Socioeconomics
Discussion Paper Series

Series Paper Number 22

A combined ex-post/ex-ante impact analysis for improved sorghum varieties in Ethiopia

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10/17/2014

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This work has been undertaken as part of the CGIAR RESEARCH PROGRAM ON Dryland Cereals

Acknowledgment

The authors like to express their gratitude and thanks to Dr. Alastair Orr, Assistant Director at ICRISAT Nairobi Office who supervised the impact study, provided the necessary financial resources and gave valuable advice on the scope of analysis, methodology and structure of this report. Our special thanks go to all scientists from the Ethiopia Institute of Agricultural Research EIAR at Melkassa Agricultural Research Center who participated in the three days impact assessment workshop in Melkassa in September 2013 and the second one day workshop in June 2014. Our thanks also go to ICRISAT staff at the Ethiopian country office in Addis Ababa, namely Dr. Karuturi Rao (Head of ICRISAT office), Dr. Abdalla Mohamed Hassan, and Ms. Tigist Abrham for providing the organisational support for the two workshop events in 2013 and 2014. This study could not have been undertaken without their enthusiasm, profound knowledge of all aspects of the sorghum sector in Ethiopia and their commitment in elaborating the underlying economics and adoption information from all sorghum regions.

Executive Summary

This country-level impact study for Ethiopia combines ex-post and ex-ante estimation of research gains from improved sorghum varieties developed by the National Breeding Program of Ethiopia in collaboration with partners from international research institutions and universities. The methodological framework for the study is the standard economic surplus concept embedded in the DREAM model within a multiple domestic market configuration, price spill-overs, and separate impact parameters (adoption path and yield differentials) for each improved sorghum variety under consideration. Several model scenarios are developed and applied to test the robustness of impact parameters and portray components of ICRISAT's development approach in the socioeconomic domain. One group of scenarios refers to ICRISAT's traditional breeding and crop management activities. The other group captures elements of ICRISAT IMOD strategy (Inclusive Market Oriented Development) by defining various markets and trading frameworks.

A three days impact assessment workshop was conducted in September 2013 in Melkassa, Ethiopia and organised by the Ethiopian Institute of Agricultural Research. Sorghum breeders, agronomists and socio-economists were invited to elaborate on the necessary information for a model based impact assessment study, and guided by an ICRISAT facilitator through an eight-stage data elicitation process. A second one-day workshop followed in June 2014 to complete the pending tasks.

The Ethiopian breeding program is structured around specific agro-ecologies: the highlands, intermediate attitude, moist lowlands in the western part of Ethiopia and the dry lowlands covering large areas in the Northern and Eastern parts of the country. The EIAR sorghum scientists at the workshops identified 23 improved sorghum varieties which are already released onto the market. Some varieties were omitted as they were considered as inferior compared to other varieties. Out of the 23 varieties, 4 open pollinating varieties (OPV) are destined for the highlands, 6 OPV varieties for the intermediate altitudes, 1 OPV variety for the moist lowlands, 7 OPV and 3 hybrid varieties for the dry lowlands. Profitability of the improved varieties measured as gross margin/ha varies considerably between 250 USD for the dry lowland striga resistant varieties and 1,000 USD for the highland varieties. The major reasons are large regional variations in the yield level caused by variety specifc yield potentials and diverse growing conditions across agro-ecologies. All improved varieties are superior to local varieties at a margin of 40-50% in terms of revenue, but incur higher 10-25% higher production costs compared to local varieties.

Ethiopia's sorghum sector is still dominated by local varieties. Based on the availabilty of improved from formal seed channels and farmers' own seed production, the current share of production which comes from improved varieties is estimated at around 5%. The experts increased this rate to around 8% by an upward adjustment of farmer's own seed production. The intermediate altitudes show an adoption rate of 2% (in terms of production share) and 15% in the dry lowlands. Both agro-ecologies together produce around 90% of all sorghum in the country. The EIAR scientists' held an optimistic view with regard to a continuing strong growth and modernisation dynamic of Ethiopia's cereal sector and concluded that adoption rates in 15 years' time may reach 50% in the dry lowlands and 10% in the intermediate altitudes, which sums up to a national adoption level of improved varieties at around 30%.

Research costs are calculated in a simplified budget format at around 360,000 USD/year, then deflated for each year in the ex-post analysis and subdivided among the improved varieties according to their period under research.

The economic performance of the Ethiopian sorghum breeding program in the baseline scenario is impressive. Overall research gains account for 760 million USD between 1971 and 2040 which translates into 40 million USD on an annual base. There is a strong research bias in favour of the dry lowlands. Only a small fraction of the research gains (11%) are targeted at the intermediate altitudes while the bulk of gains are allocated in the moist and dry lowlands. **Thus, the Ethiopian breeding program as it stands now discriminates heavily against the 'intermediate altitudes**' which produce around 45 % of the national sorghum but receive little attention in genetic improvements. Shakeholders needs to assess carefully the implications of a likely shift in sorghum production away from the intermediate altititudes towards the dry lowlands that will occur if the spread of improved varieties gain momentum in the future. One of the key question is certainly the extend to which sorghum production become riskier and more exposed long period of dry spells if part of the production is moved to the high-risk dry lowlands.

The sorghum breeding program favours farmers more than consumers under the assumptions made in the DREAM model with rather high S&D price elasticity values taken from IFPRI. Eighty percent of the gains are captured by producers. Older, first generation varieties tend to be economically inferior with lower IRR (8-20%) and higher research costs than the more recently released varieties. This reflects the challenging environment and learning process in a breeding program that took off in the 70s in east Africa. Underperforming varieties, low adoption rates, slow breeding process and time delays in market release are reasons to explain the rather modest share of research gains in the past (only 20%) while over 80% of the research gains (600 million USD) are predicted to occur in the future until 2040.

Four market and trade scenarios were conducted. The 'high-market integration' scenario' which mimicries better market efficiency and integration results in a higher share of the research gains captured by Ethiopian farmers as a consequence of limited price pressure. Hoever, the diversion of gains towards famers was much less pronounced if compared with similar scenarios from other impact studies conducted in Uganda and Tanzania. Inspection of the trade scenarios shows that the effects of cross border trade at a large scale does increase the size of the overall research gains but at a modest level. Those additional gains are fairly equally distributed between producers (larger sorghum market and reduced price effects) and consumers (larger sorghum supply and lower market prices). Varietal performance is robust with regard to lower-than-expected adoption rates and yields. Cutting adoption rate or yields by 50%, the IRR for most varieties remain attractive at levels above 20% IRR.

Ethiopia has achieved tremendous success in poverty eradication over the last 15 years, from a 45% poverty rate (head count) in 1995 down to 29.6% in 2010. Regional poverty disparity is much less pronounced compared to other ESA countries and varies between 36% in Afar, the poorest region, and 29% in Oromia, the richest region. Poverty in the Ethiopian sorghum sector persists but is not higher than the national average. The percentage of sorghum production, consumption, and the number of sorghum growing

households that fall in the poverty cluster is around 29% under the simplifying assumptions made in the analysis. The reasons for the rather low 'poverty footprint' in the sorghum sector are mainly (1) widespread cultivation across regions and agro-ecological zones including wealthier regions, (2) the low regional poverty disparity, and (3) moderately negative income elasticity in sorghum consumption that softens the strong divide in sorghum consumption between rural-urban and poor-rich which can be observed in other ESA countries. However, more empirical research is needed to investigate differences in household characteristics, adoption behaviour and profitability of improved sorghum varieties alongside various wealth clusters.

From the ex-post perspective, the Ethiopian sorghum breeding program has shown limited impact so far in reaching out to the rural 'poor'. Only 50,000 'poor' households which is equivalent to approximately 250,000 'poor' people have been reached on average between 1971 and 2013 annually as a result of limited number of imporved varieties and disappointing adoption rates far below 5%. However, the prospects for the future are excellent. At the current adoption rate, improved sorghum varieties are grown among 100,000 poor farmers (around 500,000 people). Under the assumption of a 'doubled poverty rate' among sorghum growers compared to national average these numbers increase to 200,000 'poor' households equivalent to over one million 'poor' people. If the spread of improved varieties reaches the level EIAR experts predict at around 30% in the future, the number of beneficiaries in the poor cluster can reach between 1.6 million and 3.3 million people, and between 330,000 and 660,000 households. This amounts to 7 – 14% of the national 'poor' population of 25 million (2013).

From a macro-economic perspective, the returns to investment are considerable from the available set of improved varieties, most of them are high potential and already ready for release and systematic propagation. Total expected research gains compounded until 2040 amount to 135 USD for each sorghum growing household, 1,890 USD for currently adopting households and 570 USD/household for the 1.1 million households that are expected to become adopters in the future.

Keywords: adoption, dream model, economic surplus, EIAR, Ethiopia, profitability, Sorghum, research impact

JEL classification:

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Acronyms

AEZ	Agro-ecological Zone
AGPS	Agricultural Growth Program Survey
CGIAR	Consultative Group for International Agricultural Research
CPI	Consumer Price Index
CS	Consumer Surplus
CSA	Central Statistical Agency of the Federal Democratic Republic of Ethiopia
DREAM	Dynamic Research Evaluation for Management
EAGC	East African Grain Council, Nairobi, Kenya
EDRI	Ethiopia Development Research Institute
EGTE	Ethiopian Grain Trade Enterprise
EIAR	Ethiopian Institute of Agricultural Research
ERHS	Ethiopia Rural Household Survey
ESE	Ethiopian seed enterprise
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FARDPLAC	Federal Agricultural and Rural Development Partners' Linkage Advisory Council
GIS	Geographic Information System
GoE	Government of Ethiopia
GS	Government Surplus
GSP	Generalized System of Preference
HOPE	Harnessing Opportunities for Productivity Enhancement for Sorghum and Millets
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IFRPRI	International Food Policy Research Institute Wash. DC
IMOD	Inclusive Market Oriented Development
IRR	Internal Rate of Return
ITCZ	Inter-tropical Convergence Zone
MAFAP	The 'Monitoring African Food and Agricultural Policies' of the FAO
MoA	Federal Ministry of Agriculture of Ethiopia
MoARD	Federal Ministry of Agriculture and Rural Development of Ethiopia (predecessor of MoA)
NARO	National Agricultural Research Organisation
NARS	National Agricultural Research Station
NGO	Non-Government Organisation
OECD	Organisation for Economic Co-operation and Development
Opv	Open Pollinating Variety
PS	Producer Surplus
Rari	Regional Agricultural Research Institute
SMIP	Sorghum and Millet Improvement Program
TS	Total Surplus
WFP	World Food Programme

Units	
AE	Adult Equivalent
Ha	Hectare
Kg	Kilogram
Mt	Metric ton
Birr	Local Currency of Ethiopia (approx. 20 Birr/USD in 2014)

1. Introduction

The rationale of this impact study is based on the need to carry out a comprehensive country-level economic assessment of the sorghum breeding program in Ethiopia, including past performance and future potential and regardless of the breeding institutions, locations and source of breeding material. Despite ICRISATs adoption, evaluation and impact monitoring activities, there is a need for a sorghum sector update in market information, trends in the Ethiopian cereal sector over the last 10 years, and fresh adoption and profitability estimations on improved varieties that are grown across all major regions and agro-ecological zones. Study results will be useful for donors and research institutions during periods of reviews and planning by examining in the economic returns to breeding programs and the performance of each single variety and their underlying factors in more detail. Special attention is given to disaggregation of model results as much as possible, by time period (ex-post versus ex-ante), by regions and agro-ecologies and by producers and consumers as beneficiaries. Another important aspect of this study is to test how inclusive and effective the sorghum breeding program is with regard to targeting poverty at both fronts, in the rural production areas and in the consumer markets. Sorghum is the most important dryland cereal in the ESA region followed by millets. Sorghum lacks behind other cereals in the use of modern crop management practises and use of modern inputs. As a consequence, the overall importance of dryland cereals in terms of production and acreage has declined and fallen short of its rival cereals, in particular Maize and recently even rice and wheat/barley. Area and production in dryland cereals are at best growing at small pace, but often remain stagnant over the last 10 years for example in Uganda, Kenya and Tanzania. The only country in which dryland cereals kept pace with other cereal markets and even surpassed them is Ethiopia. The reasons for Ethiopia's success story in sorghum are multifaceted and go alongside Ethiopia's economic growth path, change in agricultural policy towards more liberalisation, considerable investments in infrastructure development in rural areas and the use of modern information technologies. However, Ethiopia's agricultural productivity in the cereal subgroup remains low and largely subsistence oriented with little domestic trade volumes or cross border trade.

ESA countries' agriculture is facing several challenges in feeding an ever increasing population (> 2.5% annual growth rate), where large parts of crop areas fall under dry and semi-dry conditions with high incidence of crop failure, and exposure to adverse climate change effects. ICRISAT plays an important role in helping boost agricultural production by lifting productivity and rural incomes through its diverse research agenda such as germplasm development in combination with agronomic advice and screening new market opportunities alongside a value chain approach. Demand in dryland cereals is forecast to grow strongly in ICRISAT's ESA target regions. Growth in demand will be driven primarily not only by population growth but also by new market opportunities such as in the brewery and feed industry. This study contributes to the CGIAR Research Program on Dryland Cereals CRP 3 where ICRISAT has the lead and the HOPE project (Harnessing Opportunities for Productivity Enhancement for Sorghum and Millets). The overall objectives of the two research programs (projects) are to achieve farm-level impacts, primarily through higher and more stable dryland crop productivity on smallholder farms in Africa and Asia that will increase incomes and reduce rural poverty, increase food security, improve nutrition, and help reduce adverse environmental impacts (especially in dryland crop-livestock systems).

2. Administrative Structure and Agro-ecology of Ethiopia

2.1. Administrative Structure of Ethiopia

Since 1995, Ethiopia is divided into nine ethnically-based administrative regions (kililoch; singular – kilil) and two chartered cities (astedader akababiwach, singular – astedader akababi). These administrative regions replace the older system of provinces. The word "kilil" more specifically means "reservation" or "protected" area. The nine regions and two chartered cities are shown in Map 1. The two chartered cities are Addis Ababa and Dire Dawa. While relatively small in size, Harari is considered a Region.

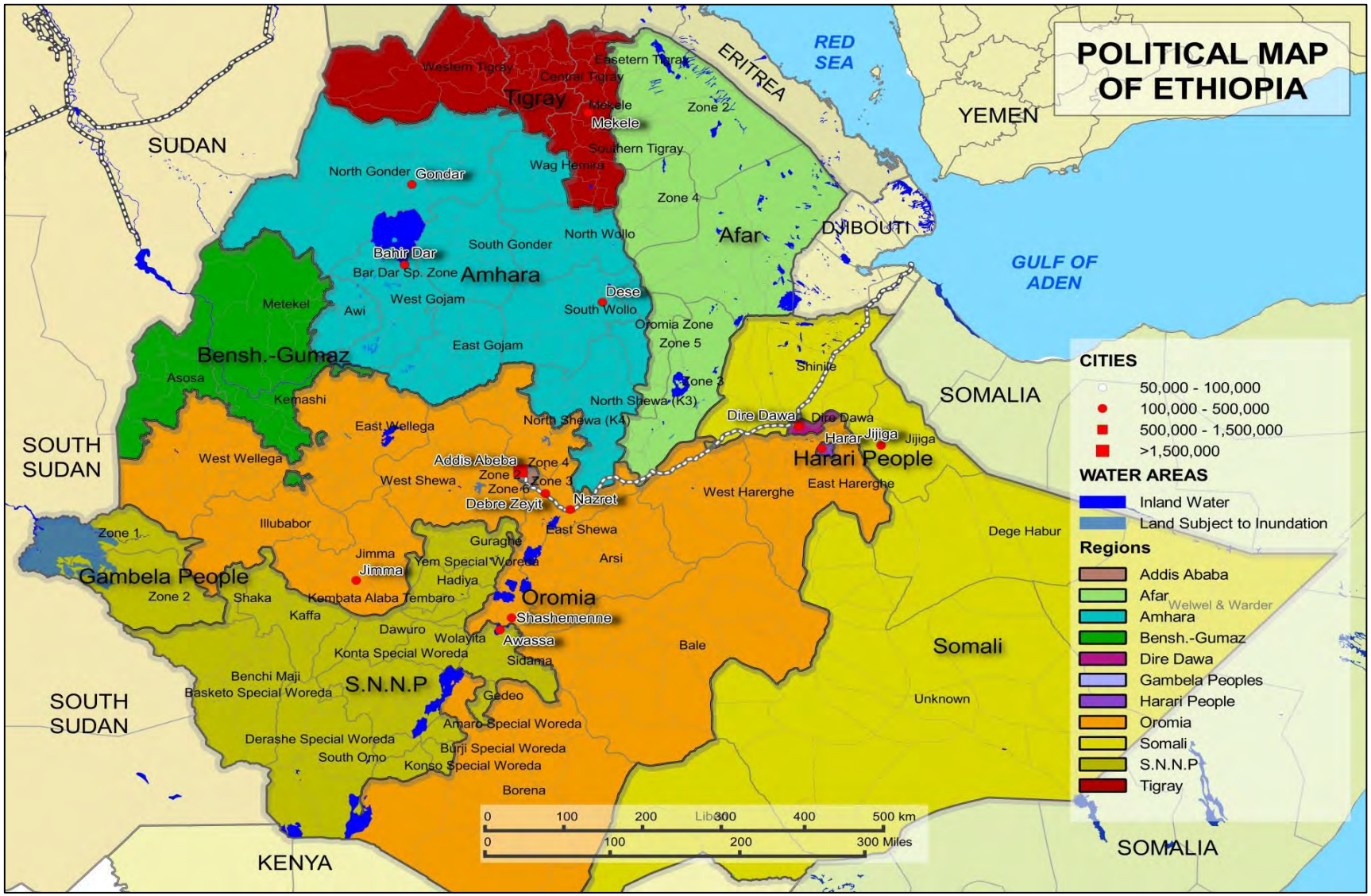
Table 1: Regions as 1st-level administrative structure of Ethiopia

Name	Abbr.	Status	Capital	Area	Population	Population	Population
Regions				(km²)	1994	2007	2013
Ethiopia	ETH	Fed Rep	Addis Ababa	1,063,652	53,477,265	73,750,932	86,614,000
Addis Ababa [Addis Ababa]	AA	City	Addis Ababa	527	2,112,737	2,739,551	3,104,000
Afar	AF	St	Asayita	72,053	1,106,383	1,390,273	1,650,000
Amhara	AM	St	Bahir Dar	154,709	13,834,297	17,221,976	19,212,000
Benishangul-Gumuz	BE	St	Asosa	50,699	460,459	784,345	1,028,000
Dire Dawa	DD	City	Dire Dawa	1,559	251,864	341,834	395,000
Gambela	GA	St	Gambela	29,783	181,862	307,096	406,000
Harari	HA	City	Harer	334	131,139	183,415	215,000
Oromia	OR	St	Addis Ababa	284,538	18,732,525	26,993,933	32,220,000
Somali	SO	St	Jijiga	279,252	3,152,704	4,445,219	5,318,000
Tigray	TI	St	Mek'ele	84,722	3,136,267	4,316,988	5,062,000
YeDebub (SNNPR) [Southern]	SN	St	Awasa	105,476	10,377,028	14,929,548	17,887,000

Source: http://www.citypopulation.de/Ethiopia.html

The regions of Ethiopia are administratively divided into 68 or more zones. The exact number of zones is unclear, as the names and number of zones given in documents by Ethiopia's Central Statistical Agency differ between 2005 and 2007. Various maps give different zone names and boundaries (http:// en.wikipedia.org/wiki/List_of_zones_of_Ethiopia). Districts or woreda (also spelled wereda) are the third-level administrative divisions of Ethiopia. They are composed of a number of wards (kebele) or neighbourhood associations, which are the smallest unit of local government in Ethiopia. Woredas are typically collected together into zones, which form a region; districts which are not part of a zone are designated Special Districts and function as autonomous entities (http://en.wikipedia.org/wiki/Districts_of_Ethiopia). There are about 670 rural woreda and about 100 urban woreda. Terminology varies, with some people considering the urban units to be woreda, while others consider only the rural units to be woreda, referring to the others as urban or city.

Map 1: Political & administrative map of Ethiopia



2.2. Climate and Agro-Ecological Zonation

The climate of Ethiopia is mainly controlled by the seasonal migration of the Inter-tropical Convergence Zone (ITCZ), which follows the position of the sun relative to the earth and the associated atmospheric circulation. Climatic elements such as precipitation, temperature, humidity, sunshine, wind, are affected by geographic location and altitude. Ethiopia, being near the equator and with an extensive altitude range, has a wide range of climatic features suitable for different agricultural production systems. **Climatic heterogeneity is a general characteristic of the country**.

Temperature and rainfall are the most important climatic factors for agricultural production in Ethiopia. Altitude is a factor that determines the distribution of climatic factors and land suitability. This influences the crops to be grown, rate of crop growth, natural vegetation types and their species diversity. Taking the two extreme altitudes, temperatures range from the mean annual of 34.5° C in the Danakil Depression, while minimum temperatures fall below zero in the upper reaches of Mt Ras Degen (4,620 metres) with a mean of less than 0° C. Between these extremes are vast areas of plateaux and marginal slopes where mean annual temperatures are between 10° and 20° C.

According to FAO (1984a) rainfall in Ethiopia is generally correlated with altitude. Middle and higher altitudes (above 1,500 metres) receive substantially greater rainfalls than do the lowlands, except the lowlands in the west where rainfall is high. Generally average annual rainfall of areas above 1,500 metres exceeds 900 mm. In the lowlands (below 1,500 metres) rainfall is erratic and averages below 600 mm. There is strong inter-annual variability of rainfall all over the country. Despite variable rainfall which makes agricultural planning difficult, a substantial proportion of the country gets enough rain for rainfed crop production (FAO, 1984b). There are different ways of classifying the climatic systems of Ethiopia, including the traditional, the Köppen's, the rainfall regimes, and the agro-climatic zone classification systems. The most commonly used classification systems are the traditional and the agro-ecological zones (AEZs). According to the traditional classification system, which mainly relies on altitude and temperature, Ethiopia has five climatic zones. Details concerning altitude, rainfall, length of growing period and temperature are described by Dejene (2003) are reproduced in Table 2.

