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OVERVIEW AND RESULTS OF A FARM HOUSEHOLD SURVEY IN TWO AGRO-ECOLOGICAL ZONES OF MALI, 2017/18

By

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Abstract

This paper summarizes principal descriptive data from farm households in two agro-ecological zones (AEZ) of Mali; the Niger River Delta and the Koutiala Plateau. Detailed causal analysis will follow in a series of technical working papers. The descriptive data provided here suggest several major themes. Cropping patterns differ clearly by zone, with rice predominating as a cash crop in the Delta, while cotton dominates in the more southerly Koutiala Plateau. Disaggregating farm households by asset levels reveals a small but highly productive group of motorized farms accounting for 4% of farm households but for over 15% of cash crop production. Overall, this group enjoyed nonfarm income four times higher than other agricultural households, enabling them to intensify agricultural production at higher rates than animal traction households.

On the policy front, over 80% of farmers interviewed received subsidized fertilizer. Regionally, subsidy access rates increased by 10% to 20% in areas served by the Office du Niger and the CMDT compared to the unstructured extension zones serviced by the Directions Régionales d'Agriculture (DRA). During the 2017/18 season, efforts to reform Mali's fertilizer subsidy system through the introduction of e-voucher pilot program operated on only a very small scale. In the 60 e-voucher pilot villages surveyed, farmers received a large majority of subsidized fertilizer through the original paper voucher system. Paper vouchers accounted for 78% of quantity of subsidized fertilizer received by Delta farmers and for 95% in the Plateau. Reasons for the slow start of the e-voucher pilot program are explored in other PRePoSAM reports.

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Abbreviations

CAT	Farm household categories
CMDT	Compagnie Malienne pour le Developpement du Textiles
ESPGRN	Equipe Système de Production et Gestion des Ressources Naturelles
FTE	full-time adult male equivalent
IER	Institut d'Economie Rurale
OMA	Observatoire du Marché Agricole
ON	Office du Niger
PRePoSAM	Projet de Recherche sur les Politique de Sécurité Alimentaire au Mali
RGPH	Récensement Général de la Population et de l'Habitat

1. Objectives

This study provides a detailed empirical look at the current status of farm intensification, productivity and commercialization in two of Mali's major agro-ecological zones. As urban population continues to grow, pressure on agriculture to ensure an ample supply of food to cities will increase. Climate change and demographic pressure, likewise, place pressure on farm households to produce higher volumes of farm output on increasingly scarce cultivable land.

Since 2008, Mali's fertilizer subsidy program has aimed to address these pressures on farm families and enable crop intensification despite sharp early spikes in international fertilizer prices from 2008-2011. In 2017, these subsidies amounted to 37 billion CFAF ($63 million). Over the prior decade they averaged 18% of total agricultural budgetary expenditures (Koné et al. 2019b). While the costs of the subsidy program are well-known, its impact has not been rigorously documented. The data collected here provide a foundation for a formal assessment of the impact of fertilizer subsidies on input use and on farm productivity. Despite ongoing reform of current fertilizer subsidy system, little empirical information exists on the impact. This study aims to provide detailed micro-economic data that will enable subsequent assessment of the impact of Mali's fertilizer subsidy program (e-voucher vs. caution technique) on input use, farm productivity and household welfare.

These data fill a major gap in Mali. The last agricultural census, in 2004/05, is now over fifteen years out of date. The more recent Living Standards Monitoring Survey (LSMS) of 2014 does not provide representative data on Mali's major farming systems. Its sample includes only a handful of irrigated rice farmers and cotton farmers. Given that these two crops account for over 80% of subsidized fertilizer use in Mali, the LSMS data are inadequate for assessing current rates of agricultural intensification, productivity or commercialization. The survey data reported provide a current snapshot documenting how farm households are responding to urban commercial opportunities in the presence of growing environmental and demographic pressures.

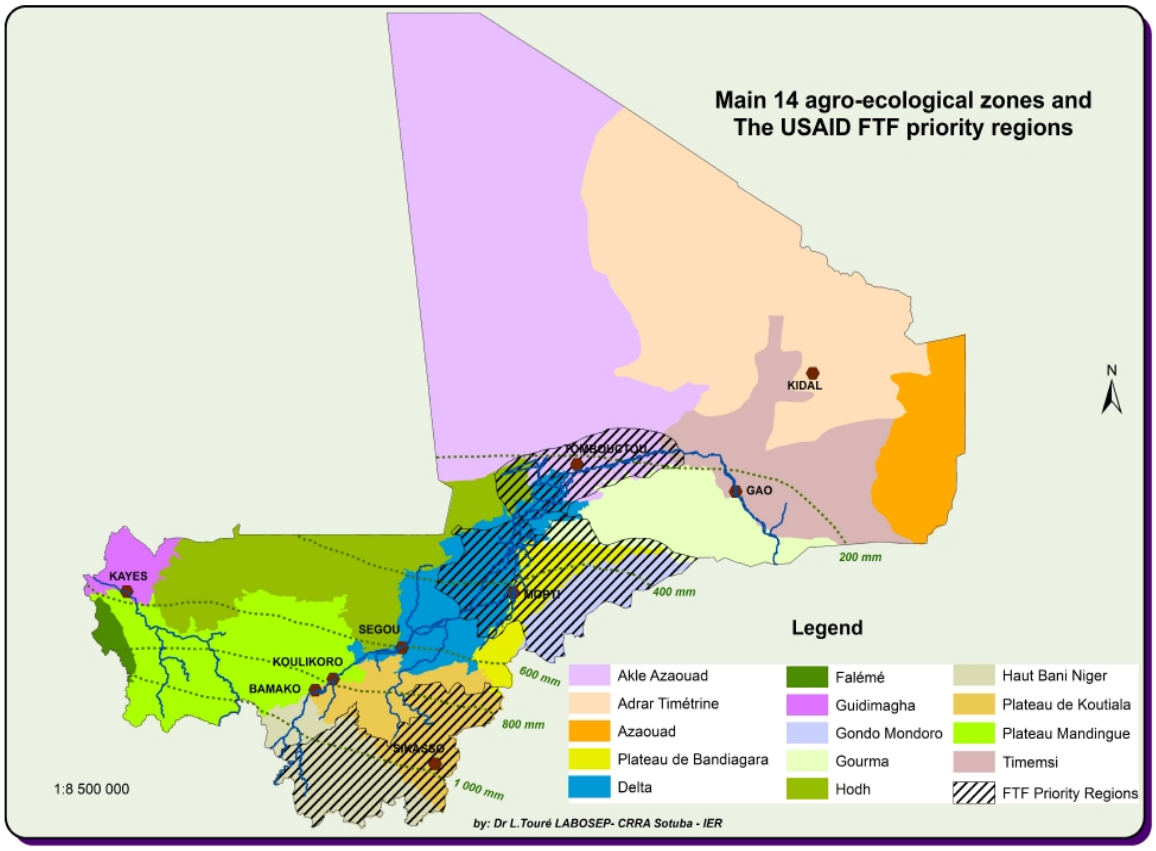
2. Survey methods

2.1. Sample design

2.1.1. Domain

Two of Mali's 14 agroecological zones (the Niger Delta and the Koutiala Plateau) were selected as the sampling universe (domain) based on a) their importance to agricultural productivity in Mali and b) geographical overlap with Feed the Future priority regions (Figure 1). The sampling frame is composed of all enumeration sections (SE) in the General Census of the Population and Housing (Recensement Général de la Population et de l'Habitat, RGPH 2009), including the total number of inhabitants per SE, in each zone.

Figure 1. Map showing the agroecological zones of Mali and USAID Feed the Future priority regions.



Source: Dr. L. Touré, Labosep, Sotuba Research Station, Institut d'Economie Rurale

The survey team categorized all enumeration sections (SE) in each zone by two stratifying variables: extension system and subsidy form. Four strata were defined per zone. In the Niger Delta, these include: 1) Office du Niger (ON)-paper voucher 2) extension through the Directions Régionales de l'Agriculture (DRA)-paper voucher ; 3) ON-electronic voucher ; 4) DRA-electronic voucher. In the Koutiala Plateau, the exention system stratification distinguished between extension services offered by the Compagnie Malienne pour le Développement du Textile (CMDT) and the remaining areas served by the DRA. This resulted in eight strata as described in Table 1.

2.1.2. Sampling stages

The sampling took place in two stages. The primary sampling unit was the population census enumeration sections (sections d'enumération (SE) in French). After selection of the primary sampling unit, the survey team visited each SE in order to compile an exhaustive list of farm households (Exploitations Agricoles Familiales, or EAFs). The secondary sampling unit was the farm household (EAFs).

2.1.3. Sample size and selection

The team selected SEs randomly within each of the eight strata, with probability proportional to size of population. In total, the team selected 20 SEs in each of the structured extension systems (ON and CMDT) and 10 SEs in each of the DRA extension service strata. This resulted in a total of 60 SEs per agro-ecological zone (AEZ) or 120 in total (Table 1). Our sampling statistician selected an additional 30 SEs per zone following the same procedure to accommodate replacement in case of accessibility problems among the original 60.

Table 1. Sample size by stratum, primary and secondary units

Agro-Ecological Zone (AEZ)	Strata		Primary Sampling Unit (SE)	Secondary Sampling Unit (EAF)
	Extension system	Fertilizer subsidy		
Niger Delta	1 ON	Paper voucher	20	400
	2 ON	Electronic voucher	20	400
	3 DRA	Paper voucher	10	200
	4 DRA	Electronic voucher	10	200
Koutiala Plateau	5 CMDT	Paper voucher	20	400
	6 CMDT	Electronic voucher	20	400
	7 DRA	Paper voucher	10	200
	8 DRA	Electronic voucher	10	200
Total sample			120	2,400

Abbreviations:
CMDT: Compagnie Malienne du Développement des Textiles
DRA: Direction Régionale de l'Agriculture
ON: Office du Niger

Source: Amidou Assima, sampling statistician.

Upon visiting each SE, the survey supervisors conducted a complete census listing of agricultural households. From this listing, they selected 20 farm households using simple random sampling with a random start from the list frame. In total, the sample consisted of 2400 farm households, allocated among zones and strata as shown in Table 1.

2.1.4. Survey weights

Given that the sample is not allocated proportionately across strata, survey weights must be used to infer population parameters (means, ratios, totals) when data are aggregated to produce results representative of the overall population. For this purpose, the team has calculated survey weights by stratum and primary sample unit.

Taking *s* for stratum and *h* for SE the probability of selection of each SE $p(s,h)$ in the first stage is given by equation (1):

$$(1)\ p(h,s) = m_s \frac{M_h}{M_s} \quad ,$$

where m_s is the number of SEs sampled in the stratum *s*, M_s is the population size of the stratum *s* and M_h is the population size of the SE *h*. Equation (2) describes the probability of inclusion $p(s,h,z_h)$ of a farm household in the second stage, conditional on stratum selection:

$$(2)\ p(z_h|h,s\ ) = \frac{n_h}{N_h} \quad ,$$

where n_h is the number of farm households sampled and N_h is the total number of farm households in the SE *h*. The overall probability of inclusion $p(z_h, h, s)$ of a farm household z_h in the sample is computed as follows in equation (3):

$$(3)\ p(z_h,h,s) = p(z_h|h,s\ ) \times p(h,s) = \frac{n_h m_s M_h}{N_h M_s}.$$

The survey weight for each farm household in the sample is the inverse of the probability of inclusion, reported in equation (4):

$$(4)\ P_{sondage} = \frac{1}{p(z_h,h,s)} = \frac{N_h M_s}{n_h m_s M_h}.$$

Average probabilities of selection of primary and secondary sampling units by stratum are shown in Table 2.

