Independent Science and Partnership Council

2019

A Country-Level Approach for Tracking the Diffusion of Agricultural Innovations in Developing Countries

SPIA TECHNICAL NOTE N. 7

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ABSTRACT

Although investments in agricultural research and development are key to agricultural growth, demonstrating this in a way that is convincing and relevant to policy requires data on adoption of agricultural innovations at scale. For CGIAR, tracking adoption of innovations remains a daunting task. Here we propose a country-level framework for identifying and prioritizing key CGIAR innovations that could warrant inclusion in country-level data collection efforts. Section 1 introduces a systematic approach for identifying a set of innovations in a given country. Section 2 discuses several ways to operationalize this approach, through piggy-backing on nationally representative surveys or using additional data sources, such as remote sensing or community surveys. Section 3 applies this framework to four countries in sub-Saharan Africa – Ethiopia, Nigeria, Tanzania and Uganda – to obtain lists of potential innovations to consider for specific data collection efforts. Finally, section 4 discusses challenges, lessons learned, and how the approach could be scaled up to a larger number of countries in the future.

INTRODUCTION: A COUNTRY-LEVEL FRAMEWORK

Agricultural growth has underwritten all major country-level transitions from predominantly agricultural economies to modernized developed economies. Early theorists (Rosenstein-Rodan, 1943; Lewis, 1954; Johnston & Mellor, 1961) emphasized the role that agricultural development can play in freeing up resources for the development of an industrial sector. Foundational empirical work on assessing the impacts of agricultural research (Hayami & Herdt, 1977; Binswanger, 1980; Hazell & Haggblade, 1993; Alston, Norton & Pardey, 1995) emphasized the importance of research-derived technologies in supporting increases in agricultural productivity and, consequently, impacts on food prices and food security.

Data on the uptake of these various types of research outputs, technologies or innovation (used synonymously in this paper) are the critical first step in a process of documenting and estimating the long-term, large-scale impact of investments in agricultural research. In the case of CGIAR, efforts to collect such data have either relied on the impetus and focus provided by special initiatives sponsored by concerned individual donors (e.g. Evenson & Gollin, 2003; Walker & Alwang, 2015), or have come from relatively small-scale one-off surveys added to the beginning or end of a sponsored project. These small-scale surveys, especially common for innovations from areas of research other than crop genetic improvement, often lead to results that are difficult to generalize and the data themselves are of limited value in terms of tracking change over time (see Doss, 2006). Improving the quality and representatively of adoption data is a priority for the CGIAR Standing Panel on Impact Assessment (SPIA) (Stevenson, Macours and Gollin, 2018),

Nationally-representative surveys provide data at a scale that is often the most policy-relevant and can enable linking of adoption data to other sources. CGIAR's activities are spread across a great many countries but are neither evenly spread across these countries nor scattered at random. In the process of de-

veloping the current phase of CGIAR Research Programs (CRPs) the science leaders in CGIAR were challenged to outline ambitious targets for the numbers of households that would adopt CGIAR innovations by 2022 and 2030. India, Bangladesh, Nigeria, Ethiopia, Tanzania and Uganda together represented more than half of this total CGIAR-wide ambition of some 200 million households. While part of this clustering of ambition can be explained by the fact that these are all large countries, it is also certainly the case that they are each host to a critical mass of scientists from many CGIAR centers – something that is not the case for most countries.

Thus, the logic of a country-level approach to tracking adoption of CGIAR outputs and assessing the impact thereof is that, if we can crowd resources for adoption studies and impact assessment into a few key geographies, we will be able to better focus our scarce resources for data collection at system level. In doing this we can raise data quality, data availability and get coverage across the range of categories of innovations. By aligning, integrating our data collection efforts with the statistical systems of these countries we can also contribute, alongside multilateral partners, to the process of supporting the development of statistical capacity in these countries – an effort that could help countries to report more comprehensively on the Sustainable Development Goals (SDGs), and that should have long-run benefits to all.

This report outlines SPIA's approach to developing and then implementing a country-level approach to tracking adoption of CGIAR research outputs. The remainder of the report is organized around the following three steps: 1) Identifying and prioritizing the research outputs or innovations that can and should be tracked; 2) Consideration of the relevant methodological issues in operationalizing data collection; and 3) Applying the framework with a focus on scoping activities carried out in four high-priority CGIAR countries in Africa – Ethiopia, Uganda, Nigeria and Tanzania. We conclude with reflections on this experience relevant to the process of scaling-up in these four countries and beyond.

SECTION 1. IDENTIFYING A SET OF INNOVATIONS

Our approach begins by identifying agricultural innovations in the four core domains of CGIAR research:

- Crop improvement
- Animal agriculture
- Natural resource management (on and off farm) (NRM)
- Policies and markets

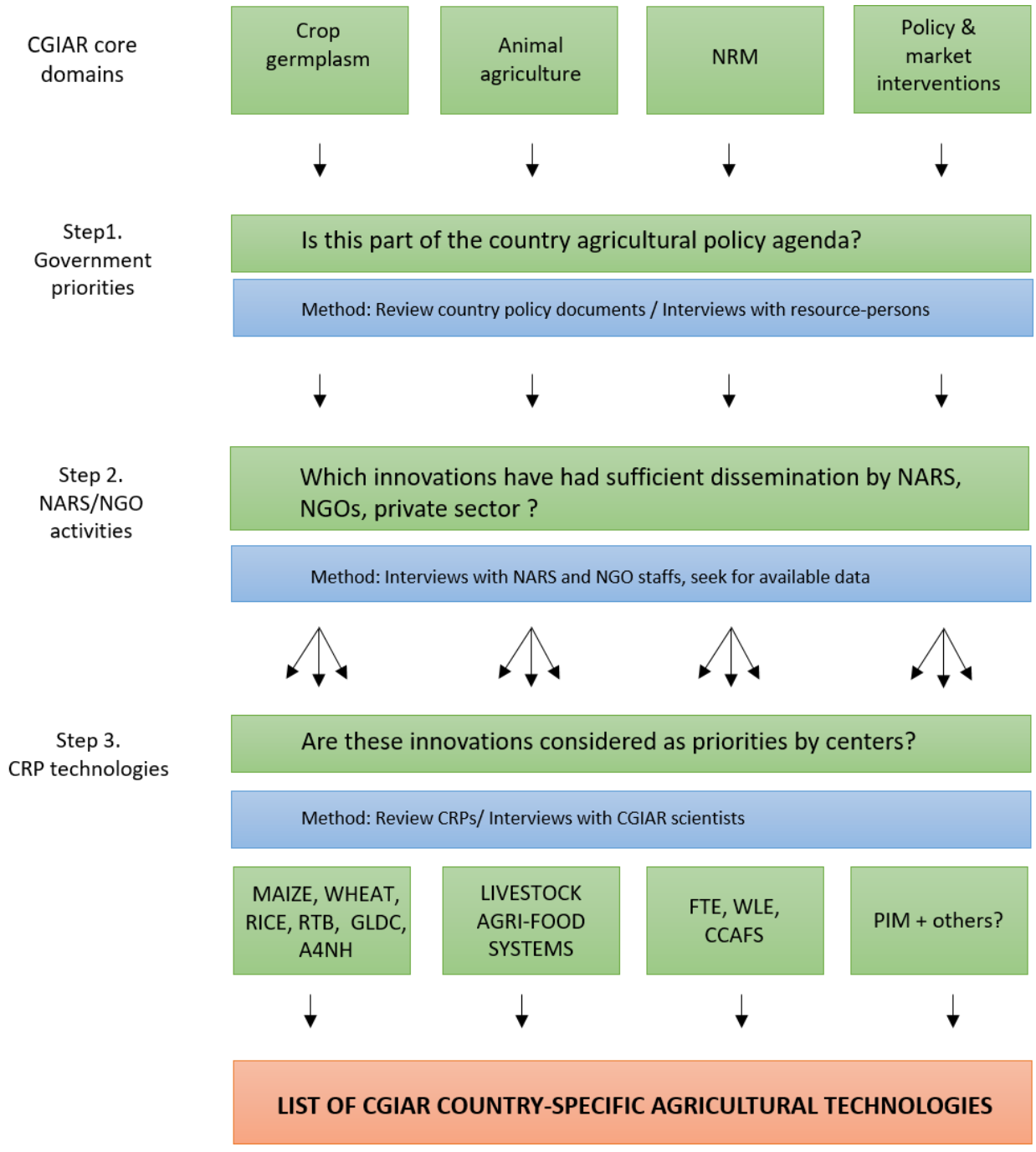
Indeed, agricultural projects and policies aiming at increasing sustainable agricultural productivity will typically include innovations in at least one of these core domains. This categorization helps to filter innovations with the aim of not omitting anything from consideration. These core domains are the basis of a systematic approach described in Figure 1. The first step relates to the relevance of the innovation for the country's current agricultural policies. Most countries have an agricultural development strategy over a given period, with publicly available documents. Consultation of all available sources is necessary to understand the relevance of the domain within the general agriculture policy framework and to identify innovations that are likely to be high priority for the government and in which government would be willing to invest in collection of diffusion data.

Secondly, the importance of diffusion efforts carried out in the past should be assessed by gathering information among relevant actors: National Agricultural Research and Extension System (NARES), donors, and Non-Governmental Organizations (NGOs). Once an innovation has been identified as an object of past dissemination efforts, it is also recommended to obtain a sense of the scale at which the innovation was diffused since only large-scale diffusion is likely to be detected in a nationally-representative survey. Since diffusion of innovations is expected to happen over several years or decades, an inherently backward-looking approach is appropriate. Additionally, analysis of existing data from past survey rounds can also be informative. Interviews with stakeholders and document reviews are the major methods required for gathering data in this step. The mechanisms for distribution of research-derived innovations are inherently specific to both the innovation in question and the country context.

Agricultural innovations emerge and diffuse as the result of multiple processes that involve public and private actors. Information on the innovations produced and disseminated in a given timeframe may not be immediately available and is sometimes not available at all. Recognizing this complexity is important and efforts should be expended for gathering relevant information for step two, using different channels.

The third step looks backwards and by considering which innovations are priorities among CGIAR centers and research programs. Centers and CRPs may have information that suggests that past innovations have been widely adopted, and they have recently-released innovations that they expected to be the focus on significant promotional efforts in coming years. CRP proposals are a good source of information for identifying these innovations, and in future, information from the CGIAR reporting system may be useful for this, especially indicators of expected uptake of innovations. As with information on dissemination, interviews with stakeholders will also be an important source of information about innovations that are priorities for Centers and CRPs.

FIGURE 1. SCHEME DESCRIBING THE SYSTEMATIC APPROACH ADOPTED TO IDENTIFY COUNTRY-SPECIFIC AGRICULTURAL TECHNOLOGIES



Once there are grounds to believe that a specific innovation may have been adopted at large scale, then the process can be repeated to refine the evidence, often by gathering additional information. Ideally, we are interested in innovations that are government priorities; that have been the subject of diffusion efforts and are adopted by farmers at a sufficient scale; for which CGIAR centers expect future research

efforts; and where significant impact assessments gaps exist. The final set of innovations will be arrived at through an iterative process. The set of innovations resulting from this systematic approach can then be ranked and prioritized for future data collection efforts.

SECTION 2. OPERATIONALIZING DATA COLLECTION

The inclusion of selected innovations into current nationally-representative surveys (of farms, households, or other unit) is the preferred choice for collecting data at large scale, as it is policy relevant and allows some flexibility regarding sample sizes and additional protocols to be included. However, household surveys might not be relevant for all innovations – in some cases other sources such as remote sensing, community surveys, farm surveys or project-based surveys may be more appropriate.

DATA COLLECTION INSTRUMENTS

LARGE SCALE HOUSEHOLD SURVEYS

Leveraging ongoing investments in nationally-representative surveys can be a cost-effective way to collect data on innovations. Several national statistical agencies conduct agricultural output estimation surveys at regular intervals, and large-scale surveys are also conducted in response to specific requests from donors. Examples of ongoing efforts include the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA), the Demographic and Health Surveys (DHS) or the Multiple Indicator Cluster Surveys (MICS). Although the two latter do not collect plot-level information on agricultural practices, they do capture several health outcomes of importance for agricultural innovations.

