Ex-Ante Impacts of Technologies and Innovations in HOPE countries in West Africa
(Burkina Faso, Mali, Niger and Nigeria)

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ICRISAT
Science with a human face

Abbreviations and acronyms

CIRAD	Centre International de Recherche Agricole pour le Développement
IAR	Institute of Agricultural Research
ICMV	ICrisat Millet Variety
ICRISAT	International Crops Research institute for the Semi-Arid Tropics
IFRA	Institut de Formation Rurale Appliquée
IKMP	ICRISAT Kamboinse Pearl millet variety
INERA	Institut de l'Environnement et de la Recherche agricole
INRAN	Institut National de la Recherche Agronomique du Niger
IPR	Institut Polytechnique Rural
IRAT	Institut de Recherche Agronomique Tropicale
ISRA	Institut Sénégalais de la Recherche Agricole
LCRI	Lake Chad Research Institute
HOPE	Harnesssing Opportunities for Productivity Enhancement

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Summary

Government and donors have invested in the development of technologies and innovations in West Africa during the last 30 years and several of these technologies and innovations are available. These include 6 pearl millet varieties and 8 sorghum varieties in Burkina Faso; 27 pearl millet varieties and 59 sorghum varieties in Mali. In Niger, 21 pearl millet varieties have been developed and 3 sorghum varieties are available. In Nigeria, 3 pearl millet varieties and 7 sorghum varieties have been released. In addition, to these technologies, a range of crop management options have been developed including the use of Nitrogen application on sorghum, broadcasting natural phosphate, phosphorus application hill placed or fertilizer micro-dosing, *Striga* control by weeding, *Striga* control by late planting and *Striga* control with leguminous. A marketing strategy such as the warrantage or inventory credit scheme is being disseminated in several countries in West Africa.

In 2009, a project called Harnessing Opportunities for Project Enhancement (HOPE) is promoting a range of technologies in 4 countries in Africa namely Burkina Faso, Niger, Mali and Nigeria. At the onset, it is important to assess the returns to investment on the promotion of these technologies ie. the gross social gains generated by the promotion of these technologies. Three of these technologies have been targeted namely the use of improved varieties, the use of fertilizer micro-dosing and the use of the warrantage scheme or inventory credit schemes because they are widely used and are being widely promoted in the region with some probability of success.

An ex-ante analysis of these investment options has been carried out using the economic surplus approach. Results showed that the potential social gains derived from the use of these technologies and innovations are estimated to USD 101,296,000 from 2009 to 2019 with the promotion of varieties accounting for 39% of potential social gains, the micro-dosing technologies for 34% and the warrantage scheme for 27%. Most of the social gains is derived from Nigeria accounting for about 75% and the remaining shared between Mali, Niger and Burkina Faso.

1. Introduction

During the past 3 decades, governments, donors, national and international research institutions have invested in the development and promotion of modern pearl millet and sorghum varieties to boost productivity and income for smallholder farmers. These efforts have resulted in the development of 52 pearl millet varieties and 78 sorghum varieties that have been released in Burkina Faso, Mali, Niger and Nigeria; 6 crop management options have been developed and a marketing strategy called warrantage or inventory credit scheme. However most of these technologies are inaccessible or unavailable to smallholder farmers in SSA and Asia due to poor technology delivery systems, poor linkages to markets and inappropriate seed supply systems.

In order to resolve these constraints and develop proofs of concept, a project called Harnessing Opportunities for Productivity Enhancement (HOPE) of Sorghum and Millets in Sub-Saharan Africa and South Asia was developed and being implemented in 4 countries in West Africa since 2009. This project is to promote technologies and innovations to increase production and income of smallholder farmers. If successful this project will be implemented in successive phases up to 10 years from the year of inception.

A number of technologies with the high probability of success are being promoted through the HOPE project. These include the promotion of modern varieties, the diffusion of micro-dosing technologies and the warrantage scheme. There is, however, little knowledge of the potential impact of the technologies and innovations promoted through the HOPE project. This paper will assess ex-ante the potential impact of technologies and innovations promoted under the HOPE project. This will provide a lower bound of social gains since some interventions will not be assessed such as the impact of increased access to information, the impact of striga management technologies etc…

In what follows, we will review the technologies and innovations currently available and disseminated in the four countries covered by the project HOPE in West Africa in section 2 then present the data used for the estimation in section 3. The results are presented in section and section 5 concludes with some implications.

2. Technologies and innovations available in the HOPE countries

2.1. Modern varieties of pearl millet and sorghum released

2.1.1 Burkina Faso

From 1986 to 2011, six improved varieties of pearl millet varieties were released in Burkina Faso. These include IKMP1, IKMP2, IKMP3, IKM P5, IKMV 8201 and CAMI IS-88102 (Annex 1). All these varieties have been developed by ICRISAT in partnership with the Institute d' Environment et de Recherche Agricole (INERA). The potential yield of these varieties ranges from 1.5 to 2 tons / ha (Annex 1).

Nine sorghum varieties have also been released. These varieties are KAPELGA, SARIASSO 9, 10 SARIASSO, SARIASSO 11, SARIASSO 12, SARIASSO 13, SARIASSO 14 and FRAMIDA. Potential yields of sorghum varieties range from 2 to 4.7 tons / ha. SARIASSO 14 has the highest potential yield estimated to 4.7 tons / ha (Annex 1).

2.1.2 Mali

During the last two decades, 27 improved pearl millet varieties have been released in Mali (Annex 2). Potential yields of modern pearl millet varieties varied from 1.5 to 3 tons / ha. Pearl millet varieties M12D1, M9D3, IRAT have potential yield estimated to about 3 tons / ha. Fifty nine sorghum varieties have been released. Potential yields range from 1.2 to 4 tons / ha (Annex 2).