Table 2. Probability of inclusion of SEs and farm households by sample strata

Agro-Ecological Zone		Strata		Probability of selection		
(AEZ)	Extension system	Fertilizer subsidy	Stratum population 2009	Primary sampling unit (SE)	Secondary sampling unit (farm household)	Farm household weights
Niger Delta	1 ON	Paper voucher	56,741	0.287	0.387	13
	2 ON	Electronic voucher	62,547	0.247	0.688	9
	3 DRA	Paper voucher	520,242	0.015	0.376	268
	4 DRA	Electronic voucher	18,789	0.332	0.470	12
Koutiala Plateau	5 CMDT	Paper voucher	547,275	0.033	0.385	130
	6 CMDT	Electronic voucher	129,257	0.146	0.403	26
	7 DRA	Paper voucher	258,792	0.026	0.568	90
	8 DRA	Electronic voucher	14,483	0.520	0.418	6

Abbreviations:
CMDT: Compagnie Malienne du Développement des Textiles
DRA: Direction Régionale de l'Agriculture
ON: Office du Niger

Source: Annex table a3.

2.2. Data collection

Four survey teams conducted data collection in each of the 120 selected SE's. Each team consisted of one supervisor and three numerators, both women and men. To ensure data quality, a three-member monitoring team visited each team in the field and in between visits maintained daily phone contact with supervisors. This monitoring team included a statistician, a survey expert and an agricultural economist from the Ecofil unit of Mali's Institute d'économie rurale (IER).

Data collection took place during five rounds of visits over the course of a single cropping season. This sequencing enabled data collection during all phases of the cropping cycle -- land preparation, planting, weeding, harvesting and marketing (Table 3). Each round of interviewing began with a two-day pretesting of draft questionnaires in an unsampled village. Based on this experience, the research team revised and finalized questionnaires for full administration in the 120 selected SEs. Full questionnaires are available upon request from the authors.

Table 3. Survey calendar

Round	Timing	Contents
1	September 26-October 21, 2017	Household assets, demography, inventory of cultivated plots
2	December 11, 2017 - February 1, 2018	Planting, weeding
3	March 15-May 25, 2018	Production
4	July 7-August 22, 2018	Marketing, diet diversity
5	February-March, 2019	Diet diversity, harvest season

Source: 2017/18 MSU/IER farm household survey.

In the first round visit, upon arrival in each SE, the survey team organized a focus group with the village chief, his key advisors, leaders of local farmer organizations, local resource persons with detailed knowledge of the village, women and youth leaders (where custom allowed) and several heads of farm households. The total number of participants ranges from 10 to 20 people. In villages where women are not able to meet publicly with men, the team held two focus groups, one with men and the other with women. During these focus group meetings, the survey team explained the purpose of the survey, described how it would unfold, and asked a series of general questions about village infrastructure and market access.

Following the focus group meeting, usually the following morning, the team conducted a full listing of all agricultural households in the SE. The supervisor then used a random number generator to select 20 of the households for interviewing. To assist the team in locating the selected households, the village chief designated several young boys to assist the team in finding the household. The team re-interviewed the same selected households during the second through the fourth rounds. During the fifth round, the team visited a subsample of these households. In each round, the survey interviews required 30-60 minutes to administer.

In Round 1, the team interviewed the household head to generate a profile of household members, key economic activities, a listing of productive household and an inventory of all cultivated plots, crops planted and which household member managed each plot. From this listing of crops and plot managers, the team selected all plots and plot managers of the following target crops: in the Delta, rice, millet and maize; in the Plateau cotton, rice and maize. This selection ensured a sampling of the major cash and food crops in each region.

Rounds 2-4 focused on collecting plot-level input and output data from the individual plot managers. For collective family fields, the head of household or his designated "chef de travaux" was interviewed. For individually managed plots, the team interviewed the male or female adult responsible for each plot and measured the plot size using a GPS. In addition, Round 4 included a short module on diet diversity which required interviews with all adult females between 15 and 60 years of age. In round 5, the team re-interviewed a subsample of these adult women to capture information about diet diversity during the plentiful post-harvest season.

Enumerators recorded interview responses on table computers which the supervisors backed up onto laptop computers every evening. Upon completion of each survey round, the teams returned to Bamako where the team statistician consolidated all responses onto a single laptop using CSPro. He then converted the data files into Stata format for cleaning and subsequent analysis. The summary results presented below include basic descriptive statistics from each of these major modules.

MSU and IER are committed to making these data available to Malian students and researchers interested in exploring specific themes empirically. In order to access these data, interested researchers should contact Yenizie Koné, MSU's project director, or Alpha Kergna of IER at the contact emails listed on the authors' page.

3. Farming system differences by agro-ecological zones (AEZ)

Access to arable land is more constrained in the Niger Delta, where irrigation infrastructure and water is prevalent, than in the largely rainfed Koutiala Plateau. Demographic pressure is more severe in the Delta because controlled water systems permit higher yields as well as multiple crops annually on a single parcel. On average, farm households in the Delta cultivate 8.5 hectares compared to 12.3 in the Plateau. As a result, farm households in the Delta tend to be smaller than in the Plateau. Over one-third of farm families cultivate less than 5 hectares of land in the Delta, while only 11% of Plateau farms are that small. At the other end of the farm size distribution, over one quarter of all farm families in the Plateau cultivate 15 hectares or more, while only 14%% in the Delta farm holdings that large (Table 4).

Table 4. Farm size distribution, by agro-ecological zone (AEZ)

	Percent of farm households		
Farm size (ha)	Niger Delta	Koutiala Plateau	Total Sample
< 2.5 ha	15	2	9
2.5 - 4.9 ha	21	9	15
5 - 9.9 ha	32	35	33
10 - 14.9 ha	19	27	23
15 ha or more	14	27	20
total	100	100	100

Source: MSU/IER Farm household survey, 2017/18

In the Delta, millet and rice dominate cropped area, attracting two to four times as much planted area as in the Plateau. Delta farmers plant 1.8 ha in rice compared to 0.4 ha for farmers in the Plateau. Millet area, which dominates in the unirrigated parts of the Delta (4.0 ha/household), falls to 1.5 ha/household in the Plateau, where sorghum (2.0 ha/household) assumes greater importance. Among non-cereal crops, groundnuts are most prevalent, with farmers in both zones planting on average 0.5 ha/household (Table 5).

In contrast, in the Plateau, cotton dominates farming systems, accounting for over one-third to total cropped area (4.6 out of 12.2 hectares). Two coarse cereals, maize and sorghum, account for a further one-third of cropped area, with land allocations of 2.7 and 2.0 ha/household respectively (Table 5).

Cowpea intercropping appears most important in the Delta, where it accounts for over one-third of millet and sorghum area. In all, Delta farmers intercrop cowpeas on 23% of all cropped area, 1.9 hectares out of 8.5 total. In the Plateau, farmers intercrop cowpeas primarily with millet and sorghum, sometimes also with maize and cotton. In total, however, these cowpea intercrops cover only 4% of total planted area in the Plateau. Pure stand of cowpea

exist in all regions, though at very small scale, with average cultivated area of 0.1 hectares per household (Table 5).

Table 5. Cultivated area, by crop and AEZ (hectares per EAF)

	Niger Delta		Koutiala Plateau		Total Sample	
Primary crop	area	cowpea intercrop	area	cowpea intercrop	area	cowpea intercrop
millet	4.0	1.4	1.5	0.1	2.8	0.8
sorghum	1.4	0.5	2.0	0.1	1.7	0.3
rice	1.8	0.0	0.4	0.0	1.1	0.0
maize	0.2	0.0	2.7	0.1	1.3	0.1
cotton	0.3	0.0	4.6	0.2	2.3	0.1
groundnuts	0.5	0.0	0.5	0.0	0.5	0.0
cowpea	0.1	0.0	0.1	0.0	0.1	0.0
sesame	0.1	0.0	0.0	0.0	0.1	0.0
fonio	0.1	0.0	0.0	0.0	0.1	0.0
other	0.1	0.0	0.4	0.0	0.2	0.0
total cropped area	8.5	1.9	12.2	0.5	10.2	1.3

Source: MSU/IER Farm household survey, 2017/18

Livestock ownership is more prevalent in the Plateau than in the Delta. Given larger farms, larger cultivated area and the availability of grazing areas, Plateau farmers own more plowing oxen and other cattle than do Delta farmers. Small ruminants, however, are more evenly dispersed with a majority of farmers owning sheep and goats in both zones (Table 6).

With farm equipment, distinct differences also emerge. Delta farmers, who cultivate irrigated rice, are ten times more likely to own motorized pumps and mechanical threshers than their counterparts in the Plateau. In contrast, Plateau farmers are more likely to own mechanical grain mills and tractors (Table 6).

Table 6. Farm assets, by agro-ecological zone

	Niger Delta		Koutiala Plateau		Total Sample	
Assets	Ownership (percent of farm households)	Number, if owned	Ownership (percent of farm households)	Number, if owned	Ownership (percent of farm households)	Number, if owned
Farm equipment						
motorized pump	11%	1.3	1%	1.1	7%	1.2
grain mill	2%	1.0	9%	1.0	5%	1.0
dehuller	5%	0.9	2%	1.0	4%	0.9
thresher	8%	1.1	0%	1.3	5%	1.1
tractor	0%	1.0	2%	1.2	1%	1.2
motorized cultivator	4%	1.0	3%	1.3	3%	1.1
Transport						
cart	92%	1.3	94%	1.3	93%	1.3
truck/vehicle	3%	1.0	1%	1.4	2%	1.2
Livestock						
oxen	82%	2.9	95%	3.9	88%	3.4
other cattle	36%	8.5	58%	11.2	46%	10.1
sheep	71%	6.3	72%	8.7	71%	7.4
goats	58%	10.4	81%	7.8	69%	9.0

Source: MSU/IER Farm household survey, 2017/18

4. Farm household classification (CAT)

IER has developed a typology for the classification of farms households in the CMDT zone, known the IER/CMDT classification. (Kébé, et al., 1999). For many decades, Mali's CMDT has utilized that four-tiered classification system designating farm households according to their level of animal traction ownership (Koné 2010; Tefft 2010). The A-level farm households are those that own at least 2 teams of plowing oxen plus 6 additional cattle. These farms can plow on time using their own plowing teams. In addition, they generate significant volumes of organic manure which they can deliver to their fields as required. The B-level households own only one team of plowing oxen. This leaves them vulnerable to animal diseases; should an ox become sick they become unable to perform key tasks (plowing, planting, weeding) punctually. In addition, the lack of a troop of cattle limits their ability to supply organic manure to their fields. The C-level households, who own some cattle but less than a full plowing team, depend on rental or borrowed oxen to complete key cultural tasks. Since cattle-owning households prepare their own fields before renting out oxen, the C-level households often perform key tasks late, suffering a yield penalty as a result. The D-level households practice manual cultivation, preparing land, planting and weeding by hand. This limits the total area they can cultivate.