Table 2: Traditional agro-climatic zones and their physical characteristics

Zone	Altitude	Rainfall (mm/year	Length of growing Period (days	Average Annual Temperature (^{0}C)
Wurch(cold and moist)	3200 plus	900 – 2200	211 – 365	>11.5
Dega (cool and humid)	2300 – 3200	900 – 1200	121 – 210	17.5/16.0– 11.5
Weyna Dega (cool sub-humid)	1500 – 2300/2400	800 – 1200	91 – 120	20.0 – 17.5/16.0
Kola(warm semi-arid)	500 – 1500/1800	200 – 800	46 – 90	27.5 – 20
Berha (hot arid)	under 500	under 200	0 – 45	>27.5

Source: Dejene (2003)

Most agricultural production takes place in the Dega and Weyna Dega zones, where land productivity has traditionally coincided with the densest rural population. The crops most suited to grow in the Dega and Weyna Dega zones in Ethiopia are also the most commonly produced crops in Ethiopia. Most producers in these zones are smallholders, occupying on average less than a hectare of land per household. Smallholder production is dominated by five major cereal crops accounting for almost three-quarters of the total cultivated area, and about 68 % of total production.

In contrast to climate, the zonation of agro-ecologies is usually defined based on combining growing periods with temperature and moisture regimes. According to the AEZ classification system, Ethiopia has 18 major AEZs, which are further subdivided into 49 AEZs based on homogeneity in terms of climate, physiography, soils, vegetation, land use, farming system and animal production. These AEZs are grouped under six major categories (MoA, 2000), which include the following (MoA, 2000):

1. **Arid Zone** – less productive and pastoral and occupies 53.5 million ha (31.5 % of the country)
2. **Semi-arid** - less harsh and occupies 4 million ha (3.5 % of the country)
3. **Sub-moist** – occupies 22.2 million ha (19.7 % of the country) highly threatened by erosion
4. **Moist** – covers 28 million ha (25 % of the country) of the most important agricultural land of the country, and cereals are the dominant crops
5. **Sub-humid and Humid** – cover 17.5 million ha (15.5 % of the country) and 4.4 million ha (4 % of the country) respectively; provide the most stable and ideal conditions for annual and perennial crops; home of the remaining forest and wildlife and biological diversity
6. **Per-humid** – covers about 1 million ha (close to 1 % of the country) and suited for perennial crops and forests

This study however does not use the 49 but the 32 class AEZ system as depicted in Table 3 and Map 2. The reason is that the Ethiopian Institute for Agricultural Research (EIAR) provided ICRISAT with the GIS map of the 32 class system that is sufficiently detailed for the purpose of this study and delineation of the agro-ecologies relevant for the improved sorghum varieties under consideration. Each of these zones has a characteristic crop mix found within its boundaries. Some crops are found with several zones, others are restricted to one or two. In addition to showing the complex mosaic of temperature and moisture pattern across the country, the AEZ map highlights fundamentally different production environments across the arid eastern and humid western lowlands, and across the highlands, which are moister in the west than in the north.

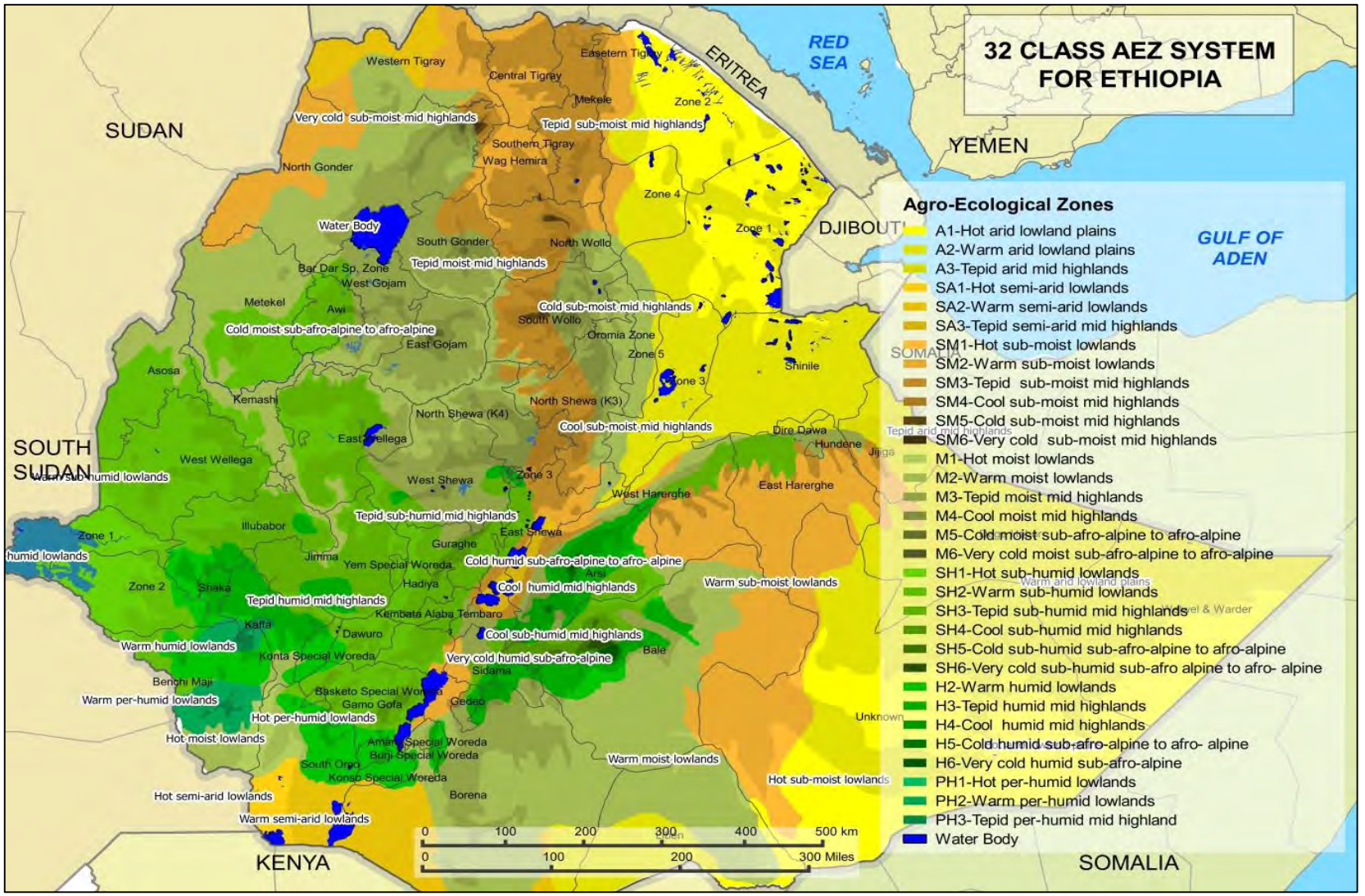
These agro-ecological classifications have important implications for strategies in development of appropriate technologies for agricultural and rural development, natural resources management (NRM) and for genetic improvement programs such as sorghum breeding, which will be expounded later.

Table 3: 32-AEZ system of Ethiopia

Main Category	AEZ ID	Sub-Category	Area		Population (2012)	
			in ha	in %	count	in %
(1) Arid	A1	Hot arid lowland plains	3,841,844	3.4	998,029	1.2
	A2	Warm arid lowland plains	14,429,601	12.8	4,169,630	5.1
	A3	Tepid arid mid highlands	42,265	0.0	13,176	0.0
(2) Semi-arid	SA1	Hot semi-arid lowlands	14,161	0.0	6,293	0.0
	SA2	Warm semi-arid lowlands	563,859	0.5	343,312	0.4
	SA3	Tepid semi-arid mid highlands	13,767	0.0	16,101	0.0
(3) Sub-moist	SM1	Hot sub-moist lowlands	70,225	0.1	22,029	0.0
	SM2	Warm sub-moist lowlands	11,400,502	10.2	7,391,495	9.1
	SM3	Tepid sub-moist mid highlands	6,538,710	5.8	7,109,139	8.7
	SM4	Cool sub-moist mid highlands	548,229	0.5	777,222	1.0
	SM5	Cold sub-moist mid highlands	6,651	0.0	8,365	0.0
	SM6	Very cold sub-moist mid highlands	1,418	0.0	2,040	0.0
(4) Moist	M1	Hot moist lowlands	68,773	0.1	24,370	0.0
	M2	Warm moist lowlands	28,820,230	25.7	14,136,621	17.3
	M3	Tepid moist mid highlands	16,548,330	14.7	14,689,835	18.0
	M4	Cool moist mid highlands	1,699,717	1.5	2,111,932	2.6
	M5	Cold moist sub-afro-alpine to afro-alpine	13,030	0.0	16,689	0.0
	M6	Very cold moist sub-afro-alpine to afro-alpine	1,320	0.0	1,886	0.0
(5) Sub-humid/ humid	SH1	Hot sub-humid lowlands	163,937	0.1	205,734	0.3
	SH2	Warm sub-humid lowlands	10,767,495	9.6	8,712,151	10.7
	SH3	Tepid sub-humid mid highlands	11,635,897	10.4	13,389,160	16.4
	SH4	Cool sub-humid mid highlands	245,735	0.2	420,862	0.5
	SH5	Cold sub-humid sub-afro-alpine to afro-alpine	2,708	0.0	2,754	0.0
	SH6	Very cold sub-humid sub-afro alpine to afro-alpine	824	0.0	917	0.0
	H2	Warm humid lowlands	1,244,837	1.1	949,625	1.2
	H3	Tepid humid mid highlands	3,118,677	2.8	4,998,740	6.1
	H4	Cool humid mid highlands	408,313	0.4	637,725	0.8
	H5	Cold humid sub-afro-alpine to afro- alpine	5,915	0.0	7,537	0.0
	H6	Very cold humid sub-afro-alpine	2,389	0.0	3,614	0.0
(6) Per-humid	PH1	Hot per-humid lowlands	206	0.0	44	0.0
	PH2	Warm per-humid lowlands	72,294	0.1	64,814	0.1
	PH3	Tepid per-humid mid highland	9,589	0.0	5,722	0.0
Total			**112,258,268**	**100**	**81,237,561**	**100**

Source: Own calculation based on GIS analysis

Map 2: The 32-AEZ system of Ethiopia



Source: own map, based on EIAR GIS shapefile of the 32 AEZ system

3. Ethiopia's Cereal Sector: Overview and Trends

By and large, agriculture in Ethiopia is subsistence. This is particularly true to the major food crops grown in the country and covered in the survey. The major food crops are produced in almost all regions of the country in spite of the variation in volume of production across the regions. The variation may be attributed to the extent of area devoted to each crop type, weather change and a shift in preference for the crops grown.

Cultivated crop area accounted for 13.5 million hectares in the 2011/12 Meher season. This is only a small fraction of the Ethiopian land area of over 100 million ha because most of the land is not suited for cultivation. Table 4 summarizes the area and production levels of the main crops cultivated in 2011/12. Cereals dominate Ethiopian crop production. Cereals were grown on 70.7% of the total area cultivated by a total of 13 million farmers. Together these holders produce around 18 million mt of cereals. In terms of area cultivated, the composition of cereals is somewhat different from other countries in the East African region, more types of cereal grown and a lesser dominance of maize. Teff accounts for 28% of the cereal area, followed by maize (21.4%) and sorghum (20.1%). In terms of production volume, maize is the largest cereal with an annual production of over 6 million metric tons, with sorghum ranks second with 3.9 million mt in 2011/12.

Table 4: Area and production of main crops in the 2011/12 *Meher* season

		Area cultivated			Production
	Number of holders	Area	Share in total area	Share in cereal area	Production
Unit	('000)	'000 ha	%	%	'000 mt
Grain	**13,477**	**12,087**	**89.1**		**21,857**
Cereals	***13,088***	***9,589***	**70.7**	**100.0**	***18,810***
Teff	6,300	2,731	20.1	28.5	3,498
Barley	4,085	948	7.0	9.9	1,585
Wheat	4,325	1,437	10.6	15.0	2,916
Maize	9,155	2,055	15.2	21.4	6,069
Sorghum	5,167	1,924	14.2	20.1	3,951
Finger millet	1,556	433	3.2	4.5	652
Oats/Aja'	253	31	0.2	0.3	49
Rice	93	31	0.2	0.3	89
Pulses	***7,482***	***1,617***	**11.9**		***2,316***
Oilseeds	***3,577***	***881***	**6.5**		***731***
Vegetables	6,397	160	1.2		756
Root crops	5,645	200	1.5		1,671
Fruit crops	3,230	61	0.5		539
Chat	2,446	180	1.3		181
Coffee	4,042	516	3.8		377
Hops	1,921	23	0.2		29
Sugar cane	1,092	22	0.2		1,034
Enset	4,305	312	2.3		729
Total	42,555	13,561	100.0		27,172

Source: CSA 2012

After cereals, the second most important crop group (in terms of acreage) is pulses. 7.5 million holders grew pulses on 12% of the total area cultivated with an output of 2.3 million mt. Oilseeds form the third most important crop group. Oilseeds were cultivated on 881 thousand hectares with a production of 731 thousand mt in 2011/12.

3.1. Trends in Cereal Production and Composition

According to Taffesse (2012) data on national cereal production levels and trends are controversial. Changes in government and methodologies have coincided with breaks in the data making it difficult to distinguish between actual changes and statistical artifacts. Beginning in 1981/82 there have been two alternative data sources, one from the Ministry of Agriculture and Rural Development (used by FAO) and the Central Statistical Agency (CSA). In the 1990s, growth in cereal production gathered tremendous momentum (according to FAO and CSA data) after turbulent 1980s and 1970s that had witnessed major political turmoil and widespread famines in the Ethiopia. The rise in the 1990s was entirely due to increase in the cultivated area. As Table 5 shows, during 1993 and 2000, annual growth in area accounted for 8.6%. Growth rates were particularly high for Sorghum (12.3%) and Maize (10.2%). During the same period, yield continue to decline at a considerable rate of (-2.3) for all cereals and was dramatic for wheat and barley (Table 7). Cereal production and yields were rapid during 2000 and 2011 (6.1% in production and 3.9% in yields), while cereal acreage showed a slower annual growth of 2.3%. The spread of growth was somewhat varied among cereals crops. Sorghum can be singled out as the winning cereal crop during this period of dynamic growth. The growth in output during 1993 and 2000 reached 9.5% and 9.8% between 2000 and 2011. Similarly impressive were yields growth at a rate of 4.9% during 2000 and 2011.

Table 5: Cultivated area under cereals between 1993 and 2011 (in '000 ha)

	Cereals	Maize	Teff	Wheat	Barley	Sorghum	Millet	Rice
Annual growth rate (2000-2011)	**2.3**	**0.6**		**3.2**	**2.5**	**4.7**	**1.7**	**18.3**
Annual growth rate (1993-2000)	**8.6**	**10.2**		**9.1**	**6.2**	**12.3**	**10.8**	**6.1**
2011	10,087	2,000	2,761	1,650	1,200	2,150	410	45
2010	9,233	1,772	2,589	1,684	1,129	1,619	369	48
2009	8,770	1,768	2,481	1,454	978	1,615	408	35
2008	9,152	1,767	2,565	1,425	985	1,534	399	13
2007	8,510	1,695	2,405	1,474	1,019	1,464	374	6
2006	8,106	1,526	2,246	1,460	998	1,468	391	6
2005	9,812	1,950	2,136	1,570	1,209	1,512	335	6
2004	9,135	1,802	1,989	1,458	1,255	1,311	314	7
2003	8,498	1,791	1,923	1,166	1,075	1,336	305	7
2002	6,662	1,507	1,896	1,006	821	1,133	281	8
2001	8,002	1,893		1,204	938	1,359	347	8
2000	7,184	1,656		1,062	880	1,011	361	8
1999	7,463	1,651		1,031	1,045	1,069	448	8
1998	6,320	1,449		832	897	982	291	7
1997	7,505	1,718		846	897	1,443	292	7
1996	7,738	1,881		959	1,060	1,332	273	7
1995	6,532	1,464		827	1,141	920	230	6
1994	5,395	1,243		747	934	754	251	7
1993	4,040	838		578	579	448	176	5

Source: FAOSTAT

Table 6: Cereals production between 1993 and 2011 (in '000 mt)

	Cereals	Maize	Teff	Wheat	Barley	Sorghum	Millet	Rice
Annual growth rate (2000-2011)	**6.4**	**4.2**		**6.0**	**5.3**	**9.8**	**7.2**	**19.4**
Annual growth rate (1995-2000)	**6.1**	**9.1**		**4.7**	**0.3**	**9.5**	**13.1**	**6.0**
2011	17,761	4,986	3,498	2,856	1,703	3,960	635	90
2010	15,534	3,897	3,483	3,076	1,750	2,971	524	103
2009	14,496	3,933	3,179	2,538	1,519	2,804	560	71
2008	13,012	3,776	3,028	2,463	1,352	2,316	484	24
2007	11,846	3,337	2,993	2,219	1,271	2,174	397	11
2006	13,390	4,030	2,438	2,779	1,410	2,313	500	12
2005	13,365	3,912	2,176	2,307	1,398	2,200	397	11
2004	10,697	2,906	2,026	2,177	1,376	1,718	333	12
2003	9,533	2,744	1,677	1,618	1,087	1,784	305	13
2002	9,002	2,826	1,627	1,448	1,184	1,546	306	14
2001	9,586	3,298		1,596	1,017	1,549	316	15
2000	8,020	2,683		1,235	804	1,188	320	15
1999	8,393	2,832		1,150	962	1,334	382	14
1998	7,210	2,344		1,143	983	1,083	260	13
1997	9,485	2,987		1,093	953	2,040	296	12
1996	9,395	3,164		1,162	1,125	1,808	244	15
1995	6,751	1,990		1,084	986	1,141	154	11
1994	5,255	1,396		803	875	703	177	10
1993	5,305	1,456		896	787	628	135	10

Source: FAOSTAT

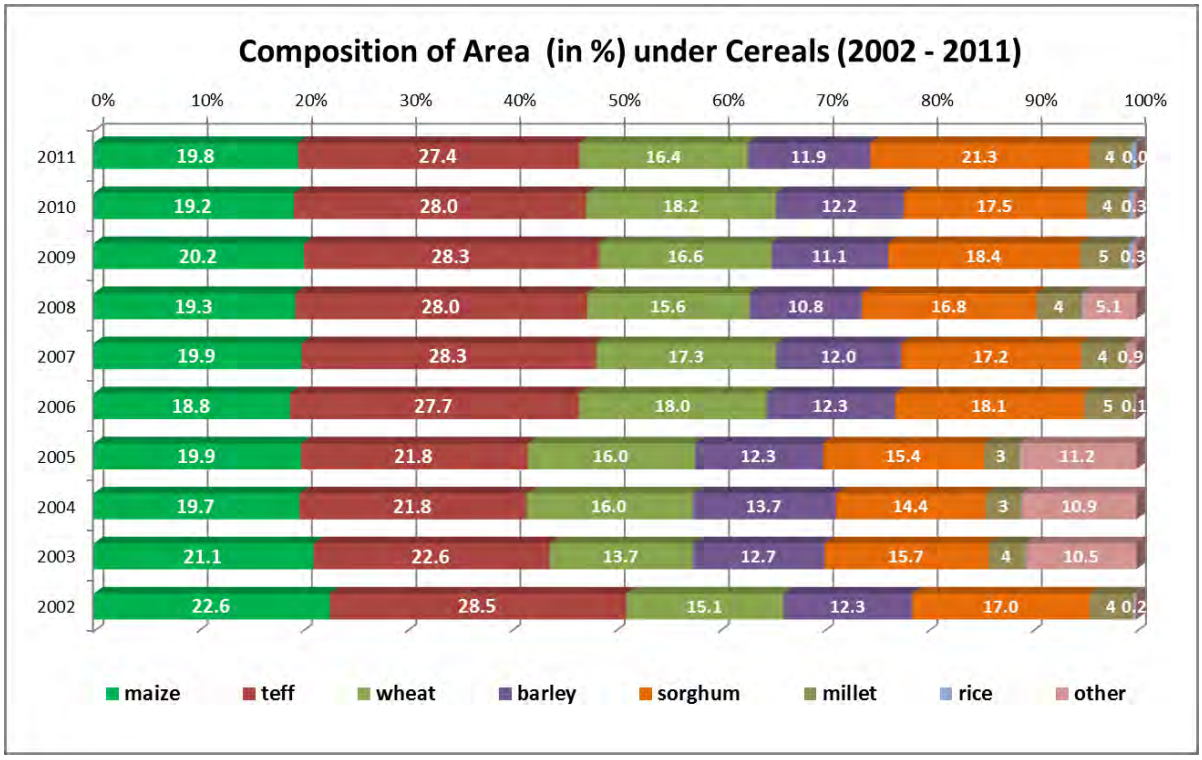
Table 7: Cereals yields between 1993 and 2011 (in mt/ha)

	Cereals	Maize	Teff	Wheat	Barley	Sorghum	Millet	Rice
Annual growth rate (2000-2011)	**3.9**	**3.6**		**2.7**	**2.7**	**4.9**	**5.4**	**0.9**
Annual growth rate (1995-2000)	**-2.3**	**-1.0**		**-4.0**	**-5.5**	**-2.5**	**2.1**	**-0.2**
2011	1.76	2.49	1.27	1.73	1.42	1.84	1.55	2.01
2010	1.68	2.20	1.35	1.83	1.55	1.84	1.42	2.16
2009	1.65	2.22	1.28	1.75	1.55	1.74	1.37	2.04
2008	1.42	2.14	1.18	1.73	1.37	1.51	1.21	1.88
2007	1.39	1.97	1.24	1.51	1.25	1.48	1.06	1.84
2006	1.65	2.64	1.09	1.90	1.41	1.58	1.28	1.87
2005	1.36	2.01	1.02	1.47	1.16	1.46	1.19	1.80
2004	1.17	1.61	1.02	1.49	1.10	1.31	1.06	1.85
2003	1.12	1.53	0.87	1.39	1.01	1.34	1.00	1.81
2002	1.35	1.88	0.86	1.44	1.44	1.37	1.09	1.82
2001	1.20	1.74		1.33	1.08	1.14	0.91	1.84
2000	1.12	1.62		1.16	0.91	1.17	0.89	1.83
1999	1.12	1.72		1.11	0.92	1.25	0.85	1.87
1998	1.14	1.62		1.37	1.10	1.10	0.89	1.86
1997	1.26	1.74		1.29	1.06	1.41	1.01	1.85
1996	1.21	1.68		1.21	1.06	1.36	0.89	2.19
1995	1.03	1.36		1.31	0.86	1.24	0.67	1.86
1994	0.97	1.12		1.07	0.94	0.93	0.70	1.37
1993	1.31	1.74		1.55	1.36	1.40	0.77	1.85

Source: FAOTSTAT

As cereals performed differently, the composition of cereals in the area cultivated changed over time. Sorghum and wheat were able to increase their area share (sorghum from 17% to 21% and wheat from 15% to 16%) at the expense of maize and teff. However, these changes are not as dramatic as the overall speed of expansion in the Ethiopian cereal sector during the last 15 years.

