# Ethiopia Socioeconomic Panel Survey (ESPS)
# ESS Panel II

# 2021/2022

*Basic Information Document*

**Ethiopian Statistics Service**

**and**

**Living Standards Measurement Study, World Bank**

**December 2022**

## ACRONYMS

| | |
|---|---|
| AgSS | Annual Agricultural Sample Survey |
| BID | Basic Information Document |
| BMGF | Bill and Melinda Gates Foundation |
| DFS | Digital financial services |
| EA | Enumeration area |
| ESPS | Ethiopia Socioeconomic Panel Survey |
| ESS | Ethiopian Statistics Service |
| FIES | Food Insecurity Experience Scale |
| HCES | Household Consumption and Expenditure Survey |
| LSMS-ISA | Living Standards Measurement Study–Integrated Surveys on Agriculture |
| NSDS | National Strategy for the Development of Statistics |
| PH | Post-harvest |
| PP | Post-planting |
| PPS | Probability proportional to size |
| SRS | Simple random sampling |

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# 1. Introduction

The Ethiopian Socioeconomic Survey (ESPS) is a collaboration between the Ethiopia Statistics Service (ESS) and the World Bank Living Standards Measurement Study—Integrated Surveys of Agriculture (LSMS-ISA), with funding from the Bill and Melinda Gates Foundation (BMGF). [1] The objective is to collect multitopic panel household data giving special attention to improving agricultural statistics and better understanding the link between agriculture and other household income activities. The ESPS is rooted in the need for a survey that responds to Ethiopia's data demands, fills gaps, and is of high quality, accessible to the public, and aligned with the National Strategy for the Development of Statistics (NSDS). The project is also designed to build capacity, share knowledge with other countries, and improve survey methodologies and technology. With the ESPS, the ESS has established a guide for consulting with organizations, national and international, that could provide technical guidance and for collecting data to inform policy decisions and research.

Ethiopia is one of seven countries the World Bank is supporting as they work to produce more reliable data on agricultural households. The main objective of the LSMS-ISA is to better understand how agriculture in Sub-Saharan Africa relates to poverty reduction and household welfare. The project will boost the data collection capacity of the national statistical organizations and the quality of household-level agriculture statistics; the data will be analyzed for insights into ways to foster agricultural innovation and efficiency.

The 2021/22 survey (ESPS-5) is the second wave of the panel that began in 2018/19 (ESPS-4), rather than being a follow-up to previous ESPS waves. For security reasons, ESPS-5 was not conducted in the Tigray region.

ESPS responds to Ethiopia's needs for individual, household, and community data. The questionnaires collect data on a wide range of demographic and socioeconomic variables. Because most Ethiopians depend on agriculture, the questionnaire for the rural sample has an extensive agriculture module.

The ability to follow the same households over time makes the ESPS a powerful tool for studying the role of agriculture in household welfare over time because it supports analyses of how households add to their human and physical capital, how education affects earnings, and how government policies and programs affect poverty. The ESPS is the first ESS panel survey that links a multitopic household questionnaire with detailed questions about agriculture; the ESS has also introduced innovative survey approaches and technologies over time.

The purpose of this Basic Information Document (BID) is to provide detailed information on how the 2021/22 wave was carried out. The following sections present details of the survey instruments used in this wave, sample design, field work, and data management.

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[1] For more information on the LSMS and LSMS-ISA go to http://surveys.worldbank.org/lsms.

## 2. The ESPS-5 Survey Instruments

The ESPS-5 survey consisted of five questionnaires, similar to those used in previous waves but revised based on the results of those waves and on needs for new data they revealed. The following new topics are included in ESPS-5:

a. **Dietary Quality:** This module collected information on the household's consumption of specified food items.

b. **Food Insecurity Experience Scal**e (FIES): In this round the survey has implemented FIES. The scale is based on the eight food insecurity experience questions on the *Food Insecurity Experience Scale | Voices of the Hungry | Food and Agriculture Organization of the United Nations* (fao.org) .

c. **Basic Agriculture Information**: This module is designed to collect minimal agriculture information from households. It is primarily for urban households. However, it was also used for few rural households where it was not possible to implement the full agriculture module due to security reasons[2] and administered for urban households. It asked whether they had undertaken any agricultural activity, such as crop farming and tending livestock) in the last 12 months. For crop farming, the questions were on land tenure, crop type, input use, and production. For livestock there were also questions on their size and type, livestock products, and income from sales of livestock or livestock products.

d. **Climate Risk Perception**: This module was intended to elicit rural household perceptions, beliefs, and attitude about different climate-related risks. It also asked where and how households were obtaining information on climate and weather-related events.

e. **Agriculture Mechanization and Video-Based Agricultural Extension:** The rural area community questionnaire covered these areas rural areas. On mechanization the questions related to the penetration, availability and accessibility of agricultural machinery. Communities were also asked if they had received video-based extension services.

The ***household questionnaire*** was administered to all households in the sample; and several modules were administered to each eligible household member. The ***community questionnaire*** was administered to a group of community members to collect information on the socioeconomic indicators of the EAs where sample households reside.[3] The three ***agricultural questionnaires,*** consisting of ***post-planting and post-harvest questionnaires*** and a ***livestock questionnaire,*** were administered to all members of households engaged in agricultural activities.

An agricultural *holder* is a person who exercises management control over the operations of a holding and makes the major decisions about use of the resources available. Holders have technical

[2] These rural areas were not accessible during the post planting season. The team visited them when the security situation improved. The timing was past post-planting and crop-cut seasons and it was not possible to implement the full agriculture questionnaire in these areas.

[3] The community questionnaire does not collect sociological information about communities so the data cannot be used to represent communities in Ethiopia. It simply collects information that is common to the households selected for inclusion in EAs.

and economic responsibility for the holding, which they may operate as an owner or as a manager. It is possible to have more than one holder in a single household, in which case the relevant agriculture questionnaires are administered to each holder.

The household questionnaire elicits information on education; health (including anthropometric measurement for children); COVID-19; labor and time use; savings; digital financial services; food and nonfood expenditures; shocks and food insecurity; housing conditions; ownership of and user rights in assets; household nonfarm activities and entrepreneurship; urban agriculture (all crop and livestock production activities); climate risk perception; other sources of household income; assistance; and credits  (Table 2.1). Household location is geo-referenced in order to later link ESPS data to other geographic data sets (see Appendix 1 for discussion of the geospatial data provided with the ESPS).

The *community questionnaire* elicits information on access to basic services and infrastructure; community organizations; resource management; changes in the community; key events; community needs, actions, and achievements; local retail prices; and agricultural mechanization practices and Visual Aid Training (Table 2.2).

The post-planting and post-harvest agriculture questionnaires for crop farmers elicit information on land ownership and use; land use and agricultural income; farm labor; use of inputs; GPS land area measurement and coordinates of household fields; agricultural capital; irrigation; environment and conservation practices; and crop harvest and utilization (Tables 2.3 and 2.5).

The livestock questionnaire collects information on animal holdings and costs; and production, costs and sales of livestock and its byproducts (Table 2.4).

**Table 2.1: Household Questionnaire**

| Section | Topic | Respondent | Description |
|---|---|---|---|
| Cover | Cover | Field staff | Household location and size, household head's name, and field staff identification. |
| 1 | Household roster | Household head or spouse | List of individuals living in the household with basic demographics; for members younger than 18, parental education and occupation. Household members who left the household and their socioeconomic status |
| 2 | Education | Household members 4 years and older. For data for children 4–12, caregivers were asked. | Educational attainment, enrollment, attendance, school characteristics, and expenditures for the 2021–22 academic year.[a]<br><br>[a] The school year started in September 2021 and ended in July 2022. |
| 3 | Health | All household members. Caregivers were asked for data on children up to age 12. | Health problems, types of injury/illness, medical assistance/consultation, health insurance, disabilities, vital registration (birth certificate), breast feeding, and child anthropometrics. |
| 3b | COVID-19 | Household members 12 and older. | COVID-19 vaccination status and future plans; reason for getting or not getting vaccinated. |
| 4 | Labor and time use | Household members 7 and older. Caregivers | Use of time, labor market participation in the last 7 days and the last 12 months, unpaid apprenticeship, temporary absence, job search, casual or temporary |

| Section | Topic | Respondent | Description |
| --- | --- | --- | --- |
| | | were asked for the data on children aged 7–12. | work; participation in food, cash for work, or public works programs; unpaid labor (free or as exchange labor with other households). and contribution of free labor to community activities. |
| 5A | Banking and financial inclusion | Household members 18 and older | Saving (formal, informal, or both), financial literacy, insurance, and ownership of financial asset accounts (exclusive and joint), and value of financial assets owned privately or jointly. |
| 5B | Digital financial services (DFS) | Household members 18 and older and those who held a formal bank account | Individual disaggregated DFS utilization module: use of such DFS as ATM (debit) cards, online banking, and mobile banking; airtime purchase, money transfer, bill payment, cash withdrawal, etc.; benefits of using DFS; plus mobile phone ownership and associated social media usage |
| 6A | Food consumption, last 7 days | Person responsible for food purchase and preparation | Household food consumption (quantity and value) in the last 7 days and source of foods consumed by the household from a list of food items. |
| 6B | Food shared by non-household members & Food consumed outside home | Person responsible for food purchase and preparation | Food consumption by non-household members food consumption by household members away home in the last 7 days and. |
| 6C | Dietary quality | Household members 15 years and older | List of foods or drinks groups each household member consumed yesterday (at home or somewhere else) |
| 7 | Nonfood expenditure | Household head or most knowledgeable member | Household spending, previous month and 12 months, on nonfood items, including contributions to social, religious, and political institutions |
| 8 | Food Insecurity Experience Scale | Household head or most knowledgeable member | Information on household food insecurity over the past 12 months. |
| 9 | Shocks | Household head or eligible adult | Shocks during the last 12 months and their impact on income, assets, food production, and purchase. Strategies the household used to cope with the three worst shocks. |
| 10A | Housing | Household head or eligible adult | Dwelling ownership and property tax, characteristics of the dwelling and utilities, including WASH indicators, water and energy sources, cooking facilities, sewerage and solid waste management |
| 11 | Assets | Household head or eligible adult | Ownership and number of listed assets (Bajaj-taxi and personal computer or laptop were added to the list in this wave) |
| 12 (A &B) | Nonfarm enterprises | Owner or manager of enterprise | Characteristics of enterprises owned and managed or operated by any members of the household (including businesses permanently or temporally closed during the previous 12 months); sector, workplace, ownership, employment, revenue, expenses, and tax and fees related to the business. Business operation and start-up challenges. |
| 12C | Agriculture by urban households | Holder, owner, or manager of parcel | Crop production-related activities during 2021 Meher season (for temporary crops) or during last 12 months (for permanent crops) on agricultural land owned or |

| Section | Topic | Respondent | Description |
|---|---|---|---|
| | (crop production) | | rented or acquired in any way. Household information gathered focuses primarily on production size and inputs utilized. |
| 12D | Agriculture by urban households (livestock production) | Holder, manager, or owner of livestock | Information on livestock production–related activities during previous 12 months, such as current stock held by household; and sales, household income generated, and own consumption during previous 12 months. |
| 12E | Perception of climate risk | Household head or most knowledgeable member | Information on perception of a household from a list of climate events and shocks experienced over the previous 5 years and thought likely to occur in the next 5 years; losses likely to be shouldered, and mitigating measures to be taken. |
| 12F | Weather/climate information | Household head or most knowledgeable member | Household use of weather or climate-related information, information source, and how obtained. |
| 13 | Other income sources | Household head or eligible adult | Other sources of household income in the last 12 months, and any taxes related to the income. |
| 14 | Assistance | Household head or eligible adult | Assistance provided to the household by agencies, governmental and nongovernmental. |
| 15 | Credit | Household head or eligible adult | Household loans or credit received: source, repayment, collateral, and challenges in accessing credit |
| 16 | Contact information | Household head or eligible adult | Confidential–not included in the public data. |

### Table 2.2: Community Questionnaire

| Section | Topic | Respondent | Description |
|---|---|---|---|
| Cover | Cover | Field staff | Community location identified, field staff identified, dates and times of interviews |
| Cover2 | Cover | Direct observation by field staff (supervisor) | Community characteristics |
| 2 | Roster of informants | Informants | Respondent characteristics |
| 3 | Community basic information | Informants | Mobility, population, religion, marriage types, common land use |
| 4 | Access to basic services | Informants | Transportation, markets, proximity to the nearest town and major urban centers, electrification, access to education and health services, bank and microfinance institutions, and piped water |
| 5 | Economic activities | Informants | Main sources of employment, migration to and from the locality for work, cooperatives and microenterprises |
| 6 | Agriculture | Informants | Agricultural activities: major crops, main planting and harvesting seasons, rainy seasons, input use and accessibility, agricultural extension, and irrigation schemes |
| | | | |
| 8 | Community needs and actions | Informants | Initiation, participation and mobilization of resources for community projects like roads, school, health facility, |

| Section | Topic | Respondent | Description |
|---|---|---|---|
| | | | water, natural resource management, public transport, agriculture, and law enforcement |
| 9 | Productive safety nets program | Informants | Participation in the productive safety nets program; management and performance of the program |
| 10 | Market prices | Sellers in nearby market | Market prices in the closest market for a sample list of household items |
| 11 | Agricultural mechanization | Informants | Information on ownership, usage, and rental services for different types of farm machines in the community; familiarity with 2-wheel tractors, their accessibility, maintenance, and spare parts, and impact on production |
| 12 | Video-based agricultural extension or training | Informants | Availability of video-based extension or training: content, when introduced, and how functional it is |