2.1.3. Niger

From 1986 to 2011, 21 varieties of pearl millet have been developed or adapted by ICRISAT and INRAN (Annex 3). Potential yields range between 0.8 to 3 ton per ha. The variety with the lowest yield (0.8 to 1.2 ton per ha) is the CT-3 while the DG-P1 (Dan Gombe) and HKB-PI may have the highest yields about 3 tons per ha.

There are however fewer sorghum varieties. During the last 25 years, only three new varieties were registered in the official catalog of Niger. These are Sepon 82 developed by ICRISAT in 1990 with a potential yield of 2 to 2.5 tons / ha, S RN 39 developed by IAR in Nigeria in 1991 with a yield potential about 2 tons / ha and the sorghum hybrid NAD-1 developed by INRAN/INTSORMIL in 1991 with potential yield between 3 to 4 tons / ha (Annex 3).

2.1.4. Nigeria

During the last 25 years, three varieties have been released in Nigeria. These are LCICMV-2 (2000) and LCICMH-1 (2005) and SOSAT-C88 with a potential yield of 2.5 tons/ha. Modern sorghum varieties developed and released include CSR 01 (Farafara Ex-Kano), CSR 02 (Farafara former Katsina), SAMSORG-45 (ICSV89001), SAMSORG-41 (ICSV - 111), SAMSORG-44 (ICSV89009) and SAMSORG-40 (ICSV - 400) and S RN 39 (Annex 4).

2.2. Crop management options

The major crop management options are summarized in Annex 5 below. These include the use of the application of per ha nitrogen fertilizer (50 kg of N) on sorghum, ie. about 108 kg of urea, 178 kg of calcium nitrate, or 178 kg of 330 kg of NPK. The major crop management technology promoted under the project is the fertilizer micro-dosing. Since 1999, the fertilizer micro-dosing technology is being promoted in 3 countries in West Africa mainly Burkina Faso, Mali and Niger via several projects including the USAID target, the CORAF ADB project and now the AGRA Micro-dosing project. These projects have improved the access to fertilizers by smallholder farmers and invested in the promotion of the micro-dosing technology. The promotion of these was coupled with 2 innovations including the establishment of input shops and a market innovation called the warrantage scheme or the inventory credit scheme. In Nigeria in 2005, the fertilizer micro-dosing is being promoted through a largely funded IFAD/CBDAP project (Annex 5). The promotion of these was coupled also with a market innovation called the warrantage scheme or the inventory credit scheme.

The micro-dosing technology was developed between 1994 and 1996 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the University of Hohenheim (Germany), and the International Fertilizer Development Center. It consists of the use of low levels of fertilizers (4 kg of P per ha) applied to the planting mound at sowing time or 2 to 3 weeks after planting. Partial budgeting analysis showed that the profitability of P application, defined as marginal income gains per unit of fertilizer, was highest for the given placement (Bationo et al. 1997; Buerkert and Hiernaux 1998). Productivity gains were estimated to average more than 50 percent over the local practice, with value-cost ratios ranging from 2 to 4.

Further refinements of the technology consisted of using a different type of fertilizer with higher P concentration and using DAP instead of NPK. No significant yield differences were found between the NPK and DAP applications (for the same level of P application). However, significant cost reductions resulted from using DAP instead of NPK, estimated at 7,800 FCFA per hectare (US$16 per hectare), leading to higher benefit-cost ratios using DAP.

As originally developed by agricultural researchers, micro-dosing meant applying small quantities of fertilizer with the seed in the planting hole. However, because of labor constraints, farmers have modified this application method. To save labor, farmers usually mix their seed with the fertilizer and then plant them together. Other variants include applying the fertilizer directly to the plant after it emerges, allowing farmers to maximize fertilizer uptake by the plant. This side dressing of inorganic fertilizer is farmers' attempt to reduce the quantity applied while increasing the efficiency, because the fertilizer is applied directly to the plant and usually covered by soil. In this paper, the term *micro-dosing* is be used to mean any application of a small quantity of inorganic fertilizer, whether applied directly in the hole during planting, mixed with seed before planting, or applied after the plant emerges (Pender et al. 2008).

2.3. Inventory credit schemes or warrantage

The warrantage scheme or the inventory scheme is a major marketing strategy promoted in the Sahelian region. Since 1999, the FAO Projet Intrants has attempted to improve household liquidity by introducing and promoting inventory credit (warrantage) schemes. These schemes provide credit to farmers at harvest time using part of their production pledged as collateral. In 2004, the value of credit supplied was estimated at about US$1.4 million.

At harvest, farmers place part of the produce (usually millet or sorghum) in a local storage warehouse ("crop bank"), usually operated by a farmers' association, in exchange for a warehouse receipt that can be used as collateral with a financial institution. Against this, farmers receive an amount of credit less than the current value of the collateral at harvest, helping to reduce default risk. The fact that prices normally rise after harvest also helps to reduce default risk by increasing the borrower's equity. Formally, farmers are obligated to repay the loan even if the value of their collateral falls rather than rises while in storage. However, the risk of default by borrowers is greater in this case, of course. Crop banks are often linked to small savings and loans institutions as sources of funding for the inventory credit scheme. In addition, the Projet FAO Intrants conducted a training program on alternative income generating activities enabling farmers to use the credit to invest in those activities.

3. Methodology and data

The methodology and data is presented in this section.

3.1. The project sites and potential adoption area

In each country, only the project sites have been considered as potential sites for first diffusion or adoption. The area covered by the project sites are those that were considered in the calculation of ex-ante social gains. Table 1 summarizes the potential area of adoption of technologies and innovations in HOPE countries.

Table 1. Estimated area where HOPE interventions are located.