Figure 1: Change in area composition under cereals (2002-2011)



3.2. Trends and Geography in Sorghum Production:

Sorghum production in Ethiopia is fairly spread out covering not only a large area of almost 4 million hectares but also is grown in several distinct agro-ecologies, see chapter 8 for sorghum production statistics by agro-ecological zonation. This makes Ethiopia unique among other sorghum growing countries in East Africa as in those countries sorghum is rather confined to the dry and semi dry areas. The main sorghum regions are Oromia, Amhara and Tigray. There is sorghum grown in other regions as well but they make up together less than 10% in production share. Table 8 provides a comprehensive geographic overview of sorghum area, production and yields between 2001/02 and 2011/12. There has been a steady expansion in area at a similar rate across the major sorghum regions at around 5% annually in terms of acreage and 7% in production. Sorghum yields in Ethiopia range close to 2 mt/ha at national level. Tigray and Amhara in the North have yield levels somewhat higher (2.1 and 2.2 mt/ha). More detailed production data by zones can be found in the Annex Tables A3-A5. Sorghum production outside the traditional regions is less productive with lower yields, probably as a result of adverse climate conditions and generally less fertile soils. The geographic pattern in sorghum production can be studied from the Maps 3-6. There are roughly three clusters of highly intense production Two clusters

alongside the Ethiopian-Sudanese border in the Amhara and Tigray regions and another cluster 200 km east of Addis Ababa.

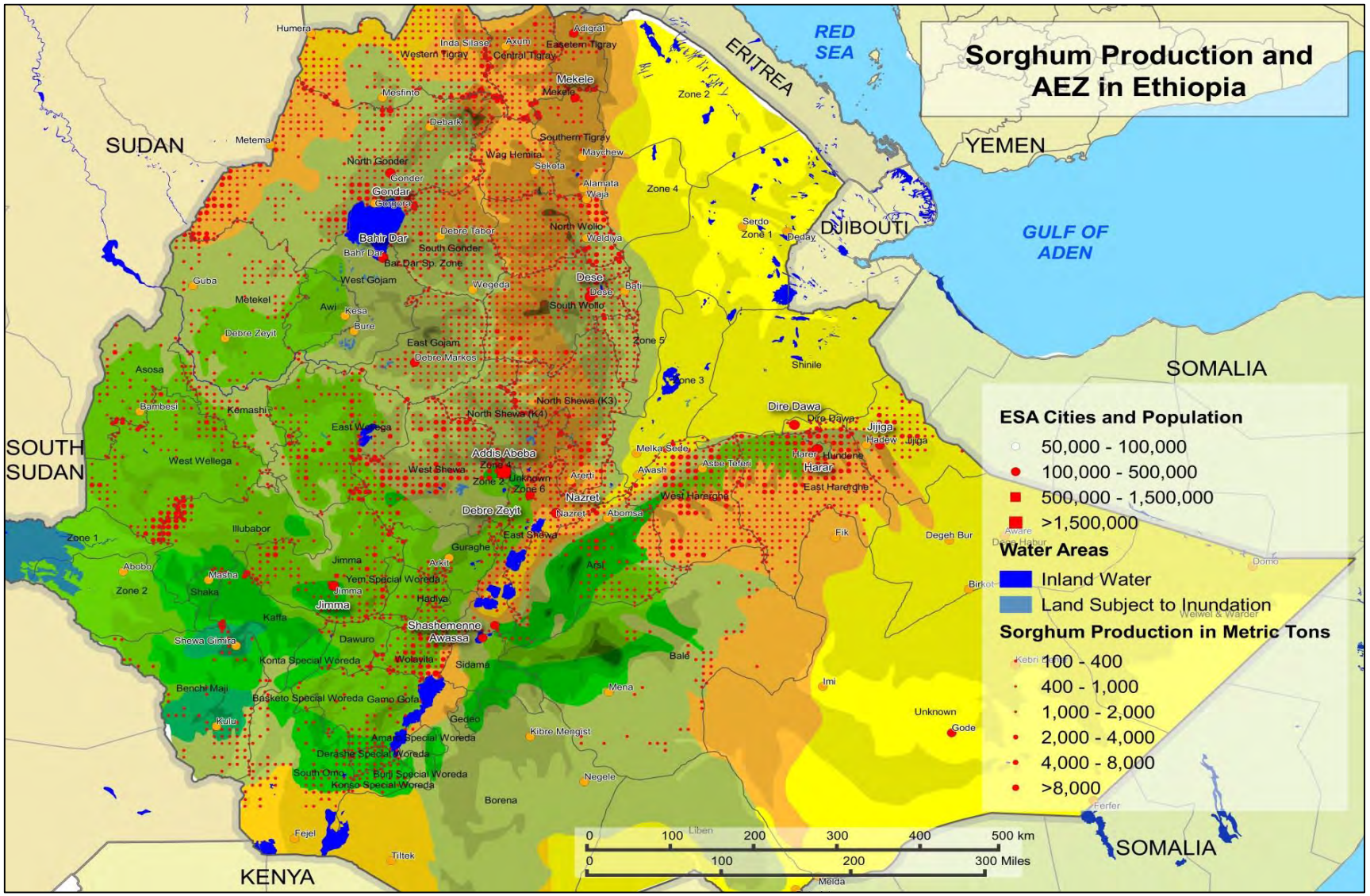
Table 8: Sorghum production, acreage and yield by region (2001/02 – 2011/12)

Year	2001/ 02	2003/ 04	2004/ 05	2005/ 06	2006/ 07	2007/ 08	2008/ 09	2009/ 10	2010/ 11	2011/ 12	Annual growth rate (%)
Production in metric tons											
TOTAL	1,565	1,742	1,713	2,174	2,316	2,678	2,801	2,970	3,960	3,950	**7.7**
Afar	1	3	1	1	1	21	0	0	5	0	27.7
Amhara	526	604	567	852	789	791	913	792	1,534	1,432	7.6
Benishangul-Gumuz	67	54	51	72	89	95	95	133	118	111	5.1
Dire Dawa Astedader	9	7	4	7	9	9	10	9	15	14	2.1
Gambella	3	0	0	4	4	5	10	9	8	5	8.6
Harari	4	4	0	5	6	7	9	7	10	15	10.2
Oromia	636	757	795	818	945	1,305	1,251	1,466	1,581	1,627	8.6
Somali	29	27	14	18	15	34	35	57	48	76	5.8
Tigray	192	194	184	293	335	271	306	281	466	474	6.5
S.N.N.P.	98	92	98	103	123	139	173	217	175	197	6.2
Acreage in ha											
TOTAL	1,165	1,281	1,249	1,468	1,464	1,532	1,613	1,618	1,898	1,923	**4.0**
Afar	1	3	2	2	2	0	0	0	3	0	6.8
Amhara	415	457	412	538	481	499	547	486	711	733	3.7
Benishangul-Gumuz	52	48	50	53	59	60	59	60	67	60	1.5
Dire Dawa Astedader	6	7	7	7	8	7	7	9	9	9	2.7
Gambella	3	0	0	3	3	3	4	5	4	3	3.3
Harari	4	5	0	5	5	6	6	6	7	8	4.5
Oromia	437	501	522	542	563	650	677	755	739	743	5.0
Somali	22	31	22	30	24	34	22	33	35	28	3.2
Tigray	114	129	142	184	207	171	180	155	217	215	5.1
S.N.N.P.	109	100	92	103	111	102	111	109	108	123	0.1
Yield in metric tons/ha											
TOTAL	1.34	1.36	1.37	1.48	1.58	1.75	1.74	1.84	2.09	2.05	**3.48**
Afar	0.78	0.94	0.62	0.64	0.50				1.72		8.24
Amhara	1.27	1.32	1.38	1.58	1.64	1.58	1.67	1.63	2.16	1.95	3.57
Benishangul-Gumuz	1.28	1.13	1.03	1.37	1.50	1.59	1.61	2.21	1.77	1.84	3.50
Dire Dawa Astedader	1.46	1.10	0.64	1.01	1.24	1.32	1.37	0.97	1.73	1.47	-0.60
Gambella	1.25			1.43	1.43	1.67	2.62	1.98	2.33	1.65	5.09
Harari	0.87	0.80		0.90	1.17	1.21	1.53	1.11	1.50	1.93	5.30
Oromia	1.45	1.51	1.52	1.51	1.68	2.01	1.85	1.94	2.14	2.19	3.37
Somali	1.30	0.87	0.63	0.59	0.61	1.01	1.62	1.75	1.40	2.67	2.68
Tigray	1.69	1.51	1.29	1.59	1.61	1.59	1.70	1.81	2.15	2.20	1.14
S.N.N.P.	0.90	0.93	1.06	1.00	1.10	1.36	1.56	1.99	1.63	1.60	6.09

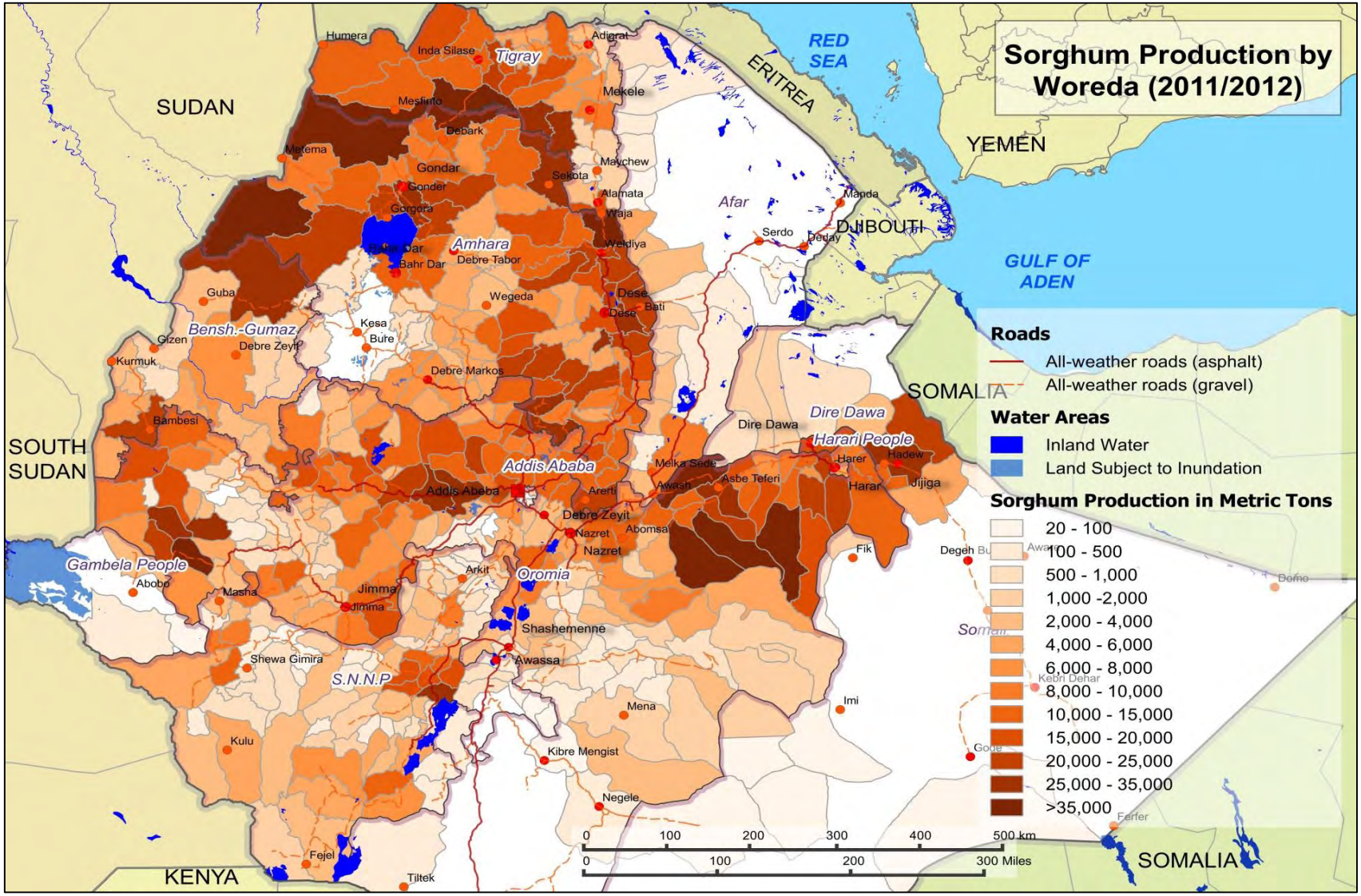
Source: own calculation, based on CSA, agricultural sample survey, various years

As can be studied from Map 6, sorghum production coincides with densely populated areas. Map 5 shows the spatial pattern of the main cereal crops in terms of share in acreage. All maps are based on the 2005 'MapSpam' crop data set developed by IFPRI, and updated with 2011/12 production/area statistics from the Central Statistical Agency (CSA).

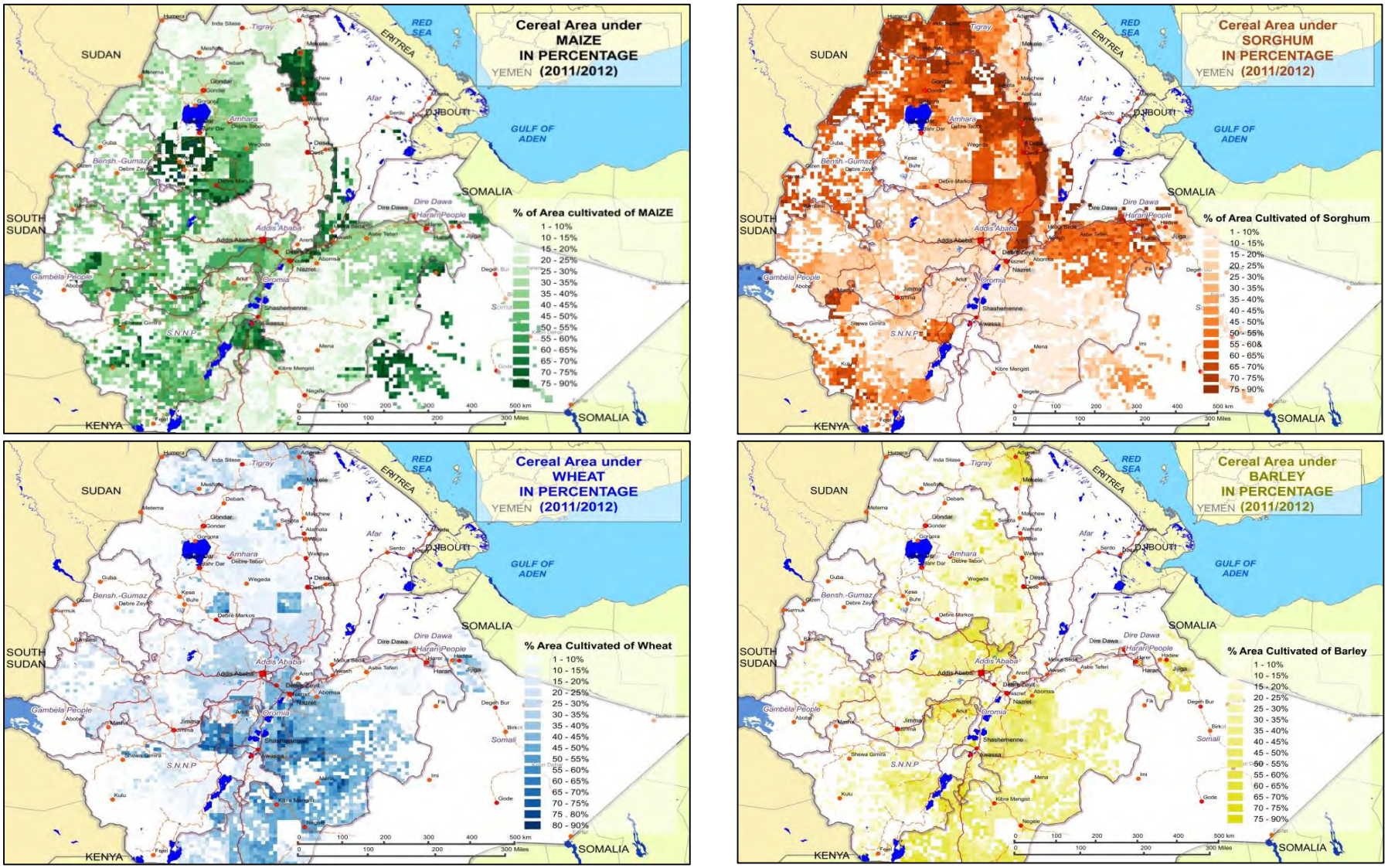
Map 3: Sorghum production in Ethiopia by AEZ (2011/2012, 32 AEZ system)



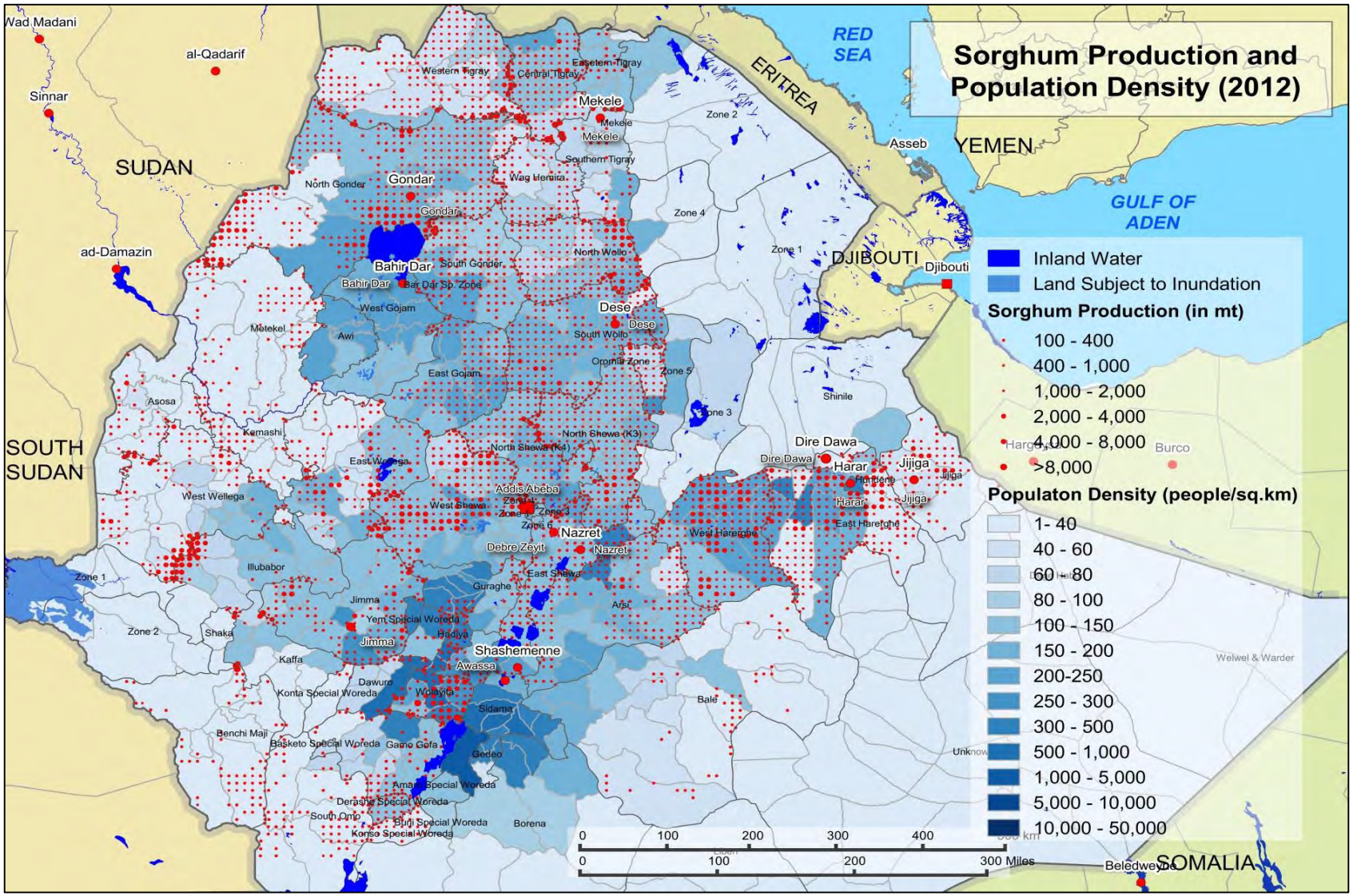
Map 4: Sorghum production in Ethiopia by woreda (2011/2012)



Map 5: Maize, sorghum, wheat and barley: % share in area under cereals (2011/2012)



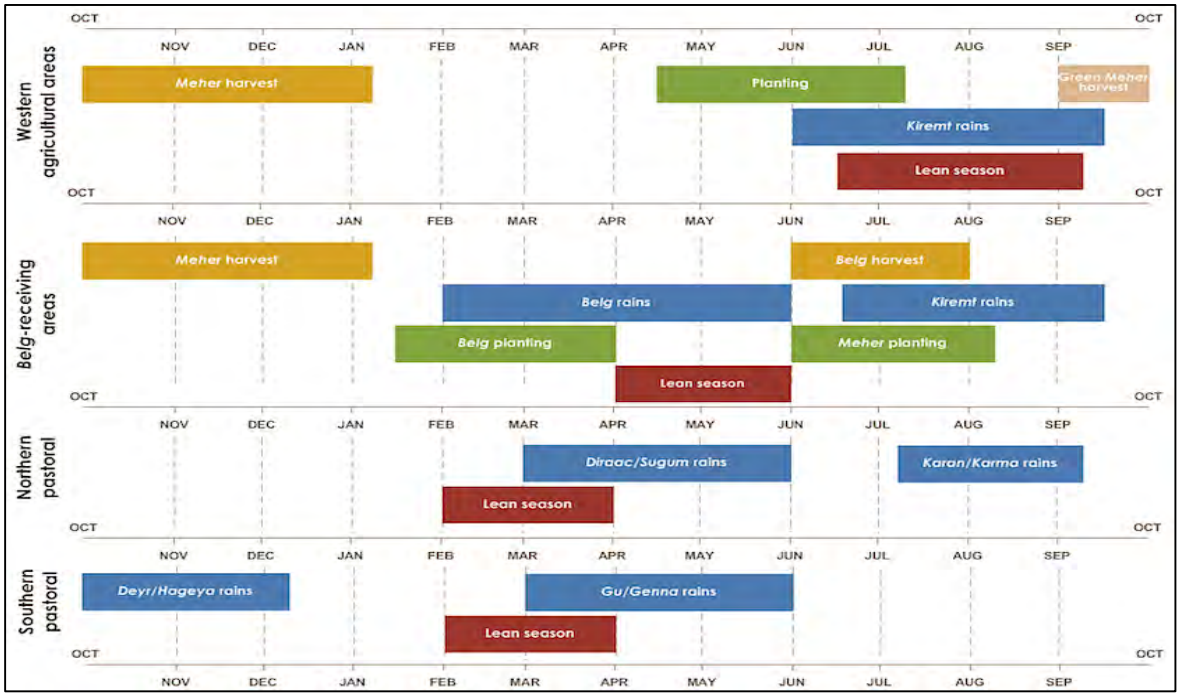
Map 6: Sorghum production in Ethiopia and population density (2011/2012)



3.3. Seasonal Variation in Cereal Production

In the main agricultural regions of Ethiopia, there are two rainy seasons, the *meher* and *belg* seasons, and consequently there are two crop seasons. The meher season is the main production season and encompasses crops harvested between September and February (see Figure 2). Crops harvested between March and August are considered part of the *belg* season crops. Table 9 and Table 10 provide recent data on crop area, production and yields in the 2010/11 *meher* and *belg* seasons, and disaggregated by private smallholders and large commercial farms.