## Table 2.3: Post-Planting Questionnaire[4]

| Section | Topic | Respondent | Description |
|---|---|---|---|
| Cover | Cover | Field staff | Holder location identification; name of household head, name of holder, household size, type of agricultural holding: farming, livestock, or both; field staff identification |
| 1 | Household roster | Household head or eligible adult | Name, age, and gender of each household member, and holding type: farming, livestock, or both |
| 2 | Parcel roster | Owner or manager of the parcel | Information on all parcels owned or managed by the holder |
| 3 | Field roster | Staff who measure fields using GPS and compass; field manager for questions not related to measurements. | Information on all fields (sub-parcels) owned and managed, including holder-reported area, GPS and compass-measured area, irrigation practice; use of labor and other inputs, soil erosion-prevention practices (e.g., legume production, fallowing, afforestation), and other details about each field |
| 4 | Crop roster | Field manager | Crop planting and management of each crop on each field, including information on cropping methods, use of improved seed and other inputs, management of crop damage, and crop produce sales |
| 9a. Crop cut | Crop cut | For the 4m x 4m crop cut: field staff and holder | Crop cut information for selected fields including fresh and dry weight (from a 4m x 4m crop cut) and barcode registration, excluding permanent, tree, and root crops |
| 5 | Seeds roster | Field manager | Seed-related information for each crop planted on each field. |
| 7 | Miscellaneous | Field manager | Information from holder on use of chemicals, e.g., fertilizer use, ploughing practices, access to and use of credit, extension, and other advisory services, watershed activities, irrigation practices, participation in commercial agriculture n cluster farming, and negative impacts of COVID-19 |

[4] There is no Section 6 in the post-planting questionnaire.

**Table 2.4: Livestock Questionnaire**[5]

| Section | Topic | Respondent | Description |
|---|---|---|---|
| 1 | Cover | Household head or eligible adult | Name, age, and gender of each household member, and holding type: farming, livestock, or both |
| 8_1 | Ownership | Holder, manager, or owner of livestock | Characteristics of livestock owned and their purpose |
| 8_2 | Change in stock | Holder or manager/owner of livestock | Total number of livestock by type; stock changes over the year due to birth, purchase, gifts given or received, sale, loss, slaughter, etc. |
| 8_3 | Livestock breeding, health, shelter, water, and feed | Holder, manager, or owner of livestock | Livestock breeding methods and costs; livestock shelter and feed types and sources; livestock treatments and treatment expenses |
| 8_4 | Milk and egg production, animal power, and dung | Holder, manager, or owner of livestock | Quantities of milk and eggs produced; production, disposition, and income from milk and eggs, income from other animal byproducts; use of livestock for transport, crop cultivation, and harvesting; disposition of livestock dung |

**Table 2.5: Post-Harvest Questionnaire**

| Section | Topic | Respondent | Description |
|---|---|---|---|
| Cover | Cover | Field staff | Holder location; names of household and holder; household size, agricultural holding type: farming, livestock, or both; field staff identification |
| 1 | Household roster | Household head or eligible adult. | Name, age, and gender of each household member and holding type: farming, livestock, or both |
| 9 | Crop harvest by field | Holder | Harvest information for all crops: crop use, area harvested, amount harvested, and any damage to crops |
| 10 | Harvest labor | Holder | Hired and household member labor used in harvesting each crop on each field, excluding permanent, tree, and root crops |
| 11 | Crop disposition/ sales | Holder | Information on crop disposition or sales. |

Major questionnaire revisions in the 2021/22 wave included the following:

- **Finance Module:** The financial assets module has been updated to collect more information on utilization of digital finance.

- **Labor Module:** The labor module has been updated to respond to the concepts and definitions endorsed by the 19th International Conference of Labor Statistics in 2013. *Employment* is defined as work for pay or profit, *work* as all activities to produce goods

[5] For ESPS 2021/22, because livestock questionnaires were fielded during post-planting visit September 2021-January 2022, there is only one cover page for both modules.

and services. Thus, the module covers employment, volunteering, own-use production, and unpaid training, among other forms of work.

- **Tax-related Questions:** Previous ESS waves sought some information on formal and informal taxes; ESPS-5 added questions on formal taxes paid (direct tax only) and informal taxes paid by households, income taxes (e.g., salary, rent, and agricultural income tax) and land use as well as housing tax, among others. For informal tax, it asks about household cash and in-kind contributions for such purposes as community development and religious and sociopolitical commitments. It also asked business owners and managers to report on business *direct tax* and business-related formal fees. The tax questions are distributed among modules.

- **Consumption Module:** The consumption module has been revised to reflect the contemporary consumption patterns of Ethiopian households. ESPS-5 specified several new consumable items, based on detailed results of the recent national Household Consumption and Expenditure Survey (HCES) and the consumption module of ESS Fixed Panel I. Some items were dropped in this wave because they had not been reported by households in previous waves.

# 3. Sample Design

## 3.1.Design and Coverage

The slight modification in scope and content that was made starting in the fourth wave of the Ethiopian Socioeconomic Panel Survey (ESPS-4), was strengthened in ESPS-5. For ESPS-4, the sample frame was refreshed and expanded so that it became not only nationally representative but also representative for each of Ethiopia's 11 regions and for rural and urban areas. The ESPS-5 kept all the ESPS-4 sample except for those in the Tigray region and a few other places (see section 7).

## 3.2.Sample Size and Allocation

The ESPS-5 duplicated the sample used for ESPS-4; Table 3.1 summarizes the EAs sampled, and the corresponding households targeted.

**Table 3.1: EAs and Households Sampled in ESPS-4 by Region and Urban and Rural Areas**

| Region | Urban | | Rural | | Total | |
|---|---|---|---|---|---|---|
| | EAs | Households | EAs | Households | EAs | Households |
| Tigray | 19 | 285 | 35 | 420 | 54 | 705 |
| Afar | 15 | 225 | 31 | 372 | 46 | 597 |
| Amhara | 19 | 285 | 43 | 516 | 62 | 801 |
| Oromia | 20 | 300 | 45 | 540 | 65 | 840 |
| Somali | 17 | 255 | 36 | 432 | 53 | 687 |
| Benishangul Gumuz | 16 | 240 | 30 | 360 | 46 | 600 |
| SNNP | 18 | 270 | 42 | 504 | 60 | 774 |
| Gambela | 20 | 300 | 22 | 264 | 42 | 564 |
| Hareri | 24 | 360 | 18 | 216 | 42 | 576 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Addis Ababa | 53 | 795 | - | - | 53 | 795 |
| Dire Dawa | 28 | 420 | 14 | 168 | 42 | 588 |
| **Ethiopia** | **249** | **3,735** | **316** | **3,792** | **565** | **7,527** |

### 3.3.Sample Selection

ESPS-5 used the sample selected for ESPS-4. which was based on the 2018 pre-census cartographic database of EAs. The ESPS-4 sample was a two-stage stratified probability sample. Rural ESPS-4 EAs were a subsample of the AgSS[6] EA sample. Thus, the first stage of sampling in rural areas entailed using simple random sampling (SRS) to select EAs—the primary sampling units—from the sample for the 2018 AgSS EAs. The first stage of sampling for urban areas was selecting EAs directly from the urban EAs within each region using probability proportional to size (PPS) systematically. This automatically produced a proportional allocation of the urban sample by zone within each region.

The second stage of sampling was to use systematic random sampling to select households to be surveyed in each EA. From the rural EAs, 10 agricultural households were selected as a subsample of the households selected for the AgSS[7] and, when available, up to 2 nonagricultural households were selected from the nonagricultural households listed in each EA specified. [8] For urban areas, 15 households were selected per EA regardless of their economic activity. The households were selected using systematic random sampling from all the households listed in each EA.

As Table 3-1 illustrates, 7,527 households were sampled. These households were sampled using 565 EAs, of which 316 were from the rural AgSS and 249 from urban areas. Table 3.2 shows the distribution of EAs sampled and households interviewed during ESPS-4.

**Table 3.2: Final ESPS-4 Sample and Households Interviewed by Region and Rural and Urban Areas**

| | Urban | | Rural | | Total | |
|---|---|---|---|---|---|---|
| **Region** | **EAs** | **Households** | **EAs** | **Households** | **EAs** | **Households** |
| Tigray | 19 | 283 | 35 | 398 | 54 | 681 |
| Afar | 15 | 165 | 29 | 110 | 44 | 275 |
| Amhara | 18 | 271 | 43 | 418 | 61 | 689 |
| Oromia | 20 | 285 | 45 | 410 | 65 | 695 |
| Somali | 17 | 255 | 35 | 346 | 52 | 601 |
| Benishangul Gumuz | 13 | 105 | 19 | 101 | 32 | 206 |
| SNNP | 18 | 254 | 40 | 423 | 58 | 677 |
| Gambella | 20 | 300 | 19 | 209 | 39 | 509 |
| Hareri | 24 | 345 | 18 | 191 | 42 | 536 |
| Addis Ababa | 52 | 778 | _ | _ | 52 | 778 |
| Dire Dawa | 28 | 419 | 14 | 161 | 42 | 580 |

[6] The AgSS EAs were selected based on probability proportional to the size of population (PPS) from the sample of rural EAs, which was stratified by zone.

[7] For AgSS, 20 agricultural households are selected using systematic random sampling. Agricultural households are those involved in farming, livestock activities, or both.

[8] In previous waves, if there were no more than two or no nonagricultural households in an EA, more agricultural households were interviewed instead. This meant the total number of agricultural households surveyed per EA varied with the number of nonagricultural households in the EAs.

| | | | | | | |
|---|---|---|---|---|---|---|
| Ethiopia | 244 | 3,460 | 297 | 2,767 | 541 | 6,227 |

Table 3.3 shows the distribution of ESPS-5 households interviewed by region and urban or rural location. For both the agriculture and household modules, 4,999 households from the 438 EAs were interviewed. Households interviewed in Addis Ababa were naturally exclusively urban. Attrition was observed in the coverage of both EAs and households.

**Table 3.3: Final Sample and Households Interviewed in ESPS-5 by Region and Rural and Urban Area**

| | Urban | | Rural | | Total | |
|---|---|---|---|---|---|---|
| **Region** | **EAs** | **Households** | **EAs** | **Households** | **EAs** | **Households** |
| Tigray | _ | _ | _ | _ | _ | _ |
| Afar | 11 | 133 | 11 | 119 | 22 | 252 |
| Amhara | 19 | 254 | 37 | 403 | 56 | 657 |
| Oromia | 19 | 249 | 38 | 398 | 57 | 647 |
| Somali | 17 | 208 | 34 | 339 | 51 | 547 |
| Benishangul Gumuz | 8 | 100 | 10 | 106 | 18 | 206 |
| SNNP | 17 | 224 | 42 | 433 | 59 | 657 |
| Gambella | 20 | 235 | 19 | 189 | 39 | 424 |
| Hareri | 23 | 256 | 18 | 188 | 41 | 444 |
| Addis Ababa | 53 | 644 | _ | _ | 53 | 644 |
| Dire Dawa | 28 | 371 | 14 | 150 | 42 | 521 |
| Ethiopia | 215 | 2,674 | 223 | 2,325 | 438 | 4,999 |

The security situation in northern parts of Ethiopia meant that, in Tigray, ESPS-5 did not cover any of the EAs and households previously sampled. In Afar, while 275 households in 44 EAs had been covered by both the ESPS-4 agriculture and household modules, in ESPS-5 only 252 households in 22 EAs were covered for both modules. During the fifth wave, security was also a problem in both the Amhara and Oromia regions, so there was a comparable reduction in the number of households and EAs covered there.

### 3.4.Data Weighting

ESPS5 was conducted in 2021/22 and is the second wave of the new panel that began in 2018/19 with ESPS4. Therefore, ESPS5 data can be used both for ***cross-sectional*** and ***longitudinal*** analysis. In order to cater to both kinds of analysis, separate cross-sectional and longitudinal weights were calculated and included in the ESPS5 data.

Cross-sectional analysis of panel data is concerned with making inferences about the target population of the survey at a given reference time, namely the time when the panel wave at hand was conducted. Cross-sectional weights are needed for each wave of a panel survey. Accordingly, ESPS5 cross-sectional weights were calculated to represent the 2021/22 Ethiopia population (excluding Tigray) at regional and rural/urban levels. Similarly, cross-sectional sample weights had previously been calculated and disseminated for the ESPS4 data. It must be noted that ESPS5 cross-sectional weights were calculated for all the households interviewed during ESPS5, regardless of whether they had been interviewed in ESPS4 or not (4,999 households, encompassing 23,042 ESPS5 roster individuals).

In addition to pure cross-sectional analysis, cross-sectional weights attached to each wave of a panel survey also allow users to make inferences about net changes between two panel waves. For instance, using cross-sectional weights from ESPS4 and ESPS5, a user can easily estimate whether and to what extent the number of poor households in the Addis Ababa region increased or decreased from 2018/19 to 2021/22. Note that this net change analysis does not require linking household-level data from the ESPS4 and ESPS5 datasets.