Region	Pearl millet			Sorghum		
	Area (ha)	Production (t)	Yield (kg/ha)	Area (ha)	Production (t)	Yield (t/ha)
Burkina Faso	31800	28800	0.906	58700	56600	0.964
Mali	29600	24000	0.811	22900	18600	0.812
Niger	196000	93200	476	74400	27700	401
Nigeria	396000	368000	968	250000	241000	974
Area covered	653400	-	-	406000	-	-

3.1.1. Burkina Faso

In Burkina Faso, the following provinces are the potential areas of diffusion of technologies and innovations in Burkina Faso. These include the provinces of Nouhoum, Namentenga, Nayala, Passore, and Sanmatenga. This occupies a total area of 31800 ha for pearl millet and 58700 ha for sorghum.

Table 2. Area, production and yield of Pearl millet and sorghum in HOPE intervention sites in Burkina Faso (2005-09)

Province	Pearl millet			Sorghum		
	Area (ha)	Production (t)	Yield (kg/ha)	Area (ha)	Productio n (t)	Yield (t/ha)
Mouhoun	37200	40300	1.083	48800	63300	1.297
Namentenga	29600	28800	0.973	57200	54500	0.953
Nayala	33800	28600	0.846	39500	34500	0.873
Passoré	17600	14800	0.841	66800	60600	0.907
Sanmatenga	40600	31500	0.776	81500	70000	0.859
Area covered	31800	-	-	58700	-	-

3.1.2. Mali

In Mali, the major cercles targeted Badiangara, Bla, Bougouni, Dioïla, Djenné, Kangaba, Kati, Kita, Kolokani, Kolondiéba, Koulikoro, Koutiala, Mopti, Sikasso, Ségou, Tominian, Yorosso located in the Kayes, Koulikoro, Sikasso, Ségou and Mopti regions.

Table 3. Area, production and yield of Pearl millet and sorghum in HOPE intervention sites in Mali (2005-06)

Region	Pearl millet			Sorghum		
	Area (ha)	Production (t)	Yield (kg/ha)	Area (ha)	Productio n (t)	Yield (t/ha)
Mali						
Badiangara	36000	12300	0.342	13800	2396	0.174
Bla	54900	56800	1.035	21500	19700	0.916
Bougouni	10500	10500	1.000	27600	25400	0.920
Dioïla	32500	25800	0.794	37400	29400	0.786
Djenné	28300	11100	0.392	4247	1058	0.249
Kangaba	5398	3672	0.680	18500	15200	0.822
Kati	8823	5290	0.600	20300	14500	0.714
Kita	7062	6333	0.897	34600	32200	0.931
Kolokani	21000	17700	0.843	40300	30500	0.757
Kolondiéba	11100	9582	0.863	14600	12700	0.870
Koulikoro	32200	21000	0.652	30200	24000	0.795
Koutiala	53900	55000	1.020	41900	39800	0.950
Mopti	25300	11600	0.458	4889	2862	0.585
Sikasso	15500	14700	0.948	14000	11200	0.800
Ségou	111000	101000	0.910	15300	12400	0.810
Tominian	35200	28400	0.807	25000	18500	0.740
Yorosso	15400	16600	1.078	25700	24600	0.957
Total	**29600**	**24000**	0.811	**22900**	**18600**	0.812
Source : FAO, COUNTRYSTAT 2011						

3.1.3. Niger

In Niger the HOPE project is involved in seven departments namely Keita, Kolo, Say, Loga, Mayahi Guidan Roumdji and Tera. Table 4 shows the agricultural statistics by department in the last 5 years (2005 to 2009).

Table 4. Area, production and yield of Pearl millet and sorghum in HOPE intervention sites in Niger (2005-06)

Departement	Pearl millet			Sorghum		
	Area (ha)	Production (t)	Yield (kg/ha)	Area (ha)	Production (t)	Yield (t/ha)
G/Roumdji	199000	95500	479	153000	57700	380
Keita	142000	67600	468	72900	28100	382
Kollo	215000	128000	594	12900	7091	551
Loga	162000	58000	352	4973	1360	271
Mayahi	185000	89100	484	159000	54900	340
Say	169000	98400	570	27400	14700	539
Tera	301000	116000	385	90300	29800	342

Departement	Pearl millet			Sorghum		
	Area (ha)	Production (t)	Yield (kg/ha)	Area (ha)	Production (t)	Yield (t/ha)
Area covered	196000	-	-	74400	-	-

3.1.4. Nigeria

In Nigeria, 6 states were targeted namely Borno, Jigawa, Katsina, Kebbi, Sokoto and Yobe. Table 6 below presents the agricultural statistics in terms of area, production and yield.

Table 5. Area, production and yield of Pearl millet and sorghum in HOPE intervention sites in Nigeria (2005-06)

State	Pearl millet			Sorghum		
	Area (ha)	Production (t)	Yield (kg/ha)	Area (ha)	Production (t)	Yield (t/ha)
Borno	461000	504000	1096	337000	416000	1246
Jigawa	393000	279000	790	310000	198000	738
Katsina	424000	337000	849	354000	357000	1000
Kebbi	188000	203000	1089	144000	167000	1205
Sokoto	548000	495000	899	149000	92100	604
Yobe	363000	387000	1085	205000	216000	1053
Area covered	396000	-	-	250000	-	-
***Sour*ce : FAO, COUNTRYSTAT 2011**						

3.2. Data collection

The values of the key parameters utilized in the calculation of ex-ante gross social gains are presented in Table 7. We use expert opinions for the estimates of productivity as well as the maximum adoption changes and crop management. Productivity gains from crop improvement ranged from 10 to 15% and that of crop management from 20 to 35%. The maximum adoption rate from 20 to 30% from crop improvement and is lower for crop management. A three year lag was assumed to reflect the time needed to start using technologies and innovations in project sites. The adoption lag was set to 10 years in this case to reflect the project life expected to be 10 years. The elasticity of supply was estimated to 0.7 was most cereal grains, and the demand was assumed to be perfectly elastic. The discount rate was assumed to 5% almost equivalent to the central bank discount rate in many Sahelian countries.

