between baseline and follow-up in two study groups) | |
| 1) What is the effect of the supply interventions? | Compare supply group to control group (ΔT2 vs ΔT1) |
| 2) What is the combined effect of the supply, demand, and FEE interventions? | Compare supply + demand + FE group to control group (ΔT3 vs ΔT1) |
| 3) What is the added benefit of providing demand and FE interventions together with the supply interventions over providing only supply interventions? | Compare supply + demand + FE group to supply group (ΔT3 vs ΔT2) |

### 2.3.2 Food environment assessment

The primary objectives of the FE assessment are to: 1) characterize market FE in terms of food availability, food affordability, and physical access at baseline, especially with respect to F&V; 2) to assess longitudinal changes in FE throughout the study period; and 3) to test associations between FE measures and dietary intake of F&V. Within the analysis of the food environment's influence on F&V intake, the FE assessment will also aim to assess whether FE and F&V intake associations vary according to intervention participation or agricultural production.

## 2.4 Sample size and power calculation

The impact evaluation has two primary outcomes: (1) fruit and vegetable intake (g/d) among WRA, and (2) number of months vegetables were produced in the past year.

Assuming a power of 80%, type 1 error of 5%, 11 clusters per arm, coefficient of variation of cluster size of 0.46, and an intracluster correlation (ICC) of 0.03, the required sample size to detect an effect size of 10 percentage points (a change from 10% to 20% in any binary outcome) between any two groups at any time point is 726 households per arm (66 households per village) for a total of 2,178 households. Given mean vegetable intake of 80 g/d (SD 150 g/d) among a nationally representative sample of Tanzanian

adults 25-64 years of age (Kalmpourtzidou et al., 2020), this sample size would allow us to detect a difference of 42.3 g/d in vegetable intake. Data on fruit intake from Tanzania is limited. Estimates from Sri Lanka, another one of the FRESH focal countries, showed per capita mean fruit consumption of 161 g/d (SD 171 g/d). Using this estimate, the estimated sample size would allow us to detect a difference of 48.4 g/d. Thus, the estimated sample size of 2,178 households would allow us to detect relatively small changes in F&V intake (small relative to global WHO recommendation of ≥400 g of F&V/day), which would be important given the limited evidence of the effect of supply, demand, and FE interventions individually or combined on F&V intake. Accounting for 20% loss to follow-up, we would need 871 households per intervention arm (80 households per village), or a total sample size of 2,614 households.

Data from the villages with WP2/3 activities suggests an average size of 672 households per village. Data from the 2015-16 DHS suggests that 14.6% of rural households in the Arusha and Kilimanjaro regions have an adolescent 10-14 years of age. This implies that 94 households per village will have an adolescent 10-14 years of age, which will allow us to meet the required sample size of 80 household per village even in the event of imperfect compliance (i.e., some households refuse to participate in the survey). Three additional villages will be randomly selected (one per intervention arm) to serve as back-up in case the required sample size is not achieved in the 33 primary villages.

We do not have data on the agriculture production indicator. However, we use information on three different but related indicators of production from a household survey in rural Bangladesh. These are number of homestead crops cultivated, total harvested quantity of vegetables (in kilograms) and total harvested quantity of fruits (in kilograms). With a sample of 726 households per cluster, the detectable difference in number of homestead crops is 1.0 crops; the detectable difference in total quantity of harvested vegetables is 0.95 kg; and the detectable difference in total quantity of harvested fruit is 0.95 kg.

## 2.5 Sampling procedures

### 2.5.1 Selection of regions

Arusha and Kilimanjaro regions are among the large producers and suppliers of horticultural crops including fruit and vegetables in Tanzania. Despite being among large producers and suppliers of horticultural crops in Tanzania, the regions are also faced with numerous challenges including high levels of contamination of both chemicals and microbial contaminants, loss of soil fertility, high levels of postharvest losses, limited judicial use of pesticides, counterfeit seeds, among others. The Arusha and Kilimanjaro Regions were also selected as twin regions offering two diverse agroecologies: intensive vegetable ecology and extensive staple ecology. The second criterion was a history of agricultural activities implemented by the World Vegetable Center (part of the FRESH Initiative) and the Tanzania Agricultural Research Institute (TARI) which implements activities as a partner to the World Vegetable Center. In intensive vegetable ecology, FRESH supply activities are focused on enhancing year-round supply of safe and sustainable vegetables with special emphasis on food safety, quality, diversity and on enhancing resource use efficiency vis-a-vis sustainability. In extensive staple ecology, the emphasis is towards using vegetables for sustainable diversification and intensification of staple production systems using vegetables and enhancing system efficiencies while optimizing synergies between a vegetable crop and vegetables.

### 2.5.2 Selection of districts

Within the Arusha and Kilimanjaro regions, the five districts where the study will take place were selected as high vegetable producing districts. Stakeholders including government extension staff were involved in the selection process for the districts, which focused on selecting areas with the two agroecologies of interest: areas with high vegetable production and areas with mostly cereal-based cropping systems with limited or no vegetable production.

### 2.5.3 Selection of wards

This study will take place in 14 wards across the Arusha and Meru Districts Councils in Arusha region and the Hai, Siha, and Moshi Rural District Councils in Kilimanjaro region. The fourteen wards were selected because FRESH supply activities are implemented or are planned to be implemented there.

### 2.5.4 Selection of villages

This study will take place in a total of 33 villages, which will be randomly selected from the 63 villages in the 14 supply wards, stratifying for village size. Of these 63 villages, 16 villages have or will have production hubs. The randomization algorithm will be re-run until all 16 villages are allocated to one of the two of supply arms (T2 or T3). Three additional villages will be randomly selected (one per intervention arm) to serve as back-up in case the required sample size is not achieved in the 33 primary villages.

### 2.5.5 Selection of households

Within the 33 villages, all households that meet the inclusion criteria below, including having at least one WRA (15-49 years of age) and at least one adolescent (10-14 years of age), will be invited to participate int the study. Approximately ~940 households per intervention group will be invited for a total of ~2,800 households.

### 2.5.6 Selection of individuals within households

In each household, one woman of reproductive age (15-49 years of age) who meets the inclusion criteria will be invited to participate in the survey along with the household head (if different than the selected woman). If more than one WRA and only one adolescent live in the household, we will enrol the mother-child pair, i.e., the WRA and her biological child. If the WRA has more than one biological child 10-14 years of age, one will be randomly selected. If the adolescent is not the biological child of the WRA, they will not be interviewed. In enrolled households, weight, height, and waist circumference of the WRA and adolescent will be assessed. Hip circumference in WRA will also be measured.

Inclusion criteria are:

- Aged 15-49 years at enrolment
- At least one adolescent 10-14 years of age resides in the household at enrolment
- Resides in one of the 33 selected villages at enrolment
- Plans on remaining in the study area for the duration of the study
- Provides informed consent

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Food environment surveys in open-air markets will not gather vendor-specific data or any personal identifying information from vendors, but data collection will only proceed with those vendors that give their permission for the enumerators to observe their trade and ask questions where needed. In non-market retail outlets (e.g., stand-alone retail shops, kiosks, or streetside vendors), vendors' names (for purposes of identifying shops) and background information on vendor's age and sex will be gathered; therefore, informed consent will be sought from these vendors. Only those vendors who provide informed consent will be enrolled in the food environment study.

### 2.5.7 Selection of markets and other retail outlets for the food environment assessment

A FE census will also be conducted in the 33 study villages to attain a listing of all the food retail outlets in the study area. From this census and input from key informants, including listings of public markets maintained by the government, the main access points for F&V will be identified. This study will seek to gather data in the main open-air market used by each study village (~14) and at least 3 other (non-market) retail outlets in each study village (~99 outlets in total), which may include retail shops, kiosks, grocery stores, streetside vendors, or other outlet types (weekly markets), purposefully selected to monitor the most important retail access points for F&V. Individual vendors within open-air markets and owners of the selected non-market retail outlets will be invited to participate in the study.