In sub-Saharan Africa, the LSMS-ISA type surveys are a good candidate for adoption data: linking specific innovations to a survey such as the LSMS-sponsored panels provides several advantages. The data from surveys in the LSMS Integrated Surveys of Agriculture (LSMS-ISA) initiative contain detailed information on agriculture at the plot level, as well as many non-agricultural facets of people's livelihoods (employment, income, consumption, shocks, assets, health and nutrition). Data are also collected at the appropriate level (community, household, individual, plot) and use best practice methods developed through their careful program of data collection research (i.e. Computer-Assisted Personal Interviewing (CAPI), survey questions, direct plot and animal observation, direct measurement such as crop cuts, geo-referencing using the Geographical Positioning System (GPS)). The advantage of integrating questions and/or new data collection protocols into the LSMS-type surveys is that we obtain data on multiple CGIAR innovations (crops, livestock, and NRM practices) in a single nationally-representative data set and, we can then link adoption status to socio-economic data collected as part of the same survey. Having this link between data about adoption status of specific technologies and other socioeconomic indicators is essential for our understanding of who is adopting, and how adoption is associated with other characteristics and outcomes. At the time of writing, LSMS type surveys were available in seven sub-Saharan countries (Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania and Uganda). An overview of the measurement methods used by each survey for our four focus countries is available in Table 1.

TABLE 1. SUMMARY OF MEASUREMENT METHODS IN LSMS-ISA ETHIOPIA, NIGERIA, TANZANIA AND UGANDA, USING THE LAST AVAILABLE SURVEY

	ETHIOPIA	NIGERIA	TANZANIA	UGANDA
Survey	Socioeconomic Survey (ESS)	General Household Survey (GHS)	National Panel Survey (NPS)	National Panel Survey (NPS)
Plot size measurement method	GPS	GPS	GPS	GPS
Yield measurement method	Crop-cuts	Farmer's estimations	Farmer's estimations	Farmer's estimations
Varietal identification measurement method	Farmer's elicitation, DNA fingerprinting on four cereals in 2018	Farmer's elicitation	Farmer's elicitation	Farmer's elicitation
NRM data	Yes	No	Yes	Yes
Livestock management data	Yes	No	Yes	Yes
Livestock breeds data	Yes	No	Yes	Yes
Aquaculture management data	No	No	No	No
Aquaculture breed data	No	No	No	No
Food consumption data	7-days	7-days	7-days	7-days
Age and sex disaggregation of some variables	Yes	Yes	Yes	Yes
Community-level data	Yes	Yes	Yes	Yes

SRF indicator 1

SRF indicator 2

SRF indicator 3

Finally, the Food and Agriculture Organization of the United Nations (FAO)-led Agricultural Integrated Surveys (AGRIS) are at an early stage at the time of writing, but certainly represent relevant data collection instruments. AGRIS surveys are farm-surveys synchronized with the Agricultural Census, which operate over a 10-year cycle. The typical AGRIS survey contains a core module on current agricultural production (crop and livestock) integrated with economic and socio-demographic statistics as well as thematic modules to be collected with lower frequency (two-five years): economy, labor, machinery & equipment, production methods & environment. The rotating module “production methods and environment quantities, type and areas” is of particular interest, including several agricultural innovations. Finally, it is worth mentioning that both the World Bank LSMS-ISA and AGRIS are part of a major expansion in survey data availability over the coming decade, announced recently at the UN General Assembly. The 50 x 2030 initiative aims to have 50 countries collecting high-quality agricultural data like LSMS-ISA and AGRIS surveys by 2030, to help improve reporting on the SDGs.

OVERSAMPLING TO ACCOUNT FOR THE STRUCTURE OF ADOPTION

Available surveys usually rely on a two-stage random sampling that draws units independently from each other with equal probability, and therefore may not reflect the non-random nature of local adoption: it is clear that prior dissemination efforts strongly influence the spatial structure of adoption. In addition, household surveys are usually representative at the national or regional levels, but are not representative for crop areas.

While one can build on the existing sampling frame, it may be necessary to oversample plots, households, farms and / or communities to ensure sufficient sample sizes, and where possible statistical representativeness, for all important innovations. Some of the innovations will only be adopted in certain regions of a country or by certain types of farmers.

In relevant cases, auxiliary information that reflects the driving forces behind adoption could be used to develop an additional sampling frame. Interviews with resource persons in each country can be used to gather innovation-specific information on past intervention areas and promotion efforts. The spatial information collected from these knowledgeable people could serve as a basis to draw stratified sampling or even to use local spatial autocorrelation to account for the spill-over effects of adoption.

Data at other scales will be needed to document uptake that takes place above the household level and, in some cases, to establish attribution to research outcomes.

COMMUNITY LEVEL DATA

Community surveys, which are often conducted in parallel with household surveys, are one option for getting information on community characteristics and how they have changed over time. This is particularly useful to track changes in institutions and related outcomes that apply at a spatial scale above the household level. This would include innovations that are directly targeted at communities rather than households, such as breeding schemes, communal ponds or common grazing areas, watershed or value chain interventions, storage facilities, etc. There are sampling issues to work through, and establishing the geographical boundaries of communities through geo-referencing can be applied when feasible, so that remote sensing information at the village level can be linked to the survey data. In contexts where more detailed information at the community level is useful to understand diffusion patterns, a complementary survey effort at the community level could also be considered.

LANDSCAPE LEVEL DATA

Remote sensing can provide data on land use and related outcomes at relevant scales in the landscape that may not be covered by household or community surveys. Satellite remote sensing is a dynamic area of research, with networks in Europe (focused on the Copernicus / European Space Agency program), United States (NASA and partners) and a growing number of private sector companies (Popkin, 2017). The Copernicus Global Land Service, for example, provides a high resolution “Hot Spot” service of monitoring activity – generating high-resolution imagery with repeat observations over years. This service does respond to ad-hoc requests, particularly in relation to the sustainable management of natural resources in protected areas and key landscapes. The Greater Virunga landscape, a highly biodiverse landscape straddling Uganda and Rwanda, is one of the focus landscapes for this service currently, and there is clear potential for such remote-sensed data to complement data collected on the ground. Furthermore, remote-sensing of the same specific agricultural plots where LSMS-ISA and other surveys are tak-

ing place can help scale out data across larger geographies, as well as providing insights into what happens in the years between surveys. This process of remote-sensing based yield modelling and projection is the focus of research led by Marshall Burke and David Lobell among others (Lobell et al., 2018), working in some cases with the World Bank LSMS-ISA team.

PROJECT ACTIVITIES DATA

Development projects and programs are a key mechanism through which CGIAR research reaches end users. In some cases, development programs disseminate CGIAR innovations to their participants. In other cases, CGIAR research influences how programs are designed and implemented, leading to greater effectiveness (Renkow, 2018). In the latter case especially, data on program implementation areas could help build a link between CGIAR research and adoption of innovations and practices or other outcomes that can't be uniquely linked to CGIAR through the innovation itself or some other "signature".

There is currently not a database of such projects, however data on where development programs operate is increasingly available in the public domain due to advances in geo-coding of data and to greater commitment to open access. Centers and CRPs have data on their research projects, some of which include development interventions. Starting from publicly available data (e.g. through the published data on all relevant donor agencies for a specific country), stakeholder consultation can subsequently be used to document which innovations were promoted when, where and why. A precedent for these efforts comes from the geo-coded map of aid flows into Malawi generated by the AidData consortium (Weaver et al., 2014). Special care will be given to try to obtain relevant information regarding programs geographical targeting and placement criteria, which can potentially form the basis for subsequent quasi-experimental impact studies.

POLICY / INSTITUTIONS

CGIAR research influences policies in countries at multiple scales, from national policies and regulations to local institutions and bylaws. Centers and CRPs regularly document influence on policy and starting in 2018 they will be reporting on policy influence as part of the annual reporting template[1]. Data bases of past claims that are sufficiently supported by evidence (of CGIAR contribution) could be a compiled and mapped with a view to examining patterns and trends in outcomes and impacts. CGIAR influence in markets and value chains also falls under this broad category of policy and institutions, and is central to the impact pathway of many CRPs.

OUTCOMES

The central motivation for a country-level framework for data collection is to establish a representative picture of the adopters of research outputs, combined with a rich set of covariates regarding the agricultural system and data on the welfare of the household members. The temptation is to push further, to include variables related to a broader range of outcomes that CGIAR cares about. In the case of "agricultural productivity", the most common outcome targeted by CGIAR research outputs, we would like to have good data about both land- and labor-productivity. Empirical evidence has demonstrated the value of using crop-cuts for estimating agricultural production (Lobell et al., 2018) and GPS for measuring field

[1] Indicator 3 - Number of policies, legal instruments or investments modified in design or implementation, informed by CGIAR research (this also could relate to programs)

boundaries as the means for estimating plot area (Carletto et al., 2016). Together these form the numerator and denominator, respectively, for the calculation of land productivity, and yet the practice of carrying out crop-cuts is not well institutionalized (Ethiopia being a notable exception) and few surveys have started measuring plots using GPS. However, in general, we should be optimistic about our ability to more accurately measure yields over the coming years, especially when combined with the advances in remote sensing. Labor productivity is difficult to measure well in surveys. Data on labor allocation to agricultural tasks is subject to measurement error owing to recall bias, a particular problem for agriculture given how highly seasonal labor demand is (Beegle et al., 2012).

Beyond agricultural productivity there are a great many other indicators that are candidates for data collection – indicators for nutrition, health, women's empowerment, food security, and ecosystem services (including those related to climate change). However, the desire to be comprehensive must be balanced against the potential for the survey interview process to become overloaded. Furthermore, given that most research questions pertaining to outcomes require a sufficient number of agricultural producers that are either adopters of an innovation or are affected by specific policies / institutional innovations, we should be concerned about a likely lack of statistical power once the overall sample is divided up. In some cases, these data can be obtained from other sources and linked to adoption data as part of analysis.

SECTION 3. APPLICATION IN FOUR COUNTRIES

This section applies the country-level framework to four countries in sub-Saharan Africa: Ethiopia, Nigeria, Tanzania and Uganda. Together these represent one fifth of the aggregated individual CRP aspiration, and 30% of the headline CGIAR SRF target of: "100 million more farm HHs have adopted improved varieties, breeds or trees, and/or improved management practices by 2022" (Table 2). While CRP were always intended to be aspirational and were based on funding scenarios that were overly optimistic, they nonetheless provide a sense of where CRPs where expecting to see high levels of adoption of innovations.

TABLE 2. SELECTION OF FOUR OF THE PRIORITY COUNTRIES FOR CGIAR SITE INTEGRATION. BASED ON CGIAR SRF TARGET OF: "100 MILLION MORE FARM HHS HAVE ADOPTED IMPROVED VARIETIES, BREEDS OR TREES, AND/OR IMPROVED MANAGEMENT PRACTICES BY 2022"

	Ethiopia	Tanzania	Uganda	Nigeria	India	Bangladesh	Vietnam	CRP total (M HHs)	CRP total (all countries)	% share in priority countries
A4NH	0.50	0.56	1.80	2.79	2.50	3.10	-	11.25	20.47	55
CCAFS	0.80	0.40	0.30	-	3.00	0.50	1.00	6.00	10.85	55
Fish	-	0.11	-	0.35	-	1.80	-	2.26	4.86	47
FTA	3.30	1.00	0.50	-	4.30	-	1.50	10.60	31.20	34
Livestock	2.05	1.44	0.31	0.76	0.48	0.16	0.11	5.31	6.52	82
Maize	2.50	1.10	0.30	1.00	3.70	0.80	-	9.40	15.00	63
PIM	1.00	0.50	-	1.00	2.00	1.50	-	6.00	10.00	60
Rice	-	0.09	-	0.24	4.27	1.19	0.76	6.56	16.50	40
RTB	-	0.30	0.80	1.20	0.30	-	-	2.60	8.00	33
Wheat	2.00	0.01	-	-	8.00	0.34	-	10.35	17.17	60
WLE	1.00	0.55	-	-	12.50	2.75	-	16.80	20.45	82
Country total (M HHs)	13.15	6.06	4.01	7.34	41.06	12.14	3.37	87.14	161.02	54
Approximate % share of rural HHs	76	80	61	39	22	52	22			
(Rural HHs calculated using SP.RUR.TOTL from World Bank data for rural population, and HH size from a range of different sources listed here)	DHS 2011	Census	UBOS (09/10)	DHS	NFHS-3	ArcGIS.com	ArcGIS.com			

In these four countries, the agriculture sector (including forestry and fishing), accounts for between 20 and 34 percent of GDP and makes up between one third and two thirds of the total employment (World Development Indicators, 2018). These countries have engaged in collaborative research activities related to the generation and diffusion of agricultural innovations, and are also considered as priority countries by many development agencies, along with the CGIAR system.