To modernize this classic CMDT typology, our team has added a mechanized category (Table 7). The M-level farm households own either a tractor or a motorized cultivator, these latter being most common on the small irrigated plots in the Niger Delta.

Table 7. A typology of farm households in Mali

	Category	Farming asset ownership
M	Mechanized	motorized land preparation equipment: at least 1 tractor or motoculteur
A	Well-equipped ANTRAC	2 animal traction (ANTRAC)* teams plus 6 or more other cattle
B	Equipped ANTRAC	1 animal traction (ANTRAC)* team
C	Partially equipped	some cattle but less than a full plowing team; this category must borrow or rent
D	Manual	hand equipment only; no plowing oxen or mechanized farm equipment

* ANTRAC team = two plowing oxen plus 1 plow.

Source: MSU/IER survey, modified from Kébé et al. (1999).

Data from our farm household survey indicate that a majority of farm households in both zones fall into the Category B, with one plowing team (Table 8). Both zones likewise have a small minority (4-5%) mechanized farms. In the Delta this means motorized cultivators and, in the Plateau, tractors. About 8% of farm households in each zone are Category C partially equipped farms.

Table 8. Distribution of farm households, by category and agro-ecological zone

	Category	Agro-ecological zone: Delta	Agro-ecological zone: Plateau	Total Sample
M	Mechanized	4	5	4
A	Well-equipped ANTRAC	8	23	15
B	Equipped ANTRAC	63	59	61
C	Partially equipped	8	8	8
D	Manual	17	5	12
	Total	100	100	100

Source: MSU/IER Farm household survey, 2017/18

Major regional differences emerge in the Category A-and D farms. In the Plateau, 23% of all farm households are well-equipped animal traction (Category A) farms compared to only 8% in the Delta. In large part, this difference arises because, in the Plateau, cotton farmers have historically benefited from subsidized equipment, including animal traction, leading to far high levels of well-equipped (Category A) farms there. In contrast, the Delta houses three times as many manual farms (Category D), 17% compared to 5%. This is consistent with the smaller farm sizes in the Delta resulting from the partition of parcels in the irrigated zone of the Office du Niger.

Table 9. Asset holdings of farm households, by category and agro-ecological zone

Agro-ecological zone		Category	Cultivated land (ha)	Family size	Education: literacy hh head	Education: maximum education	Livestock holdings: plowing oxen	Livestock holdings: other cattle	Livestock holdings: sheep	Livestock holdings: goats
Niger Delta										
	M	Mechanized	10	19	26%	9	2	12	5	3
	A	Well-equipped	20	24	19%	6	5	25	13	16
	B	Equipped	9	15	20%	5	3	3	5	5
	C	Partially equipped	5	12	17%	5	1	1	2	2
	D	Manual	3	12	24%	6	0	1	2	1
		Total	8	15	21%	6	2	5	4	4
Koutiala Plateau										
	M	Mechanized	25	26	3%	10	6	19	13	9
	A	Well-equipped	19	22	21%	7	6	20	12	12
	B	Equipped	11	15	27%	6	3	2	5	6
	C	Partially equipped	8	12	27%	5	2	1	3	3
	D	Manual	5	9	25%	5	0	0	2	3
		Total	13	16	25%	6	4	7	6	7
Total sample										
	M	Mechanized	13	21	21%	10	3	14	6	4
	A	Well-equipped	19	23	21%	7	6	22	13	14
	B	Equipped	10	15	23%	6	3	2	5	5
	C	Partially equipped	6	12	21%	5	2	1	2	2
	D	Manual	3	12	24%	6	0	1	2	1
		Total	10	16	23%	6	3	6	5	5

Source: MSU/IER Farm household survey, 2017/18

Cultivated area clearly varies by farm category. The mechanized (Category M) and well-equipped animal traction farms (Category A) cultivate the largest areas, 10-20 ha per household in the Delta and 19-25 ha in the Plateau. In contrast the manual and partially equipped families (Categories C and D) cultivate only 3-5 hectares in the Delta and 5-8 ha in the Plateau (Table 9). The larger farms in Categories M and A likewise have larger families, roughly 20 household members compared to an average of 16 (Table 9). Over time, the gradual break-up of large family exploitations results in a growing percentage of under-equipped households (Categories C and D).

Literacy and education vary across farm categories and zones (Table 10). Surprisingly, the least well-equiped (Category C and D) have above average literacy rates in both agro-ecological zones.

Table 10. Family structure, by category and agro-ecological zone

Agro-ecological zone	Category		Family size	Age of hh head	Household composition: adult males	adult females	children
Niger Delta							
	M	Mechanized	21	58	6	6	10
	A	Well-equipped	23	61	6	7	11
	B	Equipped	15	59	4	4	7
	C	Partially equipped	12	56	3	4	6
	D	Manual	12	53	3	3	6
		Total	15	58	4	4	7
Koutiala Plateau							
	M	Mechanized	27	61	7	7	12
	A	Well-equipped	21	58	5	6	10
	B	Equipped	14	53	4	4	7
	C	Partially equipped	11	53	3	3	5
	D	Manual	8	49	2	2	4
		Total	16	54	4	5	8
Total sample							
	M	Mechanized	24	60	6	6	11
	A	Well-equipped	22	59	5	6	10
	B	Equipped	15	56	4	4	7
	C	Partially equipped	12	54	3	3	6
	D	Manual	11	52	3	3	5
		Total	16	56	4	4	7

Source: MSU/IER Farm household survey, 2017/18

Comparing family structure, the mechanized and well-equipped animal traction farms (Categories M anA) appear quite similar with 21-27 household members and household heads aged 58 or older (Table 10). In contrast, the manual farms (Category D) have the smallest families (8-12 members) and the youngest household heads (49-53 years of age). This suggests that they have split off from the extended family. Government policy stipulates that 30% of irrigated Delta land area should be managed by young entrepreneurs or women. However, these survey data suggest that this goal has not been achieved; in fact, age of household head is lower in the Plateau than in the Delta.

Nonfarm income, likewise, differs considerably across farm categories. Mechanized farms (Category M) earn by far the highest level of nonfarm income, at 62,000 CFAF/year, four time the average (Table 11). The manual farms (Category D) earn the second most at 24,000 CFAF per household per year. This group relies more heavily on nonfarm earnings and remittances than the oxen-based cultivator households. The partially equipped (Category C) farms generate the lowest level of remittances and nonfarm income of any group. This suggests they may be the most cash-constrained of all farm household groups. The following section will explore whether or not these differences in asset endowments and nonfarm income translate into differences in purchased input use and agricultural intensification.

Table 11. Nonfarm earnings of farm households, by category and agro-ecological zone

Farm household category		Nonfarm activity yes	Nonfarm activity numbers	Nonfarm income (CFAF/hh/year)	Remittances (CFAF/hh/year)
M	Mechanized	63%	1.3	61,974	51,052
A	Well-equipped	74%	1.8	17,590	39,947
B	Equipped	67%	1.2	11,982	58,296
C	Partially equipped	61%	1.1	10,580	22,220
D	Manual	70%	0.9	23,538	44,249
	Total	68%	1.3	16,101	50,627

Legend:
= higest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

5. Agricultural intensification

5.1. Purchased inputs

Farmers planted improved seeds on over one-third of plots surveyed. Improved cotton (92%) and rice (57%) seeds attracted the highest level of farmer interest. In addition, improved varieties of maize introduced by the Malian agricultural research system in the CMDT and OHVN zones now cover 33% of maize plots overall (Table 12). Since all maize seed grown in Mali has been introduced, and most of this seed is likely to have originally been of improved open-pollinated varieties (there are no maize hybrids in farmers' fields), the relatively lower adoption rate (33%) confirms that growers recycle maize seed. The adoption rate for sorghum (16%, which includes some recently released sorghum hybrids) is within the range estimated across numerous studies (13-30%); estimates vary by method and geographical area (Smale et al. 2018). In either maize or sorghum, determining whether or not a variety named by a farmer is in fact improved, and to what extent it is true to type, poses challenges.

Over one-third of plots received manure while nearly two-thirds of all plots surveyed received mineral fertilizer applications. Fertilizer use proved highest in the well-structured extension areas (the Office du Niger and the CMDT zones), where 77% to 79% of plots received mineral fertilizer. Across crops, cotton attracted the highest rate of manuring (56%) followed closely by maize (51%). Thus, over half of cotton and maize parcels received a base application of organic fertilizer. In addition, over 80% of all cotton, maize and rice plots likewise received mineral fertilizer applications (Table 12).

Among pesticides, herbicides proved roughly twice as popular as insecticides. While farmers applied herbicides to 40% of all plots surveyed, only cotton crops (78% of plots) received significant quantities of insecticides. Cotton plots also attracted highest rates of herbicide application (83%). Together, these high rates of pesticide application suggest that risks related to pesticide use will likely be highest in the cotton zone. Although maize plots attracted the lowest level of insecticide use in 2017/18, this situation will likely change in coming years given maize's sensitivity of the Fall Armyworm, a highly invasive exotic pest transferred to West Africa from Brazil the following season. Herbicide use, like mineral fertilizer, appears highest in the well-structured extension zones and on cotton, maize and rice plots (Table 12). In addition, many cereal farmers plant fongicide-coated seeds to prevent depredation from fungal disease, birds and small rodents after planting.

Across all farm categories, mechanized farms consistently applied the highest levels of improved seeds, mineral fertilizer and herbicides. High levels of nonfarm earnings and remittances relieve cash constraints, thus enabling mechanized farms to procure higher levels of purchased inputs.