Table 6. Values of key parameters used in the projection of sorghum and pearl millet impacts by country.

Parameter		Values						
		Burkina Faso		Mali		Niger	Nigeria	
		PM	S	PM	S	PM	PM	S
Productivity change (%)								
	Crop improvement	10	15	15	15	15	10	15
	Crop management	20	25	25	30	30	30	35

Maximum adoption (%)								
	Crop improvement	20	25	30	30	25	30	30
	Crop management	10	15	20	25	15	10	10
Gestation lag (years until start of adoption)		3	3	3	3	3	3	3
Adoption lag (years until maximum adoption)		10	10	10	10	10	10	10
Elasticity of supply		0.7	0.7	0.7	0.7	0.7	0.7	0.7
Elasticity of demand		PE	PE	PE	PE	PE	PE	PE
Discount rate (%)		5		5		5	5	5
Project duration		2009-19	2009-19	2009-19	2009-19	2009-19	2009-19	2009-19
Time path of benefits from investments		2012—19	2012—19	2012—19	2012—19	2012—19	2012—19	2012—19
PM means Pearl millet; S means Sorghum, PE perfectly elastic								

3.3. Economic surplus

An economic surplus model (Alston et al., 1995) was used to derive summary measures of the potential impacts of legumes improvement under certain reasonable assumptions for research starting in 2009 and benefits accruing from 2011 (beginning of adoption of improved technologies) to 2019. The benefits were measured based on a parallel downward shift in the (linear) supply curve following research. The annual flows of gross economic benefits from crop improvement were estimated for each of the countries and aggregated, with the aggregate benefits finally discounted to derive the present value (in 2011) of total net benefits from the intervention. The key parameters that determine the magnitude of the economic benefits are: (1) the expected technology adoption in terms of area under improved technologies; (2) expected yield gains following adoption; and (3) pre-research levels of production and prices.

Specifically, the economic surplus empirical model for an open economy was used to calculate the economic benefits for each country from a downward shift in the supply curve. In an open economy, economic surplus measures can be derived using formulas presented in Alston et al. (1995)—i.e. change in economic Surplus (ΔES) = $P_0 Q_0 K_t (1+0.5K_t\varepsilon)$; where K_t is the supply shift representing cost reduction per ton of output as a proportion of product price (P); P_0 represents pre-research price for 2006—2008 (US$/ton); Q_0 is pre-research level of production for 2006—2008; and ε is the price elasticity of supply. The research-induced supply shift parameter, K, is the single most important parameter influencing total economic surplus results from unit cost reductions and was derived as $K_t = A_t (\Delta Y/Y)/\varepsilon$ where $\Delta Y/Y$ is the average proportional yield increase per hectare, with the elasticity of supply (ε) used to convert the gross production effect of research-induced yield changes to a gross unit production cost effect.

Annual supply shifts were then projected based on projected adoption profile for improved technologies (A_t) for the period from 2011 to 2019 for research starting in 2011. Adoption (A_t) is assumed to follow the logistic diffusion curve starting in 2011 with less than 1% of the area put under improved technologies in 2011. In view of the already available pool of improved technologies some of which would only need investments in seed production and distribution, a research lag of only 2 years was assumed from the year of initial research investment in 2011 to the beginning of adoption of technologies in 2019. Table 1 presents the values of some of the key project-, technology-, and market-related parameters used in the projection of impacts of legumes research and extension. The values of these parameters and others were assembled from several sources—such as project proposal, past empirical work (e.g. Alston et al. 1995; Alene et al. 2009), and others (e.g. FAOSTAT). Figure 1 presents the projected technology adoption profiles for legumes implied by the expected values of the technology parameters.

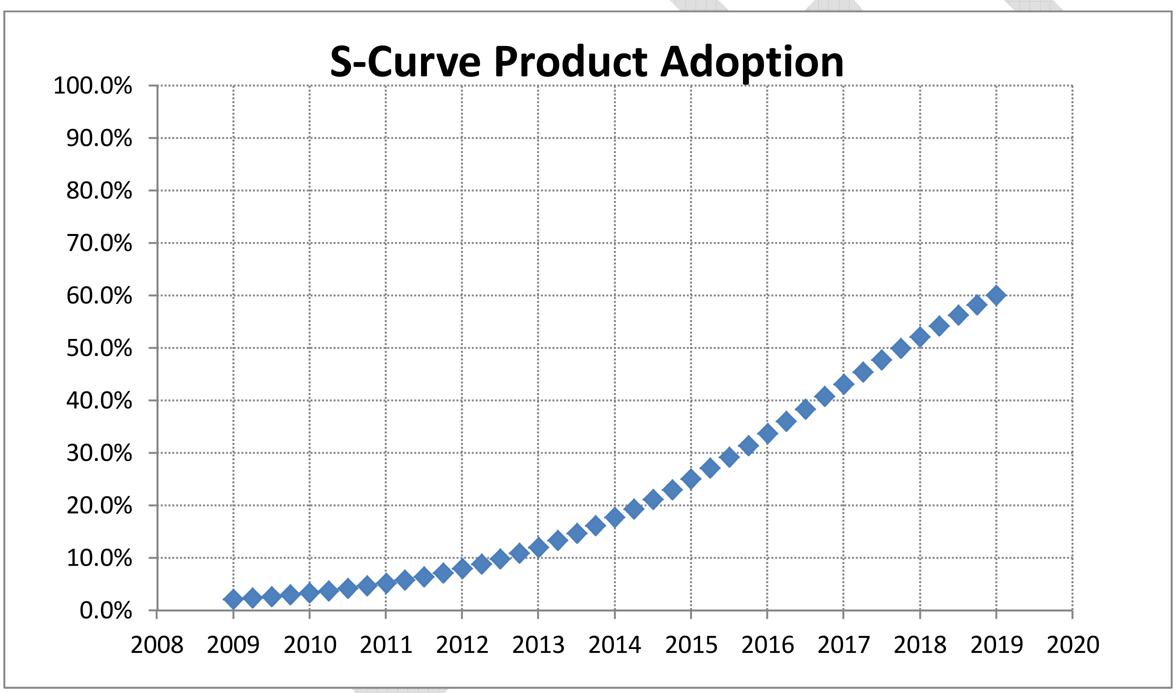

Figure 1. Projected adoption profile for technologies and innovations from 2009 to 2019 (adoption curve)