## 2.6 Randomization of villages to interventions

As described earlier, the 33 villages will be randomly assigned to one of three intervention groups: control (n=10 villages), supply (n=11 villages), or supply+demand+FE (n=12 villages) (Figure 2). The study statistician will create a computer-generated randomization algorithm randomly selecting 33 villages stratified by village population size. The randomization algorithm will allocate the 17 villages that have or will have production hubs to supply arms (T2 or T3). At this point, the village ID will be Intervention assignment will not be revealed linked to one of the three study codes indicating the intervention that the village will receive. At the village level, intervention assignment will not be revealed to avoid any potential social desirability bias in responses.

## 2.7 Data collection

Prior to the baseline survey, we will conduct a food environment census that will assist in sampling of markets and vendors.

For the household participating in the study, data will be collected using household surveys, a dietary intake survey, and anthropometric assessment. These assessments will be conducted at baseline and follow-up. We will also conduct a village survey at baseline. Selected modules from the village surveys will be conducted annually. Market and retail surveys will be conducted bi-monthly from baseline to follow-up. An overview of the methods, sample size, and estimated time needed for each data collection method is provided in **Table 2**. More detailed explanations on the different methods are provided in the sections below.

**Table 2** Data collection methods for the evaluation

| Methods | Sample size (n) | Estimated duration | Time points |
|---|---|---|---|
| Village survey | 33 villages | 30 minutes per village | Baseline |
| Household survey | ~2800 households | Head of household: 75-90 mins; WRA: 60-75 mins | Baseline and follow-up |
| 24-hour diet recall | ~2800 women of reproductive age with ~700 repeat recalls | 30-40 minutes per recall | Baseline and follow-up |
| Nutritional status (height, weight, waist circumference, hip circumference) | ~5,600 household members<br><br>The ~2800 WRA and ~2800 adolescents 10-14 years of age per households | 20-30 minutes | Baseline and follow-up |
| Food environment census<br>Food environment survey | 33 villages<br><br>~ 14 open-air food markets, and<br>~ 99 retail outlets | 10-15 mins per retail outlet<br>80 – 175 minutes per market, and 65-90 minutes per shop, kiosk, or stall | Baseline<br><br>Baseline and bi-monthly follow-ups |

### 2.7.1 Village survey

To understand village-level factors in each of the study sites that may relate to the study outcomes, a village survey will be conducted with 3-4 key informants (e.g., village leader, village chairperson, village executive secretariat) with knowledge of the infrastructure; community groups; agricultural, health, nutrition, and development programs implemented in the village; transportation; electricity; shocks or unexpected events experienced by the community/village in the past 5 year; and seed systems.

### 2.7.2 Household survey

Household-level data at baseline and follow-up will be collected using quantitative questionnaires. Dietary intake for the index WRA will directly assessed. Anthropometry (weight, height, and waist circumference) will also be directly assessed for the index WRA and adolescent. Hip circumference will also be directly assessed in WRA. An overview of the survey modules, assessment methods, respondent, and estimated time needed for data collection is provided in **Table 3**. More detailed explanations on the different methods are provided in the sections below.

**Table 3** Survey modules, assessment methods, respondent, and estimated time needed for the household survey

| Survey module | Assessment method | Preferred respondent | Estimate duration per survey module |
|---|---|---|---|
| Household characteristics | Self-report | Household head | 10-15 minutes |
| Household assets | Self-report | Household head | 5-10 minutes |

| Survey module | Assessment method | Preferred respondent | Estimate duration per survey module |
|---|---|---|---|
| Livestock ownership | Self-report | Household head | 5-10 minutes |
| Drivers of food choice | Self-report | WRA | 15-20 minutes |
| Food safety perceptions | Self-report | WRA | 5-10 minutes |
| Women's empowerment | Self-report | WRA<br>Household head | 20 minutes<br>20 minutes |
| Food consumption and expenditures | Self-report | Household head | 15-20 minutes |
| Non-food expenditures | Self-report | Household head | 10-15 minutes |
| Household food security | Self-reported | Household head | 5-10 minutes |
| Water security | Self-report | Household head | 5 minutes |
| Agricultural production | Self-report | Household head | 30-45 minutes |
| Unexpected events/shocks | Self-report | Household head | 10 minutes |
| Fruit and vegetable knowledge | Self-report | WRA | 5 minutes |
| Social desirability bias | Self-report | WRA | 2 minutes |
| Anthropometry | Direct assessment | WRA<br>Adolescent 10-14 years of age | 20-30 minutes |
| Dietary intake | Quantitative multi-pass 24-hour recall | WA | 30-40 minutes |
| | F&V food frequency questionnaire | WRA | 10-15 minutes |

Note: All modules will be collected at both baseline and follow-up. Abbreviations used: WRA, woman of reproductive age.

*Household characteristics*

This purpose of this module is to collect the household's dwelling characteristics such as floor, roof, wall material, number of rooms, primary source of energy for lighting and whether the dwelling is rented. In addition, the module will collect information on ownership of agricultural or non-agricultural (i.e., residential, commercial) land. Data from this module will be used to construct control variables for data analysis such as household wealth index.

*Household assets*

This module collects information on household ownership of different types of assets. These assets include common household items, such as radio, television, table, sofa as well as agricultural assets such as rakes, tractors, and water pumps. Additionally, it covers modes of transportation like carts, bicycles, cars, among others. Data from this module will be used in the construction of a household wealth index.

*Livestock ownership*

This module will be used to collect information on household ownership of livestock in the past 12 months. Livestock includes draught animals, cattle, sheep, pigs, chickens, among others. This data will help us assess the types of pastoral activities the household is involved in.

*Drivers of food choice*

This module will be used to understand the household level determinants and behaviours related to purchasing and eating of F&V. The module will be administered to the WRA. The questions will ask about purchasing patterns and intake behaviour for F&V. Various indicators will be created at the market level including markets/sellers accessed, factors driving purchasing decisions, purchasing frequency, and perceived convenience. Questions on eating will assess desirability, habit, preparation, and allocation of F&V. From this module, we will be able to connect food related decision making to actual intake.

*Food safety perceptions*

This module will be used to understand household level perceptions around safety of F&V. The questions related to perceived meaning of food safety, concerns, and measurement of reported safety practices around purchasing and intake.

*Women's empowerment*

Women's empowerment will be measured using specific modules from Abbreviated Women's Empowerment in Agriculture Index (A-WEAI). The A-WEAI is based on the original WEAI launched in 2012 but consists of six composite indicators that can be mapped across six domains of empowerment (i.e., production, resources, income, leadership, and time). For our survey, questions will be asked to both the WRA and her spouse (or the household head if she has no spouse) and will be related to roles in household decision making around agricultural production and income, and time spent on different kinds of day-to-day activities. From these two modules, three indicators will be constructed: input in productive decisions (production domain), control over use of income (income domain), and workload (time domain).

*Household expenditures*

Total per capita household expenditures will be assessed by combining household food and non-food expenditures. For food expenditure the amount and value of food consumed, purchased, from own production, given away and/or received in the past 7 days will be collected. For non-food expenditure the consumption of non-food items, including expenditures on household consumables (soap, candles, etc.), electricity, fuel, health, education, transportation, housing, clothing, tobacco, alcohol, and larger items such as farm equipment, a television, a bike, a car. The recall period will depend on the specific item (the past month or past 12 months).

*Household food security*

The severity of household food insecurity will be measured using the Food Insecurity Experiences Scale (FIES) developed by the FAO (Ballard et al., 2013). The FIES is one of two indicators used for measuring progress toward Sustainable Development Goal 2.1 to end hunger and ensure food access. The version of the FIES used in the current study will be the household version with a 30-day recall period. The FIES includes 8 yes/no items which ask about the household's experiences related to uncertainty or worry about food, inadequate food quality, and insufficient food quantity. Item response theory will be used to measure the level of food insecurity experienced by the respondents (Rasch, 1960).

*Water security*

This module will be used to understand if the household water situation during the last rainy season influenced activities related to vegetable, fruit, and crop cultivation, and livestock and poultry rearing. Frequency of water problems will also be assessed.