Conversely, longitudinal analysis of panel data is mainly concerned with inferences about gross changes across panel waves or estimation of parameters of longitudinal unit-level models. As an example of gross change analysis, consider the problem of estimating how many households in the Addis Ababa region which had been poor in 2018/19 were no longer poor in 2021/22. To calculate this estimate, cross-sectional weights for ESPS4 and ESPS5 are not enough. Rather, the user needs to link household-level data from the ESPS4 and ESPS5 datasets and use longitudinal weights attached to households that are common to both. As an example of longitudinal unit-level analysis, consider a statistical model that explains the probability for an Addis Ababa household to exit from poverty between 2018/19 and 2021/22 as a function of household size, the number of employed household members at the two reference times, and possibly other explanatory covariates. To estimate the parameters of such a model, once more, linked household data and longitudinal weights must be used. Against this background, longitudinal weights were also calculated for the sample of households that were interviewed in both ESPS4 and ESPS5 (4,906 households, encompassing 22,632 ESPS5 roster individuals).

The methodology used to calculate the cross-sectional and longitudinal weights for the households and the roster individuals of ESPS5 is described in Appendix 2. The fundamental objectives of the calculation procedure were (i) mitigation of bias risks and (ii) improvement of estimation efficiency. In addition, the procedure was designed to produce *integrated* individual-household weights. As a result, for both cross-sectional and longitudinal weights, individual weights are constant within each household and are equal to the weight of the household.

From a procedural standpoint, the main difference between the calculation steps followed to produce cross-sectional and longitudinal weights is that the former incorporates a calibration adjustment to official population projections for 2022 that were published by ESS, whereas the latter do not. This is because longitudinal weights are not meant to expand to any specific cross-sectional population, but rather to a longitudinal population which is inherently dynamic (i.e. time-varying) and for which no external sources of information were available.

# 4. Training, Data Collection, and Monitoring

## 4.1.Training

Six training sessions were held for ESPS-5: two (in July 2021and February 2022) for Training of Trainers and four (in August, September, and October 2021 and March 2022) for field staff enumerators and supervisors. All six sessions emphasized not only the content of the questionnaires and *Survey Solutions* CAPI but also their practical applications in data collection and supervision. All the trainees had survey and CAPI experience and most had participated in other ESS surveys.

## 4.2.Field Work Organization and Data Collection

ESPS-5 was conducted in two visits, following the AgSS field schedule. For rural households, in the first visit, between September 2021 and January 2022, the post-planting agriculture[9] and livestock, questionnaires were administered. In the second visit, between April and June 2022, the

[9] Crop cut questionnaire was included in the post-planting questionnaire.

post-harvest agriculture, household, and community questionnaires were administered. For urban households, there was a single visit, between April and June 2022, to administer the household and community questionnaires.

**Table 4.1: ESPS-5 Fieldwork Timeline**

| **Questionnaire** | **2021** | | | | | | **2022** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Sept** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Apr** | **May** | **Jun** |
| Post-planting agriculture and livestock | ■ | ■ | ■ | ■ | ■ | | | | |
| Crop cut | | ■ | ■ | ■ | ■ | | | | |
| Post-harvest agriculture | | | | | | | ■ | ■ | ■ |
| Household and community | | | | | | | ■ | ■ | ■ |

In separate visits the post-planting and post-harvest questionnaires collected information on the same fields and crops. The post-planting questionnaire collected field and crop information, such as area planted, inputs, and other farming factors, and the post-harvest questionnaire captured harvest, harvest inputs, crop damage, and end use of crops.

Most of the questions in the post-planting, post-harvest, and livestock questionnaires were asked of the holder (Tables 2.3–2.5). However, some were answered by the enumerator following specific instructions in the questionnaires and field manuals. In the post-planting questionnaire, the enumerator measured all the fields (sub-parcels) managed by the holder using GPS; if the field were small (40 $m^2$ or less), it was measured using a compass as well as GPS.[10]

The enumerator also was the respondent for the crop-cutting questionnaire, which was applied for all cereal, pulse, and oilseed crops. In each EA, field workers carried out a 4 x 4-meter crop cut on 10 fields of eligible crops. (The detailed procedure can be found in the crop cut manual.)

Similarly, household questions were collected from the most knowledgeable person, usually an adult; for children, it was a parent or another adult in the household (Table 2.1). The enumerator carried out the anthropometric measurements for children aged 6–59 months.

The community questionnaire was collected in both local focus groups and through direct observation (Table 2.2). Community informants in each EA were chosen based on instructions in the community questionnaire and the manual. The questionnaire also collected commodity price information from one or two nearby markets with the help of sellers there.

Resident enumerators administered the household, agricultural (post-planting and post-harvest), and livestock questionnaires in rural areas, except for the Afar and Somali regions. A resident enumerator was assigned for each EA and lived there for the entire survey period, from September 2021 to June 2022. Daily laborers were also hired for a few days as field guides to help the enumerators to measure parcels and fields and for cutting crops. They also helped with child measurements. Mobile enumerator teams covered all Afar and Somali EAs.

[10] GPS estimates are less accurate for smaller fields; in these cases, enumerators were instructed to use rope and compass to measure the area.

One field supervisor managed the work of enumerators in two to four EAs and also administered community questionnaires in each of the EAs.

Data were collected using *Survey Solutions* CAPI.

### 4.3.Fieldwork Monitoring and Evaluation

Field supervisors in ESS branch offices provided routine supervision. Branch statisticians and supervisors were assigned to this project; the branch supervisors made extended visits to the EAs between September 2021 and June 2022. One field supervisor checked the work of enumerators in assigned EAs. The last visit was combined with community interviews conducted by the supervisors. Branch statisticians were also in the field to check the work of supervisors and enumerators.

World Bank staff and consultants also provided supervision. The extremely volatile security situation during the post-planting data collection period limited their visits to the post-harvest data collection period, April to June 2022.

## 5. Data Management and Description of Datasets

### 5.1.Final Data Cleaning

Final cleaning was carried out on all data files. Only errors that the team could fix clearly and confidently were corrected; errors that had no obvious fix were left in the datasets. Cleaning methods for these errors are up to the data user.

### 5.2.Description of Public Datasets

The electronic datasets are organized by questionnaire with the following file name labels in parentheses: household (*hh*), community (*com*), post-planting agriculture (*pp*), post-harvest agriculture (*ph*), and livestock (*ls*). Data within each questionnaire do not contain any constructed variables. For example, the ESS data provide almost all the variables needed to estimate total household consumption, but the data set has no such estimate. The only compiled data included with the ESS files are the geospatial variables described below.

Within each questionnaire type, the data-file naming scheme is a combination of the prefix '*sect*', followed by section number, and then suffix '*hh_w5*' for household wave 5 data, and '*com_w5*' for community wave 5 data. Similarly, the suffixes for post-planting, post-harvest, and livestock wave 5 data are '*pp_w5*', '*ph_w5*', and '*ls_w5*'.

For example, the data set that corresponds with section 1 of the household questionnaire is in file '*sect1_hh_w5*'. Exceptions are sections where the files are broken down even further due to different reference periods or different levels of recording the data. An example is section 6 of the household questionnaire, on consumption, which is split into 5 files with each file corresponding to the reference period collected in it. In this case, the corresponding files will be named '*sect6a_hh_w5*', '*sect6b2_hh_w5*', 'sect6b3_hh_w5', '*sect6b4_hh_w5', and 'sect6c_hh_w5.'*

Each dataset has identification variables, a rural and urban indicator variable (*saq14*), and sampling weights for cross-sectional weight (*pw_w5*) and panel weight (pw_w5_Panel)

To keep all names and addresses confidential, in the post-planting questionnaire contact addresses, field descriptions, and names of field staff have been removed from the datasets; GPS coordinates have also been removed because they could be used to accurately locate households and fields. However, as a courtesy to users, geospatial variables are provided with the data described in Appendix 1.

*Household data* are organized in 35 data files (Table 5.1).

**Table 5.1: Household Data Files[11]**

| Section | Topic | Dataset Filename | Unique Identification Variables |
|---|---|---|---|
| Cover | Cover | *sect_cover_hh_w5* | *household_id* |
| 1 | Roster | *sect1_hh_w5* | *household_id individual_id* |
| 2 | Education | *sect2_hh_w5* | *household_id individual_id* |
| 3 | Health | *sect3_hh_w5* | *household_id individual_id* |
| 3B | COVID-19 | *Sect3B_hh_w5* | *household_id individual_id* |
| 4 | Labor and time use | *sect4_hh_w5* | *household_id individual_id* |
| 5A | Banking and financial inclusion | *sect5a_hh_w5* | *household_id individual_id* |
| 5B | Digital financial services | *sect5b1_hh_w5* | *household_id household_id* |
| 6A | Food consumption last 7 days | *sect6a_hh_w5* | *household_id item_cd* |
| 6B | Food shared by non-household members (Filter Question) | *sect6b2_hh_w5* | *household_id* |
| 6B | Food shared by non-household members | *sect6b3_hh_w5* | *household_id Age_Group* |
| 6B | Food consumed outside home | *sect6b4_hh_w5* | *household_id meal_id* |
| 6C | Dietary quality | *sect6c_hh_w5* | *household_id individual_id* |
| 7 | Nonfood expenditure, one month | *sect7a_hh_w5* | *household_id item_cd_30day* |
| 7 | Nonfood expenditure, 12 months | *sect7b_hh_w5* | *household_id item_cd_12months* |
| 8 | Food insecurity experience scale | *sect8_hh_w5* | *household_id* |
| 9 | Shocks | *sect9_hh_w5* | *household_id shock_type* |
| 10A | Housing | *sect10a_hh_w5* | *household_id* |
| 11 | Assets | *sect11_hh_w5* | *household_id asset_cd* |
| 12A | Nonfarm enterprises participation filter | *sect12a_hh_w5* | *household_id* |
| 12B | Nonfarm enterprises roster | *sect12b1_hh_w5* | *household_id enterprise_id* |
| 12B | Nonfarm enterprises start-up barriers | *sect12b2_hh_w5* | *household_id* |
| 12C | Agriculture for All Urban EAs and rural EAs that are not part of agriculture survey: filter | *sect12c_q1_hh_w5* | *household_id* |
| 12C | Agriculture for All Urban EAs and rural EAs that are not part of the agriculture survey | *sect12c_hh_w5* | *household_id, field_id crop_id* |
| 12D | Livestock for All Urban EAs and rural EAs that are not part of the agriculture survey | *sect12d_hh_w5* | *household_id ls_code* |
| 12E | Perception of climate risk | *sect12e_hh_w5* | *household_id risk_type* |
| 12F | Perception of climate risk: source of information | *sect12f_hh_w5* | *household_id* |

[11] Data for sect5a_hh_w5, sect5b2_hh_w5, sect6c_hh_w5, sect15a_hh_w5, and sect15b_hh_w5 are not currently available. The data will be available soon.

| Section | Topic | Dataset Filename | Unique Identification Variables |
|---|---|---|---|
| 13 | Other income | *sect13_hh_w5* | *household_id source_cd* |
| 14 | Assistance | *sect14_hh_w5* | *household_id assistance_cd* |
| 15 | Credit access filter and constraints | *sect15a_hh_w5* | *household_id* |
| 15 | Credit details | *sect15b_hh_w5* | *household_id loan_id* |
| 16 | Contact information (not public) | *sect16_hh_w5* | *household_id* |
| cons_agg aggregate | Consumption aggregate | *Cons_agg_w5* | *household_id* |

*Community data* are organized in 12 data files (Table 5.2).

**Table 5.2: Community Data Files**

| Section | Topic | Dataset Filename | Unique Identification Variables |
|---|---|---|---|
| 1A | Cover/ identification | *Sect01a_com_w5* | *ea_id* |
| 1B | Cover/ community overview/ observation | *Sect01b_com_w5* | *ea_id* |
| 2 | Roster of informants | *Sect02_com_w5* | *ea_id ROSTER_OF_INFORMANTS__id* |
| 3 | Community basic information/ demographics | *Sect03_com_w5* | *ea_id* |
| 4 | Access to basic services and infrastructure | *Sect04_com_w5* | *ea_id* |
| 5 | Economic activities and employment | *Sect05_com_w5* | *ea_id* |
| 6 | Agriculture | *Sect06_com_w5* | *ea_id* |
| 7 | Changes and events | *Sect07_com_w5* | *ea_id2 event_id* |
| 8 | Community needs | *Sect08_com_w5* | *ea_id cs8q00* |
| 9 | Productive safety net program | *Sect09_com_w5* | *ea_id* |
| 10A | Market prices: market location | *sect10a_com_w5* | *ea_id2* |
| 10B | Prices in market | *sect10b_com_w5* | *ea_id2 cs10bq02* |
| 11 | Agriculture mechanization | *sect11_com_w5* | *ea_id2 cs11q00* |
| 12 | Virtual/video extension services | *sect12_com_w5* | *ea_id* |

*Agricultural data* are in three folders: post-planting, post-harvest, and livestock. The sections and the file names are shown in Tables 5.3–5.5.