Table 12. Input intensity among five major food and cash crops, by AEZ and CAT (percent of plots using each input)

		Seeds			Fertilizer		Pesticides	
		local	improved	hybrid	manure	mineral	herbicide	insecticide
Agro-ecological zone								
	Niger Delta	68%	30%	1%	37%	52%	14%	17%
	Koutiala Plateau	59%	41%	0%	30%	77%	65%	23%
	Total sample	64%	36%	1%	34%	65%	40%	20%
Extension support								
	Delta - ON	12%	86%	2%	20%	79%	58%	39%
	Delta - DRA	75%	25%	0%	39%	47%	10%	16%
	Plateau - CMDT	58%	42%	0%	31%	77%	59%	23%
	Plateau - DRA	66%	31%	3%	33%	65%	46%	17%
Crop								
	millet	89%	10%	1%	37%	46%	8%	14%
	sorghum	83%	16%	0%	16%	30%	20%	8%
	rice	42%	57%	1%	12%	81%	50%	12%
	maize	66%	33%	1%	51%	92%	71%	2%
	cotton	7%	92%	1%	56%	99%	83%	78%
Farm household category								
M	Mechanized	41%	58%	1%	26%	79%	61%	17%
A	Well-equipped	63%	36%	0%	32%	67%	47%	23%
B	Equipped	67%	32%	1%	35%	62%	36%	20%
C	Partially equipped	61%	37%	1%	37%	69%	39%	16%
D	Manual	52%	47%	0%	29%	64%	40%	18%
	total sample	64%	36%	1%	34%	65%	40%	20%

Legend:
= higest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

5.2. Land preparation

During land preparation tasks, hand labor and ox-drawn animal traction dominate, with application on over two-thirds of plots surveyed (Table 13). Motorized land preparation, with tractors, takes place on 24% of Plateau farms and, with motorized cultivators, on 8% of Delta farmers, particularly in the Office du Niger where farmers prepared 50% of all plots with small motorized cultivators. One of the most important trends in the irrigated rice zone is the increasing use of motorized cultivators, which is steadily increasing in popularity across all types of exploitations and the corresponding decline in use of plowing oxen. These data suggest that motorized land preparation now accounts for half of all land preparation in the Office du Niger (Table 13). Tractor-powered land preparation proves most prevalent on cotton fields, accounting for 27% of plots. In addition, farmers frequently use carts, motorized cultivators and tractors for transport of inputs and outputs throughout the season.

Rental markets appear prevalent, for both animal traction teams and motorized land preparation. Over half of partially equipped (Category C) and manual farms (Category D) use animal traction to prepare their fields, implying high rates of animal traction (ANTRAC) rental. Since owners prepare their own fields first, this suggests that risks of late planting and weeding are highest among the Category C and D renters. Rental markets appear similarly important for mechanized cultivators, since over one-fourth of manual farms (Category D) prepare fields with mechanized cultivators. The 10-15% of Category A-D farms who prepare land using tractors must also be renting these services (Table 13).

Although hand seeding occurs on most plots, mechanical seeders are used on over half of all maize and cotton plots (Table 13). This leads to higher rates of mechanical seeding on the Plateau than in the Delta, where transplanting of rice is most common.

Table 13. Mechanization (percent of plots)

		Land preparation				Planting	
		hand	oxen	motoculteur	tractor	hand	seeder
Agro-ecological zone							
	Niger Delta	66%	65%	8%	7%	95%	4%
	Koutiala Plateau	74%	69%	0%	24%	96%	53%
	Total sample	70%	67%	4%	15%	96%	28%
Extension support							
	Delta - ON	63%	47%	50%	0%	90%	0%
	Delta - DRA	65%	66%	4%	8%	96%	1%
	Plateau - CMDT	74%	69%	0%	24%	96%	51%
	Plateau - DRA	76%	74%	1%	17%	97%	57%
Crop							
	millet	60%	65%	0%	0%	96%	0%
	rice	69%	64%	15%	17%	92%	6%
	maize	78%	74%	0%	19%	97%	49%
	cotton	74%	69%	0%	27%	98%	66%
Farm household category							
M	Mechanized	68%	30%	25%	42%	89%	32%
A	Well-equipped	72%	70%	1%	15%	96%	43%
B	Equipped	71%	70%	1%	15%	96%	28%
C	Partially equipped	83%	79%	2%	8%	91%	17%
D	Manual	47%	50%	26%	10%	96%	4%
	total sample	70%	67%	4%	15%	96%	28%

Legend:
= higest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

5.3. Weed control

Weed pressure appears moderate across most cropping systems. Overall, farmers indicated that slightly more than two-thirds of plots faced medium weed pressure. The highest weed pressure appears on irrigated rice farms, where 22% of plots confronted high weed pressure (Table 14). In the irrigated farming perimeters of Mali's Office du Niger (ON), pressure from the wild rhizomatous weed, *horiza logistaminata*, has spurred increasing farmer interest in herbicides, particularly glyphosate.

Table 14. Weed control methods

		Weed Pressure			Weed control systems		
		low	medium	high	hand	mechanical	herbicides
Agro-ecological zone							
	Niger Delta	15%	66%	19%	61%	25%	14%
	Koutiala Plateau	19%	67%	13%	91%	41%	65%
	total sample	17%	67%	16%	76%	33%	40%
Extension support							
	Delta - ON	24%	62%	14%	20%	5%	58%
	Delta - DRA	15%	68%	17%	64%	25%	10%
	Plateau - CMDT	18%	67%	15%	90%	43%	59%
	Plateau - DRA	16%	65%	19%	87%	38%	46%
Crop							
	millet	20%	66%	14%	93%	39%	8%
	rice	16%	63%	22%	22%	0%	50%
	maize	12%	72%	16%	96%	48%	71%
	cotton	13%	69%	18%	98%	49%	83%
Farm household category							
M	Mechanized	17%	63%	20%	46%	23%	61%
A	Well-equipped	21%	65%	14%	84%	32%	47%
B	Equipped	15%	68%	16%	78%	36%	36%
C	Partially equipped	21%	64%	15%	75%	26%	39%
D	Manual	19%	62%	18%	51%	25%	40%
	total sample	17%	67%	16%	76%	33%	40%

Legend:
= higest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

Hand weeding takes place on three-fourths of cultivated plots. In addition, 40% of plots receive herbicide treatment, while one-third are weeded mechanically (Table 14). Even where farmers use herbicides or mechanical weeders, they also supplement with follow-up hand weeding. Mechanized weeding is most prevalent on cotton, maize and millet plots, where farmers use motorized cultivators for weeding and cultivating on cotton, maize, millet and sorghum. Farmers apply herbicides primarily on cotton (83% of plots), maize (71% of plots) and rice (50% of plots). Herbicide use is most prevalent among mechanized farms, where 61% of plots receive herbicide applications.

Table 15. Mechanization of post-harvest processing (percent of plots)

		Threshing	
		hand	mechanical
Agro-ecological zone			
	Niger Delta	31%	37%
	Koutiala Plateau	17%	7%
	total sample	24%	22%
Extension support			
	Delta - ON	20%	84%
	Delta - DRA	35%	34%
	Plateau - CMDT	17%	7%
	Plateau - DRA	14%	6%
Crop			
	millet	42%	19%
	rice	30%	54%
	maize	22%	9%
	cotton	0%	0%
Farm household category			
M	Mechanized	15%	43%
A	Well-equipped ANTRAC	26%	11%
B	Equipped ANTRAC	23%	20%
C	Partially equipped	31%	19%
D	Manual	25%	52%
	total sample	24%	22%

Legend:
= higest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

5.4. Post-harvest processing

Both mechanical and hand threshing are more prevalent in the Delta than in the Plateau, because cotton, the major cash crop in the Plateau, does not require on-farm processing. Instead, cotton farmers sell their raw seed cotton to the CMDT, where local gins separate seed from lint and then bail cotton fiber for export.

Mechanical threshing is most common among rice producers in the irrigated perimeters operated by the Office du Niger, where farmers mechanically thresh the harvest from 84% of their plots (Table 15).

Not surprisingly, mechanized farmers process large volumes (43% of plots) mechanically. More surprising is the predominance of mechanical threshing among the manual (Category D) farms, which thresh 52% of plots mechanically. This again suggests an active rental market, one which is highly visible in the form of widely available, mobile mechanical threshers that dot the countryside in the irrigated rice zones. These itinerant entrepreneurs perform service threshing on demand in or nearby farmer fields. The high level of mechanical threshing by Category D farms in the Office du Niger provides strong evidence that the majority of rice in the irrigated zone is threshed mechanically. Farmers pay mechanical service providers to thresh small quantities for immediate consumption or large quantities for sale.

6. Agricultural commercialization

6.1. Marketed shares

Rates of commercialization vary significantly across crops, ranging from 100% of cotton production to 27% of millet (Table 16). In the case of millet, of course, smaller-scale plot managers, including women, often sell small amounts in weekly markets to meet pressing cash needs (Smale et al. 2010). Farmers growing cotton, sesame and horticultural products sell over 80% of total production. Groundnut and cowpea producers are similarly market-oriented, selling over half of their household production.

Coarse cereals such as millet, maize and sorghum are produced in large quantities, but not primarily for sale. Farmers of these major cereals consume over two-thirds of household production and sell less than one-third. Among cereal crops, rice producers produce the highest average quantities per household and sell slightly over one-third of production on the market (Table 16).

Table 16. Agricultural commercialization

Crop	Production kg/hh	Sales kg/hh	Share sold percent
cotton	4,539	4,539	100%
sesame	185	169	89%
horticulture	1,683	1,247	80%
groundnut	596	398	64%
cowpea	202	118	57%
fonio	528	185	47%
rice	8,764	3,178	34%
sorghum	2,049	430	32%
maize	4,487	1,297	28%
millet	3,887	868	27%
all crops	3,808	2,330	64%

Legend:
= highest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

Looking at crop sales by farm category, Table 17 examines patterns of production and sales for rice, the largest crop in the Delta, cotton, the highest-value crop in the Plateau, and horticulture products, a highly commercialized crop in both zones. Among rice producers, mechanized producers (Category M) stand out in two ways. First, they produce triple the volume per household compared to all other farming household categories, even the most well-equipped animal traction farms in Category A. Secondly, the mechanized farms are significantly more commercial. They sell over half of total rice production compared to 20% to 30% of other farm household groups (Table 17).

Among cotton producers, the scale of production varies substantially across farm household groups. Mechanized farms (Category M) produce more than double the output of well-equipped animal traction households (Category A) and four times the output of Category B and C farms. Farm households who rely on manual labor (Category D) produce less than one ton per household, less than 10% of the output produced by mechanized farms. Despite these differences in scale, cotton remains exclusively a cash crop.

Horticulture producers generate a similarly constant marketed share, with all household groups selling roughly 80% of total production. However, scale of production per household remains much more even than for cotton. With horticultural crops, the mechanized farms produce only roughly double the output of other categories of farm households (Table 17).

Table 17. Average production and sales, by crop

Crop Farm household category		Production kg/hh	Sales kg/hh	Share sold percent
Rice				
M	Mechanized	24,123	11,751	52%
A	Well-equipped ANTRAC	6,995	2,269	38%
B	Equipped ANTRAC	7,024	2,258	31%
C	Partially equipped	6,658	1,664	25%
D	Manual	6,683	2,036	34%
	total sample	8,764	3,178	34%
Cotton				
M	Mechanized	14,524	14,524	100%
A	Well-equipped ANTRAC	6,757	6,757	100%
B	Equipped ANTRAC	3,588	3,588	100%
C	Partially equipped	2,522	2,522	100%
D	Manual	995	995	100%
	total sample	4,539	4,539	100%
Horticulture				
M	Mechanized	3,115	2,013	81%
A	Well-equipped ANTRAC	1,690	1,006	71%
B	Equipped ANTRAC	1,595	1,255	81%
C	Partially equipped	1,012	840	89%
D	Manual	1,405	1,163	79%
	total sample	1,683	1,247	80%

Legend:
= highest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

6.2. Seasonality

Coarse cereal prices vary seasonally, though with differing peaks resulting from slightly different cropping calendars. Millet and maize prices exhibit the largest seasonal price movements with trough-to-peak movements of 20% to 25% in farmgate prices. As a result, farmers who sell late in the season profit the most (Table 18). Prices of internationally traded commodities such as cotton and rice fluctuate far less, with seasonal price movements of under 10% for rice, while CMDT guarantees a fixed price for cotton (Table 18).