*Agricultural production*

To assess changes over time in household production of vegetables, various agricultural indicators will be collected at the plot level. Initially, information will be collected on the total number of plots owned and operated by households, along with their size, soil quality, estimated value, and ownership details. Subsequently, for each plot, data will be collected on the crop type (i.e., staple crop, vegetable, fruit, or permanent crop), area cultivated, quantities harvested and sold, and estimated value of harvested crops for both the short and long rainy seasons. Furthermore, the survey will collect month level information about the types of vegetables harvested, their usage, and their availability in the market. The use of home gardens will also be examined for the types of F&V grown. Additionally, there will be a module on extension services related to vegetable production.

*Unexpected shocks*

This module will be used to report any unexpected stress events faced by the household in the last 12 months. The events covered by the questions focus on loss of livelihood or income because of unemployment or farming losses, health stress and direct financial losses. The survey also asks about the frequency of these events and coping mechanism used by the households to recover from these stresses. The information will be useful to identify factors that may have contributed to economic loss for the household.

*F&V knowledge*

This module will be used to understand WRA's knowledge about F&V, including how much F&V should be consumed, what are the health risks of not consuming enough F&V, and when and why F&Vs should be washed. Exposure to information about healthy diets and food hygiene and safety will also be assessed.

*Social desirability bias*

To assess the potential of social desirability bias, WRAs will be asked 5 questions to assess their tendency to present themselves in a manner that may be viewed favourably (Crowne & Marlowe, 1960).

*Anthropometry*

Height, weight, and waist circumference will be assessed for the index WRA and adolescent 10-14 years of age if present at the time of the survey. Hip circumference will also be assessed for the index WRA. Height (to the nearest 0.1 cm), weight (to the nearest 0.1 kg), waist circumference (to the nearest 0.1 cm), and hip circumference (to the nearest 0.1 cm) will be assessed by trained enumerators using a stadiometer, electronic scale, and ergonomic measuring tape respectively. Height, weight, waist circumference, and hip circumference will be assessed twice and the average of the two measures will be taken. Height and weight will be used to calculate body mass index using the formula $kg/m^2$. BMI will be categorized as follows: underweight (BMI < 18.5 $kg/m^2$), normal (BMI 18.5–24.9 $kg/m^2$), overweight (25–29.9 $kg/m^2$) and obesity (≥30 $kg/m^2$) (World Health Organization, 2000). Height and waist circumference will be used to calculate waist-to-height ratio. Hip and waist circumference will be used to calculate waist-to-hip ratio.

*Dietary intake*

24-hour dietary recall (24hR): Dietary intake in WRA will be assessed using a quantitative multi-pass 24-hour recall (Gibson & Ferguson, 2008). This includes four passes. In the first pass, respondents recall the list of all foods, drinks and snacks consumed during the previous 24-hours. In the second pass, precise

descriptions of all foods consumed are obtained, including recipes and details for all mixed dishes. If the woman being interviewed did not prepare meals at home the previous day, the person who prepared home meals the preceding day will be asked to assist in listing the ingredients for mixed dishes/recipes prepared at home. In third pass, respondents estimate portion sizes using pre-defined methods. The quantity of food/recipes consumed will be recorded with a duplicate portion of the food/recipe, using a digital kitchen scale precisely to 2 g. In the absence of duplicate portions, the quantity consumed will be estimated in volumes, weight-to-weight with other foods (e.g., amount of sugar estimated with corn flour) or household units (e.g., ladles, tablespoons, teaspoons etc.). If any food/recipe was purchased and eaten in or outside the home, its monetary value will be preferred over the volume especially when the purchased amount was solely consumed by the subject. The research team will agree *a priori* on models (small, average, large) for food items such as some fruits (e.g., mangoes, pawpaw) and vegetables (e.g., onion, tomatoes). For shared bowl eating, usual intake for the dish will be estimated. The usual intake will be estimated by asking the woman to recall the quantity she typically/usually consumes when she eats such a dish(es) alone. The number of persons who ate from the shared bowl will be recorded to guide data processing decisions. Finally, in the fourth pass, once the description of foods is complete, the enumerator verifies all foods and quantities consumed the previous day. Enumerators will probe women for likely forgotten foods such as fruit, sweets and snacks consumed on the recall day. The enumerator will not specify the names of any particular items. Therefore, we except limited if any overreporting of these food groups. The presence of social desirability bias is possible in the case of fruits, which we will be able to account for using the social desirability bias module.

To account for differences in intake between days and interviewers, we will randomly assign women to all days of the week and interviewers. A random sample of 20% of women from the first 24-hour recall will be selected for a repeated 24-hour recall at each survey round. This will allow us to adjust for random day-to-day variation in dietary intake. All repeated recalls will be conducted on non-consecutive days to avoid dependency on intake.

The quantity (in gram) of ingredients consumed from mixed dishes (recipes) will be estimated using a standard recipe formulation from the study area. Ingredients will be estimated as the proportion of the ingredient in the dish/recipe multiplied by the amount (gram) of the recipe consumed. The proportion of ingredients in recipes will be determined by averaging the estimates of recipe formulations obtained from at least two food vendors and two individuals responsible for meal preparation in households. These participants will be randomly selected from the four communities within the study area. Given that the villages may not have a high concentration of food vendors, we have adopted a purposeful selection process for food vendors. This involves identifying and conducting interviews with food vendors in each community, focusing on the recipes they prepare and sell. Additionally, we plan to interview a minimum of 20 women responsible for household meal preparation in each of these villages. The households will be selected using a random walk method in various directions within the community, by the enumerators and supervisors. Enumerators will be assigned randomly to interview a woman in the household about 3-4 different listed recipes. To reduce potential interviewer bias, no enumerator will be tasked with working on the same recipe in each community. In other words, enumerators in each community will be assigned to interview women about different recipes.

In the standard recipe formulation, we will record the weight of a duplicate portion of each ingredient using a digital kitchen scale with a precision of 1 or 2g. In the absence of duplicate portions, amounts will be estimated as volume, food models (small, medium, or large), household units or their monetary value equivalents, in priority order. The research team will agree a *priori* on models for different sizes of food

items such as onions, tomatoes, garden eggs and similar food items that may be identified. A catalogue with coloured pictures of these models will be carried along for the interviews. The condition measured for ingredients will also be specified e.g., whether the weight specified for onion is for the peeled or unpeeled onion.

We will next estimate the total cooked volume for the recipe. All interviews will be conducted at the cooking site (for food vendors) or at home (in case of home meals) to avoid the cases of non-availability of pots or saucepans used for the estimation of the total volume cooked. In cases where the total volume cooked is too large to estimate with water, the pot size and level in the pot will be indicated. If the pot is too large to weigh (likely case for food vendors), the total amount sold may be used as a proxy measure of the total amount cooked. The total weight of cooked food sold will be estimated as the amount sold multiplied by the weight per unit price of the cooked food. The proportion of an ingredient in a recipe will be estimated as the weight (gram) of the ingredient divided by the total weight of the cooked recipe.

Recipe data will be generated for frequently consumed recipes by the respondents, considering a consumption rate of at least 5% of the population. Additionally, we will incorporate commonly consumed recipes based on the insights provided by collaborators from Sokoine University, who are knowledgeable about the study context. Recipes generated from the field will be complemented with data from the Tanzania food composition table as necessary (TZ-FCT). For recipe data taken from the TZ-FCT, the proportion of each ingredient in the recipe will be calculated by dividing the weight of the ingredient by the total weight of the prepared recipe, accounting for yield factors during the cooking process (1). These yield factors are essential as the total weight or volume of the cooked food, including water, was not specified.

Moreover, we will develop conversion factors to convert handy/household measures, weight-weight measures, volumes, food models and monetary values of food to their weight (gram) equivalents following Gibson and Ferguson (Gibson & Ferguson, 2008). All food items for the conversion factors will be purchased from at least 3 different markets from where the study is being conducted.