TABLE 3. PRESENCE OF CGIAR CENTERS IN ETHIOPIA, NIGERIA, TANZANIA AND UGANDA, INDICATED BY GREEN CELLS.

CGIAR Center	ETHIOPIA	NIGERIA	TANZANIA	UGANDA
Africa Rice				
Biodiversity International				
CIFOR				
ICARDA				
CIAT				
ICRISAT				
IFPRI				
IITA				
ILRI				
CIMMYT				
CIP				
IRRI				
IWMI				
ICRAF				
World Fish				

The following sections present progress to date in each country. In the case of Ethiopia and Uganda, we have conducted a process of consultation with CGIAR scientists and government to prioritize among the candidates. In Ethiopia, several innovations have been included in the Ethiopia Socioeconomic Survey 2015/16 and 2018/19. In Nigeria and Tanzania, we restricted ourselves to a description of the candidate innovations after it became clear that our scope for working in those countries was constrained. In both countries, Steps 1 and 2 were undertaken but Step 3 could not be completed: additional country-level discussions will be needed to prioritize candidate innovations in Nigeria and Tanzania.

As the objective is to collect household-level data on prioritized innovations, the role played by CGIAR centers on country policy and markets (Core domain 4) was not fully investigated in the four countries.

ETHIOPIA

GOVERNMENT PRIORITIES

The Growth Transformation Plan II (National Planning Commission, 2016) details the Ethiopian government's strategy for agricultural development over the 2016-2020 period. Improved varietal adoption is an important component of this strategy, with a targeted increase in the supply of improved seeds from 187.000 to 356.000 metric tons. Livestock development is also supported by the Growth Transformation Plan II and the Livestock Master Plan (Shapiro et al., 2015). The Ethiopian government has set a high target in its Livestock Master Plan: while number of crossbred cattle is estimated to 750.000 in 2016, the objective is to reach 5m crossbreeds in 2022. The GTP II is also focused on watershed management, degraded highland restoration and expansion of small-scale irrigation. All core CGIAR activities thus align with the government priorities for the 2016-2020 period.

DIFFUSION AND CURRENT ADOPTION LEVELS

CROP GERMPLASM IMPROVEMENT

Crop germplasm improvement has been a major activity of CGIAR Centers, in collaboration with the Ethiopian Institute of Agricultural Research. Table 4 provides background statistics on most important crops for the Ethiopian agricultural sector.

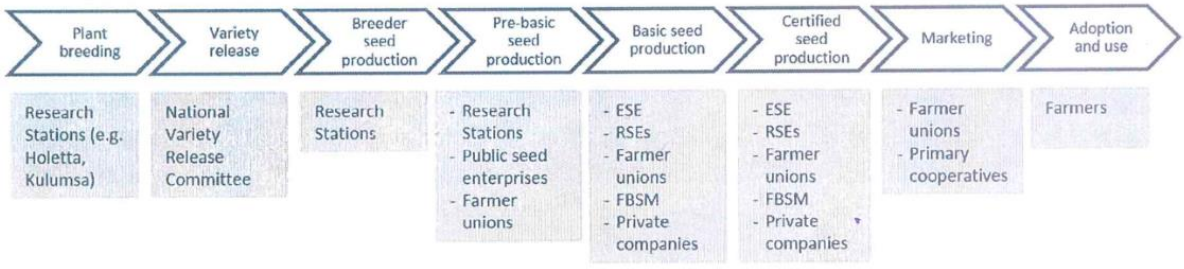
TABLE 4. CROP AND IMPROVED VARIETAL RELEASES AND ADOPTION IN ETHIOPIA

	Number of households (in millions)*	Production area (in millions Ha)*	Varieties released before 2016**	Varieties derived from CGIAR material***	Varieties certified/distributed (2017)****	Varieties from CGIAR material distributed (2017)
Maize	9.5	2.1	64	20	32	7
Teff	6.5	2.9	37	0	7	0
Sorghum	4.9	1.9	48	>16	9	3-6
Wheat	4.8	1.7	113	n.a	37	n.a
Barley	4.2	0.9	61	10	11	2
Horse bean	3.6	0.4	32	10	7	4
Haricot bean	2.4	0.2	57	16	7	5
Chick peas	1.2	0.2	26	15	6	6
Lentil	0.7	0.1	11	9	3	3
Sweet potatoes	1.5	0.04	25	n.a	n.a	n.a
Irish potatoes	1.4	0.07	36	18	n.a	n.a

** Source:* AgSS 2016/17
*** Source: Crop Variety Register Book No. 19, 2016*
**** Source: DIIVA and Crop Variety Register Book No. 19, 2016. Include pure and crossed CGIAR lines*
***** Source: Ministry of Agriculture, Certified Seed (C1) allocation and distribution, 2016/17*

Plant breeding efforts form the starting point of the seed value chain. This activity is carried out by the Ethiopian Institute of Agriculture Research (EIAR), organized in 17 federal research stations and 58 regional research stations. The involvement of CGIAR centers at this level has been important for all crops but teff.

FIGURE 2. THE SEED VALUE CHAIN IN ETHIOPIA



Source: Husmann, 2015

Once a new variety is approved by the National Variety Release Committee, research stations are responsible for the production of breeder seeds and pre-basic seeds. Public seed enterprises, farmer-based seed multiplication schemes (FBSM, also called model farms) and private companies are then responsible for producing basic seeds (Figure 2).

In Ethiopia, three types of seed producers are engaged in seed dissemination efforts at large scale:

i) *Public seed enterprises*. Ethiopian Seed enterprise (ESE), with regional seed enterprises (RSE) in Amhara, Oromia, Southern region and Somali.
ii) *Private Ethiopian seed companies*. Currently 50 companies are believed to operate in Ethiopia.
iii) *Private international seed companies*. Hi-Bred Pioneer and Seed Co (maize only).

All Ethiopian seed companies obtain basic seed from EIAR, and thus partly from CGIAR germplasm. Seed production is a centralized process that starts with an assessment of seed demand at the kebelle level. Information is then passed to the woreda, zone, region and federal levels (MoA). Quantities of seed needed per crop are then assigned to research stations and the Ethiopian Seed Enterprise (ESE) for production.

Recent changes to increase seed supply include the Direct Seed Marketing program (DSM). Under the direct seed marketing program, seed enterprises, both public (ESE, RSE) and private, are authorized to sell seed directly to farmers in selected woredas (Benson et al., 2014). This delivery scheme is supported by the Agricultural Transformation Agency (ATA) and other development agencies. Table 5 details the amount of certified seeds (in metric tons) distributed by region for the 2015 and 2016 agricultural seasons.

TABLE 5. AMOUNT OF CERTIFIED SEEDS DISTRIBUTED DURING THE 2015/16 AND 2016/17 AGRICULTURAL SEASONS BY REGION (IN METRIC TONS)

	Amhara		Oromia		SNNP		Tigray		Other		Ethiopia	
	2015/16	*2016/17*	*2015/16*	*2016/17*	*2015/16*	*2016/17*	*2015/16*	*2016/17*	*2015/16*	*2016/17*	*2015/16*	*2016/17*
Maize	4,929	5,699	13,064	12,534	7,510	7,633	60	82	217	381	30,709	26,329
Teff	9,653	3,314	44,934	37,907	18,683	14,310	5,829	1,183	65	67	88,816	56,781
Sorghum	1,250	3,314	3,655	5,323	3,070	3,787	43	2	0	0	9,268	12,426
Wheat	610	27	120	61	64	101	108	16	0	2	1,511	207
Barley	1,946	529	2,506	2,039	2,325	1,638	387	172	7	4	9,117	4,381
Faba bean	606	7	423	1,107	1,955	1,644	11	14	0	0	3,601	2,772
Haricot bean	1,141	0	1,400	275	7,826	6,042	0	14	18	2	11,525	6,333
Chick peas	254	1	1,489	653	461	188	0	0	1	0	2,459	842
Lentil	31	0	622	557	0	0	0	1	1	0	685	558

Source: Ministry of Agriculture, 2016
Note: These figures correspond to "Certified production seeds", comprising seeds produced by public seed enterprises, farmer's cooperatives as well as the private sector.

LIVESTOCK DEVELOPMENT

a) Large ruminants

The diffusion of improved livestock breeds in Ethiopia is highly dependent on National Artificial Insemination Centers (NAIC). Ten centers exist with the role of distributing semen and liquid nitrogen to A/I technicians. The number of hybrid/improved genetics cattle is currently estimated at 750.000 while GTPII objective is to reach 5m breeds in 2022. Three major production systems can be identified (Land O'Lakes, 2010). They differ by their market orientation, scale, productivity and demand for feed and improved breeds:

i) Traditional smallholder. Rural farmers usually keep a small number of milking cows (usually zebu cattle) in mixed agricultural systems. This sector is largely dependent on the indigenous zebu breeds. Low milk productivity (1.3 lt. – 1.54 lt. per day) and inefficient logistics to link producers and processor are important constraints.

ii) Urban and peri-urban specialized dairy farmers. These producers benefit from the market opportunities created by urban and peri-urban milk supply systems. They practice direct delivery to household or cafes/restaurants and also feed the 27 formal sector dairy processors in Ethiopia. Many dairy farmers depend on artificial insemination (A/I) services, own improved breeds of cows, and use improve feeds for alimentation. They sell raw as well as pasteurized milk.

iii) Specialized commercial intensive dairy farming. These farms comprise small and medium sized dairy farms and uses improved dairy stock. In 2010, 269 commercial dairy farms with 10 or more mature cows were identified within the Greater Addis milk shed (Land O'Lakes, 2010).

The Holstein Friesian cattle (called Americana by farmers) and Jersey breeds, present in the country, are products of the dairy cattle research in Ethiopia (Effa et al., 2016). They are usually crossed with local breeds, resulting in significant increases in milk yields as well as higher input requirements and costs.

Breeding activities have been a major component of the LIVES project. There are also current projects at ILRI related to molecular characterization of cattle. Among 27 cattle breed, eight have been properly characterized: Boran, Fogera, Horo, Sheko, Abigar (Nuer), Gurage, Ambo, and the Afar breeds. No dissemination efforts reported in Tadesse et al. (2016).

In the past, ILRI efforts have been directed at DAGRIS, an information system designed to facilitate the compilation, organization and dissemination of information on the origin, distribution, diversity, present use and status of indigenous farm animal genetic resources. Regarding policy influence, ILRI has played a significant role in the design of the Livestock Master Plan.

b) Small ruminants

In the past, small ruminants breeding efforts have been localized, reaching a limited number of communities. Activities include the Ethiopia Sheep and Goat Productivity Improvement Program (2005-2010) as well as various ILRI or the International Center for Agricultural Research in the Dry Areas (ICARDA) projects (IPMS, LIVES). Cross-breeds of Durpon, Borgots, Bonga and Menz sheep have reached some levels of adoption in specific regions. Several station studies have shown the superiority of crosses over local animals (Getachew et al., 2016), particularly Awassi and Correidale crossbreeds.

Under GTP II and LMP, emphasis will be given to arid and pastoralist areas to crossbreeding of selected local breeds and reproduction of improved breed of sheep and goats. The transformation of small ruminant value chain in Ethiopia is a major goal of the CGIAR Research Program (CRP) on Livestock. The project will be carried out in eight sites: Horro and Yabello (Oromia), Doyogena and Bonga (Southern Nations, Nationalities and Peoples'), Wag Abergelle and Menz (Amhara) and Tanqua Abergelle and Atsbi (Tigray). Finally, it should be noted that the Livestock CRP II has a strong focus on small ruminants.

c) Poultry

Poultry has not been on the agenda of CGIAR centers until recently. The African Chicken Genetic Gains (ACGG) is in pilot phase only. Kuroiler, Koekoek, Sasso, Fayoumi, and Horro breeds are currently trialed at ILRI. In the past, the Horro breed has achieved higher egg productivity in station trials. The adoption of improved poultry breeds follows the geographical patterns highlighted above, with a higher diffusion in urban and peri-urban areas (Table 6).