4. Results and discussions

Table 3 below summarizes the measures of the ex-ante gross economic benefits from the promotion of 3 technologies and innovations through the HOPE project in the next 10 years from 2009 to 2019. No lagas assumed between research and development investment and reaping the full benefits, the projections of benefits and returns under any short-term scenario represent more conservative estimates of the social profitability of research investments. Although subsequent benefits will not flow without further research and extension investments beyond 2019, the analysis that links project investments to a finite stream of benefits (2009 -2019) is bound to understate the true benefits.

The present value of gross benefits of technologies and innovations in HOPE area is estimated at US$101,296,000. Crop improvement and especially the promotion of modern varieties already released account for 39.24% of the gross social gains, the crop management technology; fertilizer micro-dosing will contribute about 34% and the warrantage scheme will account for 27% of the gross total gains generated with the introduction of the 3 technologies and innovations. At country level, Nigeria is by far the country with the highest share of social gains accounting for about 75% of the total, followed by Niger (14%), Burkina Faso (5.5%) and Mali (4%).

Table 7. Ex-ante social gains from technologies introduced since 2009 in the HOPE countries

		Technologies			*Total*	
Country	*Crop*	*Crop Improvement*	*Micro-dosing*	*Warrantage*	US$	Percent
Burkina Faso	Pearl millet	380.16	108.54	351.639	840.34	0.83%
	Sorghum	1,770.45	1,299.27	1690.997	4,760.71	4.70%
Mali	Pearl millet	718.77	472.33	806.901	1,998.00	1.97%
	Sorghum	428.23	914.74	589.397	1,932.37	1.91%
Niger	Pearl millet	3,947.90	4,596.04	4847.217	13,391.15	13.22%
	Sorghum	580.91		951.76	1,532.67	1.51%
Nigeria	Pearl millet	13,078.72	12,892.25	9405.281	35,376.25	34.92%
	Sorghum	18,844.45	14,006.85	8613.712	41,465.01	40.93%
Total		39,749.59	34,290.01	27,256.90	101,296.50	100.00%
% Percent		39.24%	33.85%	26.91%	100.00%	

5. Conclusions and implications

A range of technologies is available but not accessible to smallholder farmers in the semi-arid tropics of West Africa. If technologies such as improved pearl millet and sorghum varieties, the fertilizer micro-dosing technology and a market innovation such as the inventory credit scheme were made available to smallholder farmers through the HOPE project, this is likely to generate large potential social gains estimated to about US$ 101,296,000 with regard to investments estimated to about US$30,000,000 in West Africa in 10 years.

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Annex 1. Sorghum and pearl millet varieties released less than 25 years ago in Burkina Faso

Name of the variety	Year of release	Institutional source	LGP (#days)	Potential yield (ton/ha)	Plant height	Weigth of 1000 grains (grams)	Specific characteristics
Pearl millet							
IKMP2	1987	ICRISAT-INERA	105				Tolerant to leaves disease, adapted to poor soil
IKMP3	1987	ICRISAT-INERA	87		115-120		Sensible to photoperiod
IKMV 8201	1986	ICRISAT-INERA	90	1.5-2	200		Sensible to photoperiod, Tolerant to insects, leaves diseases and Striga
ICMV-IS 88 102	1994	ICRISAT-INERA-IER	120				Sensible to mold, smut and bugs
IKM P5	1987	ICRISAT-INERA	110	1.9			Tolerant to leaves disease, good response to fertilizer, good fodder quality
IKMP1	1987	ICRISAT-INERA	115-120	1.9			Tolerant to leaves disease, good response to fertilizer, good fodder quality
Sorghum							
SARIASSO 10	1989	INERA/CIRAD	125-130	4.1	250	23-26	
SARIASSO 13	1991	INERA/CIRAD	120	4.2	240-275	18-21	Tolerant to pearl mildew
KASSAROKA	1998	INERA	120-130	2.2	410	22	
SARIASSO 14	1992	INERA	110-115	4.7	190	18-22	Tolerant to smut.
SARIASSO 09	1989	INERA	80-115	3	350-400	22-25	Tolerant to pearl mil mildew
KAPELGA	1999	INERA/CIRAD	100-105	2.2	300-310	22	Non lodging, drought tolerant, and non-scent variety with good response to fertilizers, grains have good food and malting quality
SARIASSO 11	1992	INERA/CIRAD	100-105	3-4	200	20	Sensible to smut
SARIASSO 12	1991	INERA/CIRAD	110-115	3	300-350	23	

Annex 2. Sorghum and pearl millet varieties released less than 25 years ago in Mali