*F&V food frequency questionnaire*

Food frequency questionnaire (FFQ): A one-month FFQ would also be used to assess WRA's habitual intake of F&V. The first part of the FFQ includes a detailed list of F&V commonly consumed in the study area. The list was obtained from the literature (Lukmanji et al., 2013; Zack et al., 2018) and adaptations were following discussions with in-country collaborators at the Sokoine University of Agriculture. The second section of the FFQ contains the frequency of consumption of each mentioned F&V in the previous month, which includes "never", "once per month", "once per week", "2-4 times weekly", "5-6 times weekly", "once daily" and "2-3 times daily".

### 2.7.3 Food environment census

In all selected villages, we will compile a list of all food retail outlets operating in the villages, including their location, and will conduct a short (10-15 minutes per outlet) survey to collect information on the variety of food items being sold.

*Physical access to food retail outlets and F&V vendors*

Geospatial data from the FE census will be used to sample retail outlets for the bi-monthly FE assessments and will also be used to assess physical accessibility to food retail outlets and retail sources of F&V within the study area. More specifically, the distance from study households to the nearest retail source of F&V will be calculated, the distance to the nearest open-air retail market, as well as the density of F&V vendors within a 2, 3, 4, or 5 mile-radius of households. We will also calculate the density of other types of food vendors around households. Finally, we will calculate mean nearest distances and densities at the village-level and compare these across the study area.

### 2.7.4 Food environment surveys in open-air markets and other retail outlets

Market and retail shop-level data will be collected during bi-monthly follow-ups from baseline to follow-up using quantitative questionnaires. An overview of the survey modules, assessment methods, respondent, and estimated time needed for data collection is provided in **Table 4**. These modules will be used to assess several FE dimensions using methods described more in-depth in the sections below.

**Table 4** Survey modules, assessment methods, respondent, and estimated time needed for the FE assessment

| **Survey module** | **Assessment method** | **Preferred respondent** | **Estimate duration per survey module** |
|---|---|---|---|
| Market and retail outlet information | Enumerator observation and vendor self-report | Market vendors, shop owners, shop staff | 10-15 minutes |
| Fruit and vegetable vendor census (*Markets only*) | Enumerator observation | N/A | 20-30 minutes |
| F&V safety claims (*Part of the* F&V *vendor census module in market questionnaire*) | Enumerator observation | N/A | 5-10 minutes |
| Marketing and advertisements | Enumerator observation | N/A | 15-30 minutes |
| Food list (I*ncluding food quality, food availability, and food prices*) | Enumerator observation and vendor self-report | Market vendors, shop owners, shop staff | 30 – 90 minutes (*90 minutes for large markets*) |
| Wages | Self-report | Market managers, vendors, shop owners, or shop staff | 5-10 minutes |

*Market and other retail outlet properties*

Within the market and retail outlet information module, enumerators will be asked to observe the presence of different types of assets, infrastructure, and services available in the markets and retail

outlets. Binary variables will be generated for the availability of different types of storage facilities (e.g., cold storage) in the market, dedicated waste collection areas and closed sewage systems, washing stations for market produce, access to water for handwashing, electricity, and access to the markets/retail outlets via paved roads.

*Food availability*

In the food list module, enumerators will be asked to go through a pre-specified food list and indicate whether each food item is available in the market or retail shop. The food list is organized into different food groups. Food availability will be assessed for each food group, both as a binary variable (0: no items available from the group; 1: at least one item available from the group) and as a continuous variable, including the count of unique items that are available within the group. In markets, enumerators will also measure the total number of vendors that are selling specific F&V prioritized by FRESH as a continuous variable. Finally, the ability to source sufficiently diverse items to meet the variety criteria suggested in international food based dietary guidelines will be assessed, again as a binary variable (e.g., whether markets or shops are able to supply a total of three vegetables, including one green leafy vegetable).

*Cost of diet and relative caloric prices*

The cost of a healthy diet will be assessed following methods developed by the Tufts University *Food Prices for Nutrition Initiative*[1] and featured in the 2022 State of Food Security and Nutrition in the World report. Food prices will be sought for each item in the previously mentioned pre-specified food list – in most cases it is assumed that price tags will not be available, therefore enumerators will need to inquire with vendors as to the retail price the item is being sold at. In markets, to achieve a more representative estimate, enumerators will gather prices from three different vendors for each item, while in stand-alone retail shops, kiosks, etc., one price for each item will be gathered. All food items will first be converted from any non-standard units (e.g., a bunch of green leafy vegetables or a piece of fruit) to grams, then to kilocalorie equivalents using food composition tables. The lowest cost items in each food group (according to Tanzanian shillings per kilocalorie) will be selected and scaled to meet the recommended amounts for each food group. Finally, individual food group costs will be summed to calculate the cost of a healthy diet indicator.

The relative caloric price (RCPs) of different food groups will also be generated from the price per kilocalorie data. RCPs are calculated as a ratio of the caloric cost of a specified food group (e.g., vitamin A-rich fruits and vegetables, green leafy vegetables, or other fruits and vegetables) to a basket of starchy staples. The numerator is the mean caloric cost of the three cheapest food items in the specified food group. The denominator is a weighted index of starchy staples, where the weights represent the availability of starchy foods in the national food supply, according to FAO Food Balance Sheets.

*Food quality*

Food quality will be assessed as part of the food list module for specific F&V prioritized under FRESH. For each of these items, enumerators will purchase a random sample, from items positioned at the front, middle and rear of a display area, of selected F&V from retail shops, kiosks, and other outlets, and 15 units of each item in the open-air markets (5 units from each of three different vendors). Enumerators will then

[1] https://sites.tufts.edu/foodpricesfornutrition/methods/

provide a subjective grading of each sample according to pre-specified quality criteria, indicating whether it is of excellent, good, fair, poor, or inedible quality.

*Food safety*

Within the F&V census module in the market questionnaire and in the F&V safety claims module in the retail outlet questionnaire, enumerators will observe whether F&V prioritized by FRESH are being displayed above the ground (e.g., on tables, shelves, or in boxes) and away from direct exposure to sunlight, heat, or water. They will also observe whether any claims are being made by vendors regarding the safety of these F&V, including labels, posters, verbal claims, or other material that promote F&V that are free from pesticide residues, organic F&V, or F&V that are sourced from farmers that use safe production practices.

*Food advertising and promotion*

Branded food advertising and promotion will be assessed using methods adapted from the International Network for Food and Obesity/ NCD Research, Monitoring and Action Support network, based on their food promotion module[2]. In this module, enumerators will scan the market or other retail outlet area, including the inside and outside area around the perimeter, identifying food advertisements. Each advertisement will be assessed according to the food groups being advertised, the brands, promotions being offered (e.g., discounts), health claims being made, as well as whether the advertisement is child-focused.

*Wages/food affordability*

Enumerators will be asked to gather wage rate estimates for several types of unskilled workers, including agricultural day labourers, temporary market workers (e.g., loading or unloading trucks), and formally and informally employed shop assistants. Market managers, retail outlet owners, or other staff will self-report these wages, quoting the amount of Tanzanian shillings per day, week, or month. This data will be compared to cost of diet estimates to assess affordability of a healthy diet and fruits and vegetables specifically for low-income households.

## 2.8 Data analysis

Local researchers have been involved in the design of the study, development of the questionnaires and will also be involved in data analysis, interpretation of findings, preparation of publications for peer-reviewed journals and presentation of findings at various fora. Specifically, local researchers and masters' and doctoral students from Sokoine University of Agriculture will be involved in quantifying dietary intake, including estimating nutrient content of standard recipes, estimating conversation factors, and supplementing food composition tables. In addition, in developing each statistical analysis plan (SAP), local researchers from Sokoine University of Agriculture and World Vegetable Center in Arusha will be invited to collaborate based on their expertise. Researchers from other local institutions will also be invited to collaborate on the analyses and interpretation of the findings as appropriate. Partners from the local institutions implementing the supply, demand, and food environment interventions and collecting

[2] https://www.informas.org/modules/food-promotion/

the data will also be invited to collaborate on individual analyses/papers based on their experience and interest.

Data analysis will start with a descriptive analysis using baseline data, and then follow the research questions outlined in Table 1, which fall into two categories: change over time and impact analyses.