TABLE 6. BACKGROUND STATISTICS ON IMPROVED LIVESTOCK BREED ADOPTION IN ETHIOPIA

	Population (in millions)*	% of improved breed type (rural + urban) **	% of improved breed type in small town/ urban areas **
Crossbred cattle	7.2	3.9	16
Crossbred sheep	30.7	1.9	3.5
Crossbred goat	30.2	1.6	5.3
Crossbred chicken	56.5	6.6	25.6

** Source: AgSS 2016-17*

*** Source: ESS, 2015/16, based on farmer's elicitation*

d) Livestock feeds

ILRI has also played a significant role in introducing various fodder species besides its involvement in the collection and evaluation of indigenous species (Assefa et al., 2016). Although adoption is currently low and localized in peri-urban areas, feed adoption will have to follow the trend in cross-breeding cattle forecasted by GTP II. Thus, the amount of fodder seed production is forecasted to quadruple in the next three years (Shapiro et al., 2015). This should benefit smallholders as well as industrial operations.

Three important feeds are maintained by ILRI, namely elephant grass (first cultivar released in 1984), Vetch and Lablab. Currently, 4.4 percent of livestock are fed with improved feeds, but these are mostly industry-by-products that farmers purchase (Central Statistical Agency, 2016). Very rarely are livestock fed with Napier Grass or Lablab.

The Feed Assessment Tool (FEAST), developed in early 2010 is a participatory, community-level approach to assess local feed resource availability and use. The goal is ultimately to develop site-specific interventions. Ready-to-use and open access material have been produced by ILRI to upscale the approach, and FEAST have been used by research project (Africa Rising) as well as NGOs. Interventions in Ethiopia are in the approximate range of 30-50 communities targeted.

e) Animal health

Various projects related to animal health are currently carried out by ILRI. Herd health packages aims at designing tools to help assess interventions that could be useful in a specific place. These interventions shift the focus from controlling one disease to looking at several disease at the same time. Examples include community-based parasite control along with rotational grazing. Five sites are currently benefiting from herd health packages.

Another line of work relates to livestock-related health services access. Interventions here test different models of service delivery and identify bottlenecks. In collaboration with the Ethiopian Veterinary Association, training modules are being developed for farmers, extension services, communities and veterinarians. The project was starting at the time of writing, with interventions planned in 48 woredas in 3 regions.

f) Livestock insurance

Since 2013, ILRI has engaged in Index-Based Livestock Insurance. In partnership with regional insurance companies, the project uses satellite data to measure vegetation based on ground cover. When subscribing, pastoralists are insured against forage deterioration that can lead to drought, resulting in livestock deaths. The project currently operates in the Borana area, with the objective of scaling up in the future. The project benefit from a sound impact assessment strategy (Jensen et al., 2014; Takahashi et al., 2016).

NATURAL RESOURCE MANAGEMENT PRACTICES

In the past twenty years, massive soil conservation programs have been carried out by governmental and non-governmental organizations. Following a top-down approach, soil restoration practices have been promoted according to the land's physical limitations and erosion risks (WOCAT, 2003). Specific technologies included: terracing, forage grass strips, raised-bed technology, broad bed and furrows (BBF), ridge tillage, contour bunding, and tree planting / afforestation. Several CGIAR projects have

aimed at combatting soil erosion through the promotion of specific land management practices. The African Highland Initiative and the Tree for food security project are among the largest program. FTA and WLE CRPs are also considering soil restoration practices as a priority.

Concepts such as Conservation Agriculture, Integrated Soil Fertility Management (ISFM) or Site-Specific Nutrient Management (SSNM) are employed to describe a set of management practices aiming at increasing yields while sustaining the environment. Promotion of these practices has occurred in the past, although it is difficult to know to what extent. CCAFS, WLM as well as crop-specific CRPs have been promoting sustainable agriculture practices under different labels. A variety of concepts, such as Conservation agriculture, Integrated Soil Fertility Management (ISFM) or Site-Specific Nutrient Management (SSNM) are employed to describe a set of management practices aiming at increasing yields while sustaining the environment.

Similarly, agricultural water management practices at the community scale– Small reservoirs, Community managed river diversion (CMRD) schemes, Inland valleys – or at the household scale – Rainwater harvesting, groundwater-based water extraction methods – have been promoted in Ethiopia by NARS, NGOs and agricultural extension services. IWMI has managed a total of 63 projects over the last 10 years. These projects are usually operating at small scales, predominantly in the highlands of the Nile Basin, in Bale Mountains, and SNNPR (Africa Rising program). Notably, the AgWater Solutions project has provided a framework of agricultural water management solutions and practices that have been implemented in Ethiopia.

TABLE 7. BACKGROUND STATISTICS ON ADOPTION OF NATURAL RESOURCE MANAGEMENT (NRM) PRACTICES IN ETHIOPIA

	2012	2014	2016
Highland soil restoration (% parcels)			
Terracing	14.4	22.7	23.8
Forage grass strips / Plough along the line	8.3	14.9	17.2
Raised-bed technology / Broad bed and furrows / Water catchments	0.05	0.03	0.8
Tree planting / Afforestation	0.07	0.06	0.7
Sustainable Agriculture Practices (% fields)			
Crop rotation with legume	n.a	n.a	20.6
Residue cover after planting (> 30%)	n.a	n.a	7.7
Minimum tillage	n.a	62.8	55.7
Agricultural Water Management			
Rainwater harvesting (% fields)	1.1	<0.01	<0.01
Motor pumps (% fields)	n.a	n.a	0.05
Pressure treadle pumps (% household)	n.a	n.a	<0.01
Irrigation schemes (% communities)	49.2	65.1	60

Source: ESS, based on farmer's elicitation

LIST OF CGIAR COUNTRY-SPECIFIC AGRICULTURAL TECHNOLOGIES

The entire exercise is summarized in the following table that contains an assessment of CGIAR innovations in Ethiopia, along with additional protocols that have been integrated in the Ethiopia Socioeconomic Surveys in 2015/16 and 2018/19.

	CG role	Uptake	Dissemination	Evidence from IA	Priority *	Availability in ESS 2015/16	Availability in ESS 2018/19
Crop improvement							
Maize	High	National	High	High	+	Farmer's elicitation on local vs improved	Varietal-level DNA fingerprinting
Teff	Starting	National	Medium	None	+	Farmer's elicitation on local vs improved	Farmer's elicitation on local vs improved
Sorghum	Medium	National	Low	None	+++	Farmer's elicitation on local vs improved	Varietal-level DNA fingerprinting
Wheat	High	National	High	High	+	Farmer's elicitation on local vs improved	Varietal-level DNA fingerprinting
Barley	Medium	National	Medium	None	+++	Farmer's elicitation on local vs improved	Varietal-level DNA fingerprinting
Faba Beans	High	National	Medium	None	+++	Farmer's elicitation on local vs improved	Farmer's elicitation on local vs improved
Red haricot Beans	High	National	Medium	None	+++	Farmer's elicitation on local vs improved	Farmer's elicitation on local vs improved
Chickpea	High	National	Low	None	+++	Farmer's elicitation + desi/kabuli type	Farmer's elicitation on local vs improved
Lentils	Medium	Regional	Low	None	+	Farmer's elicitation on local vs improved	Farmer's elicitation on local vs improved
Sweet Potato	High	Regional	Low	High	++	Visual-Aid on OFSP + Hawassa-83 varieties	Visual-Aid on OFSP + Hawassa-83 varieties
Potato	Medium	Regional	Low	None	++	Farmer's elicitation on local vs improved	Farmer's elicitation on local vs improved
Animal agriculture							
Crossbred dairy cattle	Medium	Regional	Low	None	++	Farmer's elicitation on crossbreeds	Farmer's elicitation on crossbreeds
Small ruminants breed improvement	Medium	Regional	Low	None	++	Farmer's elicitation on crossbreeds	Farmer's elicitation on crossbreeds
Chicken breed introduction	Starting	Pilot	None	None	+	Farmer's elicitation on crossbreeds	Farmer's elicitation on crossbreeds
Livestock feed	High	Regional	Low	None	++	Farmer's elicitation on major feed types	Farmer's elicitation on major feed types
Feed Assessment Tool (FEAST)	High	>30 woredas	Low	None	+	No	No
Index-based Livestock Insurance	High	Pilot	Low	High	+	No	No

Natural resource management							
Highland soil restoration	TBD	Regional	High	Medium	+++	Farmer's elicitation on terracing, water catchments, plough along the contour and afforestation	Farmer's elicitation on terracing, water catchments, plough along the contour and afforestation
Sustainable Agriculture Practices	TBD	National	Medium	Medium	++	CA components with visual-aid on residue cover	CA components with visual-aid on residue cover
Agricultural Water Management	TBD	National	Medium	Medium	++	Irrigation method used at house-hold/community level	Irrigation method used at house-hold/community level

* Prioritization is based on evidence gathered following the three steps described in Figure 1: government priority, extent of dissemination and importance for CRPs. The relevance of the ESS sampling frame, the availability of a protocol to capture data accurately and the additional burden to current survey design were also considered before advocating new inclusion.

UGANDA

GOVERNMENT PRIORITIES

The Uganda's Agricultural Strategic Sector Plan (MAAIF, 2016) is a five-year strategy document outlining the priorities and interventions for the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) from 2016 to 2020. The key specific priority and strategic commodities are bananas, beans, maize, rice, cassava, tea, coffee, fruits and vegetables, dairy, fish, livestock (meat), and four strategic commodities, namely, cocoa, cotton, oil seeds, and oil palm. The other specific areas of investments are: research; extension; pest, vector and disease control; provision of inputs; promoting sustainable land use and soil management; post-harvest handling; improving markets access and value addition.

DIFFUSION AND CURRENT ADOPTION LEVELS

CROP GERMPLASM IMPROVEMENT

Banana: Banana is one of the top six crops grown in Uganda based data from UNPS 2014 shown in Table 8. The production of bananas in 2014 census data was estimated to be 4,6 million mt, of which 3,070 mt were exported. The sector targets to produce 13 million mt by 2020. The planting material for banana has been widely distributed under National Agricultural Advisory Services program (NAADS) as shown in TABLE 9.

Cassava: Cassava is key food security crop in Uganda and is targeted to contribute about US$30 million per year in import-substitution by 2020. The cassava production in 2014 was estimated to be 2.8 million mt. The sector targets to increase production of Cassava to 3.5 million mt by 2020. Although cassava is not widely distributed under NAADS compared to other crops, NGOS have been involved in dissemination of cassava planting material (data on quantity are difficult to get). In addition, the National research system has also distributed Cassava under different funding arrangements.

Beans: Common bean is one of the key food security crops but also serves as one of key commercial crops in Uganda. Its production in 2014 was estimated to be 1 million mt, of which 31,796 mt were exported. This generated US$26,19 million for the country. The sector targets to produce 10 million mt by 2020. Annual exports are projected to increase to US$63 million. As shown in Table 17, in terms of dissemination, beans varieties are the second highest crop after maize.

Maize: Maize is one of the major staple, commercial, and export crops in Uganda. It is the leading cereal crop grown in almost all parts of the country the crop and accounts for the highest share (25 percent) of crop income. Maize production in 2014 is estimated to be 2.9 million mt, of which 134,903 mt were exported. This generated US$43.567 million for the country. The sector targets to annually produce 10 million mt by 2020. Exports are projected to increase to US$105 million annually. Data from NASECO and NAADS show that maize OPV and hybrids are highly disseminated.