Figure 2: Crop calendar of Ethiopia



Source: www.fews.net/east-africa/ethiopia

Production and acreage data are gathered from CSA sample surveys (2011a, 2011b and 2011c) conducted for the 2010/11 season. There are some important insights from these tables. First, only smallholder farmers cultivate crops during the *belg* season, as large commercial farms concentrate their production entirely on the *meher* season. Second, the *meher* season is overwhelmingly important. The area cultivated and grain crop production in the *meher* season account for 90% of the area cultivated and 95% of the total production. Third, crop yields are usually smaller in the *belg* season than in the *meher* season. There are differences in the seasonal pattern among the cereal group. The share of cereals in terms of crop area for the *meher* season exceeds 90%, except for maize and barley which are grown at a larger scale in the *belg* season as well. Although 9.6% of the cereal area was cultivated during the *belg* season, it accounts only for 4.5% of national cereal production, a reflection of the significantly lower yields in the *belg* season. Yield differentials go as far as 88% lower yields in the *belg* season for finger millet. On average, yields are around 50% lower for cereals, and for pulses and oilseed between 70% and 90% compared to the main *meher* season.

Table 9: Grain crop production in *meher* and *belg* season (2010/11)

	Cropland area in ha				Crop production in '000 mt			
	Main (Meher)		Belg	Belg %	Main (Meher)		Belg	Belg%
	Private holders	Commercial farms	Private holders		Private holders	Commercial farms	Private holders	
Grain Crops	11,823	452	1,173	9.9	20,349	933	901	4.4
Cereals	**9,691**	**182**	**935**	**9.6**	**17,761**	**611**	**808**	**4.5**
Teff	2,761	9	78	2.8	3,483	13	43	1.2
Barley	1,047	2	162	15.5	1,703	4	113	6.6
Wheat	1,553	46	72	4.6	2,856	150	71	2.5
Maize	1,963	59	551	28.1	4,986	284	526	10.5
Sorghum	**1,898**	**62**	**57**	**3.0**	**3,960**	**149**	**40**	**1.0**
Finger millet	408	0	1	0.3	635	1	0	0.0
Oats/'Aja'	31	0	13	42.1	48	0	13	27.7
Rice	30	4	0	0.0	90	10	0	0.0
Pulses	1,358	13	211	15.6	1,953	21	91	4.7
Oilseeds	775	257	27	3.4	634	300	1	0.2

Source: own table, based on data from CSA 2011a, 2011b and 2011c

Table 10: Crop yields in the *meher* and *belg* season (2010/11)

	Meher season		Belg season	
	Private holders	Commercial farms	Private holders	Yield disadvantage %
Grain Crops	1.72	2.06	0.77	55.4
Cereals	**1.83**	**3.36**	**0.86**	**52.8**
Teff	1.26	1.45	0.56	55.9
Barley	1.63	2.48	0.69	57.3
Wheat	1.84	3.30	0.99	46.4
Maize	2.54	4.81	0.95	62.4
Sorghum	**2.09**	**2.41**	**0.70**	**66.4**
Finger millet	1.56	1.64	0.19	88.1
Oats/'Aja'	1.54	1.58	1.02	34.0
Rice	3.03	2.33		
Pulses	1.44	1.63	0.43	70.0
Oilseeds	0.82	1.17	0.06	93.3

Source: own table, based on data from CSA 2011a, 2011b and 2011c

3.4. Farm Size and Farm Size Distribution

Headey et al. (2013) from IFPRI studied farm sizes and distribution of farm sizes in the main highland regions. Results are summarized in Table 11. The top panel of Table 11 shows nationally representative statistics from the 2011–2012 Agricultural Sample Survey of the Central Statistical Agency (CSA), while the bottom panel shows analogous statistics from the Agricultural Growth Program Survey (AGPS). Average farm sizes (farm size refers to crop area per holding) in Ethiopia are very small by international standards, at 0.96 ha per

holding, and correlate closely with population density. The national average is raised by larger farm sizes in the most populous region of Oromia (1.15 ha) and in Amhara (1.09 ha), but lowered by much smaller farm sizes (just 0.49 ha) in the densely populated Southern Nations, Nationalities, and Peoples Region (SNNPR). Tigray also has relatively small farms but is much less populous than the other three regions. Although variation is marked in average farm sizes, the Gini coefficients of inequality do not vary greatly across regions and generally fall between 0.41 and 0.44 in the four highland regions. This implies, farmland is still fairly equally distributed among the rural population. Table 11 also shows the number of very small farms, defined as the percentage of holdings of less than 0.5 ha. Some 62 % of SNNP farm holdings are less than 0.5 ha, a figure double the levels observed in Oromia and Amhara.

Table 11: Farm size and farm distribution by major highland regions, 2011–2012

Panel A—Nationally representative statistics from Central Statistical Agency (2012)					
	Oromia	**SNNP**	**Amhara**	**Tigray**	**Ethiopia**
Average farm size (ha)	1.15	0.49	1.09	0.91	0.96
Farm size inequality (Gini, 0–1)	0.43	0.44	0.41	0.43	0.46
% with less than 0.5 ha	30.0	61.7	33.4	41.4	39.7
Total number of holders (millions)	5.46	3.39	4.00	0.96	14.29
Panel B—Agricultural Growth Program Survey Statistics					
Variables/region	**Oromia**	**SNNP**	**Amhara**	**Tigray**	**All AGP**
Average cultivated area (ha)	1.32	0.93	1.37	1.56	1.46
% with less than 0.5 ha	18	35	22	17	23
Number of holders*	4.15	2.38	2.54	0.28	9.36

Source: Headey et al. (2013)

3.5. Input Use and Modern Technologies

Much of the increase in crop production in the past two decades has been due to increases in area cultivated. To what extend expansion in area can continue at the same pace remains an interesting question. Taffesse (2012) argues that expansion in the highland areas will have to come from reduction in pastureland. In most instances, opening up new land frontiers in the highlands or in the drier regions require substantial infrastructure investments, might involve a reduction in forest areas at considerable environmental costs and will be less productive than the 'old land'. As a consequence, it seems that obtaining higher yield rates is the challenge of Ethiopia's agricultural system.

The limited use of modern inputs is a major characteristic of crop production in Ethiopia, and it seems to be a major explanation for its current low productivity. The use of purchased seed, fertilizer, and pesticides also varies widely by crop (Table 14: Area under improved farm management practices– 1997/98, 2001/02, 2007/08). This is partly due to the fact that crops vary in their "need" for these inputs. In particular, crops differ in the ease of collecting, storing, and re-using their seed. Furthermore, the genetic potential of some crops (such as wheat) is relatively stable over multiple generations of saving seed, while for cross-pollinated

crops such as maize, yields decline more quickly with each generation. In addition, some crops are more sensitive to fertilizer application.

Table 12 shows the use of fertilizer expressed in terms of area share and application rate. Fertilizer is relatively common on plots with cereals. Teff and wheat are the most commonly fertilized crops in Ethiopia. In each case, more than 50% of the plots in 2007/08 are fertilized. Barley and maize are also widely fertilized, though the share of fertilized plots is less than 35%. In contrast, just 10% of sorghum plots are fertilized. There has been significant progress in the promotion and use of fertilizer on all indicators between 1997/98 and 2007/08. The fertilized area under cereals grew from 32% to 39%. Consequently, the application rate in terms of kg/ha also increased from 37 kg/ha in 1997/98 to 45% based on the total cultivated area under cereals. The increase in fertilizer dosage is less pronounced if only the fertilized cereal area is considered and remained fairly constant at a level of 115 kg/ha for all cereals. It shows that the success in promoting the use of fertilizer in Ethiopia has mainly come from expansion in fertilized area rather than increased dosage of fertilizer on a per hectare base.

The low fertilization rate for sorghum is partly due to the fact that sorghum is often grown in low-rainfall areas, where the returns to fertilization are lower. However, the discrepancy in the magnitude of fertilizer application between sorghum and all other cereals is surprising which points at the particular unique perception of sorghum as a ‚low' or 'zero' input crop. A closer inspection of Table 12 shows that it is not the fertilizer dosage that is different – fertiliser dosage for sorghum stands at 105 kg/ha and for the entire cereal group at 116 kg/ha in 2007/08, but the extremely low share (3.1%) in sorghum area that is fertilized.

Table 12: Fertiliser Application by crop, private holdings - 1997/98, 2001/02, 2007/08

Crop	Fertiliser Applied area (share in total area cultivated •]			Fertiliser application (kg/ha)			Fertiliser application (kg/ha of fertiliser applied area)		
	2007/08	2001/02	1997/98	2007/08	2001/02	1997/98	2007/08	2001/02	1997/98
Cereals	39	42.8	32.3	45	30	37	116	100	115
Teff	54.3	49.9	44.9	52	40	50	95	91	111
Barley	30.5	39.6	34.4	30	20	33	99	79	97
Wheat	62.1	56.7	57	85	56	75	136	112	132
Maize	32.8	45.7	18	54	28	25	163	133	139
Sorghum	**3.1**	**16.9**	**2.9**	**3**	**1**	**4**	**105**	**54**	**126**

Source:Taffesse 2008

Newer research on fertilizer use conducted by IFPRI (Minot and Sawyer, 2013) arrived at different picture with generally lower per hectare fertilizer application rates across all cereals and a much lower rate for sorghum (Table 13), 6kg/ha in comparison to 105 kg/ha reported by Taffesse (2008). Table 14 shows the area under improved farm management practises between 1997/08 and 2007/08 for each of the three farm management categories. Improved seed has not established at a large scale so far. Only 4.7% of the area under cereals is cultivated with modern seeds in the 2007/08 season. However, this constitutes twice as much as 10 years earlier in the 1997/98 season. The figure for sorghum indicates a very low adoption rate of improved sorghum varieties. Later in the study, adoption rate are assumed

to range between 5% and 8% based on annual seed production and stocks of improved certified seed in 2013. Maize stands out as the cereal with the highest rate of improved seed which may be explained by the availability of numerous new improved varieties and the preference of farmers and private seed companies for high yielding hybrid varieties. The use of pesticides is widespread and has seen a strong dynamic during 1997 and 2007. During that period pesticide use has grown from 12% to a 21% share in cereal crop land. Wheat and teff are the crops with the highest pesticide use while it remains low for maize and sorghum. Cereals under irrigation are still the exception, only 1% in total area. Here again, maize enjoys the highest share of land under irrigation in comparison with the rainfed area.

Table 13: Average seed and fertilizer application rates by crop, 2012

	Seed application rate	Fertilizer application rate
Crop	(kg/ha)	(kg/ha)
White teff	44	81
Black/mixed teff	45	58
Barley	177	47
Wheat	160	95
Maize grain	37	67
Sorghum	29	6

Source: Minot and Sawyer 2013

Table 14: Area under improved farm management practices– 1997/98, 2001/02, 2007/08

	Share of crop area (in %)								
	Improved seed applied crop area			Pesticide applied crop area			Irrigated crop area		
	2007/08	2001/02	1997/98	2007/08	2001/02	1997/98	2007/08	2001/02	1997/98
Cereals	4.7	3.5	2.4	20.8	10.8	12	1.1	1.3	0.64
Teff	0.7	0.6	1.7	30.5	16.6	17.7	0.7	0.7	0.66
Barley	0.6	0.4	0.1	20.7	9.07	9.6	1.2	0.8	0.62
Wheat	2.9	2	5.6	43.6	28.11	31.3	0.5	0.4	0.32
Maize	19.5	12.5	5.2	2.9	1.93	1.3	2.2	3.2	1.1
Sorghum	**0.1**	**0.4**	**0.2**	**5.4**	**1.69**	**3.1**	**1.2**	**1.1**	**0.39**

Source:Taffesse 2008

Table 15: Source of purchased seed by crop (2012)

Grain	Farmer	Grain trader	Coop	Bur of Ag	Other	Total
White Teff	58	8	27	7	0	100
Black/mixed Teff	89	10	1	0	0	100
Barley	61	29	5	3	2	100
Wheat	48	10	29	9	4	100
Maize	27	13	32	26	2	100
Sorghum	88	12	0	0	0	100

Source: Minot and Sawyer 2013

Table 15 examines the main source of purchased seed by crop in 2012. For most grains, other farmers are the most common source of seed, followed by grain traders. Maize is the most important exception to this pattern. Over half (58%) of the purchased maize seed comes from cooperatives and the Bureau of Agriculture Cooperatives which represent more than one-quarter of the purchases of wheat seed and white teff.

3.6. The Cereal Seed System

This section is a summary from the reports from Alemu (2010) and IFRPI (2010). Ethiopian agriculture requires over 700,000 tons of seed each year to grow cereals (such as teff, maize, wheat, sorghum, barley, and finger millet) and pulses (such as faba beans, field peas, haricot beans, and chick peas). Farmers in Ethiopia acquire seeds for their crops from two different sources:

- The 'formal' or commercial seed sector – "Improved seeds" (seeds with better characteristics such as yield higher than normal seeds) are sold to farmers through farmer cooperatives, input suppliers, and other venues.
- The **'traditional'** or **'informal'** seed sector – These are seeds that farmers either save from their crops and use in subsequent planting seasons or trade/buy informally

The informal seed system under Ethiopian context is defined as seed production and distribution along with the different actors where there is no legal certification in the process. This includes retained seed by farmers, farmer-to-farm seed exchange, cooperative based seed multiplication and distribution, NGO based seed multiplication and distribution etc. The formal seed system on the other hand is a system that involves the production and distribution of basic seed mainly by the research system or certified multipliers (like ESE, the regional seed Enterprises and also recently licensed private seed companies like ANO and Agri-Ceft Ethiopia) and the production and distribution of certified seed along with all actors involved in the production, marketing and regulation. The dominant portion of seeds used is local seeds from the informal sector. During the 2008 main meher growing season, it is estimated that at least 95% of all seeds used were local seeds carried over from the previous harvest either by the farmers or by buying from preferred seed stock kept by other farmers in the same locality.

The type and number of actors in the formal seed system in general, and cereal seed system in particular, have been changing along with the institutional and policy changes in the system. At present, the formal seed sector comprises the National Agricultural Research System (NARS), seed producers, seed distributors and regulators. Table 16 depicts the role of the different actors in the seed system.

Crop breeding, multiplication of breeder and pre-basic seed are the responsibility of the public agricultural research, which has been decentralised since 1997 along with the decentralised political system into federal and regional research institutes. At the federal level, the Ethiopian Institute of Agricultural Research (EIAR) is responsible for running crop breeding programmes that have relevance to more than one region along with the national coordination of research to avoid redundancy of efforts. EIAR is accountable to the Federal Ministry of Agriculture (MoA).

Table 16: Major actors in the cereal seed system and their role

Components of the seed system	Institutions	Regulatory bodies	Regulatory measures
Plant breeding	EIAR, RARIs, and HLIs	MoARD	Targets in terms of crop, improvement targets
Variety release	NVRC	MoARD	Distinctiveness, uniformity and stability, uniqueness, value for cultivation
Breeder seed production	EIAR, RARIs, and HLIs	Variety Maintaining Research Centre	Seed quality control
Pre-basic seed production	EIAR, RARIs, HLIs and ESE, OSE, ASE		Seed quality control
Basic seed production	ESE	MoARD	Seed quality control
Basic seed distribution and sale	MoARD		Fair distribution among regions
Certified seed production	ESE, OSE, Private seed companies	MoARD	Seed quality control
Farmers based seed production	ESE, BoARDs, NGOs and farmers	BoARDs	Seed quality control
Seed distribution and sales	ESE, OSE, ASE, Co-operatives, BoARDs	BoARDs	Price, quantity to respective buyers
Overall sight on the seed system	National Seed Production and Distribution Committee	MoARD / EIAR	Planned production Fair distribution of different classes of seed

Source: Alemu (2010)

The research agenda setting and funding comes from the federal government. Following EIAR's institutionalisation under the MoARD in 2008, research priorities have started to be discussed by the Federal Agricultural and Rural Development Partners' Linkage Advisory Council (FARDPLAC) which is composed of relevant governmental, non-governmental and also private stakeholders involved in the sector. The council serves as a platform, where major constraints are raised and brought to the awareness of stakeholders especially policy makers. Similarly, the Regional Agricultural Research Institutes (RARIs) and Agricultural Higher Learning Institutes (AHLIs) follow the same procedure of research agenda setting and funding

The commercial sector supplies 20,000–30,000 tons of seed per year across all crops, representing only 3–6 % of farmers' actual seed need. The use of commercial seeds as a percentage of stated demand varies among crops, as shown in Table 17 with the highest use at approximately 50 % for maize and the lowest use at less than 10 % for barley.

Table 17: Percent of official seed demand supplied by commercial channels

	2005	2006	2007	2008
Maize	53	28	60	48
Wheat	20	38	23	24
Teff	5	12	22	19
Barley	16	18	10	7
Sorghum	**Na**	**7**	**16**	**48**

Source: IFRPI (2010)

In view of the high demand and potential in boosting productivity, the GOE has responded with a set of interventions to boost both access to and use of improved seed (IFRPI (2010). These approaches include (1) decentralization of the seed system through establishment of regional seed enterprises, (2) initial support for the participation of the private sector in seed production, (3) capacity-building for the National Agricultural Research System, and (4) expedited production of seeds through accelerated programs. The Ethiopian Seed Enterprise (ESE) dominates most commercial seed production in Ethiopia since the late 1950s. In 2008, approximately 80 % of all commercial seed was produced by the government despite the substantial gaps in availability or supply. As shown in Table 18, the public share of seed production varies by crop, with the public sector producing about 90 % of OPVs (such as wheat, teff, sorghum and barley) and about 60 % of hybrid maize.

Table 18: Public vs. private sector production of commercial seed (2006-2008)

Crop category	Commercial seed suppliers	% of production		
		2006	2007	2008
Hybrid maize	Public seed Enterprises	71	62	50
	Private seed companies	28	30	40
	Other (state farms, unions, research centres etc.)	1	8	10
Open-pollinated crops	Public seed Enterprises	90	85	90
	Private seed companies	0	1	0
	Other (state farms, unions, research centres etc.)	10	15	10
Total	Public seed Enterprises	84	75	77
	Private seed companies	8	13	14
	Other (state farms, unions, research centres etc.)	7	12	10

Source: IFPRI (2010)

3.7. Market and Price Policies in the Cereal Market

Cereal market policies in Ethiopia have undergone dramatic changes over the past several decades. To a large extent, these changes mirror the underlying ideological positions of successive governments, from the feudalistic system during the 1950s and 1960s, to the pervasive state interventions under the Derg regime, followed by considerable market liberalization, accompanied by an extended period of major investments in road and telecommunications infrastructure under the Meles government. Rashid (2010) differentiate three different periods of major food policy systems with the following description (excerpts):

The Imperial Regime (1960-74): Ethiopia's cereal markets in the 1960s were characterized by limited government intervention, a high volume of marketing relative to production, and very high transport costs due to limited infrastructure. During this period, agricultural land in the country was almost equally distributed among the state, church, and the social aristocrats. Small farmers had to lease lands from local landlords and political or religious authorities. Because rents to landlords and tributes to the state or church were paid in kind, marketed "surplus" of cereals is estimated to have been fairly high (25-30 % of production). One key policy instrument that led to expanded intervention in cereal markets during the later years was the formation of the Ethiopian Grain Board (EGB), established in 1952. The mandate of the EGB included export licensing, quality control, overseeing marketing intelligence, and the regulation of domestic and export purchases and sales.

State-Controlled Markets (1975-1990): The socialist government of Ethiopia instituted a wide range of controls over cereal production and marketing. These included determination of annual quotas, restrictions on private grain trade and interregional grain movement, determination of days on which the local markets had to be held, and rationing of grain to urban consumers. Wholesale prices of cereals were administratively set for many provincial markets. Land reforms under the Derg regime had assigned ownership of land to the state, but operational control to small holders, who were no longer obligated to pay large rents in kind. When this system failed to generate sufficient marketed surplus to supply urban consumption needs, in 1976 the government reorganized the EGB as the Agricultural Marketing Corporation to procure grain for public distribution and price stabilization. The agency was made responsible for handling almost all aspects of agricultural input and output markets. It was involved in export and imports of agricultural products, buying and selling inputs, and processing and marketing of finished products. In addition, AMC was engaged in the construction of storage facilities, such as silos, and other structures and machinery. In short, the government and AMC took over the grain markets.

Liberalization and Rapid Growth (1991-2009): Following the overthrow of the Derg regime in May 1991, various economic reform programs were launched, including major reforms in cereal markets. As part of the reorganization and re-structuring of government parastatals that began in 1992, the Agricultural Marketing Corporation (AMC) was reorganized as a public enterprise and allowed to operate in the open market in competition with the private sector. The name of the agency was also changed to the Ethiopian Grain Trade Enterprise (EGTE)[1] and it was given a mandate to: (a) ***stabilize prices with an objective to encourage production and protect consumers from price shocks***, (b) ***earn foreign exchange through exporting grains to the world market, and*** (c) ***maintain a strategic food reserves for disaster response and emergency food security operations***. The EGTE encountered at least three major problems. First, the tensions between fulfilling its mandate of price stabilization and that of competitiveness and profitability. Second, EGTE was not effective in stabilizing grain prices due to its limited grain purchases and sales network and shortage of working capital. EGTE's mandate was substantially revised during 1999-2000 and gradually moved away from price stabilization and focused on export promotion and facilitation of the administration of Strategic Food Security Reserves and national disaster prevention and preparedness program.