### 2.8.1 Household-level data

*Descriptive analysis*

Using the baseline household survey data, we will examine key variables across all modules included. For example, we will estimate baseline values for household consumption and expenditure, food security, agriculture production, months of vegetable production, women's empowerment and time use, and knowledge of fruits and vegetables. In addition, we will use the dietary intake data to estimate the intake of different food groups (measured in g) as well as intake of macro- and micronutrients. Using this data, we will estimate dietary diversity at the individual level and will also calculate at least one diet quality score. All descriptive analyses will be conducted for the full sample as well as for each region, each district, and each ward.

*Change over time*

To answer research questions 1 on the change over time in production of vegetables and dietary intake of F&V, we will examine the change over time in agricultural production and dietary intake indicators. We will estimate means at baselines and means at follow-up in control group T1. We will then compare the means in the two groups using t-tests. In addition, if additional follow-up surveys are conducted (depending on funding availability), we will use longitudinal mixed effects model to examine the trends and trajectories over time in production of vegetables and dietary intake of F&V.

*Impact analyses*

Impact analyses will be conducted for the seven comparisons under research questions 2 outlined in Table 1. Impact analyses will centre around assessing impact of the supply interventions and combination of supply, demand, and FE interventions. SAPs will be developed and posted publicly prior to conducting any intervention effect analyses. For each analysis, a flow diagram for participation will be prepared according to CONSORT guidelines, split by supply and non-supply strata as relevant, and a CONSORT checklist will be completed (Campbell et al., 2012).

The analysis will follow the intention-to-treat (ITT) approach comparing changes over time (between baseline and follow-up) in treatment groups. The difference-in-difference model specification has the following form:

$$\Delta Y_i = \beta_0 + \beta_1 T_i + \beta_2 Y_{i0} + \varepsilon_i$$

where $\Delta Y_i$ is the change in the outcome variable between baseline (time 0) and follow-up (time 1), $Y_{i0}$ is the outcome variable at baseline, and $T_i$ is a dummy variable for the treatment. To account for the study design and the nesting of the data (households nested within villages nested within wards nested within districts), we will use multi-level mixed effects models. We will use both fixed effects with dummies for

the treatment groups and random effects at the village level (the unit of randomisation). Depending on the variability of the data, we will also consider random or fixed effects for wards and fixed effects for districts. An alternative fixed effects models with standard errors clustered at the village level will also be considered.

We anticipate that randomization will lead to good balance across treatment groups and villages. However, we will check balance across the intervention arms using the baseline data and adjust for characteristics that may not be balanced. We will rely on this approach by adjusting for these baseline characteristics in the primary analysis. In secondary analyses, we may estimate adjusted parameters by including variables that are strongly associated with the outcome to improve the precision of our estimates (decrease the standard errors). Variable selection approaches will be pre-specified in each SAP. Additionally, pre-specified effect modification testing will be conducted by including an interaction term in minimally adjusted models to test for differences by farmer gender and age. Additional effect modification testing will be pre-specified in each SAP and will specifically focus on understanding the effect of socio-cultural factors.

### 2.8.2 Food environment data

*Descriptive analysis*

Using the FE data, village-level FE variables will be created, drawing on data from the retail outlets sampled within each village and the nearest open-air markets. These variables will measure physical accessibility to retail outlets and markets, food availability and variety, cost of diet and relative costs of specific food groups, food quality, food safety, and food promotion. Variables will be disaggregated by food group, allowing specific inspection of F&V. Summary statistics for each of these variables will be compared across villages to explore whether geographic variation exists in the study area, and associations between FE variables and village-level characteristics (e.g., population size, distance to next town, education, access to electricity and potable water) will be tested.

*Change over time*

Repeated measures of FE variables will be compared over time to assess temporal changes and seasonal patterns, especially in food availability and food costs. Mean village-level estimates will be generated at baseline and for each bi-monthly follow-up. Variables relating to food prices will be deflated by a consumer price index to account for inflation. Mean plots will be visually inspected to explore trends and whether changes in FE variables align with the timing of rainy seasons. Month-to-month variation will be estimated as well as total change from baseline to endline.

The longitudinal analysis of FEs will model separate village-level trends. Though the sample size of FEs included in the study is lower than households, this will enable a qualitative comparison of whether supply interventions are associated with changes in the FE, especially those related to specific vegetables and fruits being promoted by FRESH, such as the number of vendors selling these products and their availability in different months of the year.

*Associations between FE measures and dietary intake of F&V*

Associations between FE measures and dietary intake will be explored using cross-sectional analysis at baseline and longitudinal analysis, drawing on the bi-monthly FE follow-ups. The cross-sectional regression analysis will use multi-level, linear mixed effects models, with households nested within village-level FEs, further nested within wards. Associations between village-level FE variables and dietary intake of F&V (in grams) will be tested for significance using Wald tests. Longitudinal analysis will test whether change from baseline in F&V intake is associated with FE variables (using baseline measures and measures of variation over the study period), again using a linear mixed effects model with households nested within village-level FEs and wards.

### 2.9 Risk mitigation

As described above, the project is planned for two years (June 2023-June 2025 with two survey rounds) and, depending on funding, will be extended by six years (with up to six additional survey rounds). If additional funding is not available and only two rounds of data are collected in 2023 and 2024, both study objectives will only partially be affected. Specifically, with respect to the first objective of the study related to understanding the changes over time in production of vegetables and dietary intake of F&V among farmer and non-farmer households and among individuals within those households may be affected, we will not be able to examine how production of vegetables and dietary intake of F&V change over the medium-to-long term and what trajectories look like over time. Nevertheless, with two survey rounds we will still be able to examine the change in production of vegetables and dietary intake of F&V over one year, which will allow us to better understand short-term changes in these outcomes. The second objective of the study relates to understanding the impact of the FRESH end-to-end approach (and the interventions within it) on production of vegetables and dietary intake of F&V. With two survey rounds we will not be able to understand medium-to-long term effects of the interventions. However, similarly to the first objective, we will be able to assess short-term intervention effects over one-year of implementation. Overall, even in the absence of funding for additional data collection, the study will be able to achieve its objectives and understand short-term changes in production of vegetables and dietary intake of F&V and the short-term effects of the FRESH end-to-end approach on these outcomes.

With respect to the FE assessment, we do not expect the absence of additional funding to affect the study objectives which relate to characterizing the market FE at baseline, assessing the changes in FE over 12 months, and testing associations between FE measures and dietary intake of F&V.

## 3. Supply, demand, and food environment interventions

The FRESH end-to-end approach combines interventions at various points of the food system, from agriculture and input supply, to supply chains, food environments, and consumer behaviour, all with the objectives of improving the production and consumption of fruit and vegetables. Individual packages of interventions will contribute to different production and consumption-related outcomes. However, delivering the interventions in a coordinated, end-to-end manner is intended to achieve a greater combined impact on consumption of fruit and vegetables, by addressing multiple potential barriers at once, including their availability, affordability, accessibility, and desirability. The three packages of interventions included in FRESH are: supply interventions (including input supply, agriculture production, and supply chains); demand creation interventions; and food environment interventions.

*Supply interventions*

The FRESH package of supply interventions will address input supply (e.g., farmers' access to improved vegetable cultivars), agricultural production practices, with a focus on those practices most relevant for vegetable production, and post-harvest management of fruit and vegetables. These activities will target farmers and value chain actors linking with these farmers and will prioritize program participation among women and youth. Prior to the design of these interventions, FRESH partners (World Vegetable Center and the Tanzania Agricultural Research Institute (TARI)) carried out information gathering activities to assess the context and needs of smallholder farmers and value chain actors in the intervention area, including stakeholder engagement workshops, inventories of seed varieties available to farmers and their production practices, and a landscape analysis of informal actors operating in the middle of the supply chain (i.e. transportation, wholesale, and retail).