**Table 5.3: Post-planting Agricultural Data Files**

| Section | Section Name | Dataset Filename | Unique Identification Variables |
|---|---|---|---|
| Cover | Cover | *sect_cover_pp_w5* | *holder_id* |
| 1 | Household roster | *sect1_pp_w5* | *holder_id s1q00* |
| 2 | Parcel roster | *sect2_pp_w5* | *holder_id parcel_id* |
| 3 | Field roster | *sect3_pp_w5* | *holder_id parcel_id field_id* |
| 4 | Crop field roster | *sect4_pp_w5* | *holder_id parcel_id field_id crop_id* |
| 5 | Seed acquisition | *sect5_pp_w5* | *holder_id s5q0B s5q01a* |
| 7 | Holder questions | *sect7_pp_w5* | *holder_id* |
| 9a | Crop cut by field (for specified fields and crops only) | *sect9a_pp_w5* | *holder_id parcel_id field_id crop_id* |

* For exceptions to this data set, see Section 7.2.

**Table 5.4: Post-harvest Agricultural Data Files**

| Section | Section Name | Dataset Filename | Unique Identification Variables |
|---|---|---|---|
| Cover | Cover | *sect_cover_ph_w5* | *holder_id* |
| 1 | Household roster | *sect1_ph_w5* | *holder_id s1q00* |
| 9 | Harvest by field | *sect9_ph_w5* | *holder_id parcel_id field_id crop_id* |
| 10 | Harvest labor | *sect10_ph_w5* | *holder_id parcel_id field_id crop_id* |
| 11 | Crop utilization | *sect11_ph_w5* | *holder_id harvestedcrop_id s11q01* |

* For exceptions to this data set, see Section 7.2.

**Table 5.5: Livestock Data Files**

| Section | Section Name | Dataset Filename | Unique Identification Variables |
|---|---|---|---|
| Cover | Cover | *sect_cover_ls_w5* | *holder_id* |
| 8.1 | Livestock inventory and ownership | *sect8_1_ls_w5* | *holder_id ls_code* |
| 8.2 | Livestock change | *sect8_2_ls_w5* | *holder_id ls_code* |
| 8.3 | Livestock breeding, health, shelter, water, and feed | *sect8_3_ls_w5* | *holder_id ls_type* |
| 8.4 | Milk and egg production, animal power, and dung | *sect8_4_ls_w5* | *holder_id ls_code* |

### 5.3. Additional explanation for Basic agriculture sections (Crop and Livestock) in the household questionnaire (Section 12c and 12d)

ESPS-5 collected selected agriculture indicators (crop and livestock) from all urban households and rural households which were not visited during post-planting visit. These sections were initially intended to collect data from urban households. However, the same module was used to collect some agriculture data from households that were not visited during the post planting visit due to different reasons. If data users wanted to separate the data for the rural and urban households to do separate analysis for urban agriculture, they can drop the rural household data and keep only the data for urban households using the identifying variable "saq14 ".

### 5.4. Geospatial Data

The ESS data files include additional geospatial data computed for data users. The geo-variables are stored in two files: field-level data (ETH_PlotGeovariables_Y5), and household-level data (ETH_HouseholdGeovariables_Y5). Appendix 1 gives information on the ESS geospatial data.

## 6. Using ESS Public Data

### 6.1. File Structure

The data should always be used in conjunction with the questionnaire and the interviewer's instruction manuals. File organization depends on questionnaire structure: A file is a questionnaire section or subsection. In addition, there are three files: two for geospatial variables and the third for quantity (consumption and production) conversion factors. All the geospatial variable files are constructed based on GPS coordinates collected at homesteads and plots.

### 6.2. Merging Datasets

For ESPS-5**,** in household and agricultural data all households are uniquely identified by the variable *household_id*. This variable is used as the unique variable in the merging of all household data files. In datasets where there is more than one observation per household, additional variables may be required. With files for individuals, the variable that uniquely identifies the individual within the household is *individual_id*. In order to merge any two of these files, the variable *individual_id* would be used. In the agricultural datasets, parcel files are merged using *holder_id* and *parcel_id* and crop files by using *holder_id, parcel_id, field_id,* and *crop_code*.

The community questionnaire is administered at the EA level. A unique EA identifier, *ea_id,* is in every data file. This variable is the concatenation of the variables *region, zone, wereda, town, subcity, kebele,* and *EA*, and is used as the unique variable in merging community data files. For some community datasets, additional key variables may be needed.

The ESPS-5 is on the whole a continuation of the ESPS-4 in both scope and content, so it can be merged with relative ease with the ESPS-4. However, merging the two datasets with the earlier three waves of the ESPS requires caution. For the household and agricultural data, households in all five waves are uniquely identified by the variable *household_id*.

### 6.3. Unit Conversion Factors

To collect the item unit weights required to calculate conversion factors, in 2014 a specialized market survey was conducted. Reference photographs were also taken for all item unit weights collected. The market survey was conducted throughout Ethiopia in an effort to capture variations in conversion factors.

The 2014 survey collected a wide array of item unit weights that were then used to calculate conversion factors. For ESPS-5, we are still using the same food and crop conversion factors collected in 2014. The conversion factors for ESPS-5 data can be found in *Food_CF_Wave5.dta* and *Crop_CF_Wave5.dta*. In both files, separate variables have region-specific conversion factors (e.g., *mean_cf1* for Tigray). There is also a national conversion factor (*mean_cf_nat*). Where conversion factors were calculated for a particular region, the average conversion was included for the region. However, if there was no conversion found for a region, the national average was used for region-specific conversion variables. Although these conversion factors cover a majority of the item/crop-unit combinations in the data set, there are still gaps where conversion factors are not available. There is a continuing effort to fill these gaps; updated conversion factors will be released as they become available.

To use the conversion factors, it is necessary to multiply a crop or food item quantity by a conversion factor. To do this, it is necessary to merge the relevant dataset with the conversion factors dataset. For example, the dataset *sect5a_hh_w5.dta* features question 2, which asks how much the household consumed of each food item. One household is said to have consumed 1.5 *large medeb* of onions. To convert "*large medeb*" to kg, the dataset *Food_CF_Wave5.dta* has to be merged on the item code (*item_cd_cf*[12]) and unit code (here, *hh_s5aq02_b*); the quantity (here, 1.5) is then multiplied by the relevant conversion factor. This could be either the conversion factor for that household's particular region/stratum(variable *mean_cf5* for Oromia) or the national conversion factor (variable *mean_cf_nat)*. The same procedure can be followed to convert crop quantities using *Crop_CF_Wave5.dta* by merging crop code (*crop_code*) and unit code (*ph_s9q04_b* in *sect9_ph_w5.dta,*
for example)**.**

### 6.4.Reference Photo Album

In ESPS, reference photographs have been used to collect food consumption and crop production quantities reported in nonstandard units. The photographs depict food items or crops in nonstandard units (and, where applicable, different sizes) and were meant to ensure uniformity in the nonstandard amounts reported. The photos were collected systematically during the market survey when item unit weights were collected. Interviewers taking photographs were instructed to follow strict protocols, such as including a reference object (typically a standard-sized bottle of water) to provide a frame of reference for the size of the unit. For units with multiple sizes, all photographs used the same reference object to make comparison easier for the respondent. The reference photos taken during the market survey were compiled into an album and uploaded into the CAPI. Item-specific photos were included for non-container units (e.g., piece, medeb, and bunch); similarly, three photos of containers (e.g., tassa, kunna, and jog) were also included. Moreover, photos of farm machinery (such as various types of two-wheel tractors) were included for the community tool. The reference photo album used by interviewers is included with additional documentation on the website (under "Photo Aids"). The procedures used for collecting reference photos and the conversion factors followed the guidelines are laid out in a guidebook being produced by the LSMS team, *The Use of Non-Standard Units for the Collection of Food Quantity: A Guidebook for Improving the Measurement of Food Consumption and Agricultural Production in Living Standards Surveys*.

[12] This variable (*item_cd_cf*) was specifically created to merge with conversion factor files. This was necessary to account for the "other" categories where specific items were listed. For example, a common "other vegetable" reported was carrot. There is no code for carrot in *item_cd* but a code was assigned in *item_cd_cf* specifically for merging with *Food_CF_Wave4*. Codes for these "other" items are not listed on the questionnaire.

## 7. Problems and Challenges Faced During Wave 5 of the Survey

- **Security:** The security situation in the northern part of the country and in some EAs in other regions has affected coverage of the survey in this wave. From the original sample, 127 EAs (34 urban and 93 rural) were not included. Most of them are in Tigray (54 EAs), Benshangul-Gumuz (28 EAs), and Afar (8 EAs). In addition, 248 rural households were not accessible during the PP visit but were interviewed during the PH and HH visit. The agricultural information for these households does not include all the details available in the PP module.

- **Fieldwork challenges between PP and HH visits:** 11 households left their locations after the PP visit and 29 were in EAs that were not accessible during the second visit for a variety of reasons. For these 40 households only PP and livestock data are available.

- **Tracking problems between waves:** Some households that had been interviewed in the baseline (2018/19) survey and had changed locations were not tracked due to lack of information on their current residences.

- **Change in fieldwork schedule:** In 2021/22, the main fasting period of Christians and Muslims were in the month of April. Therefore, to avoid collecting consumption data during fasting and festive periods, the consumption module was administered after mid-May.

## Appendix 1: Geospatial Data with the ESPS

The ESPS collects confidential information on respondents. Confidential variables are (1) names of respondents to the household and community questionnaires, (2) village and constituency names, (3) descriptions of household dwellings and agricultural field locations, (4) phone numbers of household members and their reference contacts, (5) GPS-based dwelling and agricultural field locations, (vi) names of children of the household head or spouse who live elsewhere, (7) names of deceased household members, (8) names of individuals listed in the network roster, and (9) names of field staff. This confidential information is not part of the ESPS public use data.

To increase utility of the ESPS data, a set of geospatial variables has been provided by using the geo-referenced field and dwelling locations in conjunction with various spatial databases that were available to the survey team, among them measures of distance, climatology, soil and terrain, and other environmental factors. Time-series on rainfall and vegetation have also been used to describe the survey agricultural season relative to normal conditions. These variables are intended to provide some understanding of how geophysical characteristics vary at the landscape level. Tables A1.1 and A1.2 provide the name, type, source, reference period, resolution, description, and source of each variable. Household geospatial variables in the public release have been produced using anonymized location data (see below for description of anonymization method).

***Pub_ETH_PlotGeovariables_Y5***

For field locations, the geo file Pub_ETH_PlotGeovariables_Y5 contains four geospatial variables measuring field distance to household, slope, elevation, and potential wetness index. The observations are uniquely identified by the combination *of holder_id, household_id, parcel_id* and *field_id*. Observations in this file are for fields that are owned or cultivated by the household and that have been visited for GPS-based land-area measurement.

***Pub_ETH_HouseholdGeovariables_Y5***

The household geo file Pub_ETH_HouseholdGeovariables_Y5 contains a range of variables measuring (starting from the household dwelling) distance to main points, climatology, landscape typology, soil and terrain, and crop season parameters. The observations are identified by the ESPS household id.

This file also contains anonymized GPS coordinates, which enables users to generate their own spatial variables while preserving the confidentiality of sample household and communities. Following the method developed for the DHS program, the coordinate modification strategy relies on random offset of cluster center-point coordinates (or average of household GPS locations by EA in ESPS) within a specified range determined by an urban/rural classification. For urban areas a range of 0-2 km is used. In rural areas, where communities are more dispersed and risk of disclosure may be higher, a range of 0-5 km offset is used for most clusters. A range of 0-10 km offset is used for 10% of rural clusters, effectively increasing the known range for rural points while introducing only a small amount of additional noise. In some remote locations the coordinate modification does not provide sufficient anonymization and the coordinates are suppressed. Offset points are constrained at the zone level, so that they fall within the correct zone for spatial joins.

The result is a set of coordinates, representing EA location, that fall within known limits of accuracy. Users should take into account the offset range when considering different types of spatial analysis. Analysis of the spatial relationships between locations in close proximity would not be reliable. However, spatial queries using medium or low-resolution datasets should be minimally affected by the offsets. Zonal statistics (average or range of values within an area corresponding to the known range) could help minimize the effect of offsets when combining with large scale data or high-resolution grids with a high degree of local variation.

**Table A1.1: Field-level Georeferenced Data Linked to the ESPS Data**

| Theme | Source | Dataset Title | Variable Name in Strata File | Variable Type | Reference Period | Resolution | Description | Web |
|---|---|---|---|---|---|---|---|---|
| Distance | LSMS-ISA | Field Distance to Household | dist_household | Continuous | N/A | N/A | Field distance to household | |
| Soil & Terrain | NASA | SRTM 90m | plot_srtm | Continuous | N/A | 0.000833 dd[13] | Elevation (m) | ftp://xftp.jrc.it/pub/srtmV4/arcasci/ |
| | USGS | Slope (percent) | plot_srtmslp | Continuous | N/A | 0.000833 dd | Derived from unprojected 90m SRTM using DEM Surface Tools | |
| | AfSIS | Topographic Wetness Index | plot_twi | Continuous | N/A | 0.000833 dd | Local upslope contributing area and slope are combined to determine the potential wetness index: WI = ln (A s / tan(b) ) where A s is flow accumulation or effective drainage area and b is slope gradient. | http://www.ciesin.columbia.edu/afsis/bafsis_fullmap.htm# |

[13] Spatial resolution is given in decimal degrees (dd), the Coordinate Reference System units.