Name of the variety	Year of release	Institutional source	LGP (#days)	Potential yield (ton/ha)	Plant height	Weigth of 1000 grains (grams)	Specific characteristics
Pearl millet							
Sanioteli 53	2002	IER	150-160	2.5	300	12	High yielding
IBV 8004	1987	ICRISAT - ISRA	75-85	2-2.5	220	9	Sensible to smut and Pearl milletdew
GUEFOUE 16	2002	IER	105	2.5	250-300	9	High yielding
Sanioba 23	2002	IER	150-160	2.5	300	13	Good for brewing, high yielding
M2D2	1987	IER	100-105	2.5	220-250	9-10	Tolerant to Pearl milletdew and smut.
IBV 8001	1987	ICRISAT - ISRA	75-85	2-2.5	225	9	Tolerant to Pearl milletdew and smut.
M12D1	1987	IRAT-IER	130-140	3	350-450	10-11	Tolerant to leaves diseases, good response to fertilizer
NKK	1987	IER	100-110	2-2.5	250-300	10-12	Less sensible to smut and Pearl milletdew, tolerant to Striga
Pool 9	1994	IER - ICRISAT	110-115	1.2	200-275	12.5	
NBB	1987	IER	100-125	2.5	200-250	10-13	Sensible to smut and Pearl milletdew
IRAT P172	1987	IRAT	110	1.5	120	10-12	Less sensible to Pearl milletdew and smut.
Souna 3	1987	ISRA-INRAN-IER	75-95	1.2-2.5	190-240	6.5-7.6	sensible to smut
AMEL.M01	2007	IER	100	1.9	235	10	Early maturing, tolerant to striga and good palatability
Pool 6	1994	IER Mali/ICRISAT	100-105	1.5	200-205	12	
ITMV 8304	1993	ICRISAT - INRAN - IER	80-85	2.5	200-220	9	Sensible to smut
Toroniou C1	1994	IER - ICRISAT	105-110	1-2	250-300	9-10	
Indiana 05	2002	IER	110-120	2	200	14	High yielding, high quality pearl grain
HKP /IRAT P1	1987	IRAT-INRAN	80-90				sensible to smut and Pearl milletdew
Mangakolo	1994	IER	110-120	2	300-350	16	
Guefoue 16	2000	IER	105	2	250-300	13	Early maturing
Benkadinio/ICMV-IS 88 102	1994	ICRISAT-INERA-IER	120	2.5	250-300	16	
Composite Souna x Sanio	1994	IER - ICRISAT	95-100				
IBV 8003	1987	ICRISAT - ISRA	85				
Sanioba 03	2002	IER	105-110	2	250-300	13	Early maturing
IKMV 8201	1994	ICRISAT - INERA-IER	90	1.5-2	200		
M9D3	1987	IRAT-IER	125-130	3	350-400	10-12	sensible to smut
Djiguifa	1994	IER	110-120	2-2.5	200-300	13	Tolerant to smut
Sorghum							
TOROBA	2007	ICRISAT-IER-AOPP	135	3	400	21	
SARIASSO 10	1998	INERA	125-130	2	340	23	Stable yield
Séguétana/CZ	2002	ICRISAT-IER	120	1.5-2	350	24	Very sensible to photoperiod, Resistant to smut , Tolerant to grain mold, striga and

Name of the variety	Year of release	Institutional source	LGP (#days)	Potential yield (ton/ha)	Plant height	Weigth of 1000 grains (grams)	Specific characteristics
							verse, stable yield
SAKOYKABA	2007	IER-ICRISAT	135	2.8	400	21	
Kolobakari/MIPSOR 90 25-88	2001	IPR-IFRA	120-130	2.5-3.5	450-500	22	Sensible to Striga
KALABAN	2007	IER-AOPP-ICRISAT	115	3.5	270	21	
Zarra/96-CZ-FUP-99	2002	IER	125-130	2.5	400	22	Stable yield
CSM 415	1987	IER	115	2	200	30	Sensible to photoperiod, Tolerant to smut and Pearl milletdew, resistant to drought
Sofila Sigui/ Malisor 84-1	1987	ICRISAT	110	2	200	31	Very sensible to photoperiod, Tolerant to smut and Pearl milletdew, Resistant to drought
NIETA/ 97-SB-F5DT-74-2	2007	IER	120-125	2	350	23	
Tassouma/MIKSOR 86 30-42	2001	IPR-IFRA	100-120	2.5-3	350-400	22	Sensible to striga, stable yield
NAFALEN	2007	IER-AOPP-ICRISAT	130	3.5	270	21	Tolerant to helmintosporiose
Djakèlè/MIGSOR 86 30-03	1998	IPR-IFRA	90-100	2-2.5	160	22	
Malisor 84-5	1987	IER	100	2.5	150-200	23	
Kolossina/MIPSOR 90 25-95	2001	IPR-IFRA	120-130	2.5-3.5	500-550	22	Stable yield
Gnogomè/MIPSOR 90 30-23	1998	IPR-IFRA	100-120	2.5-4	400-500	22	
Sdjè/MIPSOR 90 30-75	1998	IPR-IFRA	90-100	2.5-3	350-400	22	
Marakanio/CGM 19/9-1-1	2002	ICRISAT-CIRAD	120	3	250	20	Less sensible to photoperiod, Tolerant to insects, leaves diseases and striga
N'Toko/CSM 219 E	1987	IER	105	2	230	20	
N'Tènimissa	1998	IER	125-130	2	350	23	
Soumalemba/IS 15401	2002	ICRISAT-CIRAD	110	2	440	30	Not sensible to photoperiod, tolerant to smut, good vigor
Gadiaba	1987	IER	110-120	2-2.5	250	23-30	Less sensible to photoperiod
96-CZ-F4P-98	2002	IER	125-130	2.5	400	23	Stable yield
Soumba /CIRAD 406	2002	CIRAD-ICRISAT	105-110	2.8	240	21	Less sensible to photoperiod, Tolerant to insect, Sstriga and diseases
98-SB-F2-78	2002	IER	120	2.5-3	175	21	Sensible to photoperiod, Resistant to smut , Tolerant to grain mould, adapted to drought because of it has a well-developed root system, stable yield
Kossa/CSM 485	2002	ICRISAT-IER	130	2.5	420	21	
BOBODJE	2007	ICRISAT-IER	130	2.5	380	21	
Soblé/MIKSOR 86 25-11	1998	IPR-IFRA	95-100	2-2.5	250	21	
ICSV 401	1994	ICRISAT	105	2.5	200		Less sensible to photoperiod, Tolerant to