Improvements in production practices will be tailored to two types of farming systems found in the Arusha and Kilimanjaro Regions, which are relevant for vegetable production. The first is the staple farming system, where farmers are dedicated to producing maize or other staple crops. In this farming system, technologies will be adapted with the aim of integrating production of vegetables, through intercropping and other mixed farming strategies, to increase their year-round availability. The second is the commercial vegetable farming system, where farmers are already growing vegetables, and adapted technologies will be geared towards improving resource use efficiency, especially related to reducing excess application of pesticides.

In 2023, the World Vegetable Center along with other FRESH Partner Organizations will establish 15 production hubs in supply wards, where farmers, extension agents, and other private sector value chain actors will engage in participatory testing and adaptation of improved technologies for vegetable production. At each production hub, different packages of technologies will first be tested on demonstration plots managed by the World Vegetable Center and TARI with local farmers. These technologies will address integrated pest management (IPM), irrigation and water management, conservation agriculture, integrated nutrient management and soil health, post-harvest practices, and other activities related to vegetable production. Production hub demonstration plots will also be used to test improved vegetable cultivars, including locally adapted tomato and pepper seeds, which will have undergone variety trials led by the World Vegetable Center, and traditional African vegetable seeds, selected from the most promising locally available lines as determined by demonstration and yield trials, to be concluded in April 2023 by the World Vegetable Center and TARI, working together with local seed companies.

At each production hub, the World Vegetable Center together with the local extension agents will select 30 farmers who are interested in growing vegetables, have access to water for irrigation, and have a piece of land where they can cultivate vegetables. After these 30 farmers are trained, 5 farmers will be selected to establish a demonstration plot on their own farms and to train 30 other farmers in each cropping season. During these trainings good agricultural practices (GAP) will be promoted, as determined during the testing and piloting of different technologies. Farmer field days around specific topics will also be organized, which private sector actors will also participate in, including local seed companies distributing the improved cultivars and traders and processors who purchase produce from farmers.

Further supply-side interventions will target mid-stream actors (collectors, traders, wholesalers, and retailers) operating in the Arusha and Kilimanjaro Regions, with the aim of preventing post-harvest losses and improving the food safety of fruit and vegetables offered in local informal markets. Informal groups that provide multiple functions (e.g., collection, transport, and retail) will be prioritized by the activities,

as these "short" chains were deemed most feasible for the testing and diffusion of innovations based on preliminary scoping work. Initial information gathering activities beginning in May 2022 and concluding by June 2023—including literature reviews, workshops with mid-stream actors, and value chain assessments—will be used to identify causes of post-harvest losses and sources of food safety risk, as well as possible innovations to address these at various entry points along the value chain.

Mid-stream actors will be linked to the previously mentioned production hubs, participating in trainings and farmer field days, to build awareness of the GAP being adopted, especially related to IPM and reducing excess pesticide application, and how these may improve their own business activities, e.g., by extending shelf-life of fruit and vegetables and strengthening consumer demand. Beyond farmgate, interventions will aim to improve the safe handling of fruit and vegetables during transport (e.g., through use of paper lining), and storage and hygiene practices in local markets (e.g., through improved retail stands and product washing stations). Lastly, mid-stream actors will engage in marketing and promotion of the safe production, transport, storage, and hygiene practices to consumers in local markets, in order to influence their perceptions of product quality, and ultimately desirability.

*Demand interventions*

Demand interventions will focus on creating demand and shifting consumer behaviour towards increased intake of fruits and vegetables and overall healthier diets. Even where supply-side interventions have enhanced the year-around availability of diverse fruits and vegetables, it is not guaranteed that these will be consumed by consumers, including women of reproductive age. Two key barriers to increasing intake are the affordability of fruits and vegetables and their desirability among consumers. Therefore, FRESH demand creation interventions may include income support activities aimed at increasing the purchasing power of the target population via cash-based transfers or other social assistance, as well as behavioural interventions, aimed at improving consumers' knowledge and awareness of the nutritional importance of fruits and vegetables, innovative food processing and preparation methods, understanding of price fluctuations in fruits and vegetables over the year, among other possible topics, addressing concerns around food safety, among others. These topics may be delivered via behaviour change communication (BCC) activities, nutrition education messaging, or other approaches such as recipe demonstrations or mobile phone-based nudging apps.

The specific design of these demand creation interventions will be informed by a review of existing literature and data on dietary patterns in Tanzania, as well as stakeholder engagement with national and sub-national government partners in the Arusha and Kilimanjaro Regions, local academic partners such as Sokoine University of Agriculture, and implementing partners that are delivering social assistance and nutrition programs to the target population and their households. These activities will allow the study team and its partners to assemble a menu of options for demand creation interventions, from which to select and co-design context-appropriate demand creation interventions for evaluation within the FRESH end-to-end approach.

*Food environment interventions*

FE interventions will be delivered in open-air markets and/or other food retail outlets that are key access points for fruits and vegetables in the study area. These interventions may include activities that aim to enhance the accessibility, affordability, and/or promotion of fruits and vegetables within these retail settings. A key role of the FE interventions will be to reinforce supply and demand-side activities. For

example, fruit and vegetable vendors and other partners may increase the visibility of fruits and vegetables that have been produced using GAP (e.g., low pesticide application) via labels or other promotional materials. Price promotions, such as discounts, for fruits and vegetables may also be implemented with F&V vendors alongside income support interventions targeted to consumers; or vendors may rearrange their display of F&V (e.g., placing nutrient-rich fruits and vegetables at the front of the shop or market stall to encourage their purchase). Open-air markets may also provide an appropriate physical setting for demand interventions, like recipe demonstrations.

Similar to the demand interventions, a menu of possible options for FE interventions will be developed via review of existing literature and ongoing engagement with government, academic, and implementation partners, after which context-appropriate FE interventions will be selected and co-designed for implementation and evaluation within FRESH.

