50x2030
DATA-SMART AGRICULTURE

TECHNICAL NOTE ON LAND AREA MEASUREMENT

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50x2030 Technical Notes for Country Teams

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This document is a product of the 50x2030 Initiative to Close the Agricultural Data Gap and was developed by Josefine Durazo (World Bank) and Sydney Gourlay (World Bank), with comments from Stephane Mugabe (FAO). This document draws heavily from the LSMS guidebook, "Land Area Measurement in Household Surveys: Empirical Evidence for Effective Data Collection" (Carletto et al., 2016).

The 50x2030 Initiative to Close the Agricultural Data Gap is a multi-agency effort aimed at supporting 50 low- and lower-middle-income countries to produce fundamental agricultural and rural data through the use of integrated agricultural and rural surveys. For more on the Initiative, please visit https://www.50x2030.org/.

This publication is part of a series of 50x2030 Technical Notes for Country Teams that will provide digestible, implementation-focused guidance for data producers and survey practitioners. Each note offers a brief summary of the motivation for specific survey design decisions followed by detailed, practical guidance that can be directly translated into survey design or training efforts. These notes are part of the existing 50x2030 Technical Note series.

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EXECUTIVE SUMMARY

Land area is a critical component of estimating agricultural yields and understanding drivers of agricultural productivity, in addition to various facets of livelihood and welfare. This note provides a brief background on the options available for measuring land area in the context of agricultural and household surveys, focusing primarily on recommendations for area measurement in 50x2030 surveys.

For 50x2030-supported surveys, the recommendation is implementation of handheld GPS measurement in addition to farmer self-reported estimates.[1] The recommended level of area measurement and use of these methods is summarized in Figure 1.[2] These recommendations represent the minimum in terms of coverage of what is to be measured using GPS (i.e., agricultural parcels and cultivated and fallow plots), and countries may elect to measure additional parcels or plots beyond what is indicated in Figure 1. Detailed guidance on the implementation of area measurement using handheld GPS units is available in Annex A. For guidance on the georeferencing of households and land (beyond the measurement of land area), refer to the Technical Note on Georeferencing in 50x2030 Surveys (forthcoming).

Figure 1. Area Measurement Recommendations for 50x2030 Surveys[3]

	Household Sector			Non-HH Sector
	2-visit structure: PP Visit	2-visit structure: PH Visit	1-visit structure±	1-visit structure
Handheld GPS area measurement	Cultivated & fallow plots; Agricultural parcels*	N/A	Agricultural parcels*	N/A
Farmer self-reported area estimate	All listed plots and parcels	N/A	All listed plots and parcels	All listed plots and parcels

Saving of **plot outlines is strongly encouraged**. If plot outlines are saved, the collection of coordinates from the plot center point is optional.

If plot outlines are not saved, coordinates of the center point should be collected (with CAPI).

*For the CORE, ILP, and MEA this includes fully or partially cultivated parcels. For PME this includes all parcels owned or operated (including pasture, etc.).
±Depending on the timing of the visit, for single-visit surveys, it is likely not be possible to conduct plot level GPS area measurements (if crops are out of the field and the boundaries are no longer apparent)

[1] On-going methodological development and validation of the use of tablet-based tools for area measurement under 50x2030 is ongoing and guidelines will be updated upon completion of this work, as relevant. See **Box 1** for more.
[2] Note that in 50x2030 surveys on the *non*-household sector (e.g., commercial farms), GPS measurement of land area is not recommended by default as there is an assumption that these farms have reasonably accurate measurements and/or documentation with area measurements for the land they operate. In contexts where that is not a reasonable assumption, GPS measurement can be implemented.
[3] Acronyms included in Figure 1: Computer assisted personal interviewing (CAPI); post-planting (PP); post-harvest (PH); Farm Income, Labor and Productivity questionnaire (ILP); Machinery, Equipment, and Assets questionnaire (MEA); Production Methods and Environment questionnaire (PME).

1. INTRODUCTION & BACKGROUND

This technical note is intended to be a reference for survey practitioners looking for guidance on measuring land area in household and agricultural surveys. Methods for measuring land area are diverse and selection of the appropriate method depends on several factors such as the survey objectives, accuracy requirements, and resource constraints, among others. In this note, we focus on the methods that are relevant for agricultural sample surveys such as those implemented under the 50x2030 Initiative, as well as multi-topic surveys that cover agriculture and other smaller-scale household surveys carried out for research purposes and project monitoring and evaluation.

Land area measurement is the cornerstone of agricultural statistics and analysis in both developed and developing countries alike. Along with family labor, land is arguably the most important productive asset for rural households across developing regions, and lack of access to land is often a key constraint preventing rural households from emerging from poverty. Estimation of agricultural yields, expressed as output over unit of cultivated land, rely on accurate measurements of land area and are a favorite partial productivity measure of the performance of agricultural sectors. Accurate land area measurement is also essential for identifying land tenure inequalities and monitoring land use changes over time. However, obtaining accurate land area measurements in survey settings is often challenging due to factors such as respondent biases and various sources of measurement error. Despite these challenges, advancements in technology, such as in the accuracy and affordability of handheld GPS devices, offer new opportunities for improving land area measurement in household surveys.

The recommendations put forth in this technical note are informed by a vast body of methodological research, including methodological work undertaken by the Living Standards Measurement Study (LSMS) program of the World Bank to inform the choice of measurement methods and to understand how to best implement them under real survey field conditions. The results of that work are discussed in greater detail in the LSMS Guidebook “Land Area Measurement in Household Surveys: Empirical Evidence and Practical Guidance for Effective Data Collection” (referred to as *the LSMS Area Measurement Guidebook* going forward), from which this note draws heavily.[4] This methodological work, and therefore **this technical note, is focused on the implementation of handheld GPS devices for area measurement in conjunction with respondent estimates,** in line with the 50x2030 recommendations summarized in Figure 1.

Ongoing methodological work by the 50x2030 Initiative is setting out to validate the use of tablet-based tools for area measurement, and this note will be updated to incorporate that guidance upon finalization of that work (see **Box 1**).

2. METHODS FOR LAND AREA MEASURMENTS IN SURVEYS

Several methods that can be considered for measuring land area in the context of agricultural and household surveys are summarized below. In the subsequent section, recommendations for 50x2030 surveys and related practical guidance are provided.

Self-reported estimates are collected by directly asking the respondent (household member/farmer) to report the area of a given plot or parcel. The respondent may have documents to reference that indicate the land area, but often the area is either recalled or estimated by the respondent. This is by far the most common means of collecting land area data in household surveys. The method has only negligible costs as it is quick and does not require any equipment or visitation to the parcel/plot.

[4] LSMS Area Measurement Guidebook: Carletto, Calogero; Gourlay, Sydney; Murray, Siobhan; Zezza, Alberto. 2016. *Land Area Measurement in Household Surveys : Empirical Evidence and Practical Guidance for Effective Data Collection*. LSMS Guidebook Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/606691587036985925/Land-Area-Measurement-in-Household-Surveys-Empirical-Evidence-and-Practical-Guidance-for-Effective-Data-Collection
See also: Carletto, Calogero, Sydney Gourlay, Siobhan Murray, and Alberto Zezza. "Cheaper, faster, and more than good enough: is GPS the new gold standard in land area measurement?." In *Survey Research Methods*, vol. 11, no. 3, pp. 235-265. 2017. https://doi.org/10.18148/srm/2017.v11i3.6791

However, there is a convincing body of evidence that points towards systematic bias in respondent estimates which can have, for example, implications in understanding land holdings and agricultural productivity.[5] For insights on the magnitude of measurement error observed in self-reported area estimates, see Annex B.