Name of the variety	Year of release	Institutional source	LGP (#days)	Potential yield (ton/ha)	Plant height	Weigth of 1000 grains (grams)	Specific characteristics
							smut, Pearl milletdew, resistant to drought
Foulatiéba	1998	IER	130	2.5	420	30	Very sensible to photoperiod, less sensible to smut and Pearl milletdew
Grinkan/02-SB-F4-DT-275	2007	IER	125	2.5	200	30	
Fambè/ MIKSOR 86-30-41	1998	IPR-IFRA	medium	2.5-3	350-400	22	Sensible to striga
Séguifa/Malisor 92-1	1993	IER	100	3	200	30	
Tiéblé/CSM 335	2002	ICRISAT-IER	125	2.5	360	21	Tolerant to insects and dIseases
Sariaso	1998	IER	125-130				
Dusu Suma/89-SK-F4-53-2PL	1998	IER	117	2-3	180	21	Less sensible to photoperiod, Tolerant to smut and Pearl milletdew
N'Gno-Déni/MIPSOR 90 25-93	2001	IPR-IFRA	120-130	2.5-3.5	150-600	22	Stable yield
NIATICHAMA/ 97-SB-F5DT-150	2007	IER	110-120	2	250	23	
Kolodjan/MIPSOR 90 30-61	2001	IPR-IFRA	110-120	3-4	450-500	22	Stable yield
IPS 0001	1991	IPR-IFRA	130-140	2	400-500	23	
Tièdjan/MIDSOR 88 10-01	1998	IPR-IFRA	100-110		350-400	18	
Yakaré/ICSV 1079	2002	ICRISAT-IER	105-110	2	170-180	21	Less sensible to photoperiod, Tolerant to insect, striga and diseases
Souroumani/MIPSOR 90 30-34	2001	IPR-IFRA	100-110	2-3	200-250	21	
N'Golofing/CSM 660	2002	ICRISAT-IER	120	2	355	23	Sensible to striga, Stable yield
Ansona/CMI 06	2001	IPR-IFRA	100-120	2.7-3.8	350-400	22	Stable yield
Jigisèmè/CSM 388	1987	IER	125	1.5	370	25	Less sensible to photoperiod, Tolerant to smut, Pearl milletdew, resistant to drought
Tiémarifing	1987	IER	125-130	2	350-450	21	Less sensible to photoperiod, yield stability
Malisor 84-4	1987	IER	90-110	1.2	120-200	23	Sensible to smut, cecidomya and bugs, tolerant to grain mold, drought and Striga
Wassa/97-SB-F-5DT-63	2002	IER	105				Sensible to photoperiod, Resistant to smut , Tolerant to grain mould and verse, stable yield
Gnoumanin/MIDSOR 88 10-6	1998	IPR-IFRA	100-120	2.5-3	350	18	Sensible to Striga
ACAR/ 108 99-SB-F5DT-196	2002	IER	120	2	300	25	
Kénikédjè/97-SB-F-5DT-64	2002	IER	110	2	350	20	Sensible to photoperiod, Resistant to smut , tolerant to grain mold, striga and verse, stable yield

Name of the variety	Year of release	Institutional source	LGP (#days)	Potential yield (ton/ha)	Plant height	Weigth of 1000 grains (grams)	Specific characteristics
Djéman/MIDSOR 88 10-02	1998	IPR-IFRA	100-110		350-400	18	Good response to farming practices
Djémani/MIDSOR 88 10-04	1998	IPR-IFRA	100-120	2-3	350-400	18	
Dabitinen/ Malisor 84-7	1987	IER	115	1.6	150-200	16	Very sensible to photoperiod, tolerant to smut, Pearl milletdew, sensible to birds, excellent food quality
Jakunbè/CSM 63 E	1987	IER	100	2	200	21	
Nazongola Anthocyane	2002	ICRISAT-IER-CIRAD	105-110	2	300	21	Sensible to photoperiod, tolerant to insects and diseases
Sofin /MIKSOR 86-25-13	1998	IPR-IFRA	95-100	2.5-4	250-350	21	
Tiémantiétéli/CSM 417	1994	IER	115	1.5	250	20-30	Photoperiod sensitive, tolerant to smut and Pearl milletdew, sensible to striga and resistant to drought

Annex 3. Pearl millet and sorghum varieties released during the last 25 years in Niger