# 4. Theory of change

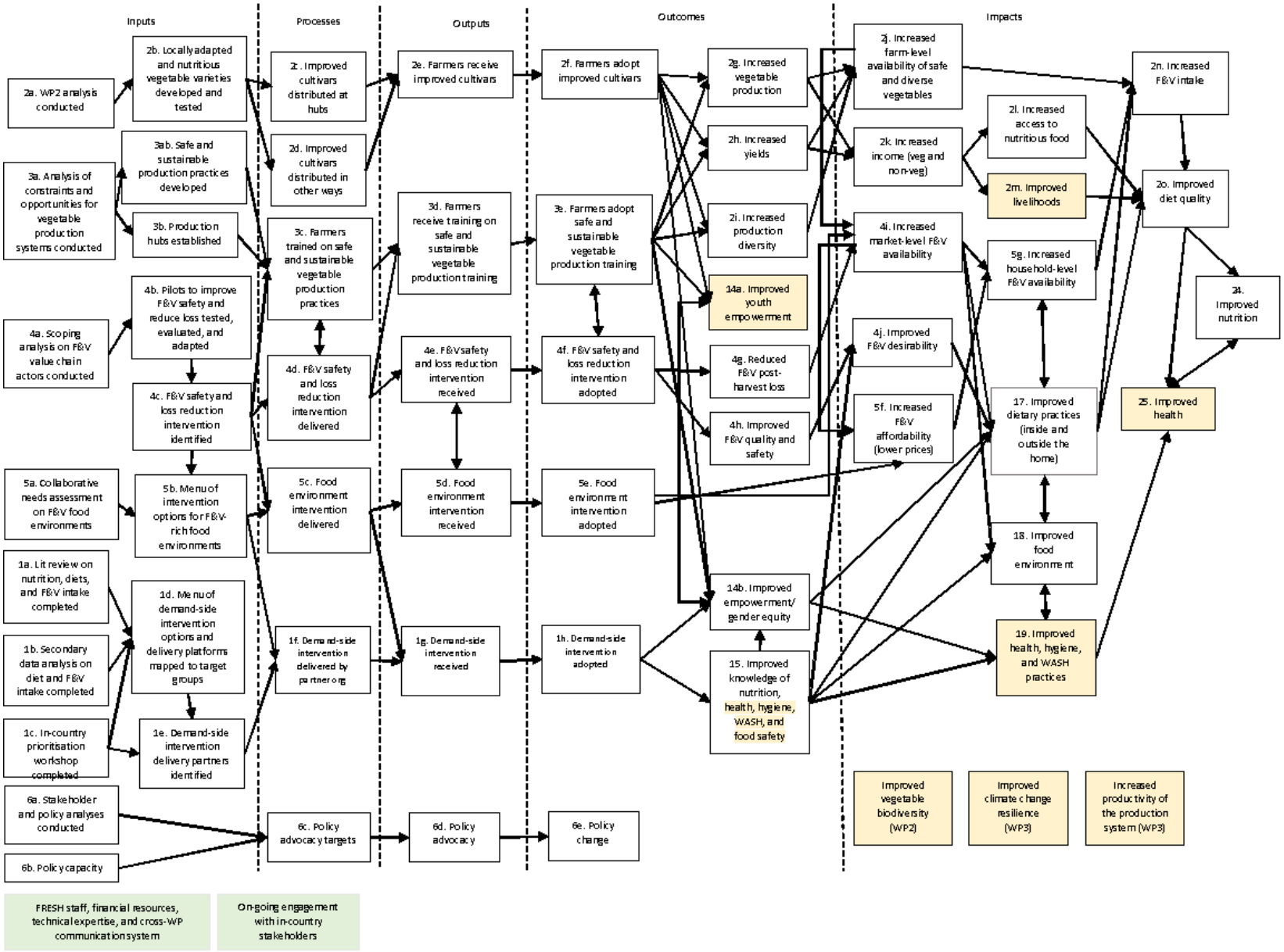


**Figure 3** Theory of change

# 5. Ethical considerations

## 5.1 Ethical approval

In addition to National Institute of Medical, ethical clearance will be requested simultaneously from the following institutions:

1) International Food Policy Research Institute (IFPRI) Institutional Review Board
2) University of California, Davis (UCD) Institutional Review Board
3) Wageningen University & Research (WUR) Research Ethics Committee

## 5.2 Consent process

Community engagement for the study will begin with interactions with village leaders, village chairperson, village executive secretariat, and other key stakeholders. We will provide information about the study, research objectives, and activities. We will seek verbal agreement to proceed with survey activities.

For participants in the household survey, a full informed consent will be required and will occur during the baseline data collection. For each eligible respondent identified within the household, the trained enumerators will explain the objectives and timelines of the study, outline any potential risks and benefits of the study, identify who to contact with questions, and emphasize confidentiality of the participant's survey data. Enumerators will also describe the anthropometry assessments (height, weight, and waist circumference) that will occur during the survey. The enumerators will read out the consent form in the local language and stress that participation is voluntary and that subjects may decline to answer any question and may stop the survey at any time. Participants will be asked if they understand the research, study procedures and all other aspects of the study. Participants will be encouraged to ask questions to ensure comprehension. Each participant will also receive an information sheet detailing all the points discussed during the consent process and will be given an opportunity to ask any questions or clarifications about the study.

Written consent will be obtained by each respondent in the household once they are satisfied with the information being presented to them. The written consent will cover consent for the baseline survey as well as any follow-up survey or anthropometry assessment administered during the project timeline. The consent form will be countersigned by a witness (e.g., the investigator). For women of reproductive age who are minors, i.e., 15-18 years of age, who are considered emancipated, written informed consent will be obtained directly. For women of reproductive age who are minors, i.e., 15-18 years of age, who are *not* considered emancipated, informed assent from the minor and written informed consent will be obtained from one parent/legal guardian. For all other minors/children <15 years of age, written assent from the minor and written informed consent from one parent/legal guardian will be obtained.

At the time of each follow-up survey, a shorter version of the consent will be used to confirm continued willingness to participate in the study. The trained enumerators will remind each respondent about the study, the duration of the survey, any potential risks and benefits to participating in the study, and that participation in the study is voluntary. An oral consent will be taken at the beginning of each follow-up survey or anthropometry assessment. Oral informed consent will be obtained for the selected food vendors and women in the household during the recipe formulation process, as the interviews will not involve any personal or demographic information.

For the FE census, an oral informed consent will be used, where owners of retail shops, kiosks, restaurants, and other food outlets will be informed about the purpose of the study, how long the census survey will take, and that they may be contacted again to participate in the FE assessment. They will also be asked for their permission to allow census enumerators to take photos of their shop. Oral consent is deemed most appropriate for the census in light of the short duration of the questionnaire, the absence of personal information collected from vendors, and the possibility that written consent may be overly intrusive or distracting in a retail setting.

After the census, for the retail shops, kiosks, or other stand-alone outlets that are selected to participate in the FE assessment, written consent will be sought from the owners. These vendors will be provided with information about the FE assessment study's length, procedures, and the potential benefits and risks. While the majority of the questionnaire for retail shops, kiosks, or other stand-alone outlets will assess the food vendor's trade—such as the type of food being sold, food prices, food advertising, and other properties of the retail space—personal information, including the shop owner's name, age, and sex will also be collected. Names will serve as a means of identifying food outlets in the event that the outlets do not have a business name. Follow-up surveys in these outlets will also ask for the shop owner's consent, using an abbreviated oral consent script.

Enumerators gathering data in open-air markets using the market questionnaire will not gather any vendor-specific information. They will only gather information about the foods being sold in the market, their prices, quality, safety, and certain market-level characteristics, including availability of washing stations, bathrooms, dedicated trash collection areas, and food advertising. Therefore, no informed consent will be sought from vendors in these markets. However, when gathering data involves talking to market vendors (for example, food price information), enumerators will explain the purpose of the study and notify the vendors that sharing the information is voluntary.

## 5.3 Potential risks

There are minimal risks to participants in this survey. We recognise the potential for a power imbalance to be perceived by participants. This may occur in any relationship between researchers and the "researched", but may be heightened in low-income settings or amongst vulnerable groups. We do not anticipate that the survey will involve highly sensitive or distressing topics, but there will be questions relating to challenges experienced by households (e.g., food insecurity, household expenditure patterns. Some questions may be considered sensitive by respondents. Study respondents will be reminded that they can refuse to answer any questions or participate in any assessments, thus minimizing any potential risks. All efforts will be made to ask potentially sensitive questions in private, out of sight or earshot from others. Interviewers will be alert for signs of discomfort or reluctance. The methods of anthropometry assessment are non-invasive and virtually risk free. However, participants may find them uncomfortable and will therefore be reminded that they can refuse any of the assessments without ramifications for their participation in the study or their relationship with study staff and institutions.

It is not anticipated that any questions in the retail shop questionnaire will be sensitive to respondents. However, respondents will also be informed that they are not required to answer any question they are uncomfortable with and can exist the study at any time.

There is also very minimal risk of breach of confidentiality associated with participation in the study. All participants will be assigned an identifying number (a unique ID code), under which all information will be

stored. All identifying information of the respondents will be destroyed no later than 5 years upon the completion of the study.

## 5.4 Potential benefits

As a token of appreciation, respondents in the village questionnaire, household survey, and retail outlet questionnaires, and those involved in the recipe creation component will receive a small incentive for a value equivalent to approximately $2USD. The actual incentive for each type of respondent (e.g., a bar of soap for women of reproductive age, airtime for key informants for the village questionnaire) will be determined through consultations with community leaders and local partners to ensure it is adequate and well accepted by the community. The information sheet for the consent form will be updated once the incentive is determined to inform respondents about it.

For food vendors, benefits may accrue in the form of additional sales from enumerators purchasing a sample of F&V for the quality assessment portion of the questionnaire, or from purchases that are required for weighing items in the event that they are sold in non-standard units (e.g., bunches of leafy greens or pieces of fruit).

Beyond receipt of the incentive for participation, the potential benefits of participating in the household survey include study participants' gaining knowledge of their height, weight, and waist circumference. To facilitate this, participants will be provided with their results immediately following the conclusion of the anthropometry assessment. Beyond the potential individual benefits, the findings of the study will contribute to our understanding of how programs and policies can increase production and consumption of fruit and vegetable which may have wider benefits for similar households in Tanzania. Food vendors may also benefit from the increased evidence around the factors that influence F&V purchases and consumption.