Measuring land area with handheld GPS devices requires the interviewer to walk the perimeter of each parcel or plot, using the device to register GPS coordinates at regular time intervals as the interviewer walks (or collect a point at each corner or turn). The GPS-measured area can be entered manually into the questionnaire, in addition to coordinates, while the full plot/parcel boundary or *polygon,* can be stored in the GPS device and later downloaded and matched with the survey data. This method has become increasingly popular among survey practitioners around the world, as it is relatively inexpensive, accurate, and precise when careful measurement protocols are devised and implemented. Factors such as signal interference and environmental conditions have the potential to impact the accuracy of measurements, though this is not a primary concern in most rural contexts. The two main concerns with this method are measuring plots that cannot be visited by survey staff if they are in inaccessible areas or too far away (resulting in missing data), and potential measurement error on very small plots.

The compass and rope method, or traversing, is often considered the 'gold standard' of land area measurement. It requires a team of 2-3 people to traverse the perimeter of each parcel or plot and, using specialized tools, record all the distances and angles between all corners of the piece of land. This data needs to be entered manually to calculate land area. Though this method has been historically considered the most accurate, it is impractical for use in largescale household surveys because it is cumbersome, time consuming, and for optimal results must be implemented by specialized, well-trained personnel (land surveyors).

Use of tablet-based GPS tools embedded directly in CAPI applications have potential for cost-effective and efficient measurement in the context of surveys, though this approach requires validation prior to recommending widespread use. See **Box 1** for more on the tools developed and being validated by the 50x2030 Initiative.

Remote sensing imagery has been used extensively for land cover classification and estimating cultivated areas and yields. While it may have potential for land area measurement in household surveys, it has not been widely used to date in low-income countries (and research on its feasibility is lacking). As imagery becomes cheaper and more detailed and technology for CAPI integration improves, the use of remote sensing data is likely to become more and more accessible. Even so, use of remote sensing imagery for measurement at the plot level, where boundaries may not be visibly delineated and can vary by season, it not likely to be a feasible approach in the context of smallholder farming environments where plots are often of small and irregularly shaped and plot boundaries frequently change.

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[5] See the LSMS Area Measurement Guidebook, as well as the following, for example:

- Carletto, C., Savastano, S., & Zezza, A. (2013). Fact or artifact: The impact of measurement errors on the farm size–productivity relationship. *Journal of Development Economics*, 103, 254-261. https://doi.org/10.1016/j.jdeveco.2013.03.004
- Carletto, C., Gourlay, S., Murray, S., & Zezza, A. (2017, October). Cheaper, faster, and more than good enough: is GPS the new gold standard in land area measurement?. *Survey Research Methods* (Vol. 11, No. 3, pp. 235-265). https://doi.org/10.18148/srm/2017.v11i3.6791
- Carletto, C., Gourlay, S., & Winters, P. (2015). From guesstimates to GPStimates: Land area measurement and implications for agricultural analysis. *Journal of African Economies*, 24(5), 593-628. https://doi.org/10.1093/jae/ejv011

RECOMMENDATIONS FOR 50X2030 SURVEYS

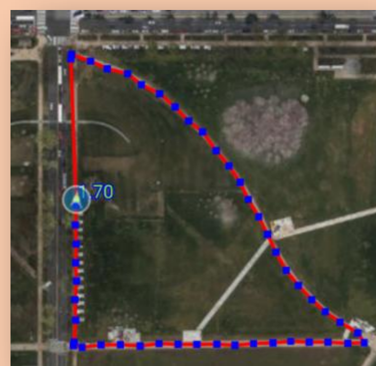
Taking into consideration the accuracy and feasibility of each measurement option, **the recommendation for 50x2030 surveys is to measure area using handheld GPS devices on all agricultural parcels[6] and cultivated and fallow plots, in addition to self-reported area for all plots and parcels listed in the questionnaire.** This recommendation is a lower bound, and in cases where a survey operation has the capacity to implement GPS measurement on additional parcels or plots beyond those that are cultivated or fallow, that is encouraged. Note that the visit structure of the survey will have implications for what methods and levels of measurement are possible. Boundaries can change by season and therefore plot-level measurement is best undertaken in the post-planting stage when crops are in the field; this also means that measurement of plots will likely not be possible in a single-visit survey structure, unless the visit is during post-planting (refer to Figure 1 for recommendations for one- and two-visit survey structures). Remote sensing, though it may have potential in the future as costs decrease and technology improves, is not currently a feasible option for household surveys. The compass and rope method can be up to four times more time consuming than GPS and, even so, not immune to measurement error (LSMS Area Measurement Guidebook). GPS measurements are a valid alternative to compass and rope for most practical purposes, with studies showing that their area measurements differ by only 1 percent on average (LSMS Area Measurement Guidebook). Although respondent self-reporting suffers from large errors and systematic bias, collecting this together with GPS area can be used to provide at least some data where GPS data is missing. It has been successfully used for imputing improved area estimations when GPS is missing, through multiple imputation approaches.[7]

[6] In the context of this technical note, an *agricultural parcel* is defined as any parcel that is partially or fully cultivated or fallow when administering the CORE, ILP, or MEA questionnaires, while it is defined as any parcel owned or operated by the agricultural household (including pasture, for example) when administering the PME questionnaire.

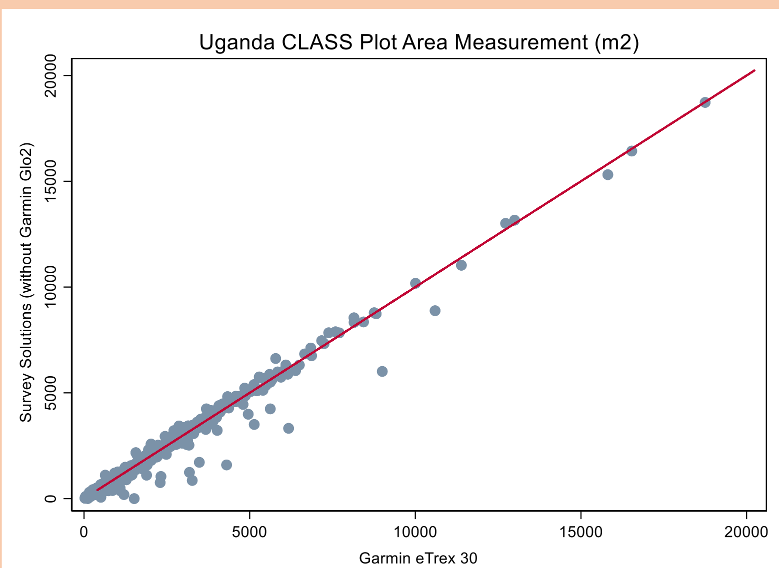
[7] See: Kilic, T., Zezza, A., Carletto, C., & Savastano, S. (2017). Missing (ness) in action: selectivity bias in GPS-based land area measurements. *World Development*, 92, 143-157. https://doi.org/10.1016/j.worlddev.2016.11.018

BOX 1. TABLET-BASED GPS MEASUREMENT: VALIDATING NEW SURVEY SOLUTIONS FEATURES

The use of handheld GPS devices has been validated in relation to compass-and-rope, and subsequently integrated in numerous household and agricultural survey operations worldwide. New tools offer potential for smoother, more cost-effective measurement of land area at potentially similar levels of accuracy. Often the hurdles for adoption of handheld GPS measurement are procurement of these separate devices and the merging of data from the survey instrument and the separate GPS device. **The 50x2030 Initiative has supported the development of new features in the World Bank's Survey Solutions CAPI software that allow for a perimeter-pacing approach to area measurement, like the approach of handheld GPS-based measurement, that record data directly in the interview tablet.** These new features require validation in smallholder agricultural contexts prior to recommending for scale-up but have the potential to eliminate the need for the separate GPS device, resulting in lower equipment costs and cleaner data.