TABLE 8: CROPS GROWN IN UGANDA (% OF FIELDS) IN 2014

Crop Name	Freq.	Percent
Beans	1,838	17.42
Cassava	1,741	16.5
Maize	1,731	16.41
Banana Food	1,345	12.75
Sweet Potatoes	736	6.98
Groundnuts	607	5.75
Sorghum	381	3.61
Finger Millet	232	2.2
Irish Potatoes	164	1.55
Pigeon Peas	141	1.34
Soya Beans	102	0.97
Banana Beer	83	0.79
Total	10,550	100

SOURCE: UNPS DATA, 2014

Irish potatoes: Breeding efforts have started in 1999 with an IFAD-FAO funded project to form Farmer Field Schools (FFS) for integrated blight management in a number of countries in Africa, Asia, and Latin America. NARO intends to produce high yielding and disease resistant varieties. Till today, there are about 13 varieties that have been developed and released. No credible adoption and impact study has been done so far.

Sweet potatoes: Sweet potato is grown by 7% of households in Uganda, contributing to diet diversification and food security. The first sweet potato varieties were officially released in Uganda in 1995. In 2004, two Orange-fleshed Sweet potato varieties Kakamega and Ejumula were released (Mwanga et al., 2007) and two additional in 2013 (Mwanga et al., 2016). Close to 192 local varieties are being grown by farmers in Uganda (Yada et al., 2010).

Agroforestry and fruits: Planned interventions to boost production and exports of fruits and vegetables have included provision of quality seedlings; improving grading standards, packaging and handling of fruits and vegetables; registration of exporters; support to quality assurance; plant quarantine restrictions; pests and disease control; and support to processing of fresh fruits. Data obtained from NAADS shows that citrus, mangoes and pineapples and cocoa are widely distributed.

TABLE 9. AMOUNT OF CERTIFIED SEEDS/TUBERS DISTRIBUTED UNDER THE NATIONAL AGRICULTURAL ADVISORY SERVICES PROGRAM (NAADS) AND SOLD BY NALWEYO SEED COMPANY LTD. (NASECO) FROM 2013 TO 2017 (IN METRIC TONS)

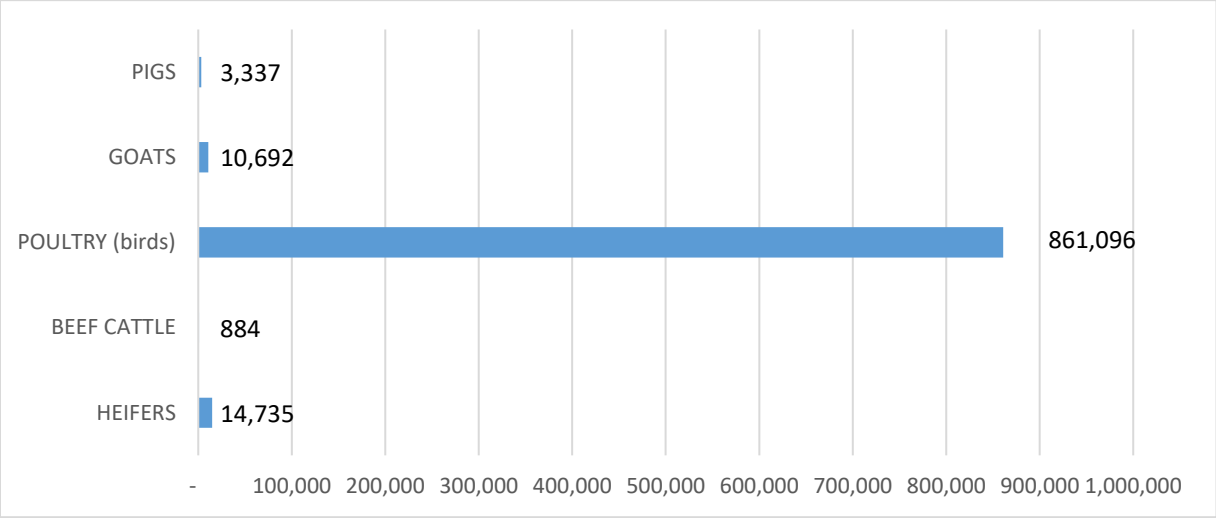
	NAADS	NASECO
Cereals and legumes		
Maize	22,753	2,743
Paddy rice	222	11,244
Beans	7,777	698
Groundnut	497	n.a
Sorghum	128	n.a
Cowpea	72	n.a
Roots and tubers		
Cassava	505	n.a
Banana	3,072	n.a
Irish potatoes	28	n.a
Sweet potatoes	n.a	n.a
Fruit trees		
Passion fruit	2,665	n.a
Citrus	38,923	n.a
Mango	24,431	n.a
Cocoa	16,815	n.a
Apples	1,905	n.a
Pineapples	29,994	n.a

Note: Units are kgs for cereals and legumes, bags for roots and tubers (4-5 roots on average) and seedlings for fruit trees;

LIVESTOCK DEVELOPMENT

Dairy: Dairy sector in Uganda has undergone sustained high growth (Mwebaze and Kjaer, 2013) and Uganda is no longer dependent on imported milk as it was in 1990s. The dairy sector contributes 9% to the GDP of Uganda and 60% of the milk produced is coming from exotic and cross breed cattle (Tech-noServe, 2008). The total milk production was estimated to be 1,55 billion liters in 2014 and the total export earnings from the sector in 2014 was estimated to be US$28,684 million. The country's target is to produce 3.35 billion liters annually by 2020. To achieve these targets, the following interventions have been undertaken restocking and distribution of improved animals as shown in diagram below

FIGURE 3. IMPROVED ANIMALS DISTRIBUTED BY TYPE OF ANIMAL UNDER NAADS ONLY



Source: NAADs

Meat products: The government of Uganda has set the following production targets for 2020 for the meat sector: beef production: 360,000 mt (valued at US$ 1.636 billion); pork production: 139,185 mt (valued at US$421 million); mutton and goat meat: 39,775 mt (valued at US$421 million); poultry: 63,647 mt. In order to achieve the targets, a number of activities have been undertaken including the provision of high genetic materials including local, exotic, and cross-breeds, pasture development, and construction of valley dams.

TABLE 18. PERCENTAGE OF LIVESTOCK RAISED OR OWNED

Livestock type	Description	Frequency	%
Exotic cattle	Household raised or owned exotic cattle in the last 12 months	144	4.02
Indigenous cattle	Household raised or owned indigenous cattle in the last 12 months	573	16.01
Goats	Household raised or owned goats in the last 12 months	1049	29.31
Pigs	Household raised or owned pigs in the last 12 months	427	11.93
Chicken	Household raised or owned chicken in the last 3 months	1252	34.98
Other poultry	Household raised or owned other poultry (rabbits/turkey/ducks/gees) in the last 3 months	134	3.74

Source: UNPS data 2014

NATURAL RESOURCE MANAGEMENT PRACTICES

Some of the soil health management practices that have been promoted in Uganda include Integrated Soil Fertility Management practices (ISFM) developed for legumes such as grain legume intercropping or rotation as well as use of biological fertilizers for legumes like inoculants, proper use of organic and inorganic fertilizers, and use of high yielding varieties. Banana-coffee intercropping is a common production

system. Pest and disease control methods vary by crop but the main approach to pest and disease control is Integrated Pest Management Practices. These approaches include: crop rotation, intercropping and use of pesticides.

MARKETING HUBS-CROPS OR INNOVATION PLATFORMS

Promoting the formation cooperatives, post handling, and contract marketing by encouraging farmers to form groups to increase access to information, technologies and market connectivity.

LIST OF CGIAR COUNTRY-SPECIFIC AGRICULTURAL TECHNOLOGIES

TABLE 10. PRIORITIES FOR AUGMENTING EXISTING PANEL DATA COLLECTION IN UGANDA TO REFLECT CGIAR-RELATED INNOVATIONS

Technology	CGIAR Center	Priority*	Note
Bananas	IITA	****	No large-scale adoption survey done but IITA is interested SPIA support to document Impact and adoption, good number of varieties have been released and it's important for food security and the market
Cassava	IITA	*****	No large-scale survey done but NARS is interested in SPIA support to document Impact and adoption, very higher number of varieties have been released, adoption is assumed to be very high and it's important for food security and the market
Irish potatoes	CIP	***	Important only for target areas food security and the market, good number of varieties have been released, Localized adoption studies already done, and adoption is high
Sweet potatoes	CIP	*****	No large-scale survey done but CIP is interested SPIA support to document Impact and adoption, good number of varieties have been released, it's important for food security and the market, adoption is assumed to be very high but no evidence
Beans	CIAT	*****	No large-scale adoption done but NARs is interested SPIA support to document Impact and adoption, good number of varieties have been released, it's important for food security and the market, adoption is assumed to be very high but no evidence
Ground nuts	ICRISAT	****	Some impact studies done but no large-scale adoption study, but ICRISAT is interested SPIA support to document varietal choice and varietal change-based attributes, good number of varieties have been released, very marketable, consumed widely but grown only in some regions of the country. Adoption is assumed to high but no evidence

Grain Legume Intensification	IITA	*	Can easily be captured in surveys. Attribution is not easy
Legume rotation	IITA	*	Can easily be captured in surveys. Attribution is not easy
Biological fertilizers	IITA	*	Too early
Banana-coffee	IITA	***	Can easily be captured in surveys. Attribution is not easy and require objective soil measurement
Innovation Platforms	IITA	****	Needed for Technology dissemination. Can be captured in surveys. Promoted widely by IITA and their impacts need to be studied.
Marketing hubs-livestock	ILRI	*	Too early
Fodder trees	ICRAF	***	Targeted areas only
Fruit trees	ICRAF	*****	No studies done on adoption but of interest to many stakeholders, adoption levels are considered high but no evidence, promoted by both CGIAR and the NARS and very marketable across the country. ICRAF desires support on adoption studies.
Indigenous trees (Shea nut and tamarindus)	ICRAF	*	Too early
Livestock cross breeds	ILRI	*****	No CGIAR effort so far but desired but important. May require DNA analysis. May require DNA analysis. The local genetic bank is being threatened.
Food Safety technologies	ILRI	*****	No large-scale survey done and ILRI has interest in this area. ILRI has been promoting pork meat safety practices. Topical and important for food and nutrition security as well as food marketing.

* Prioritization is based on evidence gathered following the three steps described in Figure 1: government priority, extent of dissemination and importance for CRPs. The relevance of the survey sampling frame, the availability of a protocol to capture data accurately and the additional burden to current survey design were also considered before advocating new inclusion.

NIGERIA (PROGRESS TO DATE)

GOVERNMENT PRIORITIES

The Agriculture Promotion Policy (APS) of the federal government of Nigeria provides an agenda for the 2016-2020 period regarding crops and livestock production, research and management (FMARD, 2016). Two gaps for the development of the Nigerian agricultural sector are identified by the policy report: *i*) an inability to meet domestic food requirements, and *ii*) an inability to export at quality levels required for market success. Efforts to fill the first gap focus on improving productivity into a number of crops and activities: rice, wheat, maize, fish (aquaculture), dairy milk, soya beans, poultry, horticulture (fruits and vegetables), and sugar. The involvement of private investors as well as farmer groups and companies is advocated in order to develop end to end value chain solutions. To decrease the second gap, the government policies will focus on the production of cowpeas, cocoa, cashew, cassava (starch, chips and ethanol), ginger, sesame, oil palm, yams, horticulture, beef and cotton.

DIFFUSION AND CURRENT ADOPTION LEVELS

CROP GERMPLASM IMPROVEMENT

In Nigeria, the promotion of improved high yielding and quality seeds is managed by the National Agricultural Seed Council, responsible for seed certification. Both public and private breeding programs exist in Nigeria and the country has domestic and foreign seed companies whose activities partially rely on the availability of seeds from the Nigerian research system. In Table 11, we present production statistics for the most important crops in Nigeria – these have also been largely prioritized by CGIAR.

TABLE 11. PRODUCTION STATISTICS ON SPECIFIC CROPS IN NIGERIA BASED ON THE GENERAL HOUSEHOLD SURVEY (GHS) 2015/16

	% of households	Mean area per household per crop (in ha)	Mean yield per household per crop (in quintals)
Maize	48.3	0.3	9.8
Cassava	41.6	0.2	7.3
Sorghum	39.0	0.4	8.4
Beans/cowpeas	30.6	0.3	2.8
Yam	28.7	0.2	27.6
Millet	24.9	0.4	6.9
Ground nut	13.7	0.3	4.5
Rice	10.6	0.4	13.8
Cocoyam	9.2	0.0	0.7
Plantain	n.a	n.a	n.a

Source: General Household Survey (GHS) 2015/16, Average household land holdings for farming households is 2.5 hectares.