Table 18. Producer prices received by farmers

Agro-ecological zone	Producer price received (CFAF/kg)			
Crop	Oct-Dec	Jan-Mar	Apr-June	July-Sept
Niger Delta				
millet	148	150	159	180
rice	237	261	224	243
Koutiala Plateau				
maize	109	116	149	136

Legend:
= highest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

With millet sales, mechanized farms wait the latest to sell their surplus, with 96% selling most in the April-June quarter (Table 19). As a result of this timing, they earn a seasonal price premium (Table 19). All other farm groups sell earlier in the season and at lower prices. Nonetheless, even the mechanized farms sell before the absolute seasonal price peak in July-September, presumably because of cash needs for purchasing inputs and performing maintenance on tractors and farm equipment before the coming season.

Maize sales among farms in the Koutiala Plateau vary substantially across farm categories. A majority of mechanized farms (61%) sell most of the harvest during the April-June quarter when maize prices peak. Surprisingly, manual farms (Category D) likewise wait until late in the season to sell the bulk of their output. In the remaining farm groups (Categories A,B and C), most farms sell the bulk of their marketed volumes early in the marketing season when prices are low (Table 19).

Among rice farmers in the Delta, a large majority of mechanized farms (71%) concentrate their sales in the January-March quarter when producer prices peak (Table 19). As a result, they receive a roughly 10% price premium compared to other farmer who sell at less favorable times in the season (Table 18). As with millet, the manual farms (Category D) also sell most of their harvest early in the season.

Table 19. Seasonality of crop sales

Agro-ecological zone / Crop / Farm household category	Timing of largest sales (percent of hh) Oct-Dec	Jan-Mar	Apr-June	July-Sept	total
Niger Delta					
Millet					
M Mechanized	2	0	94	4	100
A Well-equipped	21	53	21	4	100
B Equipped	16	53	31	0	100
C Partially equipped	1	61	37	2	100
D Manual	1	72	28	0	100
total sample	14	52	33	1	100
Rice					
M Mechanized	22	71	5	2	100
A Well-equipped	6	52	22	20	100
B Equipped	13	43	37	7	100
C Partially equipped	1	44	33	22	100
D Manual	8	76	13	4	100
total sample	11	56	25	7	100
Koutiala Plateau					
Maize					
M Mechanized	3	30	61	6	100
A Well-equipped	39	31	13	17	100
B Equipped	31	33	29	7	100
C Partially equipped	51	12	37	0	100
D Manual	8	45	47	0	100
total sample	33	31	29	8	100
Cotton					
M Mechanized	19	80	1	0	100
A Well-equipped	20	53	27	0	100
B Equipped	14	68	18	0	100
C Partially equipped	8	78	14	0	100
D Manual	13	60	27	0	100
total sample	15	66	19	0	100

Legend:
= highest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

Cotton farming exhibits far less sales seasonality. All farm groups sell most of their harvest during the January-March quarter (Table 19). Tight monitoring by the CMDT serves to help cotton farmers manage their cropping calendars in tandem with agronomic needs.

7. Gender Differences Within and Among Agricultural Households

The structure of agricultural households within the farming systems of the two zones is complex and based on the patrilineal extended family. Multiple nuclear units are organized horizontally and vertically under the headship of a senior male. In the Koutiala Plateau and other dryland systems, social norms typically dictate that production is organized under the supervision of the chef of the EAF or designate, who is typically a senior male member of the household. The chef allocates use rights to plots managed by individual male members of his family who have reached adulthood or to women who have married into the household, and occasionally, to other family members. The chef also supervises work on plots farmed collectively by the household, on which individual members contribute their labor. The output of collective plots is enjoyed by the household as a whole, but individuals have priority rights to the output from their individually-managed plots. These are norms only, and there is also a wide variation in observed modes of management. For example, the history of settlement in the irrigated rice zone is unique, and in that production system, a more nuclear organization has been observed.

Despite that, in each agroecological zone of study, respondents reported 20 categories of relationships to the head among plot managers. Differences in the percentage distribution among these did not differ meaningfully by zone—suggesting fewer differences in organization that we had expected—perhaps because we also include the drylands, millet-based systems surrounding irrigated rice zone. Table 20 presents the frequency distribution of all females in the EAFs interviewed. Among 18,954 females, only 13 were chefs. The largest categories of women were unmarried daughters, followed by wives, granddaughters and daughters-in-law. Relatively smaller numbers were sisters-in-law or nieces, mothers, grandmothers or sisters of the head. Very small numbers were cousins, mothers-in-law, distant relatives or domestic workers.

Table 20. Relationship of females surveyed to household head

Relation to head	n	%
Head of EAF	13	0.07
Spouse	3,671	19.37
Daughter	5,247	27.68
Mother	591	3.12
Grand daughter	2,912	15.36
Grand mother	235	1.24
Sister	229	1.21
Daughter-in-law	2,551	13.46
Niece	1,681	8.87
Cousin	19	0.1
Sister-in-law	1,588	8.38
Mother-in-law	27	0.14
Other female relative	107	0.56
Woman unrelated to head or spouse	9	0.05
Domestic helper	74	0.39
Total	18,954	100
n=18,954 female household members		

Source: MSU/IER Farm household survey, 2017/18

The figures shown in Table 21 provide a glimpse of human capital distribution within households. Overall, males and females are equally represented within EAFs—each representing about 50 percent of the total (females 51% and males 49%, Table 21). Women were less likely than men to have ever attended school (17% as compared with 35%). Literacy rates are extremely low for both groups (5%for women and almost 20% for men aged 15 years or older). However, considering the younger cohort that is currently attending school, we find that females are more heavily represented than males (70% vs. 54%). This may reflect the stronger need for young men to pursue income-generating activities even before they reach adulthood. If consistent with the development literature, which shows a strong association between women's education and care of children, the difference between the generations of women will have positive implications for family health. Our indicators of health do not differ between men and women. Roughly 16 percent of each group experienced an illness during the 30 days preceding the survey, and average treatments costs were slightly over (for men) and under (for women) the overall mean of 10800 FCFA.

Table 21. Gender differences in human capital of household members

Indicator		Male	Female	All
Chef EAF	n	2,392	13	2,405
	%	99.46	0.54	100
EAF Members	n	18,511	18,954	37,465
	%	49.41	50.59	100
Education				
Ever attended school (aged 15 or older)	%	34.45	16.79	25.09
Literate (age 15 or older)	%	19.67	5.27	11.23
Now attending school	%	54.3	69.73	56.81
Health				
Illness during last 30 days	%	16.18	15.23	15.7
Treatment (FCFA)	mean	10936	10652	10796
n=37,465 EAF members				

Source: MSU/IER Farm household survey, 2017/18

Stark differences are observable between men and women with respect to farm capital. As compared to 72 percent of male plot managers, only 18 percent of female plot managers stated that they acquired their plot through inheritance (Table 22). Even when they reported this, it is not clear whether they referred to the original source of the land, which is inheritance through the male line. Most female plot managers stated that their plot was a free loan or gift (meaning from the male line of the extended family). Just under 20 percent of men cited share, purchase, or ODR (Organisme de Développement Rural) attribution, compared to only 4 percent of women.

Table 22. Gender differences in plot manager's access to land

		Male	Female	All
Mode of acquisition of managed plot				
Inheritance	%	71.57	18.15	64.46
Customary attribution	%	3.66	0.94	3.3
Free loan	%	3.39	67.15	11.87
Gift	%	2.66	9.8	3.61
Share, purchase, attribution ODR	%	18.72	3.96	16.76
		100	100	100
Plot size	mean	2.16147	0.67761	1.96302
Plot management type				
Collective	%	99.82	1.14	100
Individual	%	23.73	76.27	100

n=11,971 (all listed plots)
Note: plot size as reported by farmer

Source: MSU/IER Farm household survey, 2017/18

Table 23 shows that the largest differences in working capital and livestock ownership are not between males and females per se, but between the male head of EAF, who manages these on behalf of the EAF, and "junior" (in terms of roles and status) males and females. Even so, males other than the head seem to possess more of most categories of working capital. The means for sheep, goats and poultry are fairly close (only 1-2 small ruminants, and 4-5 poultry on average). This suggests that policies promoting improved animal health for small ruminants and poultry may offer an instrument for improving productive (and nutritional) assets managed by women. It is noteworthy that in many of these categories of equipment and livestock, means are under 1.

Communication access appears significantly lower for women than for men. While only 31% of adult women own a cellphone, junior males are twice as likely to own a phone (62%). Household heads, however, own a startling 3.7 phones each, on average (Table 23).

Table 23. Gender differences in ownership of equipment and livestock, by household members

		Male, not chef	Female, not chef	Chef d'EAF
		mean numbers		
Equipment	Motorized pump	0.00	0.00	0.08
	Mill	0.03	0.00	0.05
	Dehuller	0.03	0.00	0.04
	Thresher	0.00	0.00	0.04
	Cart	0.14	0.12	1.17
	Car/truck	0.00	0.00	0.02
	Tractor	0.00	0.00	0.01
	Plow	0.35	0.04	2.02
	Motorized cultivator	0.03	0.00	0.07
	Bicycle	0.46	0.10	2.37
	Motorcycle	0.24	0.03	1.29
	Radio/dvd	0.30	0.13	1.46
	Television	0.08	0.03	0.56
	Cell phone	0.62	0.31	3.74
Livestock	Sheep	1.62	1.25	5.16
	Goats	1.97	1.71	5.47
	Poultry	5.03	4.01	23.23
	Plowing oxen	0.32	0.08	2.71
	Other cattle	0.35	0.23	5.61
	Horses	0.03	0.00	0.06
	Donkeys	0.35	0.17	1.63
	Pigs	0.00	0.00	0.11

n=361 for nonchefs, 2398 for chefs (on behalf of EAF)

Source: MSU/IER Farm household survey, 2017/18

Major cereal crops (rice, sorghum, millet) and the foremost legume crop (groundnut) represent similar ranks in importance for both male and female plot managers (Table 24). Nearly a third (31%) of primary crop plots managed by women were planted to groundnuts, compared to only about 7 percent of those managed by men. Traditionally, groundnut is a main ingredient in the stews and sauces women prepare to accompany the starchy staple based on their own plot production. Cotton and maize, however, are rarely grown by women but are key crops for men. Unexpectedly because we considered cowpea to be a crop traditionally grown by women, men appear to be more likely to grow cowpeas than women. For either, these represented only 3-4 percent of plots as primary crops However, cowpeas presented nearly half of women's secondary crops s and most of men's (88%). These six crops represent 93 percent of primary

crops (and 95 percent of secondary crops) in plots managed by men and 76 percent of primary crops (and 69 percent of secondary crops) in those managed by women. Other primary crops in the complete inventory of plots recorded for the EAFs during the first visit of the survey team include: fonio, sweet potato, Irish potato, onion, yam, manioc, Bambara groundnut, soybean, sesame, peas, ginger, hibiscus, tomato, shallot, onion, okra, eggplant, hot pepper, melon, watermelon, cucumber, cabbage, green bean, tomato and squash.