The 50x2030 Initiative has recently piloted the new Survey Solutions feature for tablet-based area measurement as part of a methodological study in Uganda – the Uganda Climate, Land Area, and Soil Study (CLASS). Survey Solutions measurements , including with and without the use of Garmin Glo2 GPS boosters for the tablets, were tested against handheld Garmin eTrex 30 GPS measurements. Preliminary results show promise for the use of the Survey Solutions feature, with strong correlations between these measures, as illustrated in the scatterplot below.



However, before recommending widespread adoption, additional analysis is needed (and underway) to better understand the implications of measurement error in Survey Solutions-based measurements compared to handheld GPS measurements in estimating and understanding agricultural productivity and other indicators. Furthermore, the accuracy of the Survey Solutions feature will vary with the type of hardware being used; those considering adoption of this approach are advised to implement a small-scale validation of their tablets against handheld GPS or compass-and-rope measurements. The Uganda CLASS study utilized Samsung Galaxy T580 tablets.

3. PRACTICAL GUIDANCE FOR MEASURING LAND AREA IN 50x2030 SURVEYS

Practical guidance for implementing the methods recommended for 50x2030 surveys, both self-reported estimates and measurement with handheld GPS devices, as well as discussion of the main advantages and disadvantages of each method are provided in this section, with particular reference to their application in large-scale national household and agricultural surveys. The accuracy of each method, as well as their demands in terms of human, financial, and time resources, are discussed.

COLLECTING BOTH SELF REPORTED AND GPS MEASUREMENTS

Self-reported estimates alone can lead to significant biases when the measures are used in agricultural economics or policy analysis – including under- or over-estimating land productivity and land inequality. As such, this method is not suitable as the primary or sole source of land area measurement – but should still be collected as part of household surveys. Such measurements have negligible fieldwork costs, and, more importantly, they can serve as a baseline for imputation where objective measurements may be missing.

The use of handheld GPS devices has emerged as the superior objective method for most practical survey purposes. Though this approach comes with its own challenges, including time and equipment requirements, potential issues of accuracy for very small plots, and missing measurements for some parcels or plots (often those too far away, in conflict areas, or too large for measurement), it has been successfully adopted in numerous countries, including 50x2030 partner countries.

This section advises on how to collect both self-reported and handheld GPS measurements together, in line with the recommendations for 50x2030 surveys. When collecting land area though both a self-reporting question and GPS measurement, as is recommended herein, the ***self-reported measurement must be asked first*** so as not to be affected by the objective area estimation (GPS). Likewise, it is very important that the self-reported are estimation is not revised based on the GPS measurement. Note that this requires attention not only in the questionnaire design, but also during implementation – the importance of this must be emphasized to interviewers during training and compliance checked on quality assurance observation visits during fieldwork, and when checking the data. Ensuring the self-reported area is not affected by the GPS-based measurement will enhance the value of the self-reported measurements for imputing improved area estimates where GPS measures are missing, following the imputation approach described in Kilic et al. (2017).

SELF-REPORTED AREA ESTIMATION

To collect farmer self-reported data on land area, surveys include a direct question to the respondent, preferably the parcel or plot manager, asking her to report on the area of a given plot or parcel. An example of these questions, as found in the 50x2030 CORE Post-Planting reference questionnaire, is provided in Figure 2. Self-reporting is in principle a straightforward method for collecting data on land area and a well-designed question must consider question phrasing, reporting quantities, and allowable measurement units. Ensuring that the necessary supporting documentation and datasets are available before data collection begins can help reduce potential measurement error and increase the value of the data for the users.

Phrasing & sequencing. The phrasing of the question should be clear and straightforward. There is no need to add qualifying words or phrases related to estimate (“in your estimate” “what do you estimate is”) because all self-reported data can be considered estimates. This question should be asked before collecting GPS measurements and is typically included in the parcel and plot roster section of the questionnaire. Additional sequencing considerations will depend on the scope of land area questions included in the survey. For example, a question on parcel area can be asked together with other parcel level details such as ownership, land tenure security, and so on. See

COMPLEMENTARY DATA: Often, surveys that collect land area measurement will also be interested in collecting data on land tenure. Land tenure questions can include asking about the existence of a land title. Though the primary reason for asking about this is to better understand land tenure security, this document usually indicates the area of land *parcels*, which can be recorded as part of the interview. This not only serves as validation of the self-reported size of the same parcel, but can also be used to improve imputations. In many low-income countries this will be a rare occurrence, but in those where land registration and titling is more advanced, official land records can be extremely useful aids to survey data collection. Surveys that include a question to check for land title should also collect metadata on whether the self-reported area has been verified with documentation.

Quantities. The number of decimal places allowed for each quantity reported will need to be determined as part of the questionnaire design. If responses are provided in only integers, important differences across small plots may be lost. Yet, keep in mind that more decimal spaces are not necessarily better, as all defined decimal spaces need to be filled in for all plots (ex 2.00, 2.250, etc). Superfluous decimal spaces require interviewers to record more numbers, which can increase the likelihood of error in recording amounts. Allowing 2 decimal spaces is often sufficient, though the choice will depend on country context, survey preference, and expected measurement units. Some CAPI software programs may further allow the number of decimal places to vary based on the measurement unit reported.

Measurement units. A survey can collect measures of land area in standard units such as acres, square meters, hectares; non-standard units such as football pitches or locally-defined or traditional units; or a combination standard and non-standard units. The country context will, to a large extent, determine the most appropriate choice. Often, respondents are not familiar with standard measurement units and may use instead a variety of traditional units, which can also vary in size. In Ethiopia, for example, *timad* is a common unit of measurement that is traditionally defined as the amount of land a pair of oxen can plough in one day. Figure 3 provides examples of self-reported area questions from the Ethiopia Socioeconomic Survey and the Nigeria General Household Survey Panel, including the locally-relevant non-standard units. Survey designers may be tempted to force the use of standard units to side-step frequent and/or variable non-standard units, especially where available conversion factors are incomplete, unreliable, or inexistent. However, extensive field experience and methodological studies show that forcing respondents to estimate plot area in a unit that is unfamiliar to them is likely to result in increased measurement error, and thus should be avoided. Land measurement units must be carefully considered, as this detail can in some cases create issues large enough to render the collected data unreliable, if not outright unusable. It is worth noting that research evidence indicates self-reporting that allows reporting in local units (non-standard units) more closely approximates GPS measurements.