## Table A1.2: Household Georeferenced Data Linked to the ESPS Data

| Theme | Source | Dataset Title | Variable Name in Stata | Variable Type | Reference Period | Resolution | Description | Web |
|---|---|---|---|---|---|---|---|---|
| | UNOCHA | Household Distance to Main Road | dist_road | Continuous | 2018 | N/A | Distance to nearest primary or secondary road, 2018 | data.humdata.org |
| | Ethiopian Statistics Services / CityPopulation | Household Distance to Towns | dist_popcenter | Continuous | 2022 | N/A | Household distance to nearest town of >20,000 based on 2022 projection | http://www.citypopulation.de |
| | USAID FEWSNET | Household Distance to Key Market Centers | dist_market | Continuous | N/A | N/A | Household distance to nearest major market (FEWSNET key market centers) | |
| | WFP | Household Distance to Border Posts | dist_borderpost | Continuous | N/A | N/A | WFP global border crossings dataset and other sources | |
| | Wikipedia and other map sources | Household Distance to Regional Capital | dist_admctr | Continuous | N/A | N/A | Household distance to the capital of the region of residence | |
| Climatology | UC Berkeley | WorldClim Bioclimatic Variables | af_bio_1 | Continuous | 1960–90 | 0.008333 dd | Average annual temperature calculated from monthly climatology, multiplied by 10 (°C) | http://www.worldclim.org/bioclim |
| | UC Berkeley | WorldClim Bioclimatic Variables | af_bio_8 | Continuous | 1960–90 | 0.008333 dd | Average temperature of the wettest quarter, from monthly climatology, multiplied by 10. (°C) | http://www.worldclim.org/bioclim |
| | UC Berkeley | WorldClim Bioclimatic Variables | af_bio_12 | Continuous | 1960–90 | 0.008333 dd | Total annual precipitation, from monthly climatology (mm) | http://www.worldclim.org/bioclim |
| | UC Berkeley | WorldClim Bioclimatic Variables | af_bio_13 | Continuous | 1960–90 | 0.008333 dd | Precipitation of wettest month, from monthly climatology (mm) | http://www.worldclim.org/bioclim |
| | UC Berkeley | WorldClim Bioclimatic Variables | af_bio_16 | Continuous | 1960–90 | 0.008333 dd | Precipitation of wettest quarter, from monthly climatology (mm) | http://www.worldclim.org/bioclim |
| Landscape Typology | Copernicus Global Land Service | Crops_CoverFraction | cropshare | Continuous | 2019 | 0.00099 dd | Percentage cropland within local area (anonymizing region) | https://zenodo.org/record/3939050 |

| Theme | Source | Dataset Title | Variable Name in Stata | Variable Type | Reference Period | Resolution | Description | Web |
|---|---|---|---|---|---|---|---|---|
| | WorldPop | WorldPop | popdensity | Categorical | 2020 | 0.00083 dd | 2020 Population Density from Global High-resolution Population Denominators Project. | https://hub.worldpop.org/geodata/summary?id=41053 |
| | IFPRI | IFPRI standardized AEZ based on elevation, climatology | ssa_aez09 | Categorical | | 0.008333 dd | Agro-ecological zones created using WorldClim climate data and 0.0833dd resolution LGP data from IIASA. | http://harvestchoice.org/production/biophysical/agroecology |
| oil & Terrain | NASA | SRTM | srtm1k | Continuous | | 0.00833 dd | Elevation (m), aggregated to 1km block | ftp://xftp.jrc.it/pub/srtmV4/arcasci/ |
| | USGS | Slope (percent) | slopepct | Continuous | | 0.00833 dd | Derived from 90m SRTM, aggregated to 1km block | http://pubs.usgs.gov/of/2007/1188/, data provided by USGS upon request |
| | AfSIS | Topographic Wetness Index | Twi | Continuous | | 0.000833 dd | Local upslope contributing area and slope are combined to determine the potential wetness index:<br>WI = ln (A s / tan(b) )<br>where A s is flow accumulation or effective drainage area and b is slope gradient. | http://www.ciesin.columbia.edu/afsis/bafsis_fullmap.htm# |
| | FAO | Harmonized World Soil Database | SQ1 | Categorical | | 0.083333 dd | Nutrient availability | http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/ |
| | FAO | Harmonized World Soil Database | SQ2 | Categorical | | 0.083333 dd | Nutrient retention capacity | |
| | FAO | Harmonized World Soil Database | SQ3 | Categorical | | 0.083333 dd | Rooting conditions | |
| | FAO | Harmonized World Soil Database | SQ4 | Categorical | | 0.083333 dd | Oxygen available to roots | |
| | FAO | Harmonized World Soil Database | SQ5 | Categorical | | 0.083333 dd | Excess salts | |
| | FAO | Harmonized World Soil Database | SQ6 | Categorical | | 0.083333 dd | Toxicity | |
| | FAO | Harmonized World Soil Database | SQ7 | Categorical | | 0.083333 dd | Workability (constraining field management) | |
| +Crop Season Parameters | NOAA CPC | Rainfall Estimates (RFE) | anntot_avg | Continuous | 2001–21 | 0.1 dd | Average 12-month total rainfall (mm) for Jan–Dec | ftp://ftp.cpc.ncep.noaa.gov/fews/newalgo_est_dekad/ |
| | NOAA CPC | RFE | wetQ_avg | Continuous | 2001–21 | 0.1 dd | Average total rainfall in wettest quarter (mm) within 12-month periods Jan─Dec | |

| Theme | Source | Dataset Title | Variable Name in Stata | Variable Type | Reference Period | Resolution | Description | Web |
|---|---|---|---|---|---|---|---|---|
| | NOAA CPC | RFE | wetQ_avgstart | Continuous | 2001–21 | 0.1 dd | Average start of wettest quarter in dekads 1–36, where first decade of Jan =1 | |
| | NOAA CPC | RFE | h2021_tot | Continuous | 2021 | 0.1 dd | 12-month total rainfall (mm) in Jan-Dec, starting January 2021 | |
| | NOAA CPC | RFE | h2021_wetQ | Continuous | 2021 | 0.1 dd | Total rainfall in wettest quarter (mm) within 12-month periods starting January 2021 | |
| | NOAA CPC | RFE | h2021_wetQstart | Continuous | 2021 | 0.1 dd | Start of wettest quarter in decades 1–36, where the first decade of January 2021 =1 | |
| | NASA MCD12Q2 v061 | Land Cover Dynamics | eviarea_avg | Continuous | 2001–21 | 0.004176 dd | Average total change in greenness (integral of daily EVI values) within main (Meher) growing season, averaged by zone | https://appeears.earthdatacloud.nasa.gov/api/ |
| | NASA MCD12Q2 v061 | Land Cover Dynamics | evimax_avg | Continuous | 2001–21 | 0.004176 dd | Average EVI value at peak of greenness, averaged by zone | |
| | NASA MCD12Q2 v061 | Land Cover Dynamics | grn_avg | Continuous | 2001–21 | 0.004176 dd | Average timing of onset of greenness increase in day of year 1–356, within main (Meher) growing season, averaged by zone | |
| | NASA MCD12Q2 v061 | Land Cover Dynamics | sen_avg | Continuous | 2001–21 | 0.004176 dd | Average timing of onset of greenness decrease in day of year 1–356, within main (Meher) growing season, averaged by zone | |
| | NASA MCD12Q2 v061 | Land Cover Dynamics | h2021_eviarea | Continuous | 2021 | 0.004176 dd | Total change in greenness (integral of daily EVI values) within main (Meher) growing season of 2021, averaged by zone | |

| Theme | Source | Dataset Title | Variable Name in Stata | Variable Type | Reference Period | Resolution | Description | Web |
|---|---|---|---|---|---|---|---|---|
| | NASA MCD12Q2 v061 | Land Cover Dynamics | h2021_evimax | Continuous | 2021 | 0.004176 dd | EVI value at peak of greenness within main (Meher) growing season of 2021, averaged by zone | |
| | NASA MCD12Q2 v061 | Land Cover Dynamics | h2021_grn | Continuous | 2021 | 0.004176 dd | Onset of greenness increase in day of year 1–356, within growing season of 2021, averaged by zone | |
| | NASA MCD12Q2 v061 | Land Cover Dynamics | h2021_sen | Continuous | 2021 | 0.004176 dd | Onset of greenness decrease in day of year 1–356, within main (Meher) growing season of 2021, averaged by zone | |

## Appendix 2: Calculation of Cross-Sectional and Longitudinal Weights

As mentioned in Section 5.2, two sets of weights were produced for ESPS5: (1) a cross-sectional weight for all the household interviewed in ESPS5 (which also applies to all the roster individuals belonging to such households) and (2) a longitudinal weight for the subset of households that were interviewed in both ESPS4 and ESPS5 (which also applies to all the roster individuals belonging to this set of households).

The weight calculation procedures were slightly different in the two cases and are thus documented here separately. The main difference is that cross-sectional weights, at odds with longitudinal weights, incorporate a calibration adjustment to official population projections for 2022 that were provided by ESS. For both cross-sectional and longitudinal weights, the fundamental objectives of the calculation procedure were (i) mitigation of bias risks and (ii) improvement of estimation efficiency.

### Cross-sectional weights - Main steps of the calculation procedure

This section lists the main procedural steps that led to the final cross-sectional weights of ESPS5. Subsequent sections will elaborate on each of these steps.

**[CS1]** Derive initial weights for ESPS5 households and roster individuals (see Section CS1).

**[CS2]** Adjust the weights of ESPS5 households and roster individuals for EA-level nonresponse (see Section CS2).

**[CS3]** Adjust the weights of ESPS5 households and roster individuals for household-level nonresponse (see Section CS3).

**[CS4]** Calibrate the weights obtained at step CS3, using as calibration benchmarks individual-level and household-level population projections for 2022 provided by ESS. Note that this step generates *integrated* household-level and individual-level calibration weights (see Section CS4).

**[CS5]** Suitably trim the calibration weights obtained at step CS4 (see Section CS5).

Step CS5 ends the procedure. At that stage, the cross-sectional weights of households and roster individuals encompassed by the ESPS5 respondent sample are ready for dissemination and to be used for general purpose statistical analysis. The ESPS5 respondent sample contains 4,999 households and 23,042 roster individuals.

### CS1 – Calculation of initial weights of households and roster individuals

As illustrated in Section 5.2, ESPS5 is the second wave of the new panel that began in 2018/19 with ESPS4. Two sets of households were included in the planned sample of ESPS5: (1) all the households that responded to ESPS4 and (2) households belonging to EAs that had been selected in the planned sample of ESPS4 but were not surveyed in 2018/19 for safety and security reasons.

Households of this second set, to which we will refer for conciseness as households in "new EAs", were randomly selected within the related EA with equal probabilities following a fresh listing exercise purposefully performed for ESPS5. For the first set, the initial weight of ESPS5 households is simply equal to the final weight computed for the same households in ESPS4. For the second set, the initial weight of ESPS5 households is instead equal to the product of the reciprocal of the EA inclusion probability in ESPS4 times the reciprocal of the probability of randomly selecting the household from the fresh listing. Therefore, ESPS5 initial weights can be written as:

$$d_{hij} = \begin{cases} w_{hij}^{\text{ESPS4}} & \forall j \in \text{ESPS4 respondent sample} \\ w_{hi}^{(1)\ \text{ESPS4}} \dfrac{M_{hi}^{*}}{m_h} & \forall j \notin \text{ESPS4 respondent sample} \end{cases} \tag{1}$$

In equation (1), $d_{hi}$ denotes the initial weight of household *j* belonging to EA *i* within stratum *h* in ESPS5, $w_{hij}^{\text{ESPS4}}$ denotes the final ESPS4 weight of the same household, $w_{hi}^{(1)\ \text{ESPS4}}$ denotes the reciprocal of the first-stage inclusion probability of EA *i* within stratum *h* in ESPS4, $M_{hi}^{*}$ denotes the total number of households in EA *i* within stratum *h* as resulting from the fresh listing exercise, and $m_h$ denotes the fixed number of households selected within each new EA of stratum *h*.

It is important to note that all the household members of each sampled household were included in the roster sample of ESPS5. Therefore, all roster individuals within any ESPS5 household share the same inclusion probability, which equals the inclusion probability of the household they belong to. The same holds true for the weights. As a result, equation (1) also gives the initial weight of each roster member *k* belonging to household *j* selected in EA *i* within stratum *h*, namely:

$$d_{hijk} = d_{hij} \quad \forall k \tag{2}$$

In what follows, unnecessary subscripts will be dropped for notational convenience and the ESPS5 initial weight of respondent sample unit *k* (be it a household or a roster individual) will be simply denoted as $d_k$.

### CS2 – Adjustment of weights for EA-level nonresponse

Total nonresponse occurs when a sampled unit, for whatever reason, either does not respond at all to a survey, or fails to provide enough information for its data to be usable in the estimation phase. Total nonresponse results in estimation efficiency loss and increased risks of bias. In an effort to mitigate the risk of bias, survey weights need to be adjusted for total nonresponse (Särndal and Lundstrom, 2005). To this end, response propensity modeling and calibration are commonly applied alternatives, the choice between the two being mainly driven by the available auxiliary information.