Table 24. Major primary and secondary crops managed by men and women

		Primary crop			Secondary crop		
		Male	Female	Total	Male	Female	Total
rice	n	2,489	282	2,771			
	row %	90	10.18	100			
	col %	24	17.61	23.15			
millet	n	1,837	165	2,002	11	0	11
	row %	91.76	8.24	100	100	0	100
	col %	17.71	10.31	16.72	1.15	0	1
sorghum	n	1,429	145	1,574	36	23	59
	row %	90.79	9.21	100	61.02	38.98	100
	col %	14	9.06	13	3.77	7.99	5
maize	n	1,462	53	1,515	3	11	14
	row %	96.5	3.5	100	21.43	78.57	100
	col %	14.1	3.31	12.66	0.31	3.82	1.13
cotton	n	1,427	8	1,435	0	1	1
	row %	99.44	0.56	100	0	100	100
	col %	13.76	0.5	11.99	0	0.35	0.08
groundnut	n	713	498	1,211	16	27	43
	row %	58.88	41.12	100	37.21	62.79	100
	col %	6.88	31.11	10.12	1.68	9.38	3.46
cowpea	n	268	71	339	844	136	980
	row %	79.1	21.3	100	86.12	13.88	100
	col %	2.58	4.43	2.83	88.38	47.22	78.84
Subtotal major crops	n	9,625	1,222	10,847	910	198	1,108
	row %	88.73	11.27	100	82.13	17.87	100
	col %	92.82	76.33	90.61	95.29	68.75	89.14
Other crops	n	745	379	1,124	45	90	135
	row %	66.28	33.72	100	33.33	66.67	100
	col %	7.18	23.67	9.39	4.71	31.25	10.86
Total	n	10,370	1,601	11,971	955	288	1,243
	row %	86.63	13.37	100	76.83	23.17	100
	col %	100	100	100	100	100	100

Source: MSU/IER Farm household survey, 2017/18

The percentage distribution of the major primary crops grown by women is shown by agro-ecological zone in Table 25. Groundnut, sorghum, and upland rice are more evident in the Plateau; millet, cowpea and sesame are more frequent in the Delta. Okra and maize are cultivated on similar shares in the two zones. Overall, however, only groundnut, millet, sorghum, rice and "other" (primarily horticultural crops) are widely grown by women. Women produce very little irrigated rice in the Delta, where only 6% of their plots are planted to rice as a primary crop. By contrast, they grew rainfed (bas-fonds, or lowland) rice as a primary crop on 28% of their plots in the Plateau.

Table 25. Major primary and secondary crops in female-managed plots, by AEZ

		Primary crop			Secondary crop		
		Plateau	Delta	Total	Plateau	Delta	Total
groundnut	n	315	183	498	21	6	27
	row %	63.25	36.75	100	77.78	22.22	100
	col %	37.37	24.14	31.11	19.81	3.3	9.38
millet	n	11	154	165			
	row %	6.67	93.33	100			
	col %	1.3	20.32	10.31			
sorghum	n	97	48	145	23	0	23
	row %	66.9	33.1	100	100	0	100
	col %	11.51	6.33	9.06	21.7	0	7.99
rice	n	232	50	282			
	row %	82.27	17.73	100			
	col %	27.52	6.6	17.61			
okra	n	57	51	108	17	25	42
	row %	52.78	47.22	100	40.48	59.52	100
	col %	6.76	6.73	6.75	16.04	13.74	14.58
sesame	n	27	63	90	3	6	9
	row %	30	70	100	33.33	66.67	100
	col %	3.2	8.31	5.62	2.83	3.3	3.13
cowpea	n	12	59	71	17	119	136
	row %	16.90	83.10	100	12.5	87.5	100
	col %	1.42	7.78	4.43	16.04	65.38	47.22
maize	n	24	29	53	3	8	11
	row %	45.28	54.72	100	27.27	72.73	100
	col %	2.85	3.83	3.31	2.83	4.4	3.82
Subtotal major crops	n	775	637	1412	84	164	248
	row %	54.89	45.11	100	33.87	66.13	100
	col %	91.93	84.04	88.19	79.25	90.11	86.11
Other crops	n	68	121	189	22	18	40

	row %	35.98	64.02	100	55.00	45.00	100
	col %	8.07	15.96	11.81	20.75	9.89	13.89
Total	n	843	758	1,601	106	182	288
	row %	52.65	47.35	100	36.81	63.19	100
	col %	100	100	100	100	100	100

Source: MSU/IER Farm household survey, 2017/18

Mean quantities of mineral fertilizer applied per hectare during the course of the growing season are reported in Table 26 by target crop for male and female plot managers. Subsample sizes are small for women, and variability on this parameter is high overall in the survey data—both in the numerator and in the denominator. Estimates should therefore be interpreted with caution. In general, average rates of application do not appear to differ significantly between men and women except in the case of millet. In fact, rates could be higher among women on their sorghum plots—a finding we also observed in the previous work that focused on sorghum in the Sudan Savanna (Smale et al. 2019).

Table 26. Fertilizer (kgs/ha) applied to primary crops on plots managed by men and women

	Male		Female		All plots	
	n	mean	n	mean	n	mean
Millet, Delta	1818	34.9	160	18.1	1978	33.5
Sorghum, Plateau	1136	36.1	120	54.5	1256	37.9
Sorghum, Delta	281	7.27	41	12.1	322	7.89
Maize, Plateau	1449	217	62	90.9	1511	212
Rice, Delta	2105	275	39	221	2144	274
Rice, Plateau	345	154	228	152	573	153
Cotton, Plateau	1388	224	8	207	1396	224

n=9194 plots

Source: MSU/IER Farm household survey, 2017/18

In Table 27, we present mean diet quality scores for women aged 15-60, by agroecological zone, farm types and season. The scores are computed from data recorded whether or not women consumed from food groups during the 24 hours preceding the survey. The Minimum Adequate Dietary Diversity is scored as 1 if the respondent consumed at least 5 of 10 food groups, 0 otherwise. The Women's Dietary Diversity Score is a count across 9 food groups. Food group definition differs slightly between the two indicators. Recently revised from decades of work on household and individual dietary diversity, these indicators are recommended for use in rapid appraisals of diet quality of women and their children in a population. Both are highly correlated with anthropometric measurements and micronutrient adequacy (for details, see FAO and FHI 360 2016; Kennedy, Ballard and Diop 2013; Smale, Thériault, and Assima 2019).

Scores indicate that malnutrition remains a serious problem among women during the "hungry" season, especially in the households of the Koutiala Plateau. Only 57 percent of

women in the Delta and 32 percent of women on the Koutiala Plateau consumed a minimally adequate diet at the time of the survey in July of 2018. Both sets of women consumed only 4-5 of the 9 food groups included in the WDDS. After harvest, numbers rose considerably—more than doubling for the MDD_W on the Koutiala Plateau. In fact, the mean scores for this indicator are similar after the harvest between the two zones (differences by zone not significant in this time period) at around 4 out of 5 women reaching adequacy. The mean numbers of food groups consumed in the WDDS was 6 in both zones.

Table 27. Household mean diet quality scores for women age 15-60, by AEZ, CAT and season

		July 2018		February 2019	
		Minimum Adequate Dietary Diversity (0-1), MDD_W	Women's Dietary Diversity Score, WDDS	Minimum Adequate Dietary Diversity (0-1), MDD_W	Women's Dietary Diversity Score, WDDS
	n	mean			
Agroecological zone*					
Koutiala Plateau	167	0.318	3.90	0.812	5.55
Delta du Niger	245	0.573	4.69	0.776	5.62
Household type					
cmdt_M motorise	23	0.742	5.317	0.853	6.052
cmdt_A bien equi	69	0.545	4.508	0.787	5.573
cmdt_B equippe	222	0.414	4.203	0.766	5.536
cmdt_C partiel	21	0.298	3.983	0.848	5.529
manuel	77	0.527	4.565	0.831	5.652

Source: MSU/IER Farm household survey, 2017/18

Turning to farm types, marked improvement also appears by season. The magnitudes of the means do not change consistently as we move from manual production to fully motorized production. However, scores for households in this last group are clearly higher than for the other groups in the "hungry" season—and especially the CMDT C Partiel. Differences between household types appear to flatten a bit after the harvest.

8. Policy Issues and Instruments

8.1. Extension systems

Well-structured extension systems – such as those managed by the Office du Niger and the CMDT – benefit the farmers they serve. Farmers operating in the ON and CMDT zones receive consistently higher rates of input subsidies and over longer periods of time (Table 28).

Table 28. Subsidy access, by type of extension support

Agro-ecological zone Exentions system	Seed subsidy	Fertilizer use	Fertilizer subsidy yes	Fertilizer subsidy # years
Niger Delta				
Office du Niger	7%	95%	79%	8
DRA	4%	80%	68%	5
Koutiala Plateau				
CMDT	43%	99%	94%	8
DRA	29%	92%	75%	6
Total sample	24%	91%	81%	7

Legend:
= highest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

Similar differences emerge by farm category. Mechanized farms all use fertilizer and, along with Category A ANTRAC farms, are most likely to receive subsidized fertilizer. Mechanized farms likewise receive far higher quantities of subsidized fertilizer than any other group (Table 29). In contrast, manual farms (Category D) are least likely to receive subsidized fertilizer. Both C and D category farms receive the lowest quantities of subsidized fertilizer of any group.

Table 29. Subsidy access, by farm category

Farm household category		Fertilizer use	Fertilizer subsidy yes	Fertilizer subsidy # years	Quantity of subsidized fertilizer received* DAP	cereal	cotton	urea
M	Mechanized	100%	91%	8	558	851	1,867	1,100
A	Well-equipped ANTRAC	98%	90%	7	169	490	1,007	628
B	Equipped ANTRAC	89%	81%	7	198	265	620	346
C	Partially equipped	90%	81%	8	167	221	443	264
D	Manual	85%	65%	6	203	147	242	285
	total sample	91%	81%	7	229	320	728	417

* Average quantity (kg/hh) among households receiving subsidized fertilizer.

Legend:
= highest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

8.2. Fertilizer subsidy policy reform

Reform of the fertilizer subsidy distribution system began in 2016/17. During the 2017/18 cropping system, when this survey took place, the e-voucher pilot system was in its second year. Nonetheless, the e-voucher distributions were extremely low in the 60 e-voucher pilot villages surveyed. Across the 30 e-voucher pilot villages surveyed in the Koutiala Plateau, farmers received at most 5% of subsidized fertilizer through -e-vouchers. In the Delta, e-voucher distribution proved slightly better, with farmers receiving up to 22% of subsidized fertilizer through e-vouchers (Table 30). Pure e-voucher distribution accounts for less than 1% of distribution, even in the e-voucher pilot villages. This suggests, that initial implementation of the pilot program has been slow. Kone et al. (2019) provide a summary of the major reasons for this sluggish roll-out of the e-voucher system.