Given the minimal risks posed by this study and the potential benefits to the individuals to gain insight into their own health and the potential benefits related to understanding how these types of programs work to improve production and consumption fruit and vegetables, it is thought that the benefits outweigh the risks.

## 5.5 Data management, storage and privacy

All data will be collected using tablets and CAPI software. The survey firm collecting the data will use technologies (e.g., batteries, phone networks, Bluetooth) to ensure that enumerators will be able to upload all data on a daily basis. Data will be stored in an encrypted folder in Dropbox and will be accessible only to the research team at IFPRI: principal investigators (PIs), co-investigators (co-Is), and selected research analysts (RAs). Once the data is entered, we will remove identifiers and store them separately in a secure, encrypted folder on institutional password protected computers to protect the identity of the participants. We need to store the identifying information to allow for the possibility of follow-up surveys. All identifying information will be destroyed within 5 years upon project completion.

All participants will be assigned an identifying number (a unique ID code), under which all information will be stored. Databases used for analysis will only link information to the unique ID code, not to the participants' names or any other identifying information. Individual information will never appear in a published report. Only a limited number of IFPRI staff mentioned above will have access to the data files

with personally identifiable information to minimize risk. Files with personally identifiable information will be stored on password protected computers in encrypted folders. Personally identifiable information will be shared with co-investigators leading sub-studies on a very limited basis to allow them to interview the same respondents. Strict data sharing and data privacy protocols will be put in place prior to any personally identifiable information being shared.

Data will be taken by IFPRI to the Washington, DC office and the Senegal office, where investigators are based. We will complete a Data Transfer Management Agreement before the start of the study. De-identified data will be shared with investigators at other institutions, including investigators at Sokoine University and the University of California, Davis who will lead the statistical analysis of the dietary intake data. Fully anonymised data will be made publicly available on the IFPRI website within 5 years of project completion.

## 6. Study team

The study has four principal investigators. Prof Kinabo, the Tanzania-based PI, has over 30 years of experience working on healthy diets and human nutrition and has led multiple studies involving diet quality assessment in Tanzania. Drs Olney, Kumar, and Bliznashka are based at the IFPRI Headquarters in Washington, DC. Dr Olney and Dr Kuman have extensive experience with evaluations of multi-sectoral health, nutrition, agriculture, and gender programs, including ones focused on improving agricultural production, diet, and nutritional status. Dr Olney has several years of experience working in Mwanza and Zanzibar. Dr Bliznashka has several years of experience working on evaluations of multi-sectoral health, nutrition, and agricultural programmes, including ones in Morogoro and Pwani.

Please see attached certificates for investigators with existing certificates on protection of study participants. All other investigators will complete an online certification before the start of data collection. In addition, all enumerators will be trained on best practices in human subject research and protection of study participants in research prior to start of data collection.

## 7. Facilities

The World Vegetable Center has a regional office in Arusha equipped with necessary office space to host investigators at key times during the study (e.g., initiation and training for baseline data collection), conference space to conduct the training of data collectors, and resources and equipment to support the study design and data collection activities. The data collection firm that will be selected will be expected to have a minimum level of infrastructure or access to the necessary equipment to support the data collection activities (e.g., printers, laptops, vehicles etc.). IFPRI has a country office in Nairobi, Kenya, a regional office in Dakar, Senegal and a headquarters office in Washington DC which have all necessary resources and equipment to execute the study (e.g., office space for investigators, statistical software, printers, laptops, etc.). All other partners listed also have the requisite office space, resources and equipment to contribute in their respective capacities.

## 8. Vulnerable populations

The study will include the following vulnerable group: (1) women of reproductive age who are minors, 15-18 years of age, (2) pregnant women, and (3) other minors <18 years of age. To protect these groups, we will ensure proper informed consent and assent is obtained. Women 15-18 years of age who are pregnant or mothers of young children meet the definition of emancipated minor and will be able to provide informed consent for themselves. For women 15-18 years of age who are not emancipated, we will obtain assent from the individual invited to participate and informed consent their parent/legal guardian. Any other minors <18 years of age who will only participate in the anthropometric assessment if they are present at the time of the survey. For them, we will obtain assent and informed consent from a parent/guardian. The interventions which will promote fruit and vegetable intake and production are anticipated to have very low to no risk of harm for this vulnerable group. Likewise, the survey itself presents no risk as none of the procedures are invasive. To ensure protection of these vulnerable groups, we will report their weight, height, waist circumference immediately after measurement, and refer those who are underweight to the health centre.

## 9. Funding

Funders supported this research through their contributions to the CGIAR Trust Fund: https://www.cgiar.org/funders/

## 10. Research sponsor

IFPRI is an international research organization, established in 1975 to identify and analyze alternative national and international strategies and policies for meeting food needs of the developing world on a sustainable basis. The mission of IFPRI is to provide research-based policy solutions that sustainably reduce poverty and end hunger and malnutrition. Through partnerships, IFPRI's regional and country research activities and programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI, as part of the Consultative Group on International Agricultural Research (CGIAR), has a role in several CGIAR Research Initiatives and is particularly involved in those mapped to the CGIAR's Systems Transformation Science Group where research activities focus on the sustainable transformation of food, land, and water systems. IFPRI is the lead institute on the CGIAR Research Initiative for Fruits and Vegetables for Sustainable Healthy Diets (FRESH).

## 11. Support letters

IFPRI, in collaboration with its partners World Vegetable Center and Sokoine University of Agriculture, is following the recommended procedure of informing all relevant parties of the objectives, timeline, and a process of the study in an effort to receive the required letters of support. At this time, informational letters have been drafted in English that will be translated into Swahili so that they may be shared with local officials. Local officials will then review and respond to the letters confirming or declining support of the study. Once local support has been expressed, IFPRI and partners will take this confirmation to regional and district level to receive final approval of the study from these officials. As custom, a pre-written letter of support in Swahili will be shared for ease of process. The individuals and their offices have already been identified for all of the locations in which the study will take place and the order in

which IFPRI and partners will need to sequence the approvals (or letters of support) from local to regional and district level.

## 12. Dissemination plan

All investigators will participate in the analysis, presentation and publication of research findings and share the related intellectual property rights. We plan to disseminate the findings from this study through primary avenues:

1. Series of in-person workshops in with stakeholders in the villages, districts, and regions where the study will be conducted.
2. Series of in-person and virtual workshops with key local, national, and international stakeholders to share findings and discuss how the results can be used to inform programs and policies at various points along the project timeline.
3. Series of in-person and virtual brown-bag seminars or presentations hosted internally by IFPRI led initiatives to share and discuss findings along the project timeline.
4. Disseminate findings to international audiences through policy briefs, blog posts, peer-reviewed publications, and presentations at scientific and programmatic meetings.

## 13. Budget

The total budget for this study is anticipated to be 830, 000 USD. The budget includes the baseline survey, 6 bi-monthly follow-up surveys for the food environment assessment, and the follow-up survey. Costs are broken down in **Table 5** below. The costs for the baseline and follow-up surveys are based on survey teams of 40 enumerators, 5 field supervisors, 5 data managers, and 5 drivers for approximately 60-70 days of data collection. At both baseline and follow-up, data collection will occur in 33 villages and approximately 2,800 households. We expect that some households may move or be otherwise unavailable for the follow-up survey. We will also not repeat the food environment census which will be conducted with the baseline survey. Therefore, we expect lower costs for the follow-up survey. Other costs include: costs for training and piloting, transportation, incentives for respondents, data collection equipment (including digital tablets for data entry and cell phones with data for transferring data). The bi-monthly food environment follow-ups are budgeted at ~5,000 USD per follow-up.

**Table 5** Estimated Study Budget

| Survey | Estimated Costs |
|---|---|
| Baseline household survey | $ 320,000 |
| Follow-up household survey | $ 320,000 |
| Food environment assessment (census and bi-monthly follow-ups) | $ 190,000 |
| | |
| **Total** | **$ 830,000** |

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