Conversion factors, supporting documentation. When non-standard or traditional units will be included, care should be exercised to ensure that high quality conversion factors exist. It is not unusual for non-standard units with the same name to correspond to different measures even within the same country: in such cases, conversion factors will need to be location-specific. If a satisfactory set of unit conversion factors is not available, they should be collected as part of the survey (see Annex C). The Ministry of Agriculture or National Statistics Office often maintain libraries of conversion factors, though these may not always be complete or available in electronic format. The importance of conversion factors cannot be overemphasized, as area data may be unusable if they cannot be converted to a common metric unit. When designing a panel of repeated survey rounds or when planning to compare self-reported data with other household survey data, attention should be paid to the units used in the other instruments – both to ensure comparability and because these may serve as a good starting point for what options might be available.

"Other, specify" as a unit. Allowing this option has its benefits and challenges. While it may allow interviewers to capture land area estimates in any non-standard units that may have been overlooked, the area reported will be very difficult to use unless appropriate conversion factors can be confirmed. "Other, specify" can be useful during the initial phases of piloting and fieldwork to capture key units of measurements that had not been listed in advance. However, interviewers should be instructed to limit as much as possible the use of this unit during fieldwork; to support this it is necessary to run careful pilots of the questionnaires, and to also discuss the matter with local experts (as it is unlikely that a pilot will have the required geographical coverage to capture the diversity of units that may be found in one country).

Figure 2. Area Measurement Questions in 50x2030 CORE Post-Planting Questionnaire

5.			6.	7A.	
What is the area of this [PLOT]? ASK THE FARMER TO ESTIMATE THE AREA FIRST. CODES FOR UNIT: ACRE.............1 HECTARE..........2 SQUARE METERS....3 OTHER (SPECIFY)..4 [UNITS TO BE CUSTOMIZED FOR COUNTRY CONTEXT]			**ENUMERATOR:** IF YOU DID NOT MEASURE THE PLOT WITH GPS DEVICE, PLEASE SPECIFY REASON. LONG DISTANCE WITHIN THIS DISTRICT.......................1 LONG DISTANCE OUTSIDE THIS DISTRICT.......................2 OTHER (SPECIFY)................3 [PROTOCOLS FOR GPS MESAUREMENT COVERAGE TO BE CUSTOMIZED FOR COUNTRY CONTEXT]	**ENUMERATOR:** RECORD THE COORDINATES RECORD THE COORDINATES OF THE CENTER OF THE PLOT, USING TABLET.	
a., b.		c.		a.	b.
FARMER ESTIMATION		GPS MEASURE		LATITUDE (S)	LONGITUDE (E)
AREA	UNIT	AREA IN [UNIT OF MEASUREMENT]	CODE		
__ __ __ __ . __ __		__ __ __ __ . __ __		__ __ ° __ __ . __ __ __	__ __ ° __ __ . __ __ __
__ __ __ __ . __ __		__ __ __ __ . __ __		__ __ ° __ __ . __ __ __	__ __ ° __ __ . __ __ __
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Figure 3. Self-reported area question from the Ethiopia Socioeconomic Panel Survey 2021-22 (left) and the Nigeria General Household Survey Panel 2018-19 (right)

2.	
ASK HOLDER: What is the area of [FIELD]? CODES FOR UNIT: HECTARE......1 SQUARE METERS.....2 TIMAD........3 BOY..........4 SENGA........5 KERT.........6 TILM.........7 Medeb........8 Rope (Gemed)..9 Ermija.........10 Other(Specify)...11	
AREA	UNIT
__ __ __ __ . __ __	
__ __ __ __ . __ __	
__ __ __ __ . __ __	

4a.	
What is the area of [PLOT]? ENUMERATOR: ASK THE FARMER TO ESTIMATE THE AREA. UNITS HEAPS..........1 RIDGES.........2 STANDS.........3 ACRES..........5 HECTARES.......6 SQUARE METERS..7	
FARMER'S RECALL	
NUMBER	UNIT
_ _ _ _ . _ _	
_ _ _ _ . _ _	

GPS MEASUREMENT

Measurement via handheld GPS unit has been shown to be a scalable, reliable approach to measuring land in the context of household and agricultural surveys and has been adopted in numerous countries. It requires interviewers to travel to the parcel or plot being measured and walk around the perimeter holding the GPS device. This section provides advice on the implementation of such measurement.

Note that in 50x2030 surveys on the *non*-household sector (e.g., commercial farms), GPS measurement of land area is not recommended by default as there is an assumption that these farms have reasonably accurate measurements and/or documentation with area measurements for the land they operate. In contexts where that is not a reasonable assumption, GPS measurement can be implemented.

Design & Planning: What Data to Capture

Layer/level of measurement. GPS measurement can be conducted at the parcel and/or plot level. Plot area measurements are especially important for understanding agricultural productivity, especially when production is measured at the plot level (as is the case in 50x2030 questionnaires). This allows for detailed analysis of agricultural productivity and estimation of crop yields. Parcel level measurement can be useful for estimating total land holdings, for example, putting bounds around self-reported area estimates for plots that may not be measured with GPS devices. **For 50x2030 surveys, we recommend measuring at least all agricultural parcels and all cultivated and fallow plots with GPS devices.**[8]

Timing of measurement. Measurement of plot area should be done when the crop is in the ground, as plot dimensions can vary be season. Therefore, it should be implemented in the post-planting visit (along with parcel measurements). In surveys that only include a post-harvest visit, plot level measurement is not recommended though parcel level measurement can still be taken as parcel boundaries are, by definition, unchanging. Within the interview, GPS measurement are often taken at the end of the interview so avoid disruptions to the interview flow.

Which plots and parcels to measure. Plots will often be in a different location from where the main household interview takes place. Time and budget should be factored into the survey design and fieldwork planning to allow for travel to the plots, keeping in mind that a household member knowledgeable about the plot must accompany the interviewer to identify the plot/parcel and plot/parcel boundaries.

Establish protocols in advance regarding which plots should be measured, taking into consideration data needs, implementation time, and survey cost. Protocols should be documented and clearly stated in interviewer manuals. The criteria for determining which plots require GPS measurement will be based mostly on distance to reach plots and location accessibility. The protocol should strike a balance between not overburdening the field team while still ensuring the quality of the resulting data. On the one hand, a protocol that includes very restrictive rules on plots to be excluded may require enumerators to travel for hours just to measure one plot. On the other hand, a protocol that allows too many exceptions to GPS plot measurement will result in a large number of missing data points in the final datasets. Box 2 illustrates protocol examples the rates of missing GPS measurement associated with those protocols.

[8] During implementation of the CORE, ILP, and MEA questionnaires, all cultivated plots, plus parcels that are at least partially used for crop cultivation should be measured. During implementation of the PME questionnaire, all cultivated plots, plus all parcels owned or operated by the household (including pasture, for example).

BOX 2. EXAMPLE PROTOCOLS FOR INCLUSION OF PLOTS FOR GPS MEASUREMENT & ASSOCIATED RATES OF MISSING MEASUREMENTS

Below are examples of guidelines from different surveys as to which plots are required to be measured with a GPS device, as well as the share of plots that were missing GPS area measurements. The rates of missingness, or *item non-response*, of GPS measurement is related to the stringency of the protocols. See the LSMS Area Measurement Guidebook for more.

Malawi Integrated Household Panel Survey 2013:
Enumerator Manual: "For a GARDEN [parcel] that lies more than 2 hours of walking distance from the dwelling (regardless of being in a rural or urban EA), the enumerator MUST consult their supervisor concerning the decision about measuring the GARDEN. You are expected to capture as many GARDENS as possible by possibly grouping together measurements of distant gardens that are close to one another."