Table 30. Share of subsidized fertilizer received through e-vouchers

Agro-ecological zone	Subsidized fertilizer delivered, by subsidy system (kg/hh)			
Subsidy system	paper voucher	both	e-voucher	total
Niger Delta				
paper voucher	315	0	0	316
e-voucher pilot zones	470	133	1	604
subtotal	329	12	0	342
Koutiala Plateau				
paper voucher	1,361	6	0	1,367
e-voucher pilot zones	1,592	79	0	1,679
subtotal	1,393	16	0	1,411
Total sample				
paper voucher	1,083	1	0	1,085
e-voucher pilot zones	1,027	111	1	1,141
E-voucher pilot zones: share of subsidized fertilizer received through paper and e-vouchers				
delta	78%	22%	0%	100%
plateau	95%	5%	0%	100%

Source: MSU/IER Farm household survey, 2017/18

8.3. Rural institutions

Farmer organizations exist throughout rural Mali. Because of the longstanding institutional and organizational support by the CMDT in Mali's cotton zones, membership in producer organizations remains highest in these zones – fully 99% of CMDT zone farmers are members of an OP (organisation paysanne). The remaining 1% do not grow cotton, since all cotton farmers must belong to a cotton cooperative. Slightly over one-third of villages in the CMDT zone have a credit institution in the village, compared to only 20% of villages in the Delta and 25% in unstructured extension zones of the Plateau (Table 31).

Credit availability varies significantly by agro-ecological zone and by extension system. In the CMDT zone, the CMDT itself is the largest supplier of credit, while in the Delta BNDA is most prominent (Table 31). It is important to recognize that the CMDT is not itself a financial institution; rather it serves as an intermediary between farmers and a range of financial institutions, including the BNDA, Cafo jiginew and others. The weakest rural financial infrastructure occurs in the unstructured (DRA) extension zones of the Delta, where only 5% of farmers report the existence of a micro-finance institution in their village. Elsewhere, micro-finance institutions play an increasingly important role, with 20% to 30% of farmers report access to micro-finance institutions (Table 31).

Table 31. Access to financial institutions

Agro-ecological zone	OP member	Credit institution	Credit received, by source			Micro-finance institutions			
Extenion system		in village	CMDT	BNDA	Caisse	in village	member	savings	credit
Niger Delta									
Office du Niger	71%	18%	0%	10%	4%	20%	19%	13%	18%
DRA	85%	20%	1%	8%	3%	5%	5%	5%	20%
subtotal	84%	20%	1%	9%	4%	7%	7%	6%	20%
Koutiala Plateau									
CMDT	99%	34%	25%	2%	3%	24%	27%	15%	34%
DRA	93%	25%	15%	3%	1%	14%	21%	12%	25%
subtotal	98%	32%	23%	3%	3%	22%	25%	15%	32%

Legend:
= highest value

Source: MSU/IER Farm household survey, 2017/18

8.4. Shocks

Malian farmers navigate growing uncertainty from changing weather patterns, diseases and lawlessness. When asked what major shocks they had experienced over the prior year, nearly two-thirds of farmers (65%) complained of drought, while another one-third (37%) cited animal diseases. In the Plateau, both drought (71%) and animal diseases (45%) were higher than in the Delta. Flooding, crop pests and price shocks proved most severe in the Delta. Physical insecurity, stemming from the breakdown of law and order in northern Mali, have affected farmers in the Delta most severely, with 19% complaining of insecurity over the prior year (Table 32).

Given the range and pervasiveness of these various shocks, technologies and systems for improving farmer resilience will become a necessary complement to efforts focused on raising productivity in the coming decade.

Table 32. Shocks experienced by farm households in rural Mali

Agro-ecological zone	Weather-related		Family	Pest and disease		Price	Insecurity
Extenion system	drought	flooding	health	crops	animals	shocks	
Niger Delta							
Office du Niger	55%	17%	6%	24%	32%	18%	17%
DRA	59%	8%	25%	16%	27%	26%	20%
subtotal	59%	9%	22%	17%	27%	25%	19%
Koutiala Plateau							
CMDT	73%	5%	13%	8%	43%	8%	5%
DRA	62%	5%	23%	6%	53%	17%	7%
subtotal	71%	5%	15%	7%	45%	10%	5%
Total sample	65%	7%	18%	12%	37%	17%	11%

Legend:
= highest value
= lowest value

Source: MSU/IER Farm household survey, 2017/18

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Annex A. Supporting Statistical Details

A.1. Statistical power

The sampling methodology adopted for this study involved stratified random sampling to detect differences in farming structure, input use, productivity and commercialization, by AEZ, subsidy forms and extension systems. The computations below calculate the statistical power and minimum detectable effect for yields of sorghum, maize, rice and cotton (the target crops) using data on yield distributions from prior studies. Since the electronic voucher subsidy program is still in its pilot stage, prior data on the estimated parameters were not available. To calculate minimum detectable effect size (MDES), we utilized yield data from previous surveys for those who received and did not receive the paper voucher (Smale et al. 2019).

Table A.1. Minimum Detectable Effect Size (MDES)

	Subsidy		No subsidy		delta
	Mean	SD	Mean	SD	MDES
Sorghum	709	753	539	535	0.26
	729	753	539	535	0.291
	823	1225	539	583	0.296
Maize	1582	944	1337	926	0.262
	1537	944	1337	926	0.214
	1829	1539	1504	1127	0.241
Rice	6435	3200	5500	2250	0.338
	7205	3600	5500	2250	0.568
	3510	1755	3000	1500	0.312
	3930	1965	3000	1500	0.532
Cotton	1012	1665	865	1665	0.088
	1125	1665	865	1665	0.156
	2548	3000	2148	2656	0.141

Source: Amidou Assima computations based on Smale et al. (2019).

Several parameters were employed to analyze statistical power as a function of the number of sampled PSUs (Table A2). The value of Type 1 error, or the significance level (α) was fixed at the standard of 5%. The number of observations per ES was fixed at 20. The maximum value of the MDES for each crop is shown in Table A2.

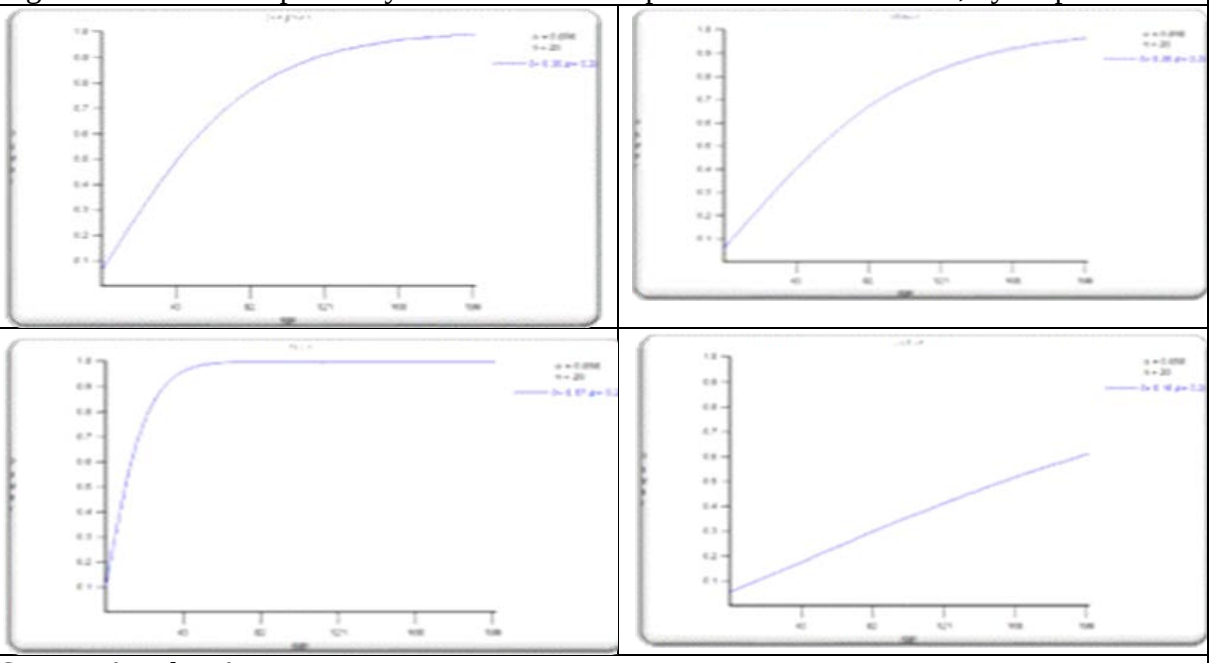
Table A.2. Parameters of statistical power analysis

	Sorghum yield	Maize yield	Rice yield	Cotton yield
α (Type 1 error)	0.05	0.05	0.05	0.05
N (nombre d'EAF par SE)	20	20	20	20
MDES (Effet minimum détectable)	0.296	0.262	0.568	0.156
RHO (Corrélation intra-classe)	0.2	0.2	0.2	0.2

Source: Amidou Assima, sampling statistician.

Figure A1, performed with optimal design software, illustrates the change in statistical power as the number of ES sampled increases with a fixed MDES by crop. In Figure A1, we note that with a PSU sample size of 120, MDES or standardized difference of 0.30 is detectable with a statistical power of 0.91 for sorghum. With maize, at the same PSU sample size, a MDES or standardized difference of 0.26 is detectable with a statistical power of 0.83. By contrast, at a PSU sample size of only 40, a standardized difference of 0.57 is attained with a statistical power of 0.96 for rice. Corresponding values for cotton are low. A sample of 200 PSUs generates a MDES or standardized difference of only 0.16 a statistical power of 0.70. Reaching optimal statistical power at 120 ES would be difficult for the case of cotton.

Figure A1. Statistical power by number of ES sampled with a fixed MDES, by crop.