The most recent and important attempt towards market development in Ethiopia has been the establishment of the Ethiopian commodity exchange. While the original thrust of the exchange was on cereals, the exchange did not succeed in attracting large volume of grain. Despite large step towards liberalized markets, Ethiopia remains alert in times of food crisis. The 2007/08 sharp price inflation in international commodity markets that followed shortly after the financial crisis in 2007 and spilled over into the Ethiopian food sector, triggered swift responses from the Ethiopian Government: (i) imposition of export ban, (ii) re-introduction of urban food rationing, (iii) informal suspension of local procurement by WFP and others, and (iv) direct government imports for open market sales and price stabilization (Rashid 2010). The 'Monitoring African Food and Agricultural Policies' MAFAP program of the FAO (2013)

[1] According to (Bekele 2010) the Ethiopian Grain Trade Enterprise, which is engaged in wholesale grain marketing activities, is an autonomous public enterprise. Formerly known as Agricultural Marketing Corporation (AMC), it was restructured and named Ethiopian Grain Trade Enterprise (EGTE) in 1992, following the change of government. The objectives of the newly formed enterprise were redefined to stabilise producer and consumer prices and maintain buffer stock for market stabilisation. The role of the EGTE in the grain industry was revised again in October 1999, when it was reoriented mainly to operate in export markets as a commercial enterprise. EGTE operates in different parts of the country, with a network of 60 purchasing centres and 18 branches. The grain purchasing activities of the purchasing centres and branches are coordinated, supervised, and controlled by the head office situated in Addis Ababa. EGTE's operating networks concentration and dispersion depends on the production potential of the regions. Thus, most of EGTE's purchasing centres and branches are located in surplus producing areas.

studied the consequences of market interventions on the cereal market, including sorghum, also factoring in macroeconomic policies on the Birr exchange rates and distributing imported cereals from food aid to urban areas at subsidized prices.

The results of the MAFAP price indicators show that the level of disincentive in sorghum production is significant. Producers gained as a result of the recent high world prices (2008 and 2009) but the favourable environment did not last long. Overvalued exchange rates and the Government policy of banning export and distributing (at times of high food prices) have kept domestic cereal prices relatively low. Food aid, which accounts for a significant share of cereal consumption, may have also contributed to the lower domestic price levels. In more detail, the nominal rate of protection (NRP) is negative at the wholesale as well as at the farm gate levels except in 2008 and 2009. The observed NRP at wholesale level averaged -10 % in 2005-2010, with a high of +25 % in 2008 and a low of -28 % in 2006. The extent of the disincentive worsens with adjusted NRP, averaging -20 % during the study period. The results confirm that sorghum buyers or consumers are generally paying less than the equivalent border prices, while producers are implicitly taxed.

Table 19: Nominal rates of protection (NRP) for sorghum in Ethiopia 2005-2010 (%)

	2005	2006	2007	2008	2009	2010	Average 2005 - 2010
Observed NRP at wholesale	-23.2	-28.1	-26.1	24.9	8.2	-19.0	-10.6
Adjusted NRP at wholesale	-29.9	-34.9	-33.5	11.9	-2.7	-28.0	-19.5
Observed NRP at farm gate	-16.6	-22.9	-23.5	35.8	17.1	-14.0	-4.0
Adjusted NRP at farm gate	-25.0	-31.2	-32.1	18.8	2.0	-26.2	-15.6

Source: FAO 2013

4. Sorghum Consumption: Trends and Regional Pattern

Food consumption patterns in Ethiopia are diverse, and unlike in many other countries, no single crop dominates the national food basket (e.g., rice in most of East Asia, maize in Latin America, or cassava in Central Africa). The Ethiopian food basket consists of a wide variety of grains and other staples. However, consumption levels and mixes of these grains vary widely according to differences in agro-ecology, socioeconomic levels and livelihood strategies. Moreover, given the high degree of home consumption and dependence from own production, particularly in rural areas, food grain consumption varies at different times of the year and are directly related to the geography of food production. Traditionally, people in rural areas consume what they produce; due to poor market linkages and the tendency to be food self-sufficient. As Berhane et al. (2011) point out, part of the diversity in consumption patterns across Ethiopia can be explained by the variations in rural and urban livelihoods and patterns tend to be stable. Due to the inherent characteristics of living in urban areas, urban consumption patterns are expected to be more dynamic, highly monetized and more sensitive to relative price and supply changes compared to rural areas. In addition, consumption patterns are likely to change more quickly in urban than in rural areas due to the relatively increased exposure of urban areas to changing global food consumption patterns.

4.1. Trends in Food and Cereal Consumption

For those with low levels of income, food accounts for the majority of a households' consumption budget. As a country develops and household income increases accordingly, the share of the food bill in comparison with other expenditures tend to fall. Despite Ethiopia's sound economic growth over the last few decades the food budget still accounts for the largest share of household expenditure (about 78 %) and remained so between 1994 and 2009 despite annual per capita income in real terms increased from 403 Birr in 1994 to 596 Birr in 2009 (Table 20)[2]. Food budget share in the low income group (79%) is greater than in the high income group (76%) by about three percentage points only. The rather small difference in food budget shares between low and high income households is typical for a country within the LLDC group ('least development'), with chronic deficits in national food availability and widespread 'food and basic needs' poverty. As income rises in such a situation, households continue to spend on food items in proportion with income rise until a satisfactory nutritional level has been obtained. Food consumption shares increased by around 1 % between 1994 and 2004 (on average, about 0.1 % per year), and at a similar rate between 2004 and 2009, indicating the sustained high share of food in the budget of the sample households. Clothing is the second most important item in the household budgets, accounting, on average, for about 7%. Housing & utensils, health, education & transport as well as household consumables are somewhat fluctuating but account for 2-4% of household budgets in the survey panel. Over the survey rounds, clothing shares declined by about 0.6 and 1.8 % points, housing & utensils by 0.4 and 0.7 %, respectively.

[2] Berhane et al. (2011) who analysed the HICES data sets arrived at different food consumption shares for Ethiopia. They argue that food consumption expenditures have declined from 60 % in 1995/96 to 56 % in 2004/05 (MoFED 2008)

Table 20: Budget shares of food and non-food items by year and income group

	ERHS Survey rounds[3]				Income groups			% Changes	
	1994	1999	2004	2009	Low	Middle	High	1994/04	2004/09
Food	***76.63***	***77.67***	***77.70***	***78.75***	***78.71***	***78.12***	***76.22***	***1.07***	***1.04***
Clothing	7.60	10.86	6.95	5.17	7.68	7.19	8.07	-0.66	-1.78
Housing & Utensils	2.79	2.02	2.43	1.77	2.04	2.18	2.54	-0.36	-0.66
Health, education, transport	3.59	1.57	3.89	3.47	2.85	2.96	3.59	0.29	-0.41
Household consumables	0.24	1.15	0.54	0.67	0.70	0.65	0.60	0.29	0.13
Other non-food	8.58	6.74	8.50	7.05	7.01	8.13	8.02	-0.08	-1.44
Annual real per capita income (in Birr)	403.4	413.2	459.3	595.6	183.7	384.7	835.2		
Family size (in number)	6.2	6.0	5.7	5.7	6.4	5.7	5.5		

Source: Tefera et al. (2012), computation from ERHS panel data

Table 21 presents budget shares for the different food categories by ERHS survey rounds as well as income groups (low, middle and high). Cereals (teff, barley, wheat, maize and sorghum) are the major staples in the Ethiopian dish and account for the lion's share of the household food budget (on average, about 45-50%). Across income groups, cereal consumption in the high income group is higher than the low income group by about 2%. Maize consumption dominates in most of the survey rounds (13.08 %) though with declining share in the high income group, followed by wheat and teff.

Table 21: Household food budget shares (in %) by food category

	ERHS survey rounds				Income groups		
	1994	1999	2004	2009	Low	Middle	High
Teff	6.6	12.6	9.2	10.8	4.5	11.1	13.8
Barley	8.2	7.4	7.8	5.9	5.5	6.6	10.0
Wheat	8.9	10.3	9.2	11.8	13.4	9.7	10.4
Maize	13.3	13.3	11.5	10.9	14.9	11.1	7.5
Sorghum	**7.6**	**7.0**	**7.0**	**9.1**	**7.1**	**10.0**	**6.0**
Cereals	**44.6**	**50.6**	**44.7**	**48.5**	**45.4**	**48.5**	**47.7**
Root crops	4.6	6.9	10.7	5.5	10.5	5.9	4.5
Pulses	10.1	8.0	7.8	8.0	7.1	9.0	9.3
Fruits &vegetables	7.6	2.0	2.2	3.5	5.4	3.1	2.8
Animals products	5.5	9.5	9.3	8.4	7.6	7.9	8.9
Other foods	27.5	23.0	25.3	26.1	24.0	25.7	26.7
Annual real per capita income (in Birr)	403.4	413.2	459.3	595.6	183.7	384.7	835.2

Source: Tefera et al. (2012), computation from ERHS panel data

The composition of the food diet changed over the years and with increasing income. Animal products and root crops gained. The consumption of fruit, vegetables and pulses declined relatively, while the budget share of cereals as a group stayed rather constant but with minor

[3] The study uses the Ethiopia Rural Household Survey (ERHS) panel waves conducted by the Economics Department of Addis Ababa University (AAU) in collaboration with the Centre for the Study of African Economies (CSAE) at Oxford University, the International Food Policy Research Institute (IFPRI) and the Ethiopia Development Research Institute (EDRI). In total about 1,477 households were included in the 1994 survey. These households have been re-interviewed in the late 1994 as well as in 1995, 1997, 1999, 2004 and 2009.

shifts within the cereal group. Consumption of teff and to a lesser extent wheat and barley expanded while all other cereals remained constant or experienced a slight decline.

Consumption of cereals by rural/urban and income group: The HICES data (2004/05) indicates that an average person in Ethiopia consumes about 150 kg of cereals per year (Table 22). Consumption levels of cereals are slightly higher in rural areas (152 kg) compared to urban ones (137 kg). The most important cereal in quantitative terms is maize, followed by sorghum, wheat, and teff. Barley is the least important of the five. Two distinct features of consumption patterns between rural and urban areas are worth noting here. First, while other cereals and processed cereals occupy a sizeable share of urban per capita budget shares (12% total food spending compared to 2% for rural areas), rural consumption is dominated by the main (raw) cereal grains.

Table 22: Consumption of cereals by rural/urban areas and Income groups

	Per capita consumption (kg)			Share in food consumption expenditures (%)						
				All			Bottom 40%		Top 60%	
	National	Rural	Urban	National	Rural	Urban	Rural	Urban	Rural	Urban
Teff	25.9	20.1	61.4	8.0	6.0	23.0	7.9	17.3	7.3	16.4
Wheat	29.6	31.2	20.2	9.0	9.0	8.0	9.8	6.0	9.5	4.3
Barley	12.8	14.3	3.8	4.0	4.0	1.0	5.5	1.3	4.7	0.9
Maize	37.7	42.2	10.4	12.0	13.0	4.0	11.1	3.2	9.1	1.2
Sorghum	**32.2**	**35.9**	**9.3**	**10.0**	**11.0**	**3.0**	**9.9**	**2.7**	**8.9**	**1.3**
Other cereals	11.4	8.1	32.2	4.0	2.0	12.0	1.7	1.2	1.7	0.7
Proessed cereals							1.3	14.3	1.6	11.6
Total cereals	**149.6**	**151.7**	**137.2**	**46.0**	**46.0**	**51.0**	**47.0**	**46.0**	**43.0**	**36.0**

Source: Berhane et al. (2011), based on HICES of 2004/2005

Second, despite the increased shift to processed cereals and other cereals, teff continues to maintain its prominence on the urban food plate (23%). Urban consumers eat three times as much teff as their rural counterparts, i.e. 61 kg versus 20 kg. Wheat also takes a substantial share (8%) in urban food expenditure, next to teff and other cereals, including processed ones. Table 22 further shows that cereals account for about half of all food expenditures of an average household and that the share of expenditures on cereals of the top 60% income bracket is significantly lower than for the poorest 40% bracket. As seen in other countries, richer people particularly in urban areas shift away from cereals to higher-valued food products, including meat, dairy products, fruits and vegetables, as well as to other non-food consumption items.

Cereal consumption pattern across regions: Overall regional consumption levels vary according income and poverty levels (see Table 23). The HICES data indicate that real per capita consumption levels are highest in Addis Ababa, followed by Harari and Dire-Dawa, and with Amhara, Oromia, Benshangul-Gumuz, and Somale being the regions with the lowest consumption levels between 1995/96 and 2004/05. Table 23 presents the shares of the five major cereals in households' total food expenditures disaggregated by region. The 2004/05 data show substantial interregional variations in the share of major cereals. In general, Tigray allocates more than half of its food budget to cereals. Amhara, Dire-Dawa

and Oromia follow Tigray allocating around 50%, 45% and 45% respectively of their total food expenditure on the five major cereals. Given the poor market integration, high proportion of own consumption and inefficiency in the mobility of goods, the regional consumption variations follows the regions' specialization in the production of specific grains in general. However, as can be seen from Table 23 this is not consistently the case for all grains, especially Teff[4]. Teff accounts for the largest share of regional food expenditure in the regions of Amhara and Tigray, after Addis Ababa, which is the highest consumer nationally. Therefore, teff seems to be traded across regions more than any other cereal

Table 23: Share of major cereals in total food expenditures by region, 2004/05

			Share in total food expenditures (%)						
Region	Per capita. expenditure in Birr	Poverty level % P0[1)]	Teff	Wheat	Barley	Maize	Sorghum	Other cereals	Total Cereals
Tigray	1,771	31.8	10.2	13.1	7.0	2.7	**13.7**	3.7	50.4
Afar	1,923	36.1	9.6	10.0	0.2	6.3	**1.4**	8.3	35.8
Amhara	1,548	30.5	12.8	10.4	6.7	5.3	**9.6**	4.5	49.3
Oromiya	1,737	28.7	8.2	9.6	4.7	10.8	**7.9**	3.8	45.0
Somale	1,651	32.8	1.0	9.7	0.8	7.0	**8.1**	10.8	37.4
Benishangul Gumuz	1,822	28.9	5.2	0.9	0.2	8.4	**21.9**	7.5	44.1
SNNP	1,594	29.6	4.0	5.5	1.5	11.9	**5.7**	4.5	33.1
Harari	2,532	11.1	6.0	7.0	0.4	1.9	**9.4**	12.9	37.6
Addis Ababa	2,577	28.1	19.6	3.4	0.5	0.5	**0.1**	17.1	41.2
Dire-Dawa	2,128	28.3	5.8	7.4	0.7	0.7	**9.2**	21.5	45.3

Source: Berhane et al. (2011), based on HICES of 2004/2005, [1)] Federal Democratic Republic of Ethiopia (2012), based on HICE survey of 2010/11

Wheat accounts for more than 10% of the food budget in many regions, including Tigray, Amhara, Oromia, Somale, and Afar. Consistent with its production potential, the people in Benishangul Gumuz are the largest consumers of sorghum in the country, followed by Tigray, which also has a great deal of sorghum production potential in its western lowlands. In line with earlier findings, the expenditure share of processed cereals (and other cereals) is highest in the urban regions of Dire-Dawa, Addis Ababa, and Harari. Overall, contrary to the urban regions, the lowland regions of Afar, Somale, Harari, and especially the SNNPR, are among the lowest consumers of cereals in Ethiopia.

ICRISAT analysis of sorghum consumption: ICRISAT (2012) examined in more detail the consumption pattern of cereals (sorghum, finger millet, teff and maize) in Ethiopia based on the same 2004/05 HICE Sample Survey as IFPRI used for its analyses. ICRISAT's consumption analysis further distinguished between rural and urban as well as taking into account the proximity of consumer clusters to the production area of the cereal under consideration. Another distinction was made with regard to income level by subdivision of the income range in the data set into three equidistant income terciles (low, middle, upper). Table 24 summarises the results for sorghum by regions and consumer clusters. At national level, consumption per adult equivalent AE, which accounts approximately for 1.6 persons

[4] According to Berhane et al. (2011) in the period 2003/04, reports showed Oromia as the highest teff producer, both in terms of total and per capita production, after Amhara region (EEA 2004, 56). However, Oromia's share of consumption expenditure on teff (8 %) is a little less than its expenditure share on maize (11 %) and wheat (10 %), and not comparable to its contribution in production (compared to Amhara, which is 13 %).

according to the Ethiopian demographic age and gender distribution, amounts to 42 kg/year. Rural consumption (48 kg/AE) is four times higher than urban consumption (11.5 kg/AE). Taking rural/urban as the sole differentiation falls short of recognizing the heterogeneity of sorghum consumption within the rural areas, particularly with regard to proximity to the sorghum producing areas. In line with the findings from IFPRI sorghum consumption has a particular location specific pattern which can be explained by the distance between production and consumption centres and limited trade volumes within the rural domain. Consumption is highest in rural areas and the urban centres close to the sorghum regions and lowest in rural and urban centres far from sorghum.

Table 24: Sorghum consumption in rural and urban areas (kg/AE/year)

	National	Urban	Rural	Rural close to sorghum areas	Rural far from sorghum areas	Urban close to sorghum areas	Urban far from sorghum areas
National	42.24	11.53	48.06	59.92	12.25	22.79	2.36
Tigray	70.5	28.85	81.65	101.65	7.51	53.73	2.57
Afar	8.79	2.35	14.89	96.52	1.43		2.35
Amhara	43.53	17.17	46.9	51.91	8.21	24.81	6.14
Oromia	43.59	11.15	48.22	65.89	8.31	18.19	1.43
Somale	54.15	18.88	71.34	95.16	6.89	23.19	4.54
Benishangul Gumuz	104.66	43.42	114.42	119.18	18.58	44.65	25.13
SNNPR	32.24	7.45	34.65	41.41	21.38	10.15	1.78
Harari	67.85	14.2	149.48	149.48		14.2	
Addis Ababa	0.6	0.6	0.52		0.52		0.6
Dire Dawa	52.37	12.3	147.93	147.93			12.3

Source: ICRISAT 2012

Sorghum consumption by income strata (see Table 25) shows an interesting pattern that runs counter to other sorghum producing countries in the East-African region such as Tanzania and Uganda. At national level, consumption in the upper income group ranges at 46 kg/AE/year which is even higher than for households with less income, thus indicating a positive income elasticity. This pattern is very pronounced in rural areas while reversed in urban areas with lower consumption, relative and in absolute terms within the upper urban income strata. Region wise, the same consumption pattern holds true with a few exceptions, Harari and Dire Dawa regions, but those regions are not representative due to their extremely small land size, distinct ethnic composition, dense population and their role in sorghum trade. Consumption analyses of similar type conducted by ICRISAT in other countries[5] usually indicate strong negative income elasticity for sorghum. There are no hard facts or analytical proof in the literature that can explain Ethiopia's unique consumption pattern. One may assume a few explanations such as low income levels even among the upper income strata compared to the other countries or chronic food shortages especially in cereals in Ethiopia during 2004/05. In times of food shortages combined with widespread

[5] ICRISAT Reports: Macharia, I, Orr, A and Schipmann, C 2012; Schipmann-Schwarze, C and Orr, A 2013; ICRISAT 2012; Macharia, I, Orr, A and Gierend, A 2014

poverty, limited choice in staple food items in rural markets and economic considerations in choosing cheap calorie sources may drive sorghum consumption in the rural areas regardless of income status.

Table 25: Consumption of millet, sorghum, and maize by income groups*

	National			Urban			Rural		
Income level	Low	Middle	Upper	Low	Middle	Upper	Low	Middle	Upper
National	31.2	49.0	46.5	12.3	13.4	10.4	33.9	52.9	59.0
Tigray	53.3	75.1	88.7	24.8	22.7	32.8	58.4	82.6	119.6
Afar	11.1	10.9	6.2	3.5	3.9	1.5	14.5	16.0	14.4
Amhara	25.8	54.6	50.4	17.5	22.3	14.8	26.6	56.8	59.9
Oromia	32.4	49.4	47.3	14.6	13.5	8.8	34.1	52.7	56.3
Somale	49.0	64.4	51.4	17.9	26.4	15.9	58.5	78.5	83.0
Benishangul Gumuz	76.4	119.5	112.7	57.0	50.4	37.8	78.3	125.1	133.9
SNNPR	28.9	32.2	36.2	7.5	9.1	6.8	30.6	33.6	41.1
Harari	58.5	85.0	66.6	29.7	16.5	8.6	105.2	158.0	161.4
Addis Ababa	0.4	0.6	0.7	0.4	0.6	0.7	0.1	1.4	0.4
Dire Dawa	62.5	71.4	35.1	16.2	12.6	10.4	129.0	162.8	158.4

Source: ICRISAT 2012, * in kg per adult equivalent/year

4.2. Price Responsiveness of Sorghum

Own-price and expenditure elasticity of cereals: Little elasticity estimation has been conducted for staple food in the East African region in recent years. However, IFPRI's market research in the region provides a valuable and detailed source on price and income elasticities for all major cereals in Ethiopia. Tables 26-28 summarize IFPRI's results. The compensated own- price elasticities are, as predicted by theory, negative for all commodities. That they are also close to -1 suggests that most of the commodities are own-price unitary elastic. Own-price elasticities of maize and sorghum are the furthest away from -1 (Table 26). Cross-price effects are also present, although they appear rather weak for most commodity pairs. Among the four major cereals (teff, wheat, maize, and sorghum) complementarity is detected between the teff-sorghum and maize-sorghum pairs, while substitution appears to be the link between teff and wheat. IFPRI's explanations in view of these results are the limited possibilities in consumption for substitution and/or complementarity in Ethiopia. Diversity in the bio-physical and socio-economic landscape is likely to constrain these possibilities. As Table 26 shows, rural and urban area results with regard to own and cross price elasticities differ only marginally. Own price elasticity in urban areas seems to be slightly higher.

The expenditure elasticity estimates (Table 27) indicate that most commodities are normal, though some are marginally so. The negative expenditure elasticities of 'other cereals' and barley indicate that the two are inferior. For the former, which is dominated by millet, the result is driven by the outcome in urban demand. Teff, other cereals, processed cereals, pulses, animal products, and services have income elastic demands. Tafere et al. (2010)

conclude that these results are consistent with the perception that Teff and animal products are generally considered superior food types in the country. On the other hand, wheat, maize, and sorghum, appear as expenditure-inelastic. That maize and sorghum are relatively less desired cereals in most parts of the country, while a significant fraction of wheat originates as food aid may be the explanations.