→ **3%** of plots missing GPS measurement

Tanzania National Panel Survey 2010-2011:
Interviewer Manual: "All plots must be measured that are within one hour's travel of the household (either on foot, bicycle, motorbike, etc.). If you think a plot is too far to measure, you must receive permission from your supervisor not to measure it."

→ **22%** of plots missing GPS measurement

Uganda National Panel Survey 2011-2012:
Enumerator Manual: "…measurement should be conducted only on those parcels located within the EA [enumeration area]."

→ **44%** of parcels missing GPS measurement

Plot outlines. Most handheld GPS devices have an option for storing plot outlines (also referred to as *polygons*). Doing so has several advantages and requires little additional effort over simply recording the area. Plot outlines provide raw GPS data that allows for the monitoring and analysis of enumerator walking speed, polygon closure, and the complexity of plot shapes. Plot outlines can also be used to clean plot coordinates data entered in the questionnaire, as the raw GPS file is not subject to potential data entry issues. To do this, plot outlines on the GPS device must be re-named by the interviewer to link the file to the corresponding plot ID in the questionnaire (further detailed below). For many GPS devices, the stored track will be exported as a gpx file, which can be opened in geospatial software. These files may also contain the elevation (if the device is equipped accordingly) and the time of collection. Plot outlines can be very useful inputs into remote sensing applications that leverage the survey data. **For 50x2030 surveys, we strongly recommend saving the plot and parcel outlines.**

Other supporting metadata. It is recommended to store either the corner points of each plot/parcel measured, or if only possible to store a single point, the center point of each plot measured (in the CAPI application, if available). This is especially true if plot outlines will not be saved, though having both the plot outline and the coordinates in the CAPI application will best facilitate data cleaning, which will be beneficial since there can often be issues with transcribing these long numbers in the handheld GPS devices.

Naming conventions. When saving raw GPS data on the device (coordinates and/or plot outlines), a clear naming convention needs to be established and included in enumerator training. The name saved in the GPS device must uniquely identify the household and plot so that it can be matched to the questionnaire data. Typically, GPS devices will autofill file names in a numeric sequence – this should be overwritten by the interviewer. A naming convention such as "[Household ID]- [Parcel ID] - [Plot ID]" ensures an easy match between the questionnaire and the raw GPS data. For example, Plot 3 on Parcel 2 in Household 7248 would be saved as "7248-02-03". Because the small screens and keypads of handheld GPS units lend themselves easily to typos, the number of digits in the unique ID should be minimized to the extent possible.

Data dissemination. Geo-referenced information must be handled with extreme care as it can allow for the identification of survey respondents, breaching the confidentiality agreement with respondents and, in most cases, national statistical laws. GPS coordinates and plot outlines should not be distributed with the household survey data and should be eliminated from the data files as they are anonymized ahead of public dissemination. Modified location information may be included in some form after first reducing precision through a process of aggregation, truncation or alteration of coordinates. Examples of this type of dissemination, for household data, include the LSMS-ISA project of the World Bank and Demographic and Health Surveys (DHS) program supported by USAID. We are not aware of similar examples for the dissemination of plot-level coordinates. The demand for more precise location is likely to grow, as very-high resolution (VHR) imagery becomes more widely available, and more research is needed to determine the effectiveness of different methods of masking in such a data-rich environment. Most importantly, however, any plans for dissemination should be approved at the onset of field data collection and communicated clearly to both respondents and governing bodies. 50x2030 is currently working to develop protocols for the anonymization and dissemination of georeferenced data.

Considerations for GPS Device Selection

Device selection. Handheld GPS devices come with a range of features and can vary significantly in price. When determining the best device for a survey, survey designers should assess the features that are needed for a particular activity. Common feature options include:

1. Compatibility: GPS devices that are also compatible with GLONASS will increase the number of satellites available to the device, increasing accuracy and reducing acquisition time, and as such is generally recommended. If operating in the United States, Europe, or Asia, compatibility with the local augmentation system (WAAS, in the US, for example) will increase point accuracy.
2. Direct area measurement functionality: essential for area measurement.
3. Track saving functionality and capacity for storing plot outlines: The track capacity refers to how many plot outlines can be saved on the device. When the device reaches its capacity, the data must be downloaded to free up space on the device for further measurements to be taken. If the device capacity is lower than the expected number of measurements, it will complicate fieldwork (requiring downloads during fieldwork) and increase the risk of losing data. When possible, it is advised to procure devices with enough track capacity to hold all plots (per device). That is, if each device is expected to capture 150 plots, procure a device with the capacity to store 200 or more tracks, rather than one with only 100 track storage capacity.
4. Built-in camera and barometric altimeter are other common features, as are different mechanisms for data sharing including USB ports, Bluetooth, or WiFi.

Generally, the number of device features is negatively correlated with battery life, and this should be taken into consideration when determining the optimal suite of features. Additionally, devices with simple and intuitive interfaces can minimize training requirements and errors during data collection.

Battery life. Survey planners should budget for backup batteries and provide each team with one or more sets of replacements, depending on battery quality and number of plots to be measured. As reference, the battery life of Garmin handheld units typically ranges from approximately 16 – 25 hours, depending on the model. To optimize battery usage, interviewer manuals and training should include instructions to keep the device powered down until necessary and to keep the display brightness as low as reasonably possible.

Device configurations. Before distributing GPS devices to field teams, set-up must be completed centrally to ensure all devices are uniformly programmed in accordance with the questionnaire. Critical settings to be adjusted include:

- ✓ Satellite system (GPS and GLONASS, if available)
- ✓ Distance units (e.g. meters versus feet)
- ✓ Area units (e.g. square meters versus acres)
- ✓ Map datum and spheroid (e.g. WGS 84, for example)
- ✓ Coordinate format (e.g. in degrees and decimal minutes, hddd° mm.mmm')
- ✓ Time (24-hour format is recommended).

Additionally, device features that are not necessary for the survey should be hidden from view to limit distractions, reduce navigation time on the device, and potentially lengthen battery life.

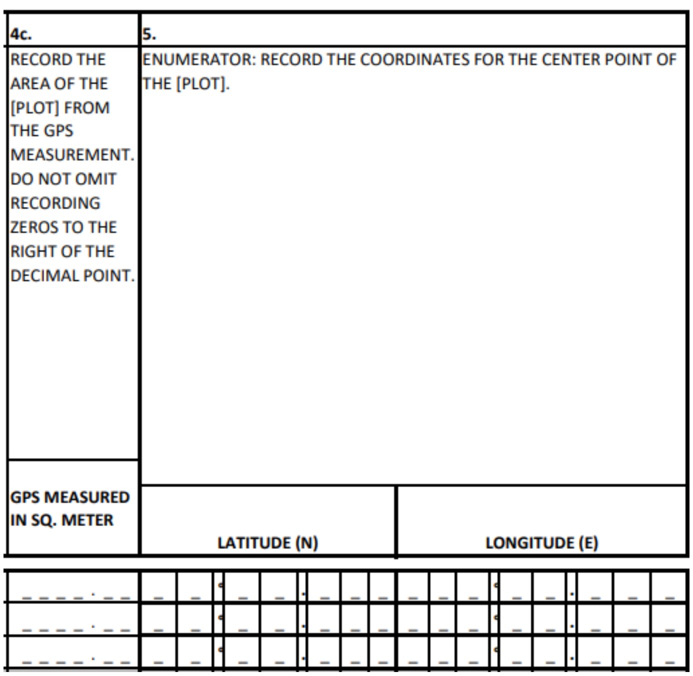
Check settings again at the close of enumerator training and periodically throughout fieldwork to ensure all units are collecting data in the same units, same map datum, and with the appropriate time zone and format.