Source: Amidou Assima

A2. Sample size, probabilities of selection and survey weights, by strata and SE

Table A3. Sample weights, by section d'énumeration (SE)

AEZ	*Strata*	Section d'enumeration	# SE's selected	Population 2009		Households (EAF)		Selection probability			Household Weight (1/Pr)
				selected SE	stratum	in SE	selected	SE from stratum	EAF from SE	EAF in overall sample	
Niger Delta											
	1. Office du Niger: paper voucher										
		BOUGOUNAM	20	718	56,741	45	20	0.253	0.444	0.112	8.9
		KANKA COURA	20	1,001	56,741	62	20	0.353	0.323	0.114	8.8
		KOKRY BOZO	20	988	56,741	83	20	0.348	0.241	0.084	11.9
		KONKONKOUROU	20	928	56,741	86	20	0.327	0.233	0.076	13.1
		KOUMARA	20	631	56,741	137	20	0.222	0.146	0.032	30.8
		MASSABOUGOU	20	792	56,741	63	20	0.279	0.317	0.089	11.3
		MEDINE	20	738	56,741	80	20	0.260	0.250	0.065	15.4
		MEROU	20	431	56,741	44	20	0.152	0.455	0.069	14.5
		MOLODO BAMBARA	20	549	56,741	22	20	0.194	0.909	0.176	5.7
		NARA	20	1,122	56,741	116	20	0.395	0.172	0.068	14.7
		NEMABOUGOU	20	1,225	56,741	167	20	0.432	0.120	0.052	19.3
		SAGNONA N6	20	692	56,741	49	20	0.244	0.408	0.100	10.0
		SIGUINOGUE	20	1,139	56,741	44	20	0.401	0.455	0.182	5.5
		SOCOURANI MOLODO	20	609	56,741	21	20	0.215	0.952	0.204	4.9
		TENINGUE N10	20	914	56,741	65	20	0.322	0.308	0.099	10.1
		TIELAN	20	751	56,741	31	20	0.265	0.645	0.171	5.9
		TOMY	20	684	56,741	56	20	0.241	0.357	0.086	11.6
		TOUARA	20	954	56,741	215	20	0.336	0.093	0.031	32.0
		WELINTIGUILA N7	20	997	56,741	71	20	0.351	0.282	0.099	10.1
		WEREKELA N8	20	446	56,741	32	20	0.157	0.625	0.098	10.2
	2. Office du Niger: electronic voucher										
		BOI BOI ND8	20	851	62,547	40	20	0.272	0.500	0.136	7.3
		DIADO WERE	20	315	62,547	20	20	0.101	1.000	0.101	9.9
		DOSSEGUELA	20	429	62,547	23	20	0.137	0.870	0.119	8.4
		HEREMAKONO	20	800	62,547	38	20	0.256	0.526	0.135	7.4
		KANKAN B7	20	630	62,547	35	20	0.201	0.571	0.115	8.7
		KANTO	20	937	62,547	20	20	0.300	1.000	0.300	3.3
		KEROUANE M5	20	656	62,547	31	20	0.210	0.645	0.135	7.4
		KOLODOUGOU CORO	20	830	62,547	148	20	0.265	0.135	0.036	27.9
		KOLODOUGOU COURA	20	446	62,547	44	20	0.143	0.455	0.065	15.4
		MADINA KM 39	20	1,334	62,547	45	20	0.427	0.444	0.190	5.3
		MADINA KM 39	20	459	62,547	33	20	0.147	0.606	0.089	11.2
		M'BEWANI	20	1,316	62,547	25	20	0.421	0.800	0.337	3.0
		NANGO DU SAHEL	20	520	62,547	24	20	0.166	0.833	0.139	7.2
		NIOBOUGOU B1	20	1,220	62,547	34	20	0.390	0.588	0.229	4.4
		N'TOMIKORO TIONGON	20	702	62,547	20	20	0.224	1.000	0.224	4.5
		SERIWALA KM 30	20	1,005	62,547	152	20	0.321	0.132	0.042	23.6
		THING	20	1,127	62,547	21	20	0.360	0.952	0.343	2.9
		TIGABOUGOU ND5	20	805	62,547	24	20	0.257	0.833	0.215	4.7
		TIONGOZANA	20	566	62,547	23	20	0.181	0.870	0.157	6.4
		TOUBA M7	20	528	62,547	20	20	0.169	1.000	0.169	5.9
	3. Unstructured (DRA): paper voucher										
		BORA	10	686	520,242	124	20	0.013	0.161	0.002	470.2
		GOUALANI	10	336	520,242	29	20	0.006	0.690	0.004	224.5
		N'GOA	10	818	520,242	186	20	0.016	0.108	0.002	591.5
		NIANI WERE	10	819	520,242	62	20	0.016	0.323	0.005	196.9
		POINT A	10	702	520,242	94	20	0.013	0.213	0.003	348.3
		RASSOGOMA	10	926	520,242	64	20	0.018	0.313	0.006	179.8
		SAMABOUGOU	10	570	520,242	71	20	0.011	0.282	0.003	324.0
		SIRABILE	10	563	520,242	33	20	0.011	0.606	0.007	152.5
		TIMINI	10	952	520,242	25	20	0.018	0.800	0.015	68.3
		ZAMBOUGOU	10	1,558	520,242	74	20	0.030	0.270	0.008	123.5
	4. Unstructured (DRA): electronic voucher										
		DONGALY	10	615	18,789	54	20	0.327	0.370	0.121	8.2
		FABA DIAKY WERE	10	301	18,789	20	20	0.160	1.000	0.160	6.2
		NANGO DU SAHEL	10	674	18,789	53	20	0.359	0.377	0.135	7.4
		N'DEBOUGOU	10	452	18,789	148	20	0.241	0.135	0.033	30.8
		N'DJICOROBOUGOU	10	974	18,789	58	20	0.518	0.345	0.179	5.6
		SIRIBALA COURA	10	578	18,789	70	20	0.308	0.286	0.088	11.4
		TANGO	10	899	18,789	21	20	0.478	0.952	0.456	2.2
		TOUMACORO	10	634	18,789	72	20	0.337	0.278	0.094	10.7
		WASSADIALA	10	473	18,789	23	20	0.252	0.870	0.219	4.6
		YOLO	10	642	18,789	240	20	0.342	0.083	0.028	35.1

Table A3. Continued

AEZ	*Strata*	Section d'enumeration	# SE's selected	Population 2009		Households (EAF)		Selection probability			Household Weight (1/Pr)
				selected SE	stratum	in SE	selected	SE from stratum	EAF from SE	EAF in overall sample	
Koutiala Plateau											
	5. CMDT: paper voucher										
		DIELE	20	1,125	547,275	35	20	0.041	0.571	0.023	42.6
		FAKONI	20	781	547,275	114	20	0.029	0.175	0.005	199.7
		FARAKALA 1	20	552	547,275	53	20	0.020	0.377	0.008	131.4
		KAFANA	20	1,288	547,275	174	20	0.047	0.115	0.005	184.8
		KATIELE	20	1,357	547,275	73	20	0.050	0.274	0.014	73.6
		KIFFOSSO 2	20	592	547,275	20	20	0.022	1.000	0.022	46.2
		KOLONI	20	1,551	547,275	112	20	0.057	0.179	0.010	98.8
		KOMBALA	20	708	547,275	70	20	0.026	0.286	0.007	135.3
		KONG KALA	20	1,407	547,275	74	20	0.051	0.270	0.014	72.0
		KONKOMBOUGOU	20	1,097	547,275	32	20	0.040	0.625	0.025	39.9
		NANKOLA	20	811	547,275	29	20	0.030	0.690	0.020	48.9
		N'DOSSO	20	451	547,275	60	20	0.016	0.333	0.005	182.0
		OUAKORO	20	698	547,275	126	20	0.026	0.159	0.004	247.0
		SEILA	20	910	547,275	93	20	0.033	0.215	0.007	139.8
		TIBY	20	781	547,275	33	20	0.029	0.606	0.017	57.8
		WAKORO	20	1,248	547,275	75	20	0.046	0.267	0.012	82.2
		WARASSO	20	512	547,275	61	20	0.019	0.328	0.006	163.0
		ZAMPERSO	20	920	547,275	32	20	0.034	0.625	0.021	47.6
		ZANTIGUILA	20	929	547,275	41	20	0.034	0.488	0.017	60.4
		ZEBALA	20	451	547,275	182	20	0.016	0.110	0.002	552.1
	6. CMDT: electronic voucher										
		BANIA	20	890	129,257	48	20	0.138	0.417	0.057	17.4
		BELESSO	20	1,181	129,257	121	20	0.183	0.165	0.030	33.1
		DEMBELA	20	600	129,257	116	20	0.093	0.172	0.016	62.5
		DIONA	20	1,112	129,257	69	20	0.172	0.290	0.050	20.1
		FONFONA	20	1,377	129,257	90	20	0.213	0.222	0.047	21.1
		KARANGASSODENI	20	854	129,257	43	20	0.132	0.465	0.061	16.3
		KOKOSSO	20	1,001	129,257	62	20	0.155	0.323	0.050	20.0
		KONINA	20	1,160	129,257	27	20	0.179	0.741	0.133	7.5
		LERESSO	20	906	129,257	113	20	0.140	0.177	0.025	40.3
		MISSIDOUGOU	20	923	129,257	37	20	0.143	0.541	0.077	13.0
		M'PETIELA	20	550	129,257	58	20	0.085	0.345	0.029	34.1
		NIGUILA	20	1,297	129,257	20	20	0.201	1.000	0.201	5.0
		N'TOSSO	20	1,025	129,257	88	20	0.159	0.227	0.036	27.7
		SOUN	20	825	129,257	74	20	0.128	0.270	0.035	29.0
		TIONTIERI	20	571	129,257	83	20	0.088	0.241	0.021	47.0
		TOROLA	20	1,145	129,257	26	20	0.177	0.769	0.136	7.3
		TRY 2	20	1,380	129,257	79	20	0.214	0.253	0.054	18.5
		WOMO	20	781	129,257	73	20	0.121	0.274	0.033	30.2
		ZANSONI	20	1,053	129,257	125	20	0.163	0.160	0.026	38.4
		ZINGOROSSO	20	245	129,257	20	20	0.038	1.000	0.038	26.4
	7. Unstructured (DRA): paper voucher										
		BOUMBA NENEBOUGOU	10	708	258,792	20	20	0.027	1.000	0.027	36.6
		KEMENA	10	762	258,792	37	20	0.029	0.541	0.016	62.8
		KEMOGOLA	10	731	258,792	31	20	0.028	0.645	0.018	54.9
		N'GONISSO BAMBARA	10	553	258,792	24	20	0.021	0.833	0.018	56.2
		N'GOROLA	10	409	258,792	79	20	0.016	0.253	0.004	249.9
		SOLOSSO	10	606	258,792	24	20	0.023	0.833	0.020	51.2
		SOROBA	10	826	258,792	38	20	0.032	0.526	0.017	59.5
		TINGOBA	10	857	258,792	70	20	0.033	0.286	0.009	105.7
		WOULA DIARABOUGOU	10	616	258,792	46	20	0.024	0.435	0.010	96.6
		YOROSSO	10	635	258,792	61	20	0.025	0.328	0.008	124.3
	8. Unstructured (DRA): electronic voucher										
		BERENIAKAN	10	744	14,483	44	20	0.514	0.455	0.234	4.3
		DJITAMANA	10	1,108	14,483	155	20	0.765	0.129	0.099	10.1
		LAMPASSO	10	412	14,483	38	20	0.284	0.526	0.150	6.7
		M'PEBOUGOU	10	730	14,483	48	20	0.504	0.417	0.210	4.8
		NAMPOSSELA	10	893	14,483	139	20	0.617	0.144	0.089	11.3
		N'GOLONIANASSO	10	782	14,483	23	20	0.540	0.870	0.470	2.1
		OUADIALA	10	609	14,483	37	20	0.420	0.541	0.227	4.4
		SINKOLO	10	582	14,483	36	20	0.402	0.556	0.223	4.5
		SIOU	10	637	14,483	68	20	0.440	0.294	0.129	7.7
		TONONDIOMBOUGOU	10	1,034	14,483	81	20	0.714	0.247	0.176	5.7