As documented in Section 7, some EAs originally included in the ESPS5 sample were not visited during fieldwork for security reasons. This resulted in nonresponses for all the households that should have been interviewed within those EAs. Since those missing EAs are unlikely to represent a sample selected completely at random from the planned sample of EAs of ESPS5, ESPS5 initial weights were adjusted for EA-level nonresponse. To this end, a quite simple non-response adjustment was developed by following a basic Response Homogeneity Groups (RHG) approach (Särndal, Swensson, and Wretman, 1992). RHG were identified with domains obtained by crossing region with rural/urban status. In other words, it was assumed that the probability of any EA to be visited during ESPS5 was the same within each RHG but did differ between different RHGs. Under this model assumption, it was possible to estimate EA visit probabilities, within each RHG, by using the ratio between the sum of the first-stage weights of the visited EAs and the corresponding sum over the planned EAs. This ratio is akin to a "weighted response rate" of ESPS5 first-stage sampling units within the RHGs. The non-response adjusted weights of ESPS5 households and roster individuals, $w_k^{NRA1}$, were finally computed by multiplying the initial weights, $d_k$, of equation (1) by the reciprocal of the estimated visit probability of the EA:

$$w_k^{NRA1} = g1\_nonresp_k \times d_k = \frac{\sum_{i \in s_g} w_i^{(1)\ \mathrm{ESPS4}}}{\sum_{i \in r_g} w_i^{(1)\ \mathrm{ESPS4}}}\, d_k \quad \forall k \in r_g \quad g = (1, \ \dots, \ G) \qquad (3)$$

In equation (3), $g1\_nonresp_k$ denotes the adjustment factor for EA-level nonresponse of unit $k$, $g$ denotes the generic RHG, and $r_g$ and $s_g$ denote the set of visited and planned EAs within the $g^{\text{th}}$ RHG, respectively.

### CS3 – Adjustment of weights for household-level nonresponse

Restricting to visited EAs, the household-level nonresponse rate was non-negligible for the ESPS5 sample. Out of 5,627 planned households, 628 did not respond, yielding 4,999 respondent households and an overall nonresponse rate of 11%. Notably, nonresponse only occurred for the panel component of ESPS5, as full-response was instead achieved for the households belonging to the "new EAs" mentioned in Section CS1 above (93 households selected within 8 new EAs). Given the origin of the ESPS5 sample, i.e. its provenance from the earlier ESPS4 panel wave, rich information was available on both respondent and non-respondent households. Moreover, non-respondent households were enough to enable a response propensity modeling approach to nonresponse. This approach, often called the propensity score method (Haziza and Beaumont, 2017), entailed several steps.

- First, a logistic model was developed to estimate household-level response probabilities, using a binary indicator, '$resp_k$ = YES/NO', as dependent variable and suitable variables derived from ESPS4, $\mathbf{z}_k$, as predictors. Potential candidate variables to be used as predictors spanned different domains, e.g. territory, socio-demographics, housing, and consumptions. After careful exploration (see, for instance, (Valliant, Dever, and Kreuter, 2013), section 13.5.2), only a parsimonious subset of the available variables was selected[14].

- Second, the logistic model was fit and used to predict response probabilities, $\hat{p}_k = \text{Prob}(resp_k = \text{YES} \mid \boldsymbol{z}_k)$, for all the ESPS5 households.
- Third, deciles of predicted response probabilities were calculated and used to cluster respondent and non-respondent ESPS5 households into ten reasonably homogeneous and non-overlapping classes, $D_q$, for $q = (1, \ \ldots, \ 10)$.
- Fourth, the ten response propensity classes, $D_q$, were treated as Response Homogeneity Groups, and household-level nonresponse adjustment factors, $g2\_nonresp_k$, were computed for the respondent households as reciprocals of weighted response rates[15] within propensity classes.

Note that the propensity score method summarized here only exploits the fitted logistic model to define the Response Homogeneity Groups. In other words, it does *not* use the predicted response probabilities, $\hat{p}_k$, to compute the nonresponse adjustment factor, $g2\_nonresp_k$. More precisely, in the usual propensity modeling approach, nonresponse adjustment factors would be calculated as the inverse of the average $\hat{p}_k$ within each class. Instead, the propensity score method calculates them as reciprocals of weighted response rates within each class (RHG). The latter choice is arguably more robust to model misspecification than the former, and less prone to generate very large weight adjustments that may result in unstable estimates.

The nonresponse adjusted weights of ESPS5 households and roster individuals, $w_k^{NRA2}$, were obtained by multiplying the weights, $w_k^{NRA1}$, of equation (3) by the nonresponse adjustment factors, $g2\_nonresp_k$, calculated using the propensity score method:

$$w_k^{NRA2} = g2\_nonresp_k \times w_k^{NRA} = \frac{\sum_{j \in s_D} w_j^{\text{NRA1}}}{\sum_{j \in r_D} w_j^{\text{NRA1}}} \, w_k^{NRA1} \quad \forall k \in r_D \quad D = (D_1, \ \ldots, \ D_{10}) \tag{4}$$

In equation (4), $D$ denotes the generic decile response propensity class, and $r_D$ and $s_D$ denote the set of respondent and planned households within the class.

## CS4 – Calibration of nonresponse adjusted weights of households and roster individuals

[14] These variables, selected through an AIC (Akaike Information Criterion) minimization procedure, are: 'region', 'locality type' (rural or urban), 'head of household highest level of education attained', 'whether or not the household received cash and in-kind transfer from relatives and friends', 'whether or not the household's main source of light was electricity or solar', 'whether or not the household had an improved drinking water source', logarithm of 'annual food consumption expenditures', logarithm of 'annual nonfood consumption expenditures', and logarithm of 'total annual consumption expenditures'.

[15] Note that these are response rates in terms of households.

Calibration minimally adjusts survey weights so that survey estimates exactly match population parameters that are known from sources external to the survey (Särndal, 2007). These known population parameters are called ‘calibration benchmarks’ or ‘calibration controls’ and usually take the form of population totals. The survey variables for which calibration benchmarks are available are called ‘auxiliary variables’.

Calibration typically increases estimation efficiency: the stronger is the correlation between the interest variable(s) and the auxiliary variables, the larger will be the efficiency gain. Moreover, depending on how the auxiliary variables are chosen[16], calibration can also provide an additional layer of protection against nonresponse and/or frame under-coverage bias (Särndal and Lundstrom, 2005).

Calibration of ESPS5 weights of households and roster individuals was performed using as calibration benchmarks both (i) individual-level population totals and (ii) household-level population totals. The individual-level totals were provided by ESS as the result of a demographic projection exercise[17] and are reported in Table A.1. These calibration benchmarks encompass 532 totals, representing predicted counts of Ethiopian persons by region, rural/urban status, five-year age class, and sex for year 2022. The second set of calibration benchmarks, reported in Table A.2, encompasses only 2 totals, representing estimated counts of Ethiopian households by rural/urban status. Since official population projections were not available for the population of households, these benchmarks were derived from a recent, large-scale population survey[18]. Note that a single set of calibration weights was sought that *simultaneously* fulfills all the 534 (= 532 + 2) calibration constraints induced by the individual-level and household-level benchmarks of Tables A.1 and A.2.

To solve the calibration problem, the R software ReGenesees (Zardetto, 2015 and 2022) was used. Owing to the simultaneous presence of household-level and individual-level population benchmarks, the calibration task had to be undertaken at individual-level. However, ReGenesees facilities for *cluster-level* weights adjustments made it possible to produce identical calibration weights across members of the same household. Calibration weights with this property are known as *integrated* individual-household weights, see (Lemaitre and Dufour, 1987) and (Heldal, 1992). This property is desirable for calibration weights since *design* weights are inherently constant within each household in the ESPS5 survey (see the end of Section CS1). Note, in addition, that a *range-restricted* calibration algorithm was applied, so as to prevent negative or exceedingly high

[16] Nonresponse bias reduction can be achieved by calibration if the auxiliary variables: (i) are correlated to response propensity; (ii) are correlated to the interest variable(s); (iii) do identify important estimation domains. Powerful auxiliary variables should ideally have all the above properties (i), (ii) and (iii). However, any of those properties is beneficial in its own right.

[17] These official population projections for 2022 are publicly available at the following URL: https://www.statsethiopia.gov.et/wp-content/uploads/2019/05/ICPS-Population-Projection-2007-2037-produced-in-2012.pdf

[18] Estimates of average household size for rural and urban areas were obtained from the Ethiopia DHS 2019, as reported at the following URL: https://dhsprogram.com/publications/publication-FR363-DHS-Final-Reports.cfm

calibration weights. More specifically, calibration adjustment factors $g\_cal_k$ (namely the so-called 'calibration g-weights') were constrained to the minimum bounding interval $g\_cal_k \in [0.1, 9.9]$. Exact convergence of the calibration algorithm was obtained: all the 534 calibration benchmarks were matched. This resulted in (i) perfect elimination of any estimation bias affecting the auxiliary variables and (ii) mitigation of possible residual bias in any variable which happens to be correlated with the auxiliary ones. Note that the additional layer of bias protection provided by the calibration step extends to individual-level nonresponse within respondent ESPS5 households.

After calibration, the integrated ESPS5 weight of sampling unit *k* (household or individual) can be expressed in terms of the nonresponse adjusted weights in equation (4) as follows:

$$w_k^{CAL} = g\_cal_k \times w_k^{NRA2} \tag{5}$$

where the calibration g-weights, $g\_cal_k$, are the same for all roster individuals which are members of any same household and are equal to the g-weight of the household as well. As usual for complex calibration tasks, the calibration g-weights $g\_cal_k$ of equation (5) cannot be expressed in analytic closed-form.

**Table A.2.1: Individual-level population totals used as calibration benchmarks for ESPS5 household and roster individual weights.**

| Region | Rural/Urban | Age Class | MALE | FEMALE |
|---|---|---|---|---|
| Afar | Rural | [0,5) | 94,547 | 89,773 |
| Afar | Rural | [5,10) | 95,120 | 87,840 |
| Afar | Rural | [10,15) | 92,812 | 84,063 |
| Afar | Rural | [15,20) | 76,768 | 62,967 |
| Afar | Rural | [20,25) | 86,046 | 65,246 |
| Afar | Rural | [25,30) | 91,166 | 65,489 |
| Afar | Rural | [30,35) | 79,390 | 59,420 |
| Afar | Rural | [35,40) | 61,185 | 49,633 |
| Afar | Rural | [40,45) | 49,171 | 42,165 |
| Afar | Rural | [45,50) | 34,780 | 34,576 |
| Afar | Rural | [50,55) | 27,683 | 27,400 |
| Afar | Rural | [55,60) | 23,258 | 20,582 |
| Afar | Rural | [60,65) | 18,146 | 14,722 |
| Afar | Rural | [65,+) | 27,701 | 16,443 |
| Afar | Urban | [0,5) | 22,774 | 21,893 |
| Afar | Urban | [5,10) | 21,194 | 22,555 |
| Afar | Urban | [10,15) | 20,050 | 22,822 |
| Afar | Urban | [15,20) | 17,741 | 18,291 |
| Afar | Urban | [20,25) | 24,695 | 21,766 |
| Afar | Urban | [25,30) | 29,809 | 22,289 |
| Afar | Urban | [30,35) | 31,015 | 19,255 |
| Afar | Urban | [35,40) | 24,701 | 14,968 |

| | | | | |
|---|---|---|---|---|
| Afar | Urban | [40,45) | 17,098 | 11,143 |
| Afar | Urban | [45,50) | 11,151 | 8,557 |
| Afar | Urban | [50,55) | 7,821 | 7,225 |
| Afar | Urban | [55,60) | 6,433 | 6,053 |
| Afar | Urban | [60,65) | 4,808 | 4,576 |
| Afar | Urban | [65,+) | 8,073 | 6,329 |
| Amhara | Rural | [0,5) | 1,136,460 | 1,098,122 |
| Amhara | Rural | [5,10) | 1,066,099 | 1,034,215 |
| Amhara | Rural | [10,15) | 1,003,976 | 971,891 |
| Amhara | Rural | [15,20) | 942,016 | 917,708 |
| Amhara | Rural | [20,25) | 872,408 | 841,156 |
| Amhara | Rural | [25,30) | 780,127 | 760,626 |
| Amhara | Rural | [30,35) | 677,477 | 686,896 |
| Amhara | Rural | [35,40) | 559,548 | 598,102 |
| Amhara | Rural | [40,45) | 480,899 | 515,579 |
| Amhara | Rural | [45,50) | 381,197 | 413,859 |
| Amhara | Rural | [50,55) | 315,361 | 335,072 |
| Amhara | Rural | [55,60) | 259,428 | 265,983 |
| Amhara | Rural | [60,65) | 208,488 | 207,595 |
| Amhara | Rural | [65,+) | 395,597 | 393,277 |
| Amhara | Urban | [0,5) | 157,138 | 139,711 |
| Amhara | Urban | [5,10) | 213,011 | 203,951 |
| Amhara | Urban | [10,15) | 267,381 | 265,913 |
| Amhara | Urban | [15,20) | 287,505 | 287,110 |
| Amhara | Urban | [20,25) | 300,313 | 285,202 |
| Amhara | Urban | [25,30) | 279,600 | 261,914 |
| Amhara | Urban | [30,35) | 229,530 | 215,619 |
| Amhara | Urban | [35,40) | 178,709 | 174,714 |
| Amhara | Urban | [40,45) | 133,093 | 137,854 |
| Amhara | Urban | [45,50) | 97,264 | 102,662 |
| Amhara | Urban | [50,55) | 71,766 | 82,972 |
| Amhara | Urban | [55,60) | 54,781 | 64,575 |
| Amhara | Urban | [60,65) | 40,748 | 53,022 |
| Amhara | Urban | [65,+) | 73,383 | 98,763 |
| Oromia | Rural | [0,5) | 2,516,534 | 2,421,171 |
| Oromia | Rural | [5,10) | 2,305,835 | 2,231,016 |
| Oromia | Rural | [10,15) | 2,043,143 | 1,980,901 |
| Oromia | Rural | [15,20) | 1,894,770 | 1,851,241 |
| Oromia | Rural | [20,25) | 1,620,397 | 1,604,717 |
| Oromia | Rural | [25,30) | 1,339,785 | 1,348,502 |
| Oromia | Rural | [30,35) | 1,109,992 | 1,145,741 |
| Oromia | Rural | [35,40) | 882,653 | 944,945 |
| Oromia | Rural | [40,45) | 725,640 | 780,461 |
| Oromia | Rural | [45,50) | 571,374 | 609,300 |