Measuring & Recording GPS Data

Questionnaire design. At a minimum, the questionnaire will include a space to record the plot area calculated by the GPS device. Capture the coordinates of the center point of the plot can also be beneficial in terms of data cleaning and for georeferencing of plots, especially (but not only) when plot outlines are not stored. If implementing A CAPI-based survey, there is likely a question type available to capture coordinates directly through the tablet. If implementing a paper-based survey, however, there are several elements to consider in structuring a question to record GPS coordinates. To facilitate easy and consistent transcription of information from the GPS device to the questionnaire itself, the format on the questionnaire should match the desired settings on the GPS device. For example, if coordinates are recorded in degrees and minutes, the questionnaire should have the proper number of decimal places, with symbols properly placed. Also, the questionnaire design should look as similar as possible to GPS device. If the device lists latitude and then longitude, the questionnaire should list them in that same order. When necessary, allow a space to specify “North” or “South” – this is especially critical for countries that span both sides of the Equator. If asking for coordinates in different sections of the questionnaire (for example, at the dwelling and at the plot) ensure consistency throughout – do not switch the order of latitude and longitude between modules. An example from the Nigeria General Household Survey Panel 2018-19 is found in Figure 4.

Regardless of where the plot level measurement is recorded in the questionnaire, the measurement itself need not occur in the order/placement indicated in the administration of the questionnaire. To minimize refusals on measurements and to ensure questionnaire flow, measurement appointments can be made to suit the respondent schedule.

Figure 4. GPS Area and Coordinates form the Nigeria General Household Panel 2018-19



4c.	5.	
RECORD THE AREA OF THE [PLOT] FROM THE GPS MEASUREMENT. DO NOT OMIT RECORDING ZEROS TO THE RIGHT OF THE DECIMAL POINT.	ENUMERATOR: RECORD THE COORDINATES FOR THE CENTER POINT OF THE [PLOT].	
GPS MEASURED IN SQ. METER	**LATITUDE (N)**	**LONGITUDE (E)**
_ _ _ _ . _ _		
_ _ _ _ . _ _		
_ _ _ _ . _ _		

Common mistakes in the transcription of GPS coordinates into the survey questionnaire include annotating longitude values in place of latitude and vice versa or using minutes when decimal degrees are required for coordinates and vice versa. For countries that span two hemispheres, failing to correctly annotate cardinal directions (north, south, east, west) is another easy error. Attention should be drawn to these common types of errors during training.

Complementary questions. Beyond area and coordinates, consider recording additional information in the questionnaire to help validate and spot check recorded data. Precision indicators include the number of satellites acquired at the time of measurement, slope of the plot, canopy cover around the perimeter of the plot, and cloud cover.

Pilot testing. Before full-scale implementation, pilot testing can enhance the quality of the collected data. Feedback from pilot enumerators can provide valuable insights into practical considerations and potential challenges that may arise during data collection, and can be used to inform the final questionnaire design and training protocols.

Training. Although training requirements can vary significantly based on interviewer competencies, surveys that collect GPS measurements must plan for at least one full day of training with the GPS devices. Field teams with little or no technological experience will require more basic introductions to the use of the keys, joysticks, and other buttons. All trainings must include hands-on practice taking measurements. Test runs conducted in a parking lot or other space adjacent to the training center will improve interviewer understanding and highlight common errors in procedure. Practice should also be conducted on agricultural plots to ensure interviewers are pacing the perimeter with precision. Field tests/training must be done with all GPS devices that will be used. The training is also an opportunity to test the interviewers' individual ability to mastering the devices, which may vary based on overall familiarity with technology, and personal characteristics such as their vision.

Measurement instructions. The main steps for implementing area measurement using handheld GPS units are summarized below, with more detailed instructions provided in Annex A. Field tests must be done with all GPS devices that will be used. Because instructions for measuring area vary by GPS device make and model, the following should be reviewed and compared with instructions provided from the GPS manufacturer and adjusted accordingly.

The below steps are based on plot level measurement using a Garmin eTrex 30 device. Instructions would be similar for parcel-level measurement.

1. Before beginning the GPS measurement of the plot, complete all other relevant sections of the questionnaire (land tenure, parcel and plot details). It is especially important that all self-reported land area measurements are recorded before this exercise begins.
2. Walk along the plot boundary with the farmer to prepare the plot for measurement, clearing the any obstructions from the boundary so that it is clearly visible and can be paced without obstruction.
3. Standing at a corner of the plot, initiate the area measurement function on the GPS unit.
4. Begin pacing the perimeter, walking directly on the plot boundary and holding the GPS unit in front of you, pausing at all turns/bends/corners to allow for point capture (point capture is automatic in most devices).
5. When you complete the walk around the boundary and return to the starting point, click “Complete” or “Finish”.
6. Conduct a visual inspection of the plot outline on the GPS device to ensure the measurement was properly taken. If you see an erroneous shape, or a shape that does not correspond to the shape of the boundary you have walked (e.g., intersecting/crossing boundary lines or a simple line instead of a polygon), the measurement should be repeated.
7. Record the area of the plot in the questionnaire and save the plot outline, saving the track name in accordance with the predetermined labelling convention.

ANNEXES

ANNEX A – INSTRUCTIONS FOR HANDHELD GPS MEASUREMENT

This annex may be used to guide interviewers in the measurement of the area of parcels and/or plots. The instructions included below are based on the use of the Garmin eTrex 30 device, although they can be adapted to fit other devices as needed.

A GPS uses the information from satellites to find the geographical position on the Earth's surface by longitude and latitude. The position is found by a continuous measurement of the time a satellite signal takes to reach the GPS device from a satellite. With clear signals from at least four satellites, the GPS is able to calculate the geographical position. The more sky that a GPS device can see, the more signals and clearer signals it can receive. Shadows of buildings and even large trees should be avoided while using a GPS device in the parcel.

Device Overview

①	Zoom keys
②	Back key
③	Thumb Stick™
④	Menu key
⑤	⏻/Backlight key

⑥	Mini-USB port (under weather cap)
⑦	Battery cover
⑧	Battery cover locking ring
⑨	Mounting spine

Using the eTrex Keys

- Move the Thumb Stick up, down, left, and right to highlight menu selections or to move around the map.
- Press the center of the Thumb Stick to select the highlighted item.
- Press **back** to move back one step in the menu structure.
- Press **menu** to display a list of commonly-used functions for the current page. Press **menu** twice to access the main menu from any page.
- Press ▲ and ▼ to zoom in and out on the map.

BEFORE calculating the area with the GPS:

1) Complete all other sections of the questionnaire, ensuring the respondent's estimate of area has been provided before beginning the GPS measurement.

2) Walk around the parcel/plot with the respondent in order to determine the boundaries. Clear any obstacles that may block your path, so that you have a clear, unobstructed path around the boundary of the parcel/plot.

3) Mark your **starting point** with a stick or other object so you can identify the point when you return. The starting point should be the northwest corner of the parcel/plot, or other location determined at the country level, to ensure consistency in measurements.

4) Wait for the device to fix on **at least four** satellites.

5) To preserve the battery, set the backlighting on the GPS as low as possible. To do this, do the following:
   a) While the device is on, click the power button once (do not hold it).

b) Move the Thumb Stick to the left to decrease the backlighting. You should decrease the backlight as much as possible in order to save the batteries.
c) Exit this page by pressing the BACK button.