Table 26: Compensated price and cross-price elasticities of cereals (National) in Ethiopia[6]

		Teff	Wheat	Barley	Maize	Sorghum
National	Teff	**-0.89**	0.10	0.06	0.05	-0.10
	Wheat	0.06	**-0.98**	0.05	0.04	0.05
	Barley	-0.02	0.00	**-0.95**	-0.02	-0.04
	Maize	0.04	0.05	0.04	**-0.75**	-0.05
	Sorghum	-0.03	0.04	0.02	-0.07	**-0.66**
Rural	Teff	**-0.905**	0.051	0.04	0.03	-0.077
	Wheat	0.027	**-0.978**	0.028	0.034	0.022
	Barley	-0.003	0.009	**-0.976**	0.003	-0.009
	Maize	0.031	0.043	0.037	**-0.873**	0.001
	Sorghum	0.007	0.053	0.048	0.012	**-0.84**
Urban	Teff	**-0.862**	0.094	0.083	0.07	-0.042
	Wheat	0.013	**-0.992**	0.015	0.022	0.008
	Barley	-0.005	0.007	**-0.978**	0	-0.014
	Maize	0.001	0.011	0.006	**-0.904**	-0.031
	Sorghum	-0.053	-0.009	-0.014	-0.5	**-0.902**

Source: Tafere et al. 2010. based on CSSA HICE 2004/05 data

Table 27: Expenditure shares and expenditure elasticities of cereals in Ethiopia

	Expenditure Share (%)			Expenditure Elasticity of Demand (QU-AIDM		
	National	Rural	Urban	National	Rural	Urban
Teff	4.96	4.37	8.17	1.69	1.08	1.14
Wheat	5.06	5.53	2.57	0.78	0.42	0.41
Barley	2.55	2.91	0.57	-0.44	0.06	0.33
Maize	4.97	5.66	1.05	0.92	0.62	0.58
Sorghum	**4.71**	**5.39**	**1.05**	**0.77**	**1.00**	**-0.81**
Other Cereals	0.89	0.97	0.47	-6.70	2.30	-6.70
Processed Cereals	1.91	0.96	7	2.33	-1.29	1.04
Total Cereals	25.05	25.79	20.88			

Tafere et al. 2010). based on CSSA HICE 2004/05 data

Elasticity estimates for cereals vary according to alternative demand models and estimation procedures though they appear to be robust for most crops. With regard to sorghum the own price elasticity ranges between -0.66 and -0.83 and expenditures elasticity between 0.54 and 1.82. Positive own-price elasticity from the LA-AIDM model for sorghum and Maize were not explained by the authors, though it is questionable that they result from an 'inverse' consumption function. Expenditure elasticity estimates point out that most consumption items are normal goods (see Table 28). The QU-AIDM model indicates that teff, other

[6] The authors of this IFPRI study empirically investigated the responsiveness of demand for various food and non-food items to changes in price and expenditure using the Quadratic Linear Almost Ideal Demand Model (AIDM). The demand system was estimated using non-linear Seemingly Unrelated Regression (NSURE) technique using Household Income Consumption Expenditure Survey 2004/05 data collected by Central Statistical Agency of Ethiopia.

cereals, processed cereals, and animal products have elastic demand in both urban and rural areas. This finding further supports the claims made above about the public perception of the different cereals. It is also interesting to find processed cereals (in rural areas) and other cereals (in rural areas) appear to be inferior goods.

Table 28: Elasticity estimates from alternative demand models or estimation procedure

	Expenditure elasticity					Compensated Own-price Elasticity				
	QU-AIDM Cens.	QU-AIDM Un-cens.	QU-AIDM Un-cens. (EA)	LA-AIDM Un-cens.	QU-AIDM Cens. (10 Com. groups)	QU-AIDM Cens.	QU-AIDM Un-cens	QU-AIDM Un-cens. (EA)	LA-AIDM Un-cens.	QU-AIDM Cens. (10 Com. groups)
Teff	1.69	1.12	0.81	1.01	0.69	-0.89	-0.92	-0.91	-0.96	-1.02
Wheat	0.78	1.08	0.83	0.99	1.19	-0.98	-0.95	-0.98	-1.03	-0.96
Barley	-0.44	1.08	0.81	0.92		-0.95	-0.76	-0.71	-0.02	
Maize	0.92	0.40	0.56	1.05	0.94	-0.75	-0.96	-0.94	2.06	-0.74
Sorghum	**0.77**	**0.61**	**0.54**	**0.90**	**1.82**	**-0.66**	**-0.83**	**-0.77**	**3.66**	**-0.66**
Other Cereals	-6.7	-2.25	-1.65	0.99		-1.07	-1.04	-1.05	-3.28	

Tafere et al. 2010). Based on CSSA HICE 2004/05 data

In summary, the findings of the IFPRI study suggest that Ethiopian households display significant consumption response to changes in prices and expenditure/income. It is interesting to note that price elasticities of demand for cereals are roughly the same in urban and rural areas of the country, while expenditure elasticities have a distinct and opposite rural and urban pattern.

5. Domestic and International Trade in Sorghum

The scientific literature about Ethiopia's agriculture and rural markets provide only rudimentary and largely fragmented information about domestic trade of major staple food including cereals. The Regional Agricultural Trade Intelligence Network RATIN NET that is monitoring major agricultural markets in the East African region and run by the East African Grain Council EAGC at its HQ in Nairobi does not cover Ethiopia, nor provides monitoring of cross-border commodity trade between Ethiopia and its East African neighbours, especially alongside market points at the North and South Sudanese borders and with Djibouti. The Famine Early Warning System Network FEWS NET reports cross border market profiles and food security outlook for famine prone regions in Ethiopia. USAID develops and publishes trade maps that shows in rough strokes domestic trade flows and cross-border trade based on seasonal monitoring of transactions in a few selected markets. However, those trade maps do not come with a detailed analysis and trade figures that could be linked and cross-checked with spatial production and consumption patterns. In a similar token the Food Security & Nutrition Working group FSNWG, a consortium of USAID, the German BMZ, FAO, WFP and FEWS NET, publishes an East Africa Trade Bulletin on a regular base that combines monitoring results from all concerned members regarding cross border trade and the supply situation of staple food in the domestic market.

As a consequence of sparse quantitative trade data, the domestic trade analysis in this chapter cannot come up with precise regional trade flow analysis for sorghum, but it can arrive at a rough approximation of the magnitude of sorghum trade between zones and woreda across the entire country in comparison to the non-traded share of sorghum that is consumed at the famers' household.

Information regarding Ethiopia's international trade in agricultural produce and cereals is more abundant and available from major sources such as FAOSTAT and the Central Statistical Agency CSA of Ethiopia. However, cross-border trade statistics (exports) from FAO & CSA do not indicate the country of destination which could help drafting a more accurate picture about the border markets. Imports indicate to a certain extend the country of origin, especially when imports are food aid shipments.

5.1. Domestic Trade in Sorghum

Domestic trade in sorghum occurs between sorghum surplus and deficit regions. With spatial production and consumption information available and already reported in previous sections it is possible to define the status of any administrative unit as a sorghum surplus or deficit unit. The usual sorghum statistics is reported at regional and zonal level. With some simplification and extrapolation of data, this study adds a higher resolution by downscaling to woreda level in the spatial decomposition of production and consumption (see Table A-6 in Annex).

Downscaling production to woreda level has already been outlined in previous chapter. On the consumption side several stages of data manipulation and calculus are necessary. Consumption analysis done by IFRPI and ICRISAT are based on the 2004 Household Income, Consumption and Expenditure Survey (HICES). Thus, dynamic consumption factors such as population increase and age composition that change over time were updated using

the population projection for 2012 from the Population and Housing Census of Ethiopia' 2007 (CSA 2012) and IFPRI's data set from the 'Population and Housing Census Atlas of Ethiopia' 2007 for age composition and conversion of the population count into adult equivalent[7].

In a next step, sorghum consumption per adult equivalent was obtained by grouping each woreda according to proximity to sorghum production based on the amount of sorghum production per capita as the cutting line. Below 30 kg/capita, the woreda was classified as being 'far from sorghum', and above 30 kg/capita as 'close to sorghum'. The last step in the calculus was the adjustment of consumption for each woreda by a common adjustment factor which ensures aggregated consumption matches aggregated production, net of exports and imports. Zonal and regional consumption figures are obtained as simple summation from the lower-level administration units.

Table 29 outlines the production and consumption balance for each region for the year 2012. With an estimated population of 84 million (equivalent to Mio. 50 in AE), sorghum consumption is assumed to total around Mio. 3.8 mt. Over 80% is consumed in rural areas (Mio 3.35 mt) and cities close to the sorghum producing areas which confirmed the very nature of region specific consumption pattern for cereals and other staple crops. Closer inspection of the major sorghum regions shows some interesting differences. Amhara and Oromia are fairly comparable in size, population and sorghum production. However, Amhara generates a large sorghum surplus (Mio. 0.4 mt) while Oromia exhibits a small deficit of around 40,000 mt. The reason is that Oromia per capita (AE) consumption is much higher than in Amhara. Tigray as the 3rd largest sorghum producer has a negative sorghum balance as well. The SNNPR region shows the largest deficit at around Mio. 0.2 mt which implies there must be major north-south trade flow of sorghum between Amhara in the North and SNNPR in the south.

GIS Maps 7-9 capture the spatial production and consumption pattern at woreda level. Map 7 highlights the aggregate consumption by woreda, including major cities and roads; Map 2 the consumption level per adult equivalent and year reflecting ICRISAT's results from the consumer analysis for Ethiopia and differentiation by region and proximity to sorghum producing areas. Map 3 captures the sorghum balances and identifies the major deficit and surplus areas at woreda level. Trade flow information is added based on the USAID/FEWS NET GIS map 'Production and Market Flow Maps: Ethiopia First Season Sorghum'.

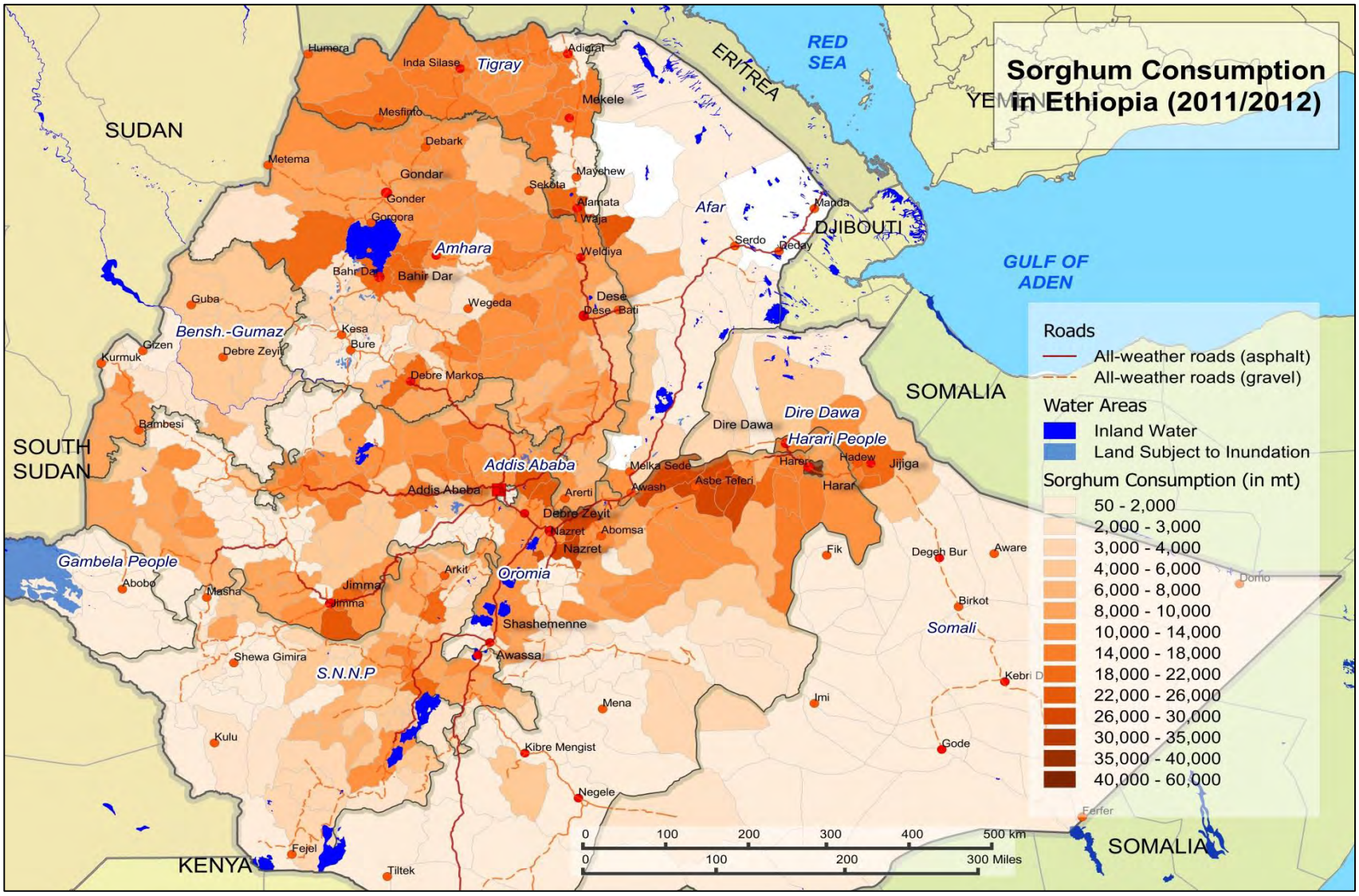
[7] The study uses the "OECD-modified scale". After having used the "old OECD scale" in the 1980s and the earlier 1990s, the Statistical Office of the European Union (EUROSTAT) adopted in the late 1990s the so-called "OECD-modified equivalence scale". This scale, first proposed by Haagenars et al. (1994), assigns a value of **1** to the household head, of **0.5** to each additional adult member and of **0.3** to each child.

Table 29: Production and consumption of sorghum by region

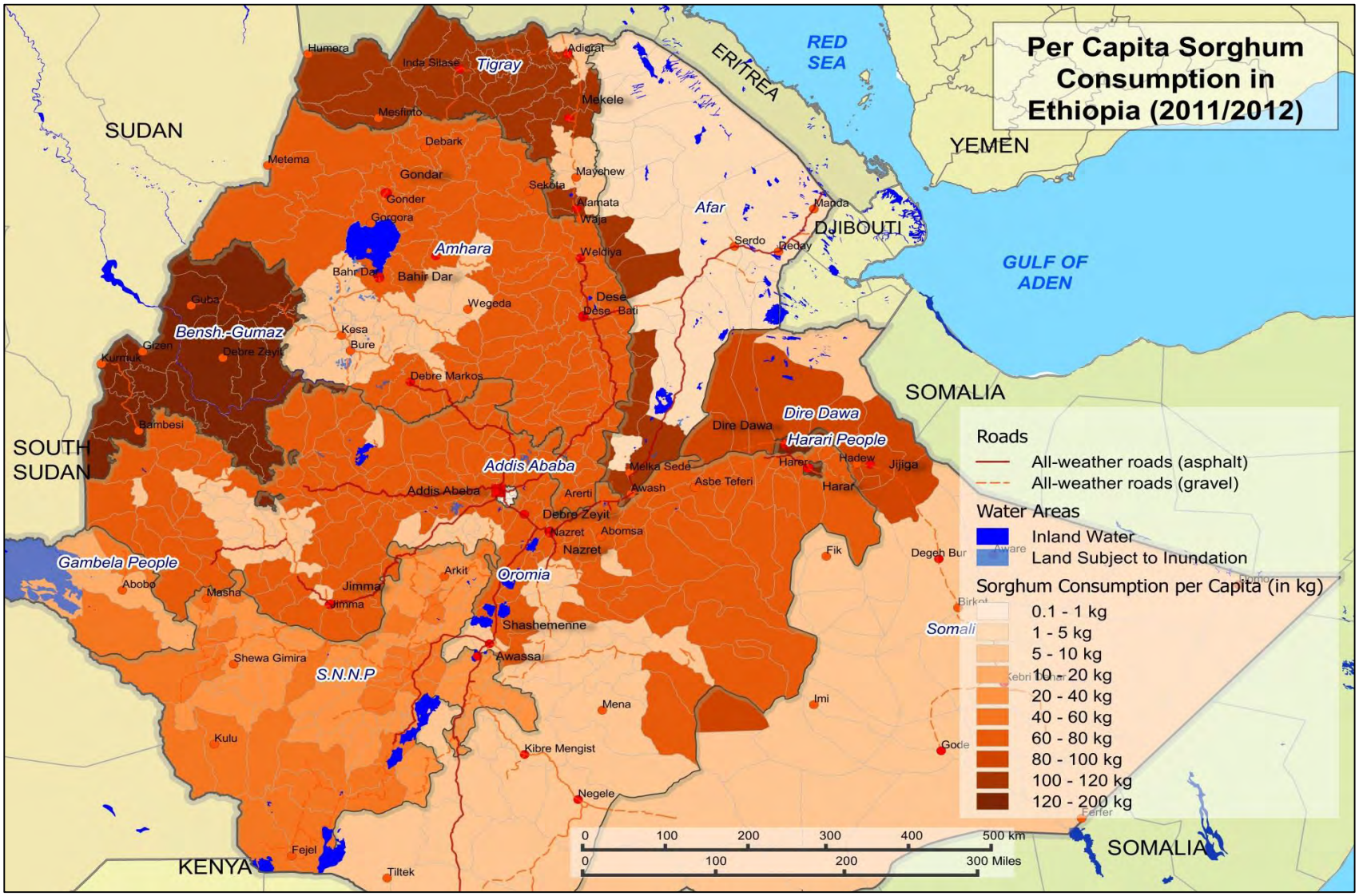
Region	Population 2012	Adult equivalent	Consumption 2012 (mt)			Production (mt)		Surplus (mt)
			Total	close to prod. area	far from prod. area	Production (2012)	Prod. kg/AE	
National	84,000,000	50,330,015	3,856,421	3,348,754	507,667	3,876,421	77	20,000
Tigray	4,604,847	2,849,628	433,578	424,566	9,011	401,588	141	-31,989
Afar	1,968,902	1,103,618	88,630	86,941	1,690	38,355	35	-50,275
Amhara	20,897,689	12,971,644	917,924	851,688	66,236	1,327,789	102	409,865
Oromia	28,716,822	16,945,680	1,587,542	1,512,617	74,925	1,545,116	91	-42,426
Somale	4,595,777	2,467,897	121,246	96,123	25,123	93,056	38	-28,190
Benishangul Gumuz	767,691	466,196	104,832	104,832	0	118,191	254	13,359
SNNPR	18,249,546	10,757,847	535,922	210,783	325,140	313,429	29	-222,493
Harari	230,389	150,639	42,486	42,486	0	5,733	38	-36,753
Addis Ababa	3,591,972	2,381,217	2,696	124	2,572	10,386	4	7,691
Dire Dawa	96,974	60,717	16,947	16,947	0	19,825	327	2,878
Gambela	279,392	174,932	4,619	1,648	2,971	2,954	17	-1,665

Source: Own calculations based on: 1) Central Statistical Agency CSA, 2012 Ethiopia, 2) Central Statistical Agency of Ethiopia CSA (2007) Population and Housing Census, 3) MAPSPAM data set (updated for 2012) for sorghum production at woreda level, 4) IFPRI 2014 Population and Housing Census Atlas of Ethiopia 2007

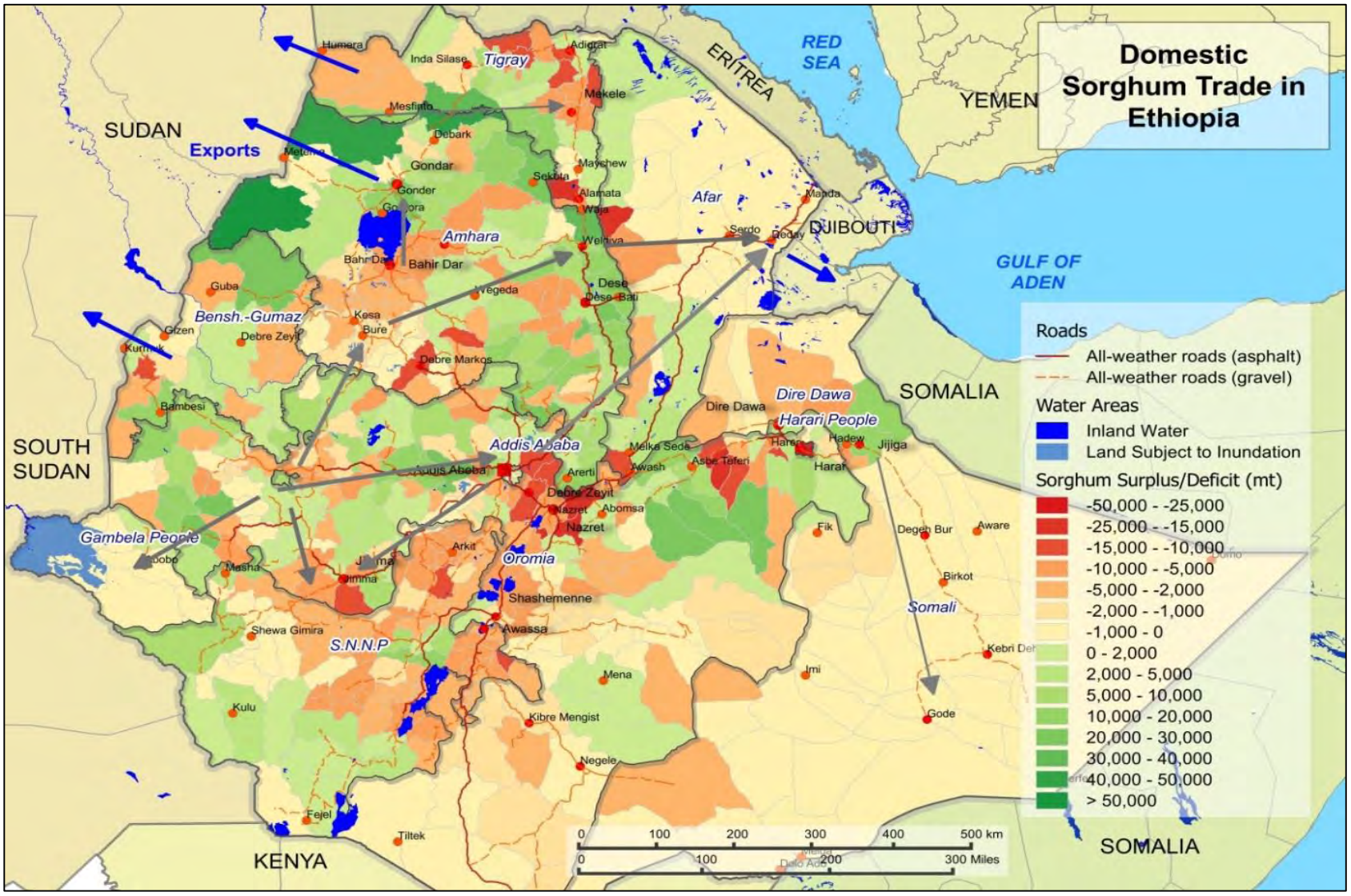
Map 7: Spatial pattern of sorghum consumption in Ethiopia at woreda level



Map 8: Spatial pattern of per-capita sorghum consumption in Ethiopia at woreda level



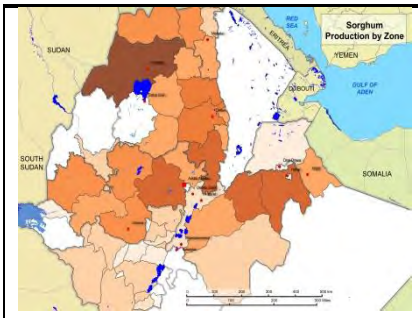
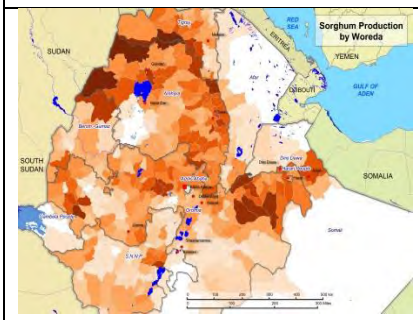
Map 9: Sorghum balance and trade flows at woreda level



A simple way to approximate the directions and magnitude of domestic sorghum trade versus home consumption is elaborated in this section. However, it does not show exact trade flows, but only the magnitude of sorghum that is traded across administrative units. Zonal and Woreda level sorghum balances are established and subsumed across all deficit zones (woreda) and all surplus zones (woreda) separately. Aggregate figures from the surplus zones (woredas) indicate the volume (and %) of sorghum that is traded across zones (woredas) and destined for the deficit areas. On contrary, aggregation across deficit zones indicates the amount of sorghum that must come from surplus zones in order to match zonal consumption. Results differ according to the administrative level under consideration. More sorghum is traded across woredas compared to zones, and more across zones compared to regions, due to the different spatial dimension between woreda, zonal and regions.