Maize: Maize is of great consumption and food security importance in Nigeria. It is essential in the realization of national food security, and is a raw material in many agro-based industries. It is produced by the largest proportion (about 50%) of farming households. Over 50 improved varieties of maize have been released through a collaboration with IITA.

Cassava: Outstanding efforts have been dedicated to cassava – IITA collaborating over the release of 100 varieties. Cassava is an important staple in Nigeria, securing a large part of the population against food scarcity. For decades, IITA in collaboration with various agricultural research institutes has produced varieties of cassava for various attributes including; high yields, disease resistance, low cyanide content, starch content, sweetness, branch height and photosynthetic ability.

Sorghum: Sorghum in Nigeria is mostly grown for commercial purposes, from whose sales households earn to smooth food consumption. ICRISAT, in collaboration with local research institutes, has bred over 45 varieties, largely distributed in the drier northern region ecologies of Kano, Samaru and Mokwa. Sorghum has also been prioritized for breeding due to pressing needs from Nigerian breweries that use sorghum as substitute to barley.

Cowpea: In collaboration with IAR, IITA has prioritized cowpea varieties for different ecologies in Nigeria, based on their resistance to stress factors and yield.

Yam: IITA has also prioritized breeding of yam germplasm for enhanced yield and disease resistance (for instance, against leaf mosaic and nematodes infections). Currently the Yam Improvement for Income and Food Security in West Africa Phase 2 project (YIIFSWA – II) focuses on establishing formal markets for improved quality clean seeds for yam. There is evidence documenting adoption of yam technologies in Nigeria for instance Agbaje et al. (2003), but there has been no representative impact evaluation of welfare effects.

Millet: Breeding of improved millet varieties is undertaken by ICRISAT in collaboration with other local research institutions. Efforts are largely concentrated in the north where it is relatively arid. Varieties that are early maturing (fitting for the short rain seasons in the northern regions of Nigeria), and striga infestation resistant have been prioritized.

Ground nut: Under the "Increasing Groundnut Productivity of Smallholder Farmers in Ghana, Mali and Nigeria" project, ICRISAT with local partner institutes has prioritized the breeding of high oil content ground nut varieties since 2015. They are as well drought tolerant and are promoted in the semi – arid northern states of Nigeria. Their high oil content is of significance for human.

Rice: Rice was identified as a major food crop, given its heavy weight on foreign exchange import costs. In the interest to cut costs of importation and reliably supporting food security in the relatively dry northern regions, varieties that are high yielding and early maturing have been prioritized by Africa Rice.

Cocoyam: For cocoyam, key efforts have been aimed at improving the crop's germplasm and breeding against diseases and pests for instance, cocoyam root rot disease (CRRD) and taro leaf blight (TLB). Breeding improved varieties is led by IITA in partnership with the National Root Crops Research Institute (NRCRI) which also distributes the technologies.

Plantain: Plantain and bananas are an important staple in Nigeria especially in the southern, eastern and western states. Since the 1970s, several plantain hybrids have been bred by IITA for yields, short stature against winds, and resistance against black sigatoka. A number of these have been diffused to farmers and others are still in the pipeline.

We then attempted to obtain dissemination data from NARS as well as private companies. Table 12 provides an overview of dissemination efforts by the National Agricultural Extension Research & Liaison Services (NAERLS).

TABLE 12. AMOUNT OF CERTIFIED SEEDS DISTRIBUTED FROM 2009 TO 2014 IN NIGERIA BY NAERLS AGRICULTURAL EXTENSION SERVICES (IN METRIC TONS)

	2009	2010	2011	2012	2013	2014
Millet	27	52	8200	3804	4582	266
Maize	8,087	585	62,133	2,468	11,007	245,130
Rice	299	528	11,447	760	76,210	95,303
Sorghum	18	24	5	4,210	18,366	314
Groundnut	3	4	0	0	0	0
Cassava	400,000	36,835	427,991	0	474,556	1,127,600
Yam	44,715	36,214	0	0	0	2,000
Cocoyam	10,200	12,800	0	0	0	0
Banana/Plantain	0	0	1,448	0	0	7,000

Source: Extension services (NAERLS)

LIVESTOCK DEVELOPMENT

Current efforts prioritizing poultry are running under the African Chicken Genetic Gains Project, (ACGG). Under ACGG, ILRI avails improved chicken to enhance chicken productivity, and disease resistance, as well as human nutrition and health. One aim of the project is to empower women through their ownership of poultry. There are yet no publicly known names for improved breeds of chickens from the ACGG. Country collaborations could be exploited here on a wide range (economic, gender, and nutrition) of impact assessments.

Combined efforts between ILRI and IITA are centered on turning cassava leaves into livestock feeds and using cassava chips to replace cereals in both poultry and livestock feeds. Breeding cassava for commercial (animal feeds) use is also a priority in IITA. Varieties best for these purposes are in the process of being empirically identified and studied for impact assessment.

TANZANIA (PROGRESS TO DATE)

GOVERNMENT PRIORITIES

In 2015, the government of Tanzania started the development of the Agricultural Sector Development Programme Phase II – ASDS II, 2015/16 to 2024/25. The ASDS II, launched in 2018, covers the priority areas of Tanzania's agricultural development plans, and sets out four priority areas to guide economic development: *i*) Expanded sustainable water and land use management; *ii*) Improved agricultural productivity and profitability; *iii*) Strengthened and competitive value chain and *iv*) Strengthened institutions, enablers and coordination framework.

ASDS II focuses on priority commodity value chains. These include maize, rice, sorghum and millet, cassava, horticultural crops, oil seed crops, cotton, coffee, sugarcane, cashew nuts, tea, potatoes, pulses, banana, dairy, beef, goat and sheep, poultry, fish and seaweed.

DIFFUSION AND CURRENT ADOPTION LEVELS

CROP GERMPLASM IMPROVEMENT

Following the Seeds Act (2003), the Tanzania Official Seed Certification Institute (TOSCI) was formed. TOSCI issues certificates permitting the seeds to be supplied to the Agricultural Seed Agency (ASA) for production of foundation seed. Scientists/plant breeders working in the Agricultural Research Institutes (ARIs) produce the breeder (or pre-basic) seeds, which are then provided to the ASA to produce basic seed in accordance with quality standards and in the quantities required by the private sector.

Both public and private breeding programs exist in Tanzania. The public-sector breeding is conducted via a network of seven zonal Agricultural Research Institutes (ARIs) located throughout the country. These often work in collaboration with the CGIAR centres in new varieties development, and they release the approved varieties. In Tanzania, a total of 11 CGIAR centres are active in various interventions. Those active in crop technologies include: Africa Rice (Rice with focus in Africa); IRRI (with a global focus of rice); Bioversity International (Banana and Biodiversity); CIMMYT (Improved maize varieties); CIP (Sweetpotato, particularly the OFSP); CIAT (Beans, such as the high Iron beans); ICRISAT (Legumes, Sorghums & Millets); IITA (Bananas, Cassava, Legumes such as soybeans and cowpeas).

A few private companies also conduct breeding activities, predominantly in maize. Private sector enterprises, e.g. small local seed companies, that do not have their own maize research materials can access them directly from CIMMYT through Material Transfer Agreements (MTAs) (USAID and Enabling Agricultural Trade (EAT) 2013)

Table 13 shows a summary of the proportion of households producing different CGIAR crops produced in Tanzania in the main (long rains) season across the four waves of the NPS. As shown in the Table, maize was the most commonly produced crop across all the waves. The country's agriculture sector is dominated by few main staple crops that include maize, paddy rice, beans, cassava, Irish potatoes, sweet potatoes and sorghum (National Bureau of Statistics, 2017). Across the four waves of NPS, there is little variation in the production of the cops by households.

TABLE 13. PROPORTION OF FARMING HOUSEHOLDS PRODUCING EACH CROP FROM 2009 TO 2015 IN TANZANIA

	2008/09	2010/11	2012/13	2014/15
Maize	54.7	57.6	57.7	61.6
Paddy rice	18.9	21.1	20.0	18.5
Cassava	23.6	21.1	18.6	13.8
Banana	7.0	10.0	9.0	10.5
Beans	6.1	4.4	5.3	6.5
Sorghum	6.8	6.0	4.9	4.5
Sweet potatoes	4.0	3.2	3.9	3.8
Groundnut	5.0	3.0	4.1	3.7
Pigeon pea	0.6	0.6	1.0	0.9
Irish potatoes	0.8	0.7	0.5	0.6
Finger millet	0.9	0.4	0.4	0.4
Chick peas	0.5	0.4	0.7	0.4
Cowpeas	0.8	0.8	1.0	0.3

Source: NPS 2008/09, 2010/11, 2012/13 and 2014/15

Additionally, Table 14 shows adoption/use of improved seed varieties for different crops over the four waves of the NPS. Across all the crop types, we find that farmers mainly use traditional varieties obtained either through purchasing or retained from the previous season. Notably, use of improved maize seed portrays an upward trend probably as a result of an increase in the release and distribution of maize varieties, particularly by the private sector.

TABLE 14. USE OF IMPROVED AND TRADITIONAL SEED VARIETIES IN TANZANIA (% WITHIN CROPS)

	IMPROVED				TRADITIONAL				IMPROVED, RECYCLED	
	2008/09	2010/11	2012/13	2014/15	2008/09	2010/11	2012/13	2014/15	2012/13	2014/15
Maize	15.00	11.10	22.90	27.30	85.00	88.90	62.20	55.70	14.90	17.00
Paddy rice	5.50	2.30	6.70	3.50	94.50	97.70	82.70	90.60	10.40	5.90
Cassava	4.60	0.00	0.00	0.00	95.40	100.00	94.40	100.00	5.60	0.00
Banana	0.00	20.00	-	-	100.00	80.00	-	-	-	-
Beans	1.80	2.10	2.10	2.10	98.20	97.90	93.50	94.60	4.40	3.20
Sorghum	3.70	1.30	1.90	1.50	96.30	98.70	88.60	94.60	9.00	4.00
Sweet Potatoes	1.30	0.40	0.00	0.90	98.70	99.60	95.90	98.20	3.80	0.90
Groundnut	3.00	2.50	1.10	1.30	97.00	97.50	90.00	95.80	8.90	2.90
Pigeon pea	1.30	0.60	0.70	1.00	98.70	99.40	85.10	97.40	14.10	1.50
Irish potatoes	1.80	10.30	1.50	6.80	98.20	89.70	83.30	78.00	15.20	15.30
Finger millet	0.00	0.00	0.00	0.00	100.00	100.00	100.00	100.00	0.00	0.00
Chick peas	0.00	21.40	3.40	5.00	100.00	78.60	96.60	95.00	0.00	0.00
Cowpeas	6.10	2.80	2.00	0.70	93.90	97.20	91.00	98.50	7.00	0.70

Source: NPS 2008/09, 2010/11, 2012/13 and 2014/15. Based on farmer's elicitation

In Table 15, we show the quantity of certified seed produced by the public and private sector between 2005/2006 and 2010/2011 cropping seasons. Generally, as private sector participation in the seed market increases, the volume of certified seed also increases.