Procedure for Area Measurement Using GPS:

1) Proceed to the northwest corner of the parcel/plot (or other predetermined starting point determined at the country level) where you have marked it with a stick.

2) Turn on the GPS device by holding the power button until an image appears on screen. The GPS device will then seek to acquire satellite signals. This may take up to three minutes. From the main menu, navigate to highlight SATELLITE and press the Thumb Stick. The green and blue bars at the bottom of the screen show the satellites that have been found. Wait until **at least four satellites** have been acquired.

    a. On the left side, you will see the GPS accuracy in meters. This number will fluctuate as satellites are acquired. **Wait until this number is steady before moving on.**

3) Press the MENU button twice to return to the main menu. You may also push the BACK button repeatedly until you arrive at the main menu. Select the AREA CALCULATION page by highlighting and clicking the center of the Thumb Stick.

4) START will appear on the screen. When you are ready to begin, click the Thumb Stick. Now the GPS device has started recording the track. You will see CALCULATE on the screen (NOTE: do NOT click this until you are finished).

5) Walk slowly clockwise around the perimeter of the parcel. You should hold the GPS device flat in your hand and stretch your hand slightly forward. You MUST walk on the edge of the parcel (NOT a meter outside the parcel). At every corner, you MUST pause for five seconds (counting slowly 1001, 1002, 1003, 1004, and 1005) and then continue walking. You MUST walk all the way around the parcel until you have returned to the location of the starting stick, with the GPS device facing the direction in which it started the area calculation.

6) When you reach the starting stick, CALCULATE should still be seen on the screen. Click CALCULATE by pressing the Thumb Stick. The GPS device will display the area measurement directly in SQUARE METERS. You should then record the results with TWO decimals. If the area is not displayed, it means you have not clicked the Thumb Stick straight. You must press the back button until you see CALCULATE on the screen and then press the Thumb Stick again.

7) Save the track you have just recorded by highlighting SAVE TRACK and pressing the Thumb Stick. **Delete the default track name and enter the name as “HHID-Parcel ID” or “HHID-Parcel ID-Plot ID”**. For example, if the HHID is 31403 and the Parcel ID is 2, enter the track name as 31403-2. Highlight DONE and press the Thumb Stick. Never erase saved tracks.

8) To review the track, view the outline on the map, or determine the distance of the perimeter, return to the main menu and navigate to the TRACK MANAGER. Press the Thumb Stick. Highlight the track you would like to review and press the Thumb Stick. From there, select VIEW MAP. This will show you the length of the perimeter in meters (called “distance”).

9) Turn off the GPS device by holding the power button.

ANNEX B – SYSTEMATIC MEASUREMENT ERROR IN SELF-REPORTED AREA ESTIMATES

Methodological research undertaken by the World Bank's Living Standards Measurement Study team has revealed systematic biases in self-reported land area estimates, in line with other literature on the topic. The bias is such that respondents tend to heavily overestimate the area of small plots and underestimate the area of large plots. The figure below, extracted from the LSMS Area Measurement Guidebook, reveals the magnitude of bias observed in self-respondent estimates relative to compass and rope measurements, an objective measurement often believed to be the most accurate benchmark measure, from methodological studies conducted in Ethiopia, Tanzania, and Nigeria. For more details on these studies and the analysis of the measurement error in the land area estimates, compass and rope measurements, and GPS measurements conducted in these studies, refer to the LSMS Area Measurement Guidebook.

Table 1. Comparison of Mean Self-Reported and Compass and Rope Measurements

Level (CR)	Ethiopia						Tanzania					
	N	SR	CR	Bias	Mean bias / mean CR	Difference in means	N	SR	CR	Bias	Mean bias / mean CR	Difference in means
1 (< 0.05 acres)	352	0.09	0.02	0.07	307%	***	44	0.32	0.04	0.28	661%	***
2 (< 0.15 acres)	392	0.27	0.09	0.18	188%	***	622	0.41	0.11	0.31	288%	***
3 (< 0.35 acres)	351	0.40	0.23	0.17	72%	***	816	0.62	0.23	0.39	173%	***
4 (< 0.75 acres)	316	0.66	0.51	0.15	29%	***	323	0.98	0.49	0.49	100%	***
5 (< 1.25 acres)	179	0.95	0.97	-0.02	-2%	-	63	1.53	0.92	0.61	66%	***
6 (>= 1.25 acres)	99	1.42	1.90	-0.47	-25%	***	20	2.05	1.81	0.24	13%	-
Total	1689	0.47	0.38	0.09	23%	***	1888	0.65	0.27	0.38	143%	***

Level (CR)	Nigeria						Pooled					
	N	SR	CR	Bias	Mean bias / mean CR	Difference in means	N	SR	CR	Bias	Mean bias / mean CR	Difference in means
1 (< 0.05 acres)	-	-	-	-	-	-	397	0.12	0.03	0.09	371%	***
2 (< 0.15 acres)	21	0.15	0.11	0.03	30%	-	1035	0.35	0.10	0.25	247%	***
3 (< 0.35 acres)	73	0.39	0.25	0.14	55%	***	1240	0.55	0.23	0.32	136%	***
4 (< 0.75 acres)	129	0.79	0.53	0.26	50%	***	768	0.82	0.50	0.31	62%	***
5 (< 1.25 acres)	108	1.31	0.99	0.32	33%	***	350	1.16	0.96	0.20	21%	***
6 (>= 1.25 acres)	153	2.56	2.87	-0.30	-11%	-	272	2.11	2.44	-0.32	-13%	**
Total	485	1.38	1.31	0.07	5%	-	4062	0.66	0.44	0.22	51%	***

Notes: Table extracted from the LSMS Area Measurement Guidebook (Table 9; Carletto et al., 2016). *** indicates statistical significance at the 1% level, ** indicates statistical significance at the 5% level. Bias is defined as mean self-reported (SR) area minus mean compass and rope (CR) measured area. All area estimates above reported in acres.

ANNEX C – CONVERSION FACTORS FOR NON-STANDARD LAND AREA UNITS

The recommendation for 50x2030 surveys is to measure, at a minimum, the area of all cultivated and fallow plots and agricultural parcels using handheld GPS devices and to also collect self-reported area for all plots and parcels listed in the questionnaire regardless of their use. Research evidence shows that when self-reported area measurements allow for reporting in local units (non-standard units, NSUs), the reported values more closely approximate GPS measurements.[9] Ensuring less measurement error in self-reported area measurements can be especially valuable for plots and parcels where GPS measurements are not possible.

Establishing valid conversion factors for all NSUs is critical for ensuring usability of all reported data. Following is a brief overview of steps to consider for successful implementation of NSUs for self-reported area measurements.[10]

Establish a list of valid NSUs. Begin by checking whether any surveys in the country have used NSUs for area measurements. The Ministry of Agriculture or National Statistics Office often maintain libraries of conversion factors, though these may not always be complete or available in electronic format. Any existing lists should be reviewed, background documentation verified, digitized, and updated as needed. If a new list will be constructed, speak with local-context experts who can provide an initial list. In both cases, be sure to also check for any regional variation in conversion factors and/or change in local names, etc.

Establishing the list of Valid NSUs - Question to consider

- What NSUs already exist?
- Do the local units used vary across the country?
- Does the same unit name refer to different measurements in different parts of the country?
- How were the conversion factors established?
- Is there documentation for the conversion factor methodology?