| | | | | |
|---|---|---|---|---|
| Oromia | Rural | [50,55) | 457,256 | 479,302 |
| Oromia | Rural | [55,60) | 356,561 | 360,179 |
| Oromia | Rural | [60,65) | 273,939 | 272,565 |
| Oromia | Rural | [65,+) | 487,050 | 485,117 |
| Oromia | Urban | [0,5) | 272,861 | 276,838 |
| Oromia | Urban | [5,10) | 338,839 | 347,337 |
| Oromia | Urban | [10,15) | 402,531 | 412,898 |
| Oromia | Urban | [15,20) | 441,982 | 445,769 |
| Oromia | Urban | [20,25) | 443,900 | 426,433 |
| Oromia | Urban | [25,30) | 391,514 | 368,013 |
| Oromia | Urban | [30,35) | 317,761 | 292,061 |
| Oromia | Urban | [35,40) | 243,746 | 229,070 |
| Oromia | Urban | [40,45) | 178,380 | 171,472 |
| Oromia | Urban | [45,50) | 129,385 | 126,499 |
| Oromia | Urban | [50,55) | 94,063 | 97,210 |
| Oromia | Urban | [55,60) | 67,485 | 72,560 |
| Oromia | Urban | [60,65) | 48,052 | 56,641 |
| Oromia | Urban | [65,+) | 77,130 | 110,322 |
| Somalia | Rural | [0,5) | 407,712 | 394,890 |
| Somalia | Rural | [5,10) | 383,309 | 373,258 |
| Somalia | Rural | [10,15) | 346,963 | 338,724 |
| Somalia | Rural | [15,20) | 230,222 | 194,044 |
| Somalia | Rural | [20,25) | 265,633 | 206,300 |
| Somalia | Rural | [25,30) | 283,160 | 210,079 |
| Somalia | Rural | [30,35) | 253,712 | 194,045 |
| Somalia | Rural | [35,40) | 196,898 | 164,829 |
| Somalia | Rural | [40,45) | 156,074 | 138,434 |
| Somalia | Rural | [45,50) | 107,449 | 110,443 |
| Somalia | Rural | [50,55) | 82,017 | 87,936 |
| Somalia | Rural | [55,60) | 68,563 | 68,200 |
| Somalia | Rural | [60,65) | 54,413 | 50,374 |
| Somalia | Rural | [65,+) | 98,621 | 60,746 |
| Somalia | Urban | [0,5) | 70,282 | 68,330 |
| Somalia | Urban | [5,10) | 65,146 | 65,202 |
| Somalia | Urban | [10,15) | 57,750 | 59,169 |
| Somalia | Urban | [15,20) | 38,661 | 33,896 |
| Somalia | Urban | [20,25) | 46,700 | 36,441 |
| Somalia | Urban | [25,30) | 53,008 | 38,163 |
| Somalia | Urban | [30,35) | 48,352 | 33,341 |
| Somalia | Urban | [35,40) | 39,088 | 27,641 |
| Somalia | Urban | [40,45) | 29,264 | 23,578 |
| Somalia | Urban | [45,50) | 18,822 | 18,976 |
| Somalia | Urban | [50,55) | 14,483 | 16,128 |
| Somalia | Urban | [55,60) | 11,986 | 13,236 |

| | | | | |
|---|---|---|---|---|
| Somalia | Urban | [60,65) | 9,062 | 9,317 |
| Somalia | Urban | [65,+) | 17,325 | 15,843 |
| Benishangul-gumuz | Rural | [0,5) | 64,680 | 61,451 |
| Benishangul-gumuz | Rural | [5,10) | 59,903 | 56,322 |
| Benishangul-gumuz | Rural | [10,15) | 54,109 | 50,513 |
| Benishangul-gumuz | Rural | [15,20) | 49,981 | 46,903 |
| Benishangul-gumuz | Rural | [20,25) | 45,132 | 44,113 |
| Benishangul-gumuz | Rural | [25,30) | 40,441 | 40,141 |
| Benishangul-gumuz | Rural | [30,35) | 34,831 | 35,307 |
| Benishangul-gumuz | Rural | [35,40) | 28,303 | 29,264 |
| Benishangul-gumuz | Rural | [40,45) | 22,805 | 23,949 |
| Benishangul-gumuz | Rural | [45,50) | 17,698 | 18,765 |
| Benishangul-gumuz | Rural | [50,55) | 14,131 | 14,536 |
| Benishangul-gumuz | Rural | [55,60) | 10,812 | 10,246 |
| Benishangul-gumuz | Rural | [60,65) | 8,007 | 7,541 |
| Benishangul-gumuz | Rural | [65,+) | 12,619 | 11,143 |
| Benishangul-gumuz | Urban | [0,5) | 14,387 | 14,601 |
| Benishangul-gumuz | Urban | [5,10) | 15,580 | 16,760 |
| Benishangul-gumuz | Urban | [10,15) | 16,804 | 18,521 |
| Benishangul-gumuz | Urban | [15,20) | 17,627 | 18,863 |
| Benishangul-gumuz | Urban | [20,25) | 18,339 | 18,657 |
| Benishangul-gumuz | Urban | [25,30) | 17,443 | 16,870 |
| Benishangul-gumuz | Urban | [30,35) | 15,448 | 13,361 |
| Benishangul-gumuz | Urban | [35,40) | 12,302 | 10,321 |
| Benishangul-gumuz | Urban | [40,45) | 8,942 | 7,328 |
| Benishangul-gumuz | Urban | [45,50) | 6,194 | 4,973 |
| Benishangul-gumuz | Urban | [50,55) | 4,278 | 3,508 |
| Benishangul-gumuz | Urban | [55,60) | 2,765 | 2,485 |
| Benishangul-gumuz | Urban | [60,65) | 2,007 | 1,658 |
| Benishangul-gumuz | Urban | [65,+) | 2,785 | 2,566 |
| SNNPR | Rural | [0,5) | 1,347,314 | 1,285,703 |
| SNNPR | Rural | [5,10) | 1,184,480 | 1,136,654 |
| SNNPR | Rural | [10,15) | 1,025,344 | 987,152 |
| SNNPR | Rural | [15,20) | 985,944 | 965,583 |
| SNNPR | Rural | [20,25) | 835,930 | 842,211 |
| SNNPR | Rural | [25,30) | 687,138 | 715,819 |
| SNNPR | Rural | [30,35) | 571,314 | 625,273 |
| SNNPR | Rural | [35,40) | 456,421 | 530,693 |
| SNNPR | Rural | [40,45) | 384,814 | 451,267 |
| SNNPR | Rural | [45,50) | 311,808 | 365,191 |
| SNNPR | Rural | [50,55) | 254,136 | 290,571 |
| SNNPR | Rural | [55,60) | 203,060 | 218,297 |
| SNNPR | Rural | [60,65) | 155,467 | 160,624 |
| SNNPR | Rural | [65,+) | 251,946 | 244,761 |

| | | | | |
|---|---|---|---|---|
| SNNPR | Urban | [0,5) | 170,943 | 184,369 |
| SNNPR | Urban | [5,10) | 201,693 | 218,001 |
| SNNPR | Urban | [10,15) | 231,672 | 248,148 |
| SNNPR | Urban | [15,20) | 262,201 | 273,403 |
| SNNPR | Urban | [20,25) | 261,356 | 253,261 |
| SNNPR | Urban | [25,30) | 226,491 | 213,908 |
| SNNPR | Urban | [30,35) | 179,988 | 165,367 |
| SNNPR | Urban | [35,40) | 135,658 | 128,806 |
| SNNPR | Urban | [40,45) | 98,009 | 96,126 |
| SNNPR | Urban | [45,50) | 71,325 | 71,315 |
| SNNPR | Urban | [50,55) | 51,866 | 54,702 |
| SNNPR | Urban | [55,60) | 37,199 | 39,983 |
| SNNPR | Urban | [60,65) | 25,766 | 30,283 |
| SNNPR | Urban | [65,+) | 35,906 | 50,265 |
| Gambella | Rural | [0,5) | 20,419 | 18,311 |
| Gambella | Rural | [5,10) | 18,417 | 16,887 |
| Gambella | Rural | [10,15) | 16,555 | 15,382 |
| Gambella | Rural | [15,20) | 16,214 | 14,373 |
| Gambella | Rural | [20,25) | 15,620 | 14,536 |
| Gambella | Rural | [25,30) | 15,065 | 14,081 |
| Gambella | Rural | [30,35) | 13,575 | 12,833 |
| Gambella | Rural | [35,40) | 11,377 | 11,080 |
| Gambella | Rural | [40,45) | 9,450 | 9,307 |
| Gambella | Rural | [45,50) | 7,434 | 7,292 |
| Gambella | Rural | [50,55) | 6,059 | 5,778 |
| Gambella | Rural | [55,60) | 4,682 | 4,050 |
| Gambella | Rural | [60,65) | 3,585 | 2,700 |
| Gambella | Rural | [65,+) | 4,738 | 3,688 |
| Gambella | Urban | [0,5) | 9,086 | 10,021 |
| Gambella | Urban | [5,10) | 9,428 | 10,083 |
| Gambella | Urban | [10,15) | 9,665 | 10,104 |
| Gambella | Urban | [15,20) | 10,493 | 10,058 |
| Gambella | Urban | [20,25) | 11,859 | 10,762 |
| Gambella | Urban | [25,30) | 12,489 | 10,389 |
| Gambella | Urban | [30,35) | 11,598 | 8,770 |
| Gambella | Urban | [35,40) | 9,205 | 6,874 |
| Gambella | Urban | [40,45) | 6,367 | 5,019 |
| Gambella | Urban | [45,50) | 4,206 | 3,823 |
| Gambella | Urban | [50,55) | 2,818 | 2,724 |
| Gambella | Urban | [55,60) | 1,777 | 1,797 |
| Gambella | Urban | [60,65) | 1,106 | 1,389 |
| Gambella | Urban | [65,+) | 1,673 | 1,569 |
| Hareri | Rural | [0,5) | 9,291 | 8,999 |
| Hareri | Rural | [5,10) | 7,984 | 7,569 |

| | | | | |
|---|---|---|---|---|
| Hareri | Rural | [10,15) | 6,680 | 6,278 |
| Hareri | Rural | [15,20) | 5,940 | 5,779 |
| Hareri | Rural | [20,25) | 5,117 | 5,374 |
| Hareri | Rural | [25,30) | 4,611 | 5,104 |
| Hareri | Rural | [30,35) | 4,264 | 4,547 |
| Hareri | Rural | [35,40) | 3,802 | 3,808 |
| Hareri | Rural | [40,45) | 3,252 | 3,115 |
| Hareri | Rural | [45,50) | 2,600 | 2,523 |
| Hareri | Rural | [50,55) | 2,219 | 1,915 |
| Hareri | Rural | [55,60) | 1,730 | 1,354 |
| Hareri | Rural | [60,65) | 1,086 | 1,031 |
| Hareri | Rural | [65,+) | 1,529 | 1,537 |
| Hareri | Urban | [0,5) | 5,364 | 5,019 |
| Hareri | Urban | [5,10) | 6,197 | 6,050 |
| Hareri | Urban | [10,15) | 7,095 | 7,057 |
| Hareri | Urban | [15,20) | 7,657 | 7,610 |
| Hareri | Urban | [20,25) | 8,311 | 8,538 |
| Hareri | Urban | [25,30) | 8,567 | 8,634 |
| Hareri | Urban | [30,35) | 7,951 | 7,847 |
| Hareri | Urban | [35,40) | 6,949 | 6,645 |
| Hareri | Urban | [40,45) | 5,577 | 5,334 |
| Hareri | Urban | [45,50) | 4,573 | 4,113 |
| Hareri | Urban | [50,55) | 3,481 | 3,278 |
| Hareri | Urban | [55,60) | 2,497 | 2,382 |
| Hareri | Urban | [60,65) | 2,026 | 1,765 |
| Hareri | Urban | [65,+) | 3,228 | 3,651 |
| Addis Ababa | Urban | [0,5) | 191,569 | 187,596 |
| Addis Ababa | Urban | [5,10) | 189,700 | 190,489 |
| Addis Ababa | Urban | [10,15) | 161,778 | 167,416 |
| Addis Ababa | Urban | [15,20) | 107,122 | 119,584 |
| Addis Ababa | Urban | [20,25) | 117,957 | 146,379 |
| Addis Ababa | Urban | [25,30) | 131,595 | 183,271 |
| Addis Ababa | Urban | [30,35) | 171,341 | 259,445 |
| Addis Ababa | Urban | [35,40) | 191,302 | 229,801 |
| Addis Ababa | Urban | [40,45) | 176,815 | 189,345 |
| Addis Ababa | Urban | [45,50) | 120,621 | 104,082 |
| Addis Ababa | Urban | [50,55) | 90,808 | 85,935 |
| Addis Ababa | Urban | [55,60) | 58,654 | 50,321 |
| Addis Ababa | Urban | [60,65) | 42,880 | 45,534 |
| Addis Ababa | Urban | [65,+) | 69,549 | 78,748 |
| Dire Dawa | Rural | [0,5) | 14,096 | 13,952 |
| Dire Dawa | Rural | [5,10) | 11,444 | 11,148 |
| Dire Dawa | Rural | [10,15) | 9,225 | 8,809 |
| Dire Dawa | Rural | [15,20) | 8,754 | 8,690 |