The trade matrix in Table 30 shows the amount and percentage of trade at both levels. At the zonal level, Mio 2.46 mt of production and Mio 1.6 mt of consumption creates a surplus of 860,000 mt of sorghum (34.9%) that is destined for the deficit region. In the deficit zones, total consumption of Mio. 2.28 mt is composed of Mio. 1.4 mt of own production (62.3%) and the remaining 860,000 mt sourced from other zones (37.7%). Assuming that all production in the deficit zones remains in the zones, the share of national production that is traded across zones is around 22.1 %. The same calculus at woreda level yields a slightly higher trade share of around 34%.

Table 30: Domestic trade flows of sorghum between surplus & deficit regions

<table>
<tr><td rowspan="5"> 
</td><td colspan="5">Trade Flows at Zonal Level</td></tr>
<tr><td colspan="2">Surplus Zones</td><td></td><td>Deficit Zones</td><td>Trade flow in % of production /consumption</td></tr>
<tr><td colspan="2">2,459 (100%)</td><td></td><td>1,417 62.3%)</td><td>859 (37.7%)</td><td rowspan="2">22.1%</td></tr>
<tr><td>1,601 (65.1%)</td><td>859 (34.9%)</td><td></td><td colspan="2">2,276 (100%)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td rowspan="3"></td><td colspan="5">Production in ‘000 mt and %</td></tr>
<tr><td colspan="5">Consumption in ‘000 mt and %</td></tr>
<tr><td colspan="5">Trade flow in ‘000 mt and %</td></tr>
<tr><td rowspan="5"> 
</td><td colspan="5">Trade Flows at Woreda Level</td></tr>
<tr><td colspan="2">Surplus Woredas</td><td>Deficit Woredas</td><td colspan="2">Trade flow in % of production /consumption</td></tr>
<tr><td colspan="2">2,665 (100%)</td><td>1,212 (48%)</td><td>1,312 (52%)</td><td rowspan="2">33.9%</td></tr>
<tr><td>1,353 (50.8%)</td><td>1,312 (49.2%)</td><td colspan="2">2,524 (100%)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="6">Source: own calculation</td></tr>
</table>

5.2. International Trade in Sorghum

According to FSNWP (2011), extensive, complex and multidirectional cross-border trade of staple foods and livestock exist in the East Africa region. However, there is limited accurate data on volumes, seasonality, and directions of cross-border trade for these commodities to indicate their contribution to regional food security. In addition, there is scarce information on the contribution of informal trade to overall cross-border trade. Ethiopia is no exception in that regard as it lacks fundamental trade statistics at international standard (volume, value, destination, and trade mirror statistics for cross-check) with the international markets and with Ethiopia's neighbouring countries. Ethiopia's trade in cereals remains miniscule compared to the national production level. Turnover in cross border trade of cereals accounts for only 5% of national production in normal years. Increased imports during 2008 and 2010 lift the trade share to 10%, but most of the imports do not come from commercial imports but from food aid. Ethiopia's trade balance remains single sided with imports outweigh exports by far. This is due to the fact that despite extraordinary expansion of land and production in cereals over the last 10 years, Ethiopia remains a chronic food deficit country in cereals and continues to receive food aid at a large scale from international organisation (WFP, USAID, EU) and bilateral partners. Exports of major cereals range between zero and 20,000 mt over the time of observation, with a peak in 2010 where exports reached around 60,000 mt composed of maize and sorghum. There is no clear indication in the literature of the country of destination nor the amount and value of exports received from Ethiopia. However, various sources on informal cross-border trade pattern, hint at North and South Sudan as well as Somalia (esp. Somaliland) as the major destinations for sorghum.

Table 31: Export and import volumes of major cereals in metric tons (1993 – 2010)

	Exports					Imports				
Year	Maize	Sorghum	Millet	Wheat	Cereals	Maize	Sorghum	Millet	Wheat	Cereals
2010	35,994	21,786	12	5	57,797	29,222	351,734	3	351,734	732,693
2009	0	0	16	1	17	54,466	268,640	1	268,640	591,747
2008	0	2,224	41	35	2,300	36,050	252,697	5	252,697	541,449
2007	17	2,402	93	1	2,513	31,912	16,468	1	16,468	64,849
2006	672	1,371	139	0	2,182	60,271	1,088		1,088	62,447
2005	2,606	13,420	5	195	16,226	30,436	2,861		2,861	36,158
2004	11,086	1,760	28	54	12,928	11,347	4,606	1	4,606	20,560
2003	746	1,412	625	58	2,841	11,582	24,416	0	24,416	60,414
2002	12,848	1,198	8,904	94	23,044	3,189	10,000	0	10,000	23,189
2001	1,327	118	50		1,495	23,500	8,500		8,500	40,500
2000	385	1,051	156	2	1,594	18,300	7,400		7,400	33,100
1999	979	408	80	20	1,487	35,000	49,000		49,000	133,000
1998	1,701	239	76	20	2,036	30,000	50,000		50,000	130,000
1997	0	63	0	0	63	26,800	10,000	0	10,000	46,800
1996	0	63	0	0	63	20,500	50,000	0	50,000	120,500
1995	0	63	0	0	63	24,500	100,354	0	100,354	225,208
1994	0	49	0	0	49	36,300	102,875	0	102,875	242,050
1993	0	0	0	0	0	21,000	19,900	1	19,900	60,801

Source: FAOSTAT

On the import side, Ethiopia' cereal imports are large driven by food aid programmes and government procurement policies for immediate distribution in times of food scarcity or for replenishment of the food buffer stocks. Most of the imported cereals are wheat and

sorghum and to a lesser extent maize. There has been variation in the scale of cereal imports with little imports reported between 2000 and 2007 and strong peak between 2007 and 2009 at a magnitude of 500,000 – 700,000 mt. In terms of revenues and expenditures, at least in the cereal fraction, exports do not play any role as a major earner of foreign exchange. On the import side, expenditures on cereal imports seem high from the FAOSTAT statistics. For examples Mio 123 USD on sorghum imports, Mio 475 USD on wheat imports that would pose a major strain Ethiopia's trade balance. The question is how much of the imports where commercial imports and how much food aid provided at subsidised prices or as grants.

Table 32: Value of cereal exports and imports (in current million USD), 1993 - 2010

	Maize				Sorghum				Wheat			
	EX	IM	GPV	% trade to GPV	EX	IM	GPV	% trade to GPV	EX	IM	GPV	% trade to GPV
2010	9.8	11.7	666.4	**3.2**	7.2	123.0	687.12	**18.9**	0.005	475.0	918.17	**51.7**
2009	0.0	22.0	972.2	**2.3**	0.0	95.0	906.69	**10.5**	0.001	490.0	1008.9	**48.6**
2008	0.0	14.9	1,321.8	**1.1**	0.6	84.5	1,033.8	**8.2**	0.124	465.2	1300.1	**35.8**
2007	0.0	14.0	898.7	**1.6**	0.5	3.3	750.6	**0.5**	0.001	210.0	876.93	**23.9**
2006	0.1	25.0	555.9	**4.5**	0.3	0.2	401.5	**0.1**	0.000	135.0	635.77	**21.2**
2005	0.5	10.5	566.0	**1.9**	3.6	0.4	415.2	**1.0**	0.029	224.4	466.43	**48.1**
2004	1.8	7.7	341.8	**2.8**	0.3	0.9	275.9	**0.4**	0.012	176.6	390.68	**45.2**
2003	0.1	5.0	347.2	**1.5**	0.4	4.8	297.3	**1.8**	0.016	362.4	288.82	**125.5**
2002	1.9	1.3	188.0	**1.7**	0.2	2.0	139.9	**1.6**	0.015	98.5	176.23	**55.9**
2001	0.2	8.5	261.3	**3.3**	0.0	1.8	156.6	**1.2**	0.000	150.0	230.79	**65.0**
2000	0.1	6.5	320.0	**2.1**	0.3	1.5	168.9	**1.1**	0.001	163.0	246.08	**66.2**
1999	0.2	4.7	345.9	**1.4**	0.1	10.0	182.8	**5.5**	0.008	77.0	252.89	**30.5**
1998	0.3	4.3	299.8	**1.5**	0.1	10.0	167.5	**6.0**	0.013	81.0	234.45	**34.6**
1997	0.0	3.5	338.3	**1.0**	0.0	2.4	285.9	**0.8**	0.000	34.4	210.12	**16.4**
1996	0.0	3.0	353.7	**0.8**	0.0	11.5	256.1	**4.5**	0.000	76.0	248.87	**30.5**
1995	0.0	3.1	306.9	**1.0**	0.0	22.7	220.4	**10.3**	0.000	132.0	274.51	**48.1**

Source; FAOSTAT. Ex = exports; IM = imports; GPV = gross production value in Mio. USD

The WFP food aid information system reports food aid deliveries for Ethiopia from bilateral and international donors. Combined it amount to over ½ Mio mt in cereals annually over the last 6 years, mostly wheat and maize. But also sorghum deliveries took place, especially in 2008 and 2010 from the USAID program. As sorghum imports from food aid sorghum are irregular, it poses a challenge to how to factor them in a modelling framework such as the DREAM model that aims to portray a regular market situation in which improved varieties take effect. Furthermore those food aid imports do not enter at a market price nor is little know about the price effects they have for Ethiopia's sorghum economy.

Table 33: Cereal imports from food aid programmes in mt (2007 – 2012)

Year	Corn-soya	Wheat	Maize	Rice	**Sorghum**
2012	46,475	460,518	28,161	28,350	
2011	36,312	328,667	103,521	845	**20,908**
2010	49,552	652,707	56,366	2,630	**229,714**
2009	46,475	460,518	28,161	28,350	
2008	44,016	416,210	34,289	690	**251,660**
2007	7,323	238,372	41,797	510	**22,205**

Source: World Food Programme, food aid information system

5.3. Sorghum Trade with Ethiopia's Neighbours and Trade Policy Issues

Despite the obvious advantages of geographical proximity, and historical and cultural ties, trade between bordering least developed countries is quite rudimentary. In Africa, for instance, in spite of the proliferation of regional trade and monetary blocs/cooperation, formal trade among neighbouring countries is largely insignificant. This also holds for Ethiopia and its neighbours such as North & South Sudan, Somalia and Kenya. South-South trade agreements have no resulted in corresponding level of trade. Ethiopia has made a number of preferential trade agreements with many countries. Under the various Generalized System of Preference (GSP) schemes, Ethiopia is one of the beneficiaries of preferential trade access for a wide spectrum of commodities from a number of developed countries, including, among others, Australia, Canada, the European Union (EU), Japan, Norway, and the United States of America (USA). The two most important duty free market access opportunities that Ethiopia currently enjoys are the EBA and AGOA schemes. Except Kenya, which is not categorized as a least developed economy, all other neighbouring countries in East Africa are beneficiaries of the EBA, and many other GSP schemes. Moreover, Ethiopia is currently negotiating to join the multilateral trading system WTO. Except Sudan and Ethiopia, members of the EAC have already joined the WTO. According to Moges (2008) low trade integration among east African countries are multifaceted:

- relatively high MFN duty rates for agricultural production, lack of complementary, and high trade costs despite the fact regional trade agreements. Ethiopia, the EAC and Sudan export largely homogenous and competing products.

- trade intensification and diversion effects between members and non- members of regional trade agreements COMESA, EAU may also contribute to the low trade volumes in the East African region and in particular to Ethiopia as it is not a member of the WTO, the EAU and faced with high tariff rates.

Tariff structure: The tariff lines and structure of Ethiopia and its most important trading partners in the region is summarized in Tables 34 to 36. Table 34 highlights the Most Favourite Nations MFN tariff structure as simple average and trade weighted average for agriculture and non-agriculture goods. All countries have in common much higher tariffs for agricultural good compared to non-agricultural goods. Trade weighted average MFN tariff level in agriculture is exceeds the average level by far, indicating two possible explanations: 1) the extremely punitive nature of high tariff lines or 2) intentional low tariffs on necessary agricultural imports. Kenya stands out as the most trade-friendly country with the lowest agricultural and non-agricultural import tariffs (except agricultural tariffs in Djibouti).

Table 35 shows the frequency of different tariff lines, ranging between duty free and > 100%. Ethiopia and Sudan are most protective in agricultural imports. 60% of MFN tariffs are between 25<> 50 % and are applied to 16% of agricultural imports. For Sudan, 57% of MFN tariffs fall in 25<> 50 % category and cover around 30% of agricultural imports. The picture, however, is quite different for the EAC. Kenya as EAC member maintains lower average rates and high duty free rates (16% of tariff lines). But Kenya imposes as high as 100 % protective rates on some products, accounting for 7.8% of the value of imports. Also the EAC imposes relatively high duty rates on most agricultural commodities and low rate on non-agricultural products. This has some implication for trade among these countries. In

general, agricultural commodities are less traded than manufacturing goods. As agriculture being relatively Ethiopia's only natural resource endowment, heavy import tariffs in Sudan and Kenya on agricultural commodities implies relatively low trade in agricultural commodities between Ethiopia and those countries. However, further investigation of the specific commodities, trade pattern and corresponding tariffs rates is needed to arrive at better founded conclusions.

Table 34: Most Favourite Nations (MFN) tariffs of Ethiopia and neighbour countries

Country	Tariff	Year	Total	Agriculture	Non-agriculture
Ethiopia	Simple average MFN applied	2010	17.3	22.3	16.6
	Trade weighted average	2009	10.4	11.1	10.3
Sudan	Simple average MFN applied	2010	19.9	30.4	18.4
	Trade weighted average	2009	18.2	16.9	18.5
Djibouti	Simple average MFN applied	2010	20.9	14.2	21.9
	Trade weighted average	2009	17.3	12.2	19.3
Kenya	Simple average MFN applied	2010	12.5	19.7	11.4
	Trade weighted average	2009	10.1	1.6	8.5

Source: own calculation, based on World Tariff Profiles 2011

Table 35: Frequency distribution of agricultural tariff lines

	Tariff lines and import values (in %)	Duty-free	0<= 5	5<=10	10<=15	15<=25	25<=50	50<=100	> 100
Ethiopia	MFN applied 2010	1.3	16.8	11.1	0	10.8	59.7	0	0
	Imports 2009	23.2	47.9	9	0	3.6	16.3	0	0
Sudan	MFN applied 2010	3.9	4.1	8.7	0.0	26.1	57.2	0	0
	Imports 2009	6.0	41.2	12.8	0	10.9	29.1	0	0
Djibouti	MFN applied 2010	0.6	26.2	0.5	37.0	0.1	34.0	0	0
	Imports 2009	5.5	20.8	1.1	53.1	2.9	16.7	0	0
Kenya	MFN applied 2010	15.9	0	16.3	0	64.4	1.4	2.1	0
	Imports 2009	23.1	0.9	5.0	0.8	20.5	42.0	7.8	0

Source: own calculation, based on World Tariff Profiles 2011

Table 36: Tariffs and imports duties for cereals and oilseeds

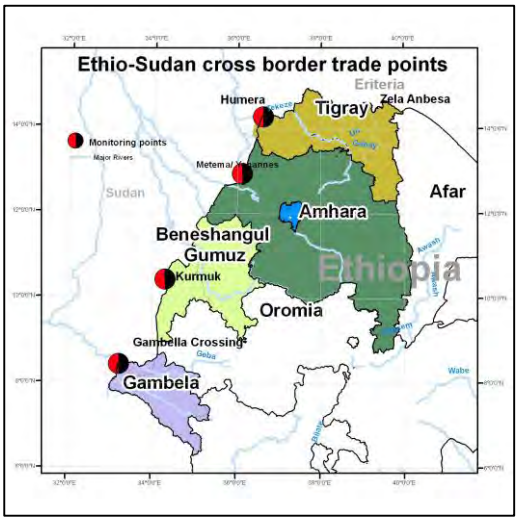
		MFN applied duties			Imports	
Country	Product group	Average	Duty-free in %	Max	Share in %	Duty-free in %
Ethiopia	Cereals	21.0	0.2	35	5.9	0.0
	Oilseeds, fats & oils	17.0	0.7	30	3.4	76.9
Sudan	Cereals	24.2	8.3	40	7.7	5.9
	Oilseeds, fats & oils	26.2	8.3	40	0.7	5.9
Djibouti	Cereals	9.4	1.3	26	10.9	1.9
	Oilseeds, fats & oils	14.0	1.3	26	1.7	45.5
Kenya	Cereals	22.7	6.2	60	8.7	1.9
	Oilseeds, fats & oils	11.6	24.0	25	4.1	80.3

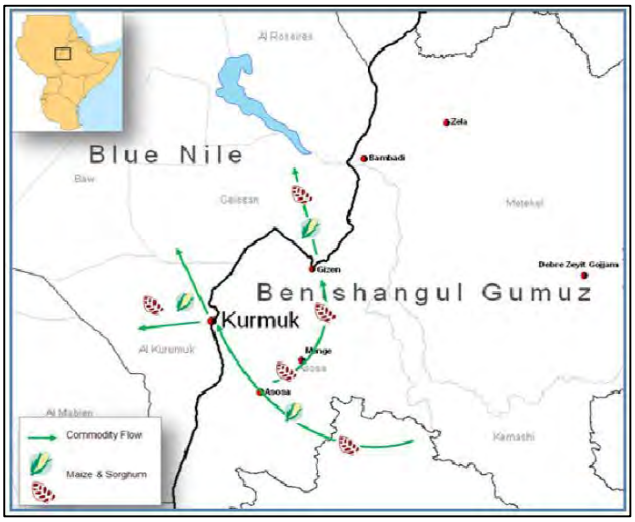
Source: own calculation, based on World Tariff Profiles 2011

The FEWS NET trade monitors allow some insights into Ethiopia's cross border trade with Sudan, Somalia, Djibouti and Kenya, though cereals are not further broken down into individual crops. Table 37 is an extract from the FEWS NET 2010 market monitoring showcasing only Ethiopia's cross border points. In 2010 Ethiopia exported considerable quantity of cereals to North Sudan, over 50,000 mt over its three border points. According to FAOSTAT export figures it was composed of around 36,000 mt of maize and 22,000 mt of sorghum. Significant cereals exports went to North Sudan and Kenya.

Table 37: Market monitoring of Ethiopian cross-border points

Market	Border Location	Start month of monitoring in 2010	**Cereals (mt)**	Pulses (mt)	Others (mt)	Cattle (heads)
Togwjale	Somalia and Ethiopia	May	**1,168**			66,332
Metema	Ethiopia and N. Sudan	May	**41,801**	28,046	24,956	39,887
Humera	Ethiopia and N. Sudan	May	**12,760**	12,753	10,013	19,066
Kurmuk	Ethiopia and N. Sudan	May	**4,264**	521	1,612	7,319
Gambella	Ethiopia and S. Sudan	May	**3,627**	78	23	0
Galafi	Djibouti and Ethiopia	January	**570**	336	0	0
Gelila	Djibouti and Ethiopia	January	**105**	396	0	0
Moyale	Kenya and Ethiopia	March	**6,672**	17,930	0	19,664





Source: Table: FSNWG 2011; maps: FSNWP 2011, FSNWP 2010

Sorghum trade with Somalia: Some of sorghum cross border trade to certain destinations has been discouraged by the Ethiopian government with the aim to secure sufficient domestic supply and to combat informal trade channels. For example, Ethiopian sorghum destined for Somaliland directly or via Djibouti has almost dried up. Sorghum is seen as "contraband" and so now only small volumes are smuggled across from Ethiopia and if discovered the grain is confiscated.