Name of the variety	Year of release	Institutional source	LGP (#days)	Potential yield (ton/ha)	Plant height	Weight of 1000 grains (grams)	Specific characteristics
Pearl millet							
H-80-10GR	1989	INRAN	80-85	2.5	200-230	9	Resistance to smut and Pearl milletdew
HKP3 Hainikinire	1987	INRAN	70-75	2	150-200	7-8	
Zongo Kolo	1987	INRAN	95-100	2.5	170-180	9-10	
SOSAT-C88	2000	ICRISAT	85-90	2.5	200	10	Drought, less sensible to photoperiod
ICMV IS 90311	1990	ICRISAT	95	1-1.5	220	9.5	
ICMV IS 92222	1992	ICRISAT	95	2	250	10.5	
ZATIB	1996	INRAN	90-95	2-2.5	160-190	12-13	Sensible to striga and drought
GGP (Gros Grain precoce)	1997	ICRISAT	80	2	220	20	Less sensible to smut, tolerant to Pearl milletdew.
CT-3	1996	INRAN	75-80	0.8-1.2	220-240	7-9	Tolerant to weeds (advantis)
Ankoutes (ANK)	1987	INRAN	80-85	2	145-150	8-9	
HKB-P-I:	1987	INRAN	90-95	2.5-3	90-200	8-9	Sensible to smut and Pearl milletdew
SOSANK	1998	ICRISAT	95	2.5	200	13	
GB8735	1987	ICRISAT	70	1.5	150	12	Sensible to photoperiod, Tolerant to insects, leaves diseases and Striga
DG-P1: Dan Gombe	1987	INRAN	85-90	2-3	145-150	10-11	Sensible to photoperiod, sensible to insects, leaves diseases and Striga
FARINGUERO	1997	ICRISAT	95	1.5	230	16	Sensible to photoperiod, Tolerant to insects, leaves diseases and Striga
T18-L	1987	INRAN	90-95	2.5	190-200	8-9	Resistant to major leaf diseases eg. leaf blight sooty stripe, zonate leaf
ICMV IS 94206	1994	ICRISAT	95	2	250	10.5	Tolerant to smut
ICMV IS 99001	1999	ICRISAT	95	1.5	250	11	
Ankoutess amelioree	1996	ICRISAT	95	2	225	10	, Very resistant to cecidomie, Adapted in intercrop wirth maize
CT-6	1996	INRAN	80-85	1-1.5	180-200	8-10	Not sensible to photoperiod, Resitant to verse, Tolerant to leaves diseases
ICMV IS 89305	1989	ICRISAT	95-100	2	250	10	
Sorghum							
SEPON – 82	1990	ICRISAT	90	2-2.5	150-170	18-20	
S RN 39	1991	IAR	90-95	2	140-160	25	tolerant to smut
NAD-1	1991	INRAN	85-90	3-4	150-200	24	

Annex 4. Sorghum and pearl millet varieties released less than 25 years ago in Nigeria

Name of variety	Year of inscription/ release	Institutional source	AEZ (# days)	Potential yield (tons/ha)	Plant height	Weight of 1000 grains (grams)	Specific characteristics
Pearl millet							
LICICMV-2	2003	ICRISAT-LCRI					Less sensible to photoperiod, Tolerant to insect, striga and diseases
SOSAT - C88	2000	ICRISAT-IER	85-90	2.5	130-180	10	High yielding
LCICMH-1	2005	ICRISAT-LCRI					Less sensible to photoperiod, Tolerant to insect, striga and diseases
Sorghum							
SAMSORG-45(ICSV89001)	1989	ICRISAT					
CSR 02 (Farafara Ex-Katsina)	2006	NBPLC (Farmer fields)					Tolerant to helmentosporiose
SAMSORG-41 (ICSV – 111)	1996	ICRISAT					and drought, less sensible to photoperiod
S RN 39	1991	IAR	90-95	2	140-160	25	tolerant to Pearl milletdew and smut.
SAMSORG-44(ICSV89009)	1989	ICRISAT					
SAMSORG-40(ICSV – 400)	1996	ICRISAT					Very sensible to photoperiod, Tolerant to smut and Pearl milletdew
CSR 01 (Farafara Ex-Kano)	2006	NBPLC (Farmer fields)					, Tolerant to striga

Annex 5. Crop management technologies in the HOPE project.

Technology	Application	Adaptation zone	Limitations	Potential yield in optimal conditions
Mode d'apport de l'engrais azoté sur le Sorghum	- Apport de 50 kg de N/ha sous forme d'urée (108kg), d'ammonitrate de calcium (CAN) (178kg) ou de NPK (330kg). - Application à la volés + Incorporation (urée et NPK) et placement au poquet avec incorporation pour le CAN. - Première moitié appliqué au démariage (3e semaine) et seconde moitié au tallage (6^{e} semaine)	Applicable en zone soudano-sahelien: pluviométrie variant entre 400et 800 mm	Pas de réponse de l'azote en cas de non correction des déficiences en phosphore	50kg of N/ha brings 1000 kg/ha of additional yield
Application à la volée de l'engrais phosphaté soluble ou naturel sur les cultures pluviales	- Apport annuel de 13 kg p/ha sous forme de P2O5 (30kg), super phosphate simple SSP (150kg) ou phosphates naturels de Tahoua PNT (130kg). - Application à la volée + incorporation - Quelques semaines avant le semis.	- Pluviométrie > 350 mm pour les phosphates solubles. - PH<5 et pluviométrie > 500 mm pour le PNT	Sols faiblement acides, neutres ou alcalins	Increase in yield by 100% with SSP application and et 30 à 60% with PNT application
P application hill placed (NPK on pearl Pearl milletlet)	- Apport de 4kg de phosphore/ha sous forme de NPK (60kg/ha ou 6g/poquet) - Placement dans le poquet au moment du semis	Sol déficient en phosphore et pluviométrie supérieur à 500 mm	Pluies de semis de moins de 25 mm	40% yield increase in station
Striga control by weeding	- Effectuer un troisième sarclage au moment de la floraison du Pearl millet	Champs de Pearl millet fortement infestés par le striga	Forte besoin en main d'œuvre ou de l'équipement approprié	• 50 à 90% reduction in striga flowering • In 4 years, réduction of striga seed stocks in the soil from 200 to 900 grains/kg
Striga control by late planting	Semis de variété de Pearl millet tardives photosensibles 8 à 10 semaines après la 1ere pluie supérieure à 20 mm	Champs de Pearl millet fortement infestés par le striga dans la zone soudanienne.	- Uniquement des zones adaptées au semis tardif - Disponibilité des variétés tardives et photosensibles	Reduction by 99% of striga infestation
Striga control with leguminous	Culture du Pearl millet et du niébé en association ou l'arachide en rotation avec le Pearl millet	Champs de Pearl millet fortement infestés par le striga	Zone adaptée à la culture des légumineuses	Reduction of striga infestation by 35% and pearl millet grain yield by 20%