Collet NSUs, if needed. If the NSU list needs to be created or updated, consider visiting rural households, of varying plot-size ownership, to ask what units are common in their area. If there are not clear conversions for the units, ask them to walk a perimeter of a given unit as an example; measure this area using GPS. This could be done as its own fieldwork activity prior to the main survey and/or it can be combined with the piloting of the main survey. Either way, when piloting the main survey consider incorporating the following steps:

1. Include "other, specify" as a unit option.
2. Include only for pilot these follow up questions.
    a. For households that report land in any non-standard units (including but not limited to 'other specify'), ask them to then estimate the same land area in a non-standard unit.
    b. For households that report any land (in any units), ask "In your region, what other units, if any, are commonly used to discuss land area? List all that apply."
    c. Then for each unit reported, ask "Do you know the estimated size of a [UNIT] in square meters?" Yes or No. Note that 'square meters' can be replaced with any other standard unit of measurement that is most common in the country.
    d. What is the area in square meters of [UNIT]?
3. During pilot, be sure to collect GPS measurements of reported land areas whenever possible.
4. Directly after the pilot, and before the main survey, review and assess the provided information. For any units that do not have sufficient estimates, or where the estimates vary greatly, follow up by reaching out to experts in the region to confirm unit conversions. Consider also finding people that use such units and have land that you can visit to walk the perimeter and measure using GPS.

Create NSU tools for the Survey. Clear conversion factors are critical for complete data usage and analysis.

[9] Refer to Table 11 in the LSMS Area Measurement Guidebook for an example from Ethiopia and Nigeria.

[10] For more detailed information on the value of non-standard units more broadly, see NSU Guidebook. For guidance on the use of NSU in 50x2030, see NSU Note.

Once land-area NSUs and their measurements are completed, establish a conversion factor table or dataset that can be used to convert both standard and non-standard units one standard unit of measurement (see example below). If there are regional differences in units, it should include those as well.

Example conversion factor tables for land area NSUs (Nigeria Panel Survey 2018/19)
The tables below show the conversion factors used to convert self-reported land areas (for agricultural land area of crops planted and harvested) into hectares.

General Conversion Factors to Hectares

Zone	**Unit**	**CF**
All	Plots	0.0667
All	Acres	0.4
All	Hectares	1
All	Sq Meters	0.0001

Note: All conversion is to Hectares

Zone-specific Conversion factors: NSUs to Hectares

Zone	**Conversion Factor**		
	Heaps	**Ridges**	**Stands**
North Central (1)	0.00012	0.0027	0.00006
North East (2)	0.00016	0.004	0.00016
North West (3)	0.00011	0.00494	0.00004
South East (4)	0.00019	0.0023	0.00004
South South (5)	0.00021	0.0023	0.00013
South East (6)	0.00012	0.00001	0.00041

Conduct Survey. The main questionnaire needs to be updated to reflect the options (see example below). Although you should have most, if not all, of the NSUs represented at this point, it is still important to ask 'other, specify' in case there are any regional/local units that have been missed in the preparation phase. As you will not yet have conversion factors for anything reported here, in cases of "other, specify" it will be helpful to also ask the household to estimate the value in a standard measure. Train interviewers to always record the initial type of units reported by the household (and to not ask household to report in an 'easier' format) – this will be valuable during the data analysis phase.

Example household survey allowing land-area reporting in standard units and NSUs
(Ethiopia Socioeconomic Survey 2015/16)

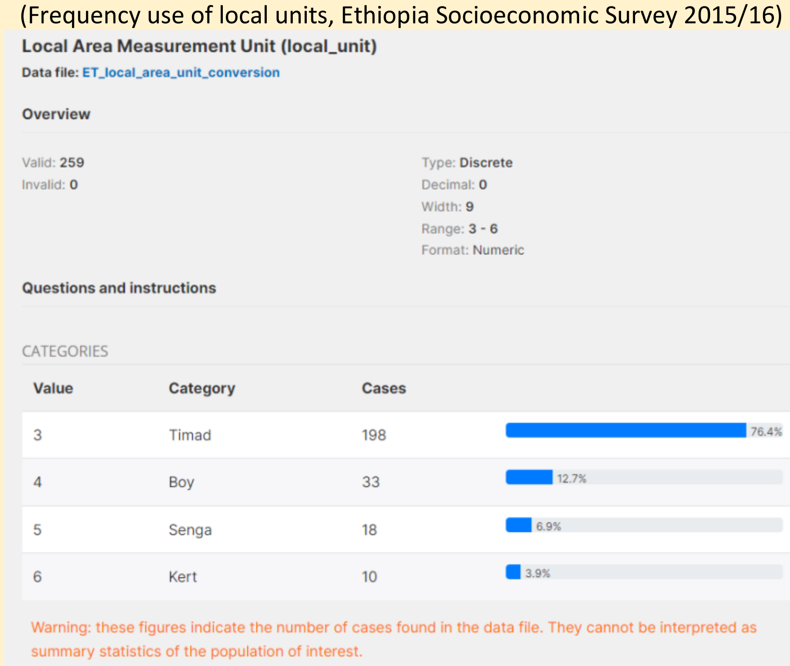
ASK HOLDER: What is the area of [FIELD]?	WAS [FIELD] MEASURED USING GPS?	RECORD AREA OF THE FIELD USING GPS.
CODES FOR UNIT: HECTARE......1 SQUARE METERS.......2 TIMAD........3 BOY..........4 SENGA........5 KERT.........6 TILM...................7 Medeb........8 Rope (Gemed)..9 Ermija.........10 Other(Specify)...11	Yes.......1 No..2(►Q8)	
AREA / UNIT		AREA IN SQUARE METERS
__ __ __ __ . __ __ /		__ __ __ __ . __ __
__ __ __ __ . __ __ /		__ __ __ __ . __ __

Finalize Data Documentation. While conversion factors are critical when using NSUs, the documentation behind them is what confirms their validity. This should include a report of how the NSUs were established, collected, measured, etc., as well as any accompanying documentation to support the report. Documentation may also include, for each NSU, the number of measurements used to establish the conversion factor, the number of surveys in which the NSU is used, or any other helpful information to confirm their validity and facilitate analysis using the data.

Keep in mind that the post-survey data finalization may require follow-up work to confirm valid conversion factors for any land area units reported in the main survey under "other, specify." This will be similar to step 4 of Collecting NSUs (above).

An NSU list is ready for use when it includes all known and commonly-used local/non-standard units; conversion factors for each to standard units; clear and reasonable documentation as to how the conversion factors were established. Once such a list exists, we encourage sharing it publicly, or at least throughout the National Statistics Organization, so that it can streamline the preparation work for all surveys in the country.

Example of complementary documentation on the conversion factors
(Frequency use of local units, Ethiopia Socioeconomic Survey 2015/16)


Local Area Measurement Unit (local_unit)

Data file: ET_local_area_unit_conversion

Overview

Valid: **259**
Invalid: **0**

Type: **Discrete**
Decimal: **0**
Width: **9**
Range: **3 - 6**
Format: Numeric

Questions and instructions

CATEGORIES

Value	Category	Cases	
3	Timad	198	76.4%
4	Boy	33	12.7%
5	Senga	18	6.9%
6	Kert	10	3.9%

Warning: these figures indicate the number of cases found in the data file. They cannot be interpreted as summary statistics of the population of interest.