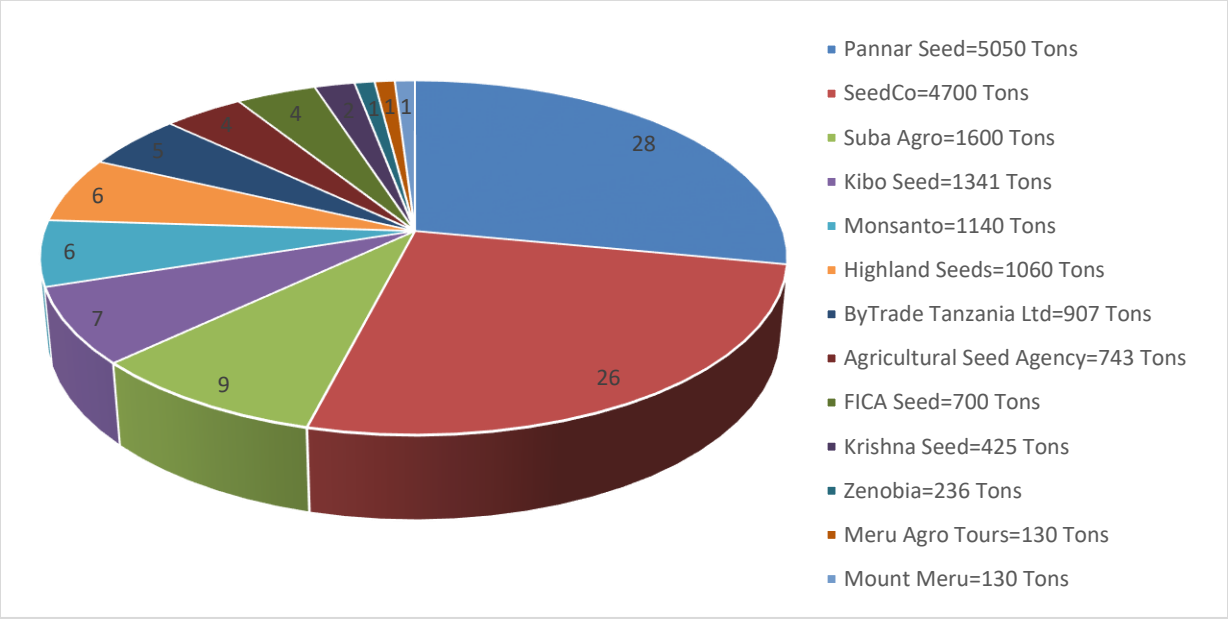
TABLE 15. QUANTITY OF SUPPLIED IMPROVED SEEDS IN TANZANIA (IN METRIC TONS)

Source	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Private companies	8,748	14,870	16,174	10,511	14,536	16,545
Public sector	1,728	1,656	217	545	1,608	5,679

Source: USAID and Enabling Agricultural Trade (EAT), 2013, using data from the Agriculture Council of Tanzania

Several large, medium and small seed companies operate in Tanzania. Some of them, such as Meru seeds and Aminata quality seeds (first released hybrid maize in 2013) distribute hybrid maize varieties, with one or more inbred parents from CIMMYT or containing a significant proportion of CIMMYT germplasm. However, information on the level of germplasm use by seed companied is often confidential. Figure 4 presents the market share, by volume of seed sold, of seed companies in Tanzania.

FIGURE 4. MAIZE SEED COMPANIES IN TANZANIA WITH THEIR MARKET SHARE IN 2010/2011 (TOTAL = 18,184 METRIC TONS).



Source: (World Bank, 2012)

LIVESTOCK DEVELOPMENT

There are several livestock development interventions that are on-going/or completed in Tanzania, covering interventions such as improved milk production, development of dairy value chains, genetic improvements, sustainable rangeland managements, feed innovations, livestock disease and vaccines, and food safety and nutrition. ILRI priority areas in the country include: Development of smallholder dairy value chains; improved genetic technologies for improvement of the African chicken; and sustainable rangeland management. ILRI's interventions in Tanzania include:

i. **Enhancing Dairy-based Livelihoods in India and the United Republic of Tanzania through Feed Innovation and Value Chain Development Approaches or "MilkIT", 2011 -2014:** An IFAD funded project led ILRI, CIAT and partners for enhancing dairy-based livelihoods in India and Tanzania (Morogoro and Tanga Regions) through feed innovation and value chain development approaches. These interventions included improving private pastures and planting forage (improved napier grass varieties, legumes and fodder crops). Farmers were taught feed conservation techniques such as making silage and also making hay using box-balers to conserve feed and reduce seasonal fluctuations in availability (Lukuyu et al. 2017). The improved forages introduced in Tanzania include: *Napier hybrid, Napier Kakamega II, green leaf desmodium, mulberry, Gliricidia sepium, Buffel grass (Cenchrus ciliaris) and Canavalia brasiliensis (demonstration plot only).* To improve cattle husbandry and reduce feed wastage, farmers in some project sites were given designs for cattle sheds that have feed troughs and crushes to handle animals. Some farmers modified their sheds as a result (Lukuyu et al. 2017).

ii. **MoreMilkiT project in the Maziwa Zaidi program (2012-2017):** This is an Irish Aid funded Tanzanian smallholder dairy value chain R&D program. The More Milk in Tanzania project ("MoreMilkiT") is implemented through the CRP on Livestock. It aims to create a coherent Tanzania country program out of various separately managed dairy value chain research for development (R4D) projects implemented by various individuals and organizations. A recent

study conducted at the "MoreMilkiT"project sites and other selected regions of Tanzania, pointed out that increasing demand for milk was increasing demand for fodder, and therefore a need for improved fodder market efficiency to enhance dairy farming profitability and income-generation opportunities among women and the youth (Lukuyu et al. 2017).

iii. **African Chicken Genetic Gains (ACGG) 2014-2019:** The ILRI-led and BMGF funded project seeks to increase access of poor smallholder farmers in sub-Saharan Africa to high-producing, locally adapted and appropriate chicken strains. The project is on-going and intends to test multiple improved breeds/strains of chicken to demonstrate high-production potential under low-input systems.

iv. **The Sustainable Rangeland Management Project 2016-2020:** This phase of the project focuses on the scaling-up of the joint village land use planning (VLUP) approach in several new clusters of villages, as well as expanding the original ones (targeted in the first phase under the Sustainable Rangeland Management Project (SRMP) between 2010-2015). Project activities include securing of grazing areas and improving the management of the areas by the established Livestock Keepers Associations through action research on such as rangeland rehabilitation, and improvement and intensification of rangeland and livestock productivity.

As shown in Table 16, a majority of livestock keepers raise local livestock breeds. Only one tenth of livestock keepers own cross breed animals (NPS, 2015). Poultry is the main type of livestock kept across all the NPS waves.

TABLE 16. BACKGROUND STATISTICS ON IMPROVED LIVESTOCK BREED ADOPTION IN TANZANIA

	2008/09	2010/11	2012/13	2014/15
Owned local livestock	95.2	96.8	95.7	96.8
Owned Improved Livestock	13.6	17.8	13.7	10.6
Livestock by type				
Cows	28.6	30.5	34.3	39.3
Goats	37.6	38.8	41.3	43.7
Pigs	11.0	10.4	9.0	6.7
Poultry	87.0	83.8	85.9	88.5
Others	25.9	30.8	23.7	24.4

Source: NPS 2008/09, 2010/11, 2012/13 and 2014/15. Based on farmer's elicitation

NATURAL RESOURCE MANAGEMENT PRACTICES

Table 17 presents the proportion of households using erosion control and irrigation technologies.

TABLE 17. BACKGROUND STATISTICS ON ADOPTION OF NATURAL RESOURCE MANAGEMENT (NRM) PRACTICES IN TANZANIA

	2008/09	2010/11	2012/13	2014/15
Irrigation Technologies	4.2	3.4	3.4	3.1
Flooding	66	69	59	51
Sprinkler	5	4	2	1
Drip irrigation	3	4	0	0
Bucket/watering can	25	16	23	34
Water hose	4	4	9	8
Other	-	3	7	6
Erosion control	26	16	12	18
Terraces	43	60	39	41
Erosion Control Bunds	30	20	30	21
Gabions/sandbags	3	2	1	0
Vetiver grass	6	5	3	3
Tree belts	9	9	5	6
Water harvest bunds	19	14	13	22
Drainage ditch	30	22	22	15
Dam	1	0	0	0

Source: NPS 2008/09, 2010/11, 2012/13 and 2014/15. Based on farmer's elicitation

Recent CGIAR project related to natural management initiatives include:

i) Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa (N2Africa) Phase II, 2014-2018: The goal of the project is to increase biological nitrogen fixation and productivity of grain legumes among African smallholder farmers, contributing to enhanced soil fertility, improved household nutrition and increased cash income.

ii) Sustainable intensification of maize-legume cropping systems for food security in eastern and southern Africa (SIMLESA). This is a collaboration between the national agricultural systems in Ethiopia, Kenya, Malawi, Mozambique and Tanzania, and CIMMYT, ICRISAT, among others. The program aims to improve maize and legume productivity by 30% and to reduce the expected yield risk by 30 % on approximately 650,000 farm households by 2023.

CONCLUSION

This technical note provides an overview of the agricultural innovations for which there could be an interest in collecting better data in surveys in four African countries – Ethiopia, Nigeria, Tanzania and Uganda. This prioritization exercise by SPIA has already led to additional data being integrated into nationally representative surveys in Ethiopia, while similar follow-up work is pending in other countries. SPIA hopes to advance this agenda in the following years.

The three-step approach presented here, although useful for filtering CGIAR innovations in a given country, has demonstrated some inherent limitations, particularly when ranking priorities:

Step 1. Government priorities – not all countries may have a clear agenda on agriculture, something we found in the four countries. Government priorities can also be volatile, and subject to political changes. Quantifying resources allocated by innovations is certainly a difficult – several departments and agencies may focus on a specific innovation – but useful step further. Without such data, one can hardly assess how the government would rank innovations.

Step 2. NARS/NGO activities – the extent of data acquisition efforts may not provide the true picture of all activities. Staff turn-over within these organizations is another limitation contributing to the loss of past information. Some stakeholders, particularly private companies in the seed business, may not be willing to share dissemination data. As information acquisition will never be perfect, the exercise is limited to seeking sufficient grounds to determine that an innovation can be found, and where. Given the importance of these data, CGIAR could play a role in facilitating investments in tracking dissemination of key innovations, as is already happening in some large-scale delivery efforts.

Step 3. CRP priorities – while CRP priorities are clear among the various CRP proposals, there is always uncertainty regarding their implementation at the country level. Clarity on allocated resources per country and per innovation would help tremendously. We found complementing CRP proposal priorities with qualitative interviews to be an important part of the process.

Finally, it is important to say that parts of the exercise are inherently subjective. We believe this prioritization exercise should evolve into refined, more objective metrics. Along with qualitative interviews and/or online surveys, data mining methods can be mobilized for extracting and quantifying innovations from official documents.

Operationalizing the ranking into existing data collection efforts has brought additional questions. The easiest and cheapest way to complement an existing survey, adding questions, may not be accurate for most innovations related to crop improvement (Stevenson et al., 2018) and animal agriculture. Varietal identification is notoriously challenging to capture. Farmer's elicitation on crossbreeds, while likely correct given the cost incurred, does not deliver information on the crossbreeding level (or genetic distance from the original breed). For innovations related to Natural Resource Management, visual-aid might provide useful support to respondents, although empirical evidence is still needed on the topic.

Another challenge of implementation resides in establishing an appropriate sampling frame. It is clear that very few innovations have reached an adoption level that made them detectable in a nationally-representative survey. Complementing existing surveys with additional sampling on specific innovations is thus another avenue of SPIA's work. Perhaps consequently, some innovations included in the Ethiopian Socioeconomic survey turned out to have adoption levels close to zero, leading to skepticism among the partner regarding the usefulness of such integration.

The next steps include the roll-out of CGIAR innovations in more countries. Within the 50 x 2030 initiative, the World Bank Living Standards Measurement Survey (LSMS) team, FAO and IFAD are working to scale up the number of countries with high-quality agricultural surveys. This initiative aims to have 50 countries implementing agricultural surveys by 2030. SPIA is in a strong position to coordinate on behalf of CGIAR issues related to collection of certain data on use of technologies, practices and other innovations and related outcomes, both at scale and in pilots to test alternative methods for measurement, where needed.

ACKNOWLEDGEMENTS

This Technical Note has greatly benefited from the comments of Karen Macours, Chair of the Standing Panel on Impact Assessment. We would like to express our thanks to the following colleagues, who have contributed through their insights into shaping the country-specific list of innovations.