| | | | | |
|---|---|---|---|---|
| Dire Dawa | Rural | [20,25) | 8,356 | 8,908 |
| Dire Dawa | Rural | [25,30) | 8,250 | 8,831 |
| Dire Dawa | Rural | [30,35) | 7,929 | 8,078 |
| Dire Dawa | Rural | [35,40) | 6,746 | 6,758 |
| Dire Dawa | Rural | [40,45) | 5,791 | 5,499 |
| Dire Dawa | Rural | [45,50) | 4,483 | 4,216 |
| Dire Dawa | Rural | [50,55) | 3,601 | 3,221 |
| Dire Dawa | Rural | [55,60) | 2,676 | 2,547 |
| Dire Dawa | Rural | [60,65) | 2,046 | 1,724 |
| Dire Dawa | Rural | [65,+) | 3,426 | 2,900 |
| Dire Dawa | Urban | [0,5) | 11,599 | 10,608 |
| Dire Dawa | Urban | [5,10) | 12,766 | 12,240 |
| Dire Dawa | Urban | [10,15) | 13,780 | 13,846 |
| Dire Dawa | Urban | [15,20) | 16,123 | 16,317 |
| Dire Dawa | Urban | [20,25) | 18,834 | 19,475 |
| Dire Dawa | Urban | [25,30) | 20,265 | 20,646 |
| Dire Dawa | Urban | [30,35) | 18,964 | 18,725 |
| Dire Dawa | Urban | [35,40) | 16,457 | 15,438 |
| Dire Dawa | Urban | [40,45) | 12,570 | 11,883 |
| Dire Dawa | Urban | [45,50) | 9,749 | 9,206 |
| Dire Dawa | Urban | [50,55) | 7,488 | 7,184 |
| Dire Dawa | Urban | [55,60) | 5,386 | 4,782 |
| Dire Dawa | Urban | [60,65) | 3,777 | 3,673 |
| Dire Dawa | Urban | [65,+) | 5,411 | 6,386 |

These totals represent counts of Ethiopian persons by region, rural/urban status, five-year age class, and sex in 2022 as predicted by official demographic projections published by ESS.

**Table A.2.2: Household-level calibration benchmarks for ESPS5 household and roster individual weights.**

| Benchmark | Rural | Urban |
|---|---|---|
| Number of households | 15,467,516 | 5,354,238 |
| Average household size | 5.0 | 4.1 |

Estimates of average household size were derived from the Ethiopia DHS 2019. Estimates of counts of households were obtained combining the reported average household sizes with the counts of individuals derived from Table A.1 above.

## CS5 – Consistent trimming of calibration weights of households and roster individuals

Unduly large calibration weights might lead to unstable estimates and inflate standard errors and confidence intervals. At the same time, negative calibration weights, or calibration weights whose value is less than one, may challenge the interpretation of end-users and therefore be perceived as undesirable. For these reasons, calibration weights may be trimmed using a suitable procedure.

However, trimming calibration weights can result in introducing bias in survey estimators. Therefore, it is advisable to apply trimming procedures sparingly and carefully.

In the light of these considerations, after careful inspection, it was decided to trim the 5‰ smallest and the 8‰ largest ESPS5 calibration weights (117 and 186 individual weights, respectively). Note that all the trimmed weights in the right tail of the distribution were greater than the maximum nonresponse adjusted weight, max($w_k^{NRA}$ ), derived from equation (4). Therefore, the trimming step is expected not to have jeopardized the nonresponse bias mitigation effect of the nonresponse adjustment steps CS2 and CS3. Moreover, no weights smaller than one had been produced in step CS4 (and negative calibration weights had been prevented by construction, given the calibration bounds described in Section CS4 above).

To tackle the trimming task, ReGenesees was used. The software made it possible to trim calibration weights to the desired interval[19] while simultaneously *preserving* (i) all the *calibration constraints* discussed in Section CS4 and (ii) the individual-household *integration* property. In other words, after trimming, ESPS5 weights are still integrated and still able to reproduce, in estimation, all the 534 population benchmarks reported in Tables A.1 and A.2.

In terms of the calibration weights in equation (5), these trimmed calibration weights can be written as:

$$w_k^{TRIM} = g\_trim_k \times w_k^{CAL} \tag{6}$$

Note that the weights in equation (6) above are the *final* ESPS5 weights for respondent households and roster individuals, namely the weights that should be used for general purpose cross-sectional analysis of ESPS5 survey variables.

Table A.3 summarizes the sample distribution of the weights of ESPS5 households as obtained along the steps CS1-CS5 of the weight calculation procedure. Kish Unequal Weighting Effect (UWE) is also reported for each set of weights. Following Kish's definition (Kish, 1992), the UWE is calculated as 1 plus the relative sample variance of the weights. It can be regarded as a measure of how far the weights at hand are from the case of a self-weighting sample (UWE = 1).

**Table A.2.3: Summary of the sample distribution of ESPS5 household-level cross-sectional weights**

| **Cross-Sectional Household Weight** | **Min** | **1st Q** | **Median** | **Mean** | **3rd Q** | **Max** | **UWE** |
|---|---|---|---|---|---|---|---|
| Design [eq. (1)] | 7.59 | 225.50 | 1,294.87 | 3,300.30 | 6,470.44 | 25,432.47 | 2.33 |
| Adjusted for EA-level nonresponse [eq. (3)] | 7.59 | 251.37 | 1,452.54 | 3,687.02 | 6,690.14 | 30,262.24 | 2.38 |

[19] The trimming interval was set to $w_k^{TRIM} \in [4.39,\ 32{,}370.29]$ (see also Table A.3).

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Adjusted for HH-level nonresponse [eq. (4)] | 8.60 | 279.30 | 1,661.60 | 3,913.20 | 6,902.10 | 31,964.70 | 2.35 |
| Calibrated [eq. (5)] | 1.42 | 202.72 | 1,194.26 | 4,165.18 | 5,716.81 | 69,814.76 | 3.47 |
| Trimmed [eq. (6)] | 4.39 | 199.85 | 1,110.50 | 4,165.18 | 5,613.48 | 32,370.29 | 3.48 |

The sample distribution along the steps CS1-CS5 of the weight calculation procedure (symbol 'Q' stands for quartile). Kish Unequal Weighting Effect (UWE) is also reported.

## Longitudinal weights - Main steps of the calculation procedure

As anticipated, longitudinal weights were only produced for the subset of households that were interviewed in both ESPS4 and ESPS5 (as well as for their roster members). For conciseness, let us denote this subsample as the "ESPS5 balanced panel". This longitudinal respondent sample amounts to 4,906 households and encompasses 22,632 ESPS5 individuals.

This section lists and concisely describes the main procedural steps that led to the final longitudinal weights of the ESPS5 balanced panel. Since most of the steps are common to both cross-sectional and longitudinal weights, the rest of this section will focus on the differences between the two treatments. For more details on the methodology, the reader is referred to the corresponding sections of the calculation pipeline of cross-sectional weights.

**[L1]** Derive initial longitudinal weights for the ESPS5 balanced panel of households and roster individuals.

These weights are still defined by equation (1) of Section CS1 and are thus identical to the initial cross-sectional weights of the same units. Note, however, that only the upper formula of equation (1) applies now, because – by definition – the ESPS5 balanced panel only contains households that are common to both ESPS4 and ESPS5.

**[L2]** Adjust the initial longitudinal weights of the ESPS5 balanced panel for EA-level nonresponse.

This adjustment was performed by adopting exactly the same RHG model described in Section CS2. Therefore, equation (3) still formally applies to longitudinal weights. Note, however, that the actual value of the adjustment factor $g1\_nonresp_k$ is now different, because the balanced panel does not include the 8 "new EAs" of ESPS5. Accordingly, those EAs do not contribute to either of the two sums appearing at the numerator and the denominator of equation (3).

**[L3]** Adjust the longitudinal weights of the ESPS5 balanced panel obtained at step L2 for household-level attrition.

This adjustment for panel attrition was performed by adopting exactly the same propensity modeling approach used to adjust cross-sectional weights for nonresponse. Once more, the propensity score method documented in Section CS3 was followed. Therefore, equation

(4) still formally applies to longitudinal weights. Note, however, that the actual value of the adjustment factor $g2\_nonresp_k$ is now different, as the underlying datasets and associated weights, as well as the fitted propensity model and resulting weighting classes, are now different. Nonetheless, the attrition adjusted longitudinal weights of the ESPS5 balanced panel are still integrated: all the roster individuals belonging to the same household share the same weight, which is also equal to the household weight.

**[L4]** Suitably trim the attrition adjusted weights of the ESPS5 balanced panel obtained at step L3.

From equation (4), it can be noted that the attrition adjustment obtained through the propensity score method is mathematically equivalent to a calibration whose calibration benchmarks are unbiased estimates coming from the planned sample (i.e. both respondents and non-respondents). Therefore, it was possible to use ReGenesees to trim exceedingly large attrition adjusted weights that might have led to unstable estimates and inflated standard errors in longitudinal analysis. The trimming adjustment was performed consistently, by simultaneously preserving all the calibration constraints enforced in step L3 and not jeopardizing the individual-household integration property of the weights. Overall, 4 large individual weights were trimmed[20].

Step L4 ends the procedure. At that stage, the longitudinal weights of households and roster individuals encompassed by the ESPS5 balanced panel are ready for dissemination and to be used for general purpose longitudinal analysis.

From a methodological standpoint, the main difference, vis-à-vis cross-sectional weights, is that the longitudinal weights do not incorporate the calibration adjustment to 2022 official population projections. This is because longitudinal weights are not meant to expand to any specific cross-sectional population, but rather to a longitudinal population (be it of households or individuals) which is inherently dynamic (i.e. time-varying) and for which no external sources of information were available.

Table A.4 summarizes the sample distribution of the longitudinal household weights of the ESPS5 balanced panel as obtained along the steps L1-L4 of the weight calculation procedure. Kish UWE is also reported for each set of weights. It can be regarded as a measure of how far the weights at hand are from the case of a self-weighting sample (UWE = 1).

[20] The trimming threshold was set to the maximum longitudinal individual-level weight after the EA-level nonresponse adjustment of step L2: $w_k^{TRIM} \leq 30{,}397.68$ (see also Table A.4).

**Table A.2.4: Summary of the sample distribution of the longitudinal household weights of the ESPS5 balanced panel**

| Longitudinal Household Weight | Min | 1st Q | Median | Mean | 3rd Q | Max | UWE |
|---|---|---|---|---|---|---|---|
| Design | 7.59 | 225.31 | 1,282.91 | 3,295.85 | 6,499.81 | 25,432.47 | 2.33 |
| Adjusted for EA-level nonresponse | 7.59 | 242.99 | 1,388.64 | 3,690.66 | 6,694.55 | 30,397.68 | 2.39 |
| Adjusted for HH-level nonresponse | 8.72 | 278.44 | 1,588.19 | 3,921.76 | 6,883.90 | 40,204.86 | 2.37 |
| Trimmed | 8.72 | 278.44 | 1,588.19 | 3,921.76 | 6,884.39 | 30,397.68 | 2.36 |

The sample distribution along the steps L1-L4 of the weight calculation procedure (symbol ‘Q’ stands for quartile). Kish Unequal Weighting Effect (UWE) is also reported.

## Appendix 3: How to Obtain Copies of the Data

The data are available on the Ethiopian Statistics Service web site:
http://www.statsethiopia.gov.et/ .

or through the World bank micro data library website:

https://microdata.worldbank.org/

Users do not need to obtain permission from the ESS to receive a copy of the data, but will be asked to fill in a data access agreement in which they agree to: (a) cite in all reports, publications, and presentations the ESS as the collector of the data; (b) provide copies of all reports, publications, and presentation to the ESS (address below) and the Development Data Group Division of the World Bank (address below); and (c) not pass the data to any third parties for any reason.

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