ETHIOPIA

Aminou Arouna (Africa Rice); Carlo Fadda, Guy Blomme, Yoseph Gebrehawaryat (Biodiversity International); Lulsegued Tamene, Biyansa Gurmessa, Enid Katungi (CIAT); Manuel Boissiere (CIFOR); David Hodson, Monica Fisher, Moti Jaleta, Kinde Tesfaye, Paswel Marenya, Jordan Chamberlin (CIMMYT); Steffen Schultz, Wellington Jogo, Thomas Miethbauer, Abiyot Aragaw, Asrat Amele, Hirut Getinet (CIP); Said Nahdy Silim, Zewdie Bishaw, Barbara Rischkowsky (ICARDA); Kiros Meles (ICRAF); KPC Rao (ICRISAT); Bart Minten, Alemayehu Seyoum, Kalle Hirvonen (IFPRI); Berhanu Gebremedhin, Barry Shapiro, Jean Hanson, Tadele Dessie, Azage Tegegne, Melkamu Derseh, Michael Blummel, Jason Sircely, Siboniso Moyo, Barbara Wieland, Silvia Alonso, Adeniyi Adediran, Ben Likuyu, Masresha Taye, Munenobu Ikegami (ILRI); Fitsum Hagos and Simon Langlan (IWMI).

Abdulesemed Abdo, Seifu Assefa (Ethiopian Ministry of Agriculture); Berhane Lakew, Abebe Atilaw, Gebremedhin Woldegiorgis, Million Eshete, Taye Mindaye (Ethiopian Institute of Agricultural Research); Fekadu Gurmu (SARI), Tilahun Wendimu and Fiseha Tadesse (Oromia Agricultural Research Institute); Yigardu Mulatu (Ethiopian Environment and Forest Research Institute); Melaku Admassu (Ethiopian Seed Association). Edward Kilawe, Oumar Diall, Harinker Makkar, Susan Minae, Filippo Brasesco, Gijs VantKlooster, Seevalingum Ramasawmy and Mathew Abang (FAO); and Manfred Smotzok, Rebeka Gebretsadik (GiZ).

UGANDA

Brigitte Uwimana (IITA); Clement Okia (ICRAF); Robert Mwanga, Julius Juma Okello, Sam Namanda, and Norman Kwikiriza (CIP); Godfrey Asea, Julius Serumaga, Daniel Bomet Kwemoi, Moses Ebelu, Solomon Kabwoyo, Annet Nakayima, Majid Walusimbi, Titus Alicai, Charles Liri, Stanley Nkalubo, Richard Ariong, (National Crops Resources Research Institute); Jerome Kubiriba, Jimmy Moses Tindamanyire, and Asher Wilson Okurut (National Banana Research Program- Kawanda).

NIGERIA

Gbassey Tarawali, Koper Hilde, Murtala Muhammad, Animam Ijeoma (IITA); Hakeem Ajeigbe (ICRISAT); Alhassan Maji Tswako (Africa Rice) and David Babarola (National Bureau of Statistics).

TANZANIA
Victor Manyong, Regina Kapinga, Shiferaw Feleke, George Mahuku (IITA); Fred Grant, Julius Okello, Kirimi Sindi, Haile Selassie Okuku (CIP), Amos Omore (ILRI), Patrick Ngwediagi (Tanzania Official Seed Certification Institute (TOSCI); The team at the Ministry of agriculture in Tanzania, the Agriculture Sector Development Programme phase 2 (ASDP 2).

REFERENCES

Agbaje, O.G., Adegbite, A.A., & Akinlosotu, A.T. 2003. Performance of New Hybrid Yam (D. rotundata Poir) Varieties in the Forest Zone of Nigeria. *Tropicultura*, 21(3): 149–152.

Alston, J.M., Norton G.W., Pardey P.G. 1995. Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting, Cornell University Press, Ithaca, NY, 513 pp., ISBN 0-8014-2937-4.

Assefa, G., Mengistu, S., Feyissa, F., Bediye, S. 2016. Animal feeds research in Ethiopia: Achievements, Challenges and Future Directions. In: Alemu, D., Derso, E., Assefa, G., Kirub, A. Agricultural Research for Ethiopian Renaissance: Challenges, opportunities and directions. EIAR, Ethiopia, Addis Ababa.

Beegle, K., Carletto, C., Himelein, K. 2012. Reliability of recall in agricultural data. *Journal of Development Economics* 98(1): 34–41.

Benson, T., Spielman, D., Kasa, L. 2014. Direct Seed Marketing Program in Ethiopia in 2013 An Operational Evaluation to Guide Seed-sector Reform. IFPRI Discussion Paper 01350.

Binswanger, H.P. 1980. Attitudes Toward Risk: Experimental Measurement in Rural India, *American Journal of Agricultural Economics* 62(3): 395–407.

Carletto, G., Gourlay, S., Murray, S., & Zezza, A. 2016. Land Area Measurement in Household Surveys: A Guidebook. Washington DC: World Bank.

Central Statistical Agency of Ethiopia. 2016. Area and Production of Major Crops 2015–2016. Addis Ababa, Ethiopia: Central Statistical Agency.

Central Statistical Agency of Ethiopia. 2018. Ethiopia - Socioeconomic Survey 2015-2016, Wave 3. Ethiopia, Addis Ababa.

Doss, C.R. 2006. Analyzing Technology Adoption, Challenges and limitations of micro studies. *Agricultural Economics* 34: 207–219.

Elven, S., Krishnan, L. 2018. Notes on CGIAR historical research investments. CGIAR Independent Science and Partnership Council, Rome.

Effa, K., Alemayehu, M., Wondatir, Z., Hunde, D., Assefa, G. 2016. Dairy cattle research and development demands for Ethiopia. In: Alemu, D., Derso, E., Assefa, G., Kirub, A. Agricultural Research for Ethiopian Renaissance: Challenges, opportunities and directions. EIAR, Ethiopia, Addis Ababa.

Ethiopian Ministry of Agriculture (2016). Crop Variety Register, Issue No. 19, Plant Variety Release, Protection and Seed Quality Control Directorate. Addis Ababa, Ethiopia: Ethiopian Ministry of Agriculture.

Evenson, R.E., Golin D. 2003. Assessing the impact of the Green Revolution, 1960 to 2000. *Science* 300: 758–762.

Federal Ministry of Agriculture and Rural Development (FMARD). 2016. The Agriculture Promotion Policy (2016 – 2020): Building on the Successes of the ATA, Closing Key Gaps. Policy and Strategy Document. Abuja, Nigeria

Getachew, T. Haile, A., Wurzinger, M., Rischkowsky, B., Gizaw, S., Abebe, S., Solkner, J. 2016. Review of sheep crossbreeding based on exotic sires and among indigenous breeds in the tropics: An Ethiopian perspective. *Africa Journal of Agricultural Research*, 11(11): 901-911.

Hayami, Y., Herdt, R.W. 1977. Market Price Effects of Technological Change on Income Distribution in Semi subsistence Agriculture, *American Journal of Agricultural Economics* 59(2): 245–256.

Hazell, P., Haggblade, S. 1993. Farm-Non-farm Growth Linkages and the Welfare of the Poor. In Michael Lipton and Jacques Van der Gaag (eds.) Including the Poor. Washington, D. C: World Bank.

Husmann, C. 2015. Transaction Costs on the Ethiopian Formal Seed Market and Innovations for Encouraging Private Sector Investments. *Quarterly Journal of International Agriculture*, 54(1): 59–76.

Jensen, N. D., Barrett, C. B. and Mude, A. 2014. Basis risk and the welfare gains from index insurance: Evidence from northern Kenya. http://dx.doi. org/10.2139/ssrn.2505764

Kosmowski, F., Aragaw, A., Kilian, A., Ambel, A., Ilukor, J., Yigezu, B., & Stevenson, J. (2018). Varietal identification in household surveys: results from three household-based methods against the benchmark of DNA fingerprinting in southern Ethiopia. *Experimental Agriculture*, 1–15.

Land O'Lakes, Inc. 2010. The Next Stage in Dairy Development for Ethiopia, Dairy Value Chains, End Markets and Food Security. Ethiopia, Addis Ababa.

Lewis, W.A. 1954. Economic Development with Unlimited Supplies of Labour. *The Manchester School* 22: 139–191.

Lobell, D.B., Azzari, G., Burke, M., Gourlay, S., Jin, Z., Kilic, T., Murray, S. 2018. Eyes in the sky, boots on the ground: assessing satellite- and ground-based approaches to crop yield measurement and analysis in Uganda (English). Policy Research working paper; no. WPS 8374. Washington, D.C.: World Bank Group.

Lukuyu, M., Njehu, A., Mwilawa, A., Lukuyu, B., Omore, A., Rao, J. 2017. The Role of Fodder Markets in Meeting the Year-round Forage Requirements of Smallholder Dairy Farmers in Tanzania. Livestock Brief 2. Nairobi, Kenya: International Livestock Research Institute (ILRI). https://cgspace.cgiar.org/handle/10568/82766.

Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). 2016. Agriculture Sector Strategic Plan 2015/16-2019/20. Uganda, Kampala.

Mwebaze, T., Kjaer, A.M. 2013. Growth and Performance of the Ugandan Dairy Sector : Elites , Conflict, and Bargaining. *International Journal of Agriculture Innovations and Research*. 2: 1–298.

National Bureau of Statistics (NBS). 2017. Tanzania National Panel Survey Wave 4, 2014 – 2015. Dar es Salaam, Ministry of Finance and Planning.

National Planning Commission of the Federal Democratic Republic of Ethiopia. 2016. Growth and Transformation Plan II (GTP II) (2015/16-2019/20). Ethiopia, Addis Ababa.

Popkin, G. 2018. Crunch time for data, *Nature* 557: 745–747.

Renkow, M. 2018. A Reflection on Impact and Influence of CGIAR Policy-Oriented Research. Rome, Italy: Standing Panel on Impact Assessment (SPIA), CGIAR Independent Science and Partnership Council (ISPC). 34 pp.

Rosenstein-Rodan, P. 1943. Problems of Industrialization of Eastern and South- Eastern Europe. *Economic Journal* 53: 202–211.

Shapiro, B., Getachew, G., Desta, S., Negassa, A., Negussie, K., Aboset, G., Mechal, H. 2015. Ethiopia livestock master plan. ILRI Project Report. Nairobi, Kenya. International Livestock Research Institute (ILRI).

Stevenson, J.R., Macours, K., & Gollin, D. 2018. The Rigor Revolution in Impact Assessment: Implications for CGIAR (forthcoming). Rome: Independent Science and Partnership Council (ISPC).

Takahashi, K., Ikegami, M., Sheahan, M., Barrett, C. B. 2016. Experimental evidence on the drivers of index-based livestock insurance demand in Southern Ethiopia. *World Development* 78, 324–340.

TechnoServe, 2008. The Dairy Value Chain in Uganda. A Rep. by TecnoServe Uganda East Africa Dairy Dev. Progr. 31.

USAID and Enabling Agricultural Trade (EAT). 2013. SeedCLIR Tanzania: Pilot Report. USAID.

Weaver, C. 2014. Malawi's Open Aid Map. International Bank for Reconstruction and Development - The World Bank.

World Bank. 2012. Agribusiness Indicators: Tanzania. Washington, D.C.: World Bank.

World Development Indicators. 2018. Washington, D.C.: The World Bank. https://data.worldbank.org/indicator [Accessed on 25.09.2018]

World Overview of Conservation Approaches and Technologies (WOCAT). 2003. A Framework for Documentation and Evaluation of Soil and Water Conservation Part A Approaches, Part B Technologies. CDE, Bern.

Walker, T.S., Alwang, J. 2015. Crop improvement, adoption and impact of improved varieties in food crops in Sub-Saharan Africa. Wallingford, UK: CGIAR Consortium of International Agricultural Research Centers; CAB International.

Wossen, T., Tessema, G., Abdoulaye, T., Rabbi, I., Olanrewaju, A., Alene, A. et al. 2017. The cassava monitoring survey in Nigeria final report. IITA, Ibadan, Nigeria.

Yada, B., Tukamuhabwa, P., Wanjala, B., Kim, D.J., Skilton, R. A., Alajo, A., Mwanga, R.O.M. 2010. Characterization of Ugandan sweetpotato germplasm using fluorescent labeled simple sequence repeat markers. *HortScience* 45: 225–230.