Informal trade: Comprehensive information about the share of formal and informal trade does not exist. FEWS Net/WPF in Ethiopia hints at a rather low incidence of informal trade between Ethiopia and Sudan. Based on trade monitoring between June to August 2010 around 86 % of sorghum exported to Sudan is recorded and only 14% passes through informal channels (Table 38). The formal trade share for maize is even larger (95%). Wheat and Teff exports to Sudan are exclusively of informal nature though trade volume is rather low making it difficult to generalize the nature of trade for other season and with other countries. FEWS NET/WFP conclude that informal trade dominates in markets whose catchment area is afflicted by civil insecurity. Examples are Dobley (Kenya-Somalia border) and Gambella (Ethiopia-South Sudan border) markets, where all of the transactions are through informal channels.

Table 38: Cereals exports from Ethiopia to Sudan from June-Aug 2010 (in mt)

Cereals	Formal trade				Informal				Total	% formal trade	% informal trade
	June	July	August	Sub total	June	July	August	Sub total			
Sorghum	8,874	7,290	2,479	18,643	1,056	1,064	920	3,040	21,683	**86.0**	**14.0**
Maize		960	17,386	18,346	530	237	162	929	19,275	**95.2**	**4.8**
Wheat				0	133	25	52	210	210	**0.0**	**100.0**
Teff				0	55	114	241	410	410	**0.0**	**100.0**

Source: World Food Programme 2010

6. Sorghum Prices and Market Integration

Given the importance of food as part of household expenditures in Ethiopia, the functioning of food markets and its impact on food prices are closely watched by policy makers and consumers alike as prices are important determinants of the overall welfare in these settings. High food marketing costs can push consumer prices up to unaffordable levels for vulnerable groups and further hampers farmers' incentives to invest in new production technologies. The importance of food markets has become even more prevalent since the recent global food crisis when food prices reached very high levels and fuelled inflation levels in Ethiopia to reach new heights.

However, important changes have happened in this area in the last decade in Ethiopia. According to Minten et al. (2012) five major drivers have been affecting the functioning of agricultural markets.

- *First*, fast economic and income growth is leading to food demand changes, most notably higher consumption levels and a shift to more preferred cereals such as teff, as well as to high-value products such as meat, dairy products, and fruits.
- *Second*, urbanization is leading to larger rural–urban food and cereal marketing flows. Urbanization has increased rapidly and it is estimated that, compared to the beginning of the decade, 3.7 million more people are living in urban settings. As urban people are much less likely to grow their own food, this implies that commercial cereal surpluses have increased significantly over the last ten years.
- *Third*, investments in road infrastructure and a better organized transport sector have led to significant real declines in transportation costs. The government has invested heavily to improve road infrastructure in the last decade. This has led to a reduction of travel times between wholesale markets by 20 %. Reduction in transportation costs have even been higher, dropping to half the costs of a decade ago—possibly driven by more competition and a shift to better and bigger trucks.
- *Fourth*, the widespread availability of mobile phones has changed access to price information for a large number of players in the commercial circuit and has led, for some, to a different way of doing commercial deals.
- *Fifth*, cooperatives, but especially private commercial farms (often privatized state farms), have started to emerge as important players for some cereals. The government has strongly supported the establishment of cooperatives in the last decade. At the end of the last decade, they were almost the sole providers of modern inputs in the country, and have been successful in organising farmers for the commercialisation of export crops.

Price data collected over the last 10 years from cereal markets at wholesale and retail level show that these five changes were associated with significant declines in real margins of wholesale food prices between supplying and receiving markets over time, in real cereal milling margins, as well as in retail margins. Cereal prices showed important real increases over the decade but price levels were affected differently by market with relatively lower price rises in cereal deficit and vulnerable regions. Minten et al. (2012) argue that the cereal marketing system is undergoing important changes in Ethiopia to the benefit of producers and consumers alike.

6.1. Food and Cereal Price Inflation

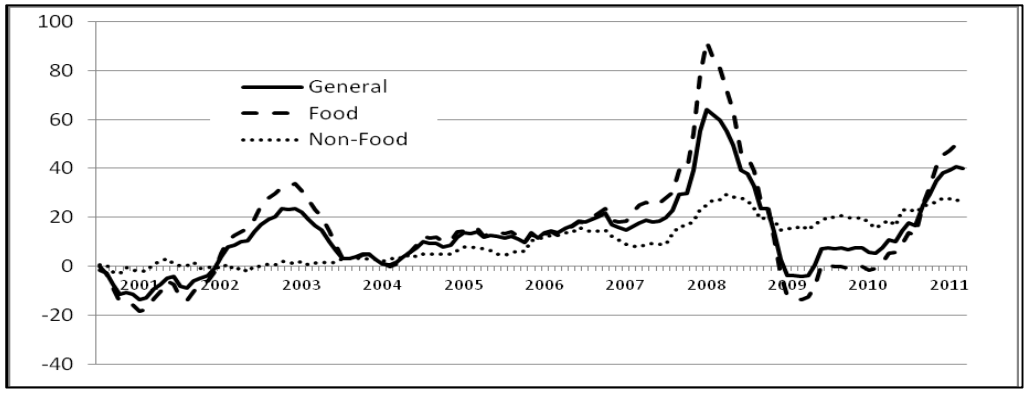
Price inflation has been an important issue in Ethiopia in most recent years, posing especially significant risks for net food buyers. Table 39 shows the differentiation of price inflation between the food and non-food sectors as a whole and between different segments within the food category. Food price inflation outpaced non-food inflation by a large margin, due to domestic shocks in the agricultural sector and bad seasons as well as developments in international commodity markets following the economic crisis in 2007. Among the food different categories, cereals and meat product prices increased fivefold between 2001 and 2011, mostly driven by international prices for meat and an increase of import prices for cereals. High-value commodities such as fruits and vegetables and dairy products show the lowest increases over time.

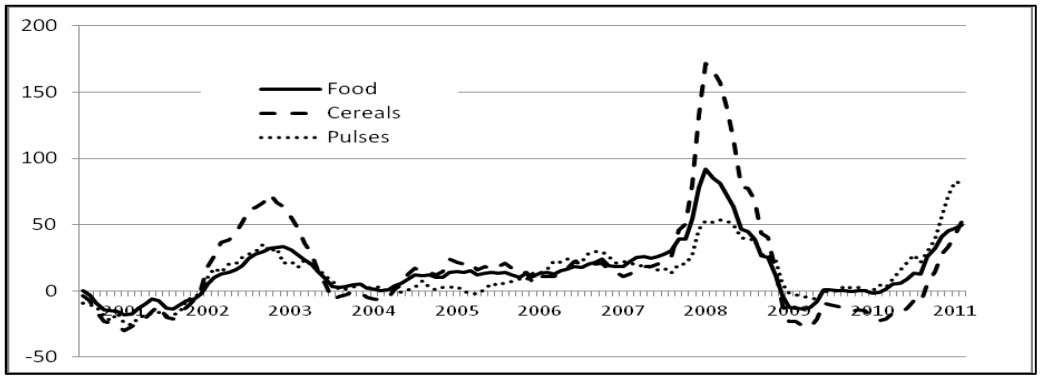
Table 39: Inflation in the food sector, 2000–2011*

	Jan. 2001– Dec.2005	Jan. 2006– Aug. 2011	Jan. 2001– Aug. 2011
General	135	305	416
Food	142	333	473
Non-Food	111	260	294
Cereals	166	319	531
Pulses	119	386	461
Dairy product	116	297	344
Meat	161	285	465
Oils & Fats	124	372	465
Potatoes & Other Tubers	133	315	422

Source: Minten et. Al. 2012, *price index at start = 100; total change of the index over the indicated period is reported)

Figure 3: Inflation in Ethiopia, using year-to-year changes, in percent





Source: Minten et al. 2012

According to Dorosh and Rashid (2012) several events can be associated with food price changes in Ethiopia. A bumper crop in 2000–2001 and 2001–2002 led to a collapse of some local market prices. On the other hand, widespread drought in 2003 led to a reduction of maize production by more than 50 % and required food assistance of 1 million tons. The global food crisis in 2008 pushed real cereal prices to very high levels. As Ethiopia is an importer of food grains, this affected local prices in an important way and exacerbated food inflation. It should be noted that non-food price inflation also went up significantly during that period, to the highest level over the period studied, suggesting that price inflation was not only due to the global food crisis. Since that high peak, the food index dropped significantly shortly after in 2008 to a level lower than zero before starting its subsequent rise.

Ethiopia responded to the food price increases in 2007 and 2008 by: (1) imposition of an export ban, (2) re-introduction of urban food rationing, (3) informal suspension of local procurement by the World Food Program (WFP) and others, and (4) direct government imports for open market sales and price stabilization. In an effort to reduce food price inflation in 2011, the government imposed price caps on 17 basic food commodity items in the beginning of that year. However, given that these price caps had negative consequences on the availability of some of the food items, that decision was reversed in June 2011 for most crops. It only stayed in effect for some higher value commodities, e.g. sugar and edible oils (Dorosh and Rashid, 2012).

6.2. Cereal Market Integration

In a spacious, diverse and highly vulnerable country such as Ethiopia, domestic market integration is important for agricultural growth and food security. Properly integrated and efficient food markets should ensure effective trade between food-deficit and food-surplus locations over long distances and can therefore lead to specialization and taking advantage of comparative advantages, a major source of economic growth. On the other hand, if prices are not properly transmitted, localized scarcities and surpluses can hurt both consumers and producers, and lead to increased price volatility. Grain marketing in Ethiopia is important for the agricultural sector for two reasons: (1) It is the largest of all the agricultural markets, based on volume of output and the geographical area covered; (2) it constitutes the most important staple food category in terms of household expenditures on food and calorie intake, and (3) it involves a large number of participants in production, trade, transportation, storage, and retail.

Tamru (2014) investigated whether regional cereal markets are integrated with Addis Ababa—the capital and geographically one of the most central markets—and if integrated, examined the level and speed of price transmission. The study relied on unique high-frequency (weekly) price data provided by the Ethiopian Grain Trade Enterprise (EGTE) and collected on a large number of cereal wholesale markets in the country, giving a good overview of the situation at the national level between 2001 and 2011. An average of 16 regional wholesale markets are selected for white teff, mixed teff, red teff, white wheat, maize, and white sorghum and each one is paired with Addis Ababa for a test of market integration. The number of markets paired with Addis Ababa varies from 4 (white sorghum) to 20 (white teff). Table 40 provides a summary of Tamru's results.

Estimation results generally indicate that markets are better integrated in 2011 compared to 2001. A look at the cereals separately shows that prices of maize, red teff, white teff, and white wheat show the existence of more and better integration with Addis Ababa at the end of 2011 in terms of number of integrated markets, speed of price adjustment, and estimated transaction cost, while white sorghum shows only mixed results. The speed of price adjustment also considerably improved, reaching -0.19 (Sorghum) and -0.34 (Maize) in 2011 compared to lower speed level from – 0.05 (wheat and maize) to -.019 (sorghum), a doubling of speed for major cereals within 10 years. Between 33 % and 50 % of the market pairs show an improvement in the speed of adjustment for price changes while it stayed the same for between 50 % and 60 % of the market pairs. None of the market pairs shows deterioration in the speed of adjustment.

Table 40: Cereal market integration for six selected markets between 2001 and 2011

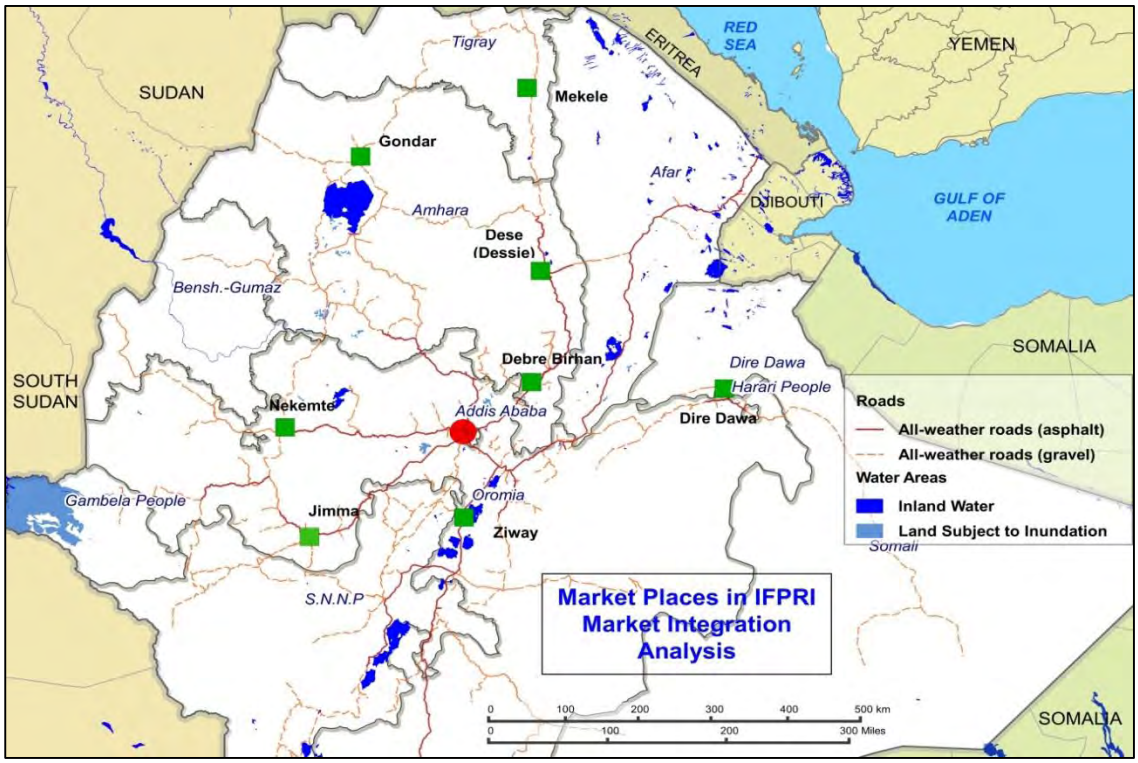
	White Teff		Red Teff		White wheat		Maize		Sorghum	
	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011
Total pairs	6	6	6	6	6	6	6	6	4	4
Percent integrated	50	83	50	100	67	83	50	100	50	50
Speed of adjustment over 2001–2011 (among those integrated):										
Improved (%)		40		33		40		50		50
Same (%)		60		67		60		50		50
Reduced (%)		0		0		0		0		0
Average speed*,**	-0.09	-0.27	-0.06	-0.24	-0.05	-0.06	-0.06	-0.34	-0.19	-0.19
Half-life (weeks)	4	3			12	6	6	4	28	25
Threshold (% of price)	9	8	15	8	33	16	45	17	19	27

Source: Tamru 2014

A look at sorghum shows a somewhat different picture. Due to lack of data, only four white sorghum markets (i.e., Mekelle, Dessie, Debre Birhan, and Dire Dawa) are considered. The first three markets are in the top ten sorghum-producing zones while Dire Dawa is a sorghum deficit area. Integration tests indicate that the degree of regional sorghum market integration with Addis Ababa has not improved over the last ten years (see Map 10). Mekele was not integrated with Addis Ababa, neither at the beginning or the end of the last decade. Dessie was integrated in 2001, but was found to be non-integrated in 2011. Dire Dawa, a market integrated in both periods, however displayed no improvement in the degree of integration over the last ten years. Only Debre Birhan, a market not integrated with Addis Ababa in 2001, demonstrated existence of a strong level of integration with Addis Ababa in 2011. The average speed of adjustment remained the same over the last ten years with an average of -0.19 at both the start and the end of the decade. Estimated transaction cost, as a percentage of average prices, on average, reached 27 %t in 2011 from its level of 19 % in 2001—an increase of 42 %. Table 41 summarize results of changes in transaction costs as percentage of average whole market price. Estimated transaction costs (i.e. thresholds), excluding those of white sorghum, declined by 50% between 2001 and 2010. Similarly, estimated transaction costs (i.e., thresholds as percentage of average price between pairs) for the major cereals—except for white sorghum—declined by 30%t during 2001–2011. The biggest decline in transaction costs between major market pairs can be observed for red teff,

followed by maize. In contrast, transaction costs in sorghum trade increased for almost all major rural sorghum markets and bilateral trade flows. The same holds true for trade from the rural areas towards Addis Ababa. For Tamru (2014) it remains a puzzle however why the sorghum market does not show improvements over time. This might be linked to the low share of sorghum in the consumption basket of consumers in Addis. As such, the tested market pairs reflect thin markets.

Map 10: Geography of market places from Table 41



Source: Author's map

Table 41: Spatial Integration of Addis Ababa and selected cereal markets in Ethiopia

	Estimated transaction costs as percentage of average price					
	Maize		Red Teff		White Sorghum	
	2001	2011	2001	2011	2001	2011
Addis Ababa–Mekelle	37.9	20.9	22.8	4.6	14.4	26.3
Addis Ababa–Dessie			16.1	3.0	26.2	33.3
Addis Ababa–Debre Birhan	7.4	8.2			18.1	24.6
Addis Ababa–Dire Dawa	11.4	23.4	23.5	13.0	15.4	24.9
Addis Ababa–Nekemte	49.7	21.7	19.0	17.6		
Addis Ababa–Gondar	8.6	11.0	16.2	4.3		
Mekelle–Dessie					19.5	24.9
Mekelle–Debre Birhan					9.8	64.4
Mekelle–Dire Dawa					5.8	97.1
Dessie–Debre Birhan					13.8	24.3
Dire Dawa–Debre Birhan					25.8	19.4
Dessie–Dire Dawa					29.8	32.8

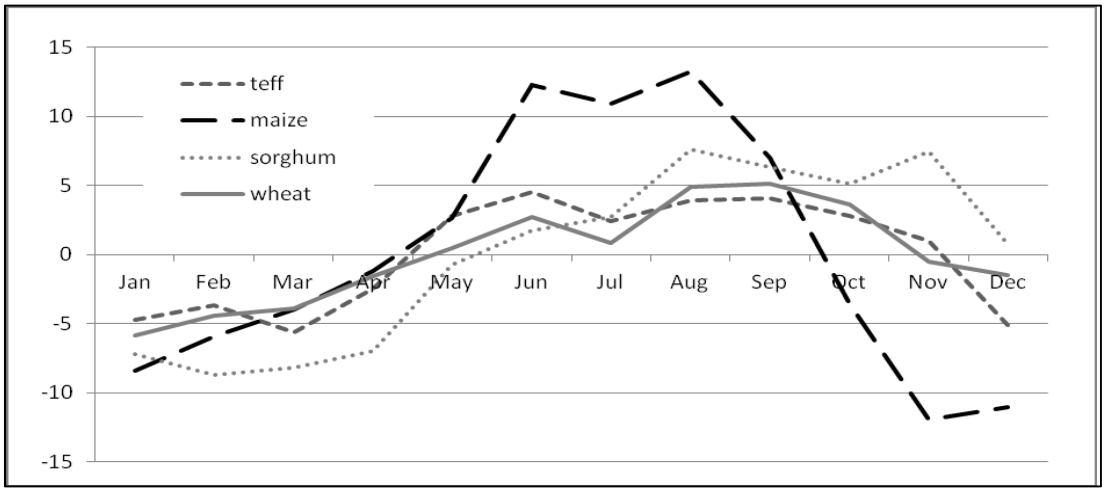
Source: compiled data from Tamru 2013, Appendix

However, the general improvement is good news for Ethiopia, but continuous investment to improve market integration is desired, given the important benefits for producers and consumers alike of having integrated cereal markets.

6.3. Seasonality in Cereal and Sorghum Prices

Agriculture is usually a very seasonal activity in any country. This is even more the case in Ethiopia given the heavy dependence on very seasonal rainfall and little use of irrigation for agricultural production. Agricultural output is mostly produced in the Meher period (where planting is done during the major rainy season in the country, i.e. July/August): that period accounted for over 90 % of total cereal production in most years (see Table xx). The small second production season (Belg) with planting being done at the end of the year contributes to only a small fraction of cereal production. Thus, prices of major cereals are characterized by large seasonal fluctuations. From September, generally prices start to decline as the *meher* harvest proceeds from north to south of the country. The bulk of the annual sales of farmers take place between December and February as farmers need cash to fulfil their obligations contracted along the season and to purchase other food and non-food commodities. Prices reach their lowest level between November and December for maize, in January for wheat and in March for teff. Then prices start rising again and reach their peak in August, during the lean season, as stocks are gradually depleting and the new *meher* harvest is approaching. In general, seasonality is higher in the case of maize due to technical difficulties of storing the product for long time as a consequence of high moisture content and insect damage. Minten et al (2012) estimated seasonal price movements for Addis Ababa. Their results show (Figure 4) that the amplitude of the seasonal price movement is largest for maize: differences of the prices between the peak and the trough are as high as 25 %. Prices are highest during the month of August and lowest during the month of November. Sorghum shows the second highest amplitude of the cereals, with price differences of about 15 %. Third and fourth come teff and wheat with an amplitude of about 10 %. In all cases is August a month of high prices while troughs depend on the crop. Maize troughs are seen at the end of the year while for other cereals, they come later, i.e. between January and March.

Figure 4: Seasonal pattern of wholesale cereal prices in Addis, in percent



Source: Minten et al 2012

Rashid and Negassa (2011) studied the seasonal price variability over the last 30 years. The results are presented in Table 42 and suggest that cereal prices were more stabilized in the 1990s than in any other period. In the 2000s post-reform period, the complete withdrawal of the Ethiopian Grain Trade Enterprise EGTE from cereal price stabilization has led to higher price variability coupled with other events such as production shocks in 2002–2003 and quite unpredictable market behaviours during 2006–08, when domestic prices went above import parity for several months. The major cause of price variability in the 1980 have been major production shocks and periods of famine, together with marketing restrictions that impeded cereal flows across administrative boundaries (Rashid and Negassa 2011).

Table 42: Cereal price variability 1983 - 2008[8]

	Measure of Variability	Maize	Wheat	**Sorghum**	Barley	Teff
2000s	Coefficient of Variation	71.3	53.4	**59.8**	61.0	51.3
	Cuddy Le Valle Index	36.4	24.4	**29.3**	23.0	28.5
	Coefficient of Variation (based on MA Series)	50.2	41.0	**43.7**	46.6	37.4
1990s	Coefficient of Variation	23.0	16.8	**20.0**	17.7	16.0
	Cuddy Le Valle Index	22.6	11.4	**18.7**	15.1	9.5
	Coefficient of Variation (based on MA Series)	17.1	13.8	**14.2**	15.2	13.3
1980s	Coefficient of Variation	41.9	31.9	**31.5**	28.4	24.7
	Cuddy Le Valle Index	41.8	31.2	**30.1**	28.4	24.4
	Coefficient of Variation (based on MA Series)	34.7	24.5	**26.7**	21.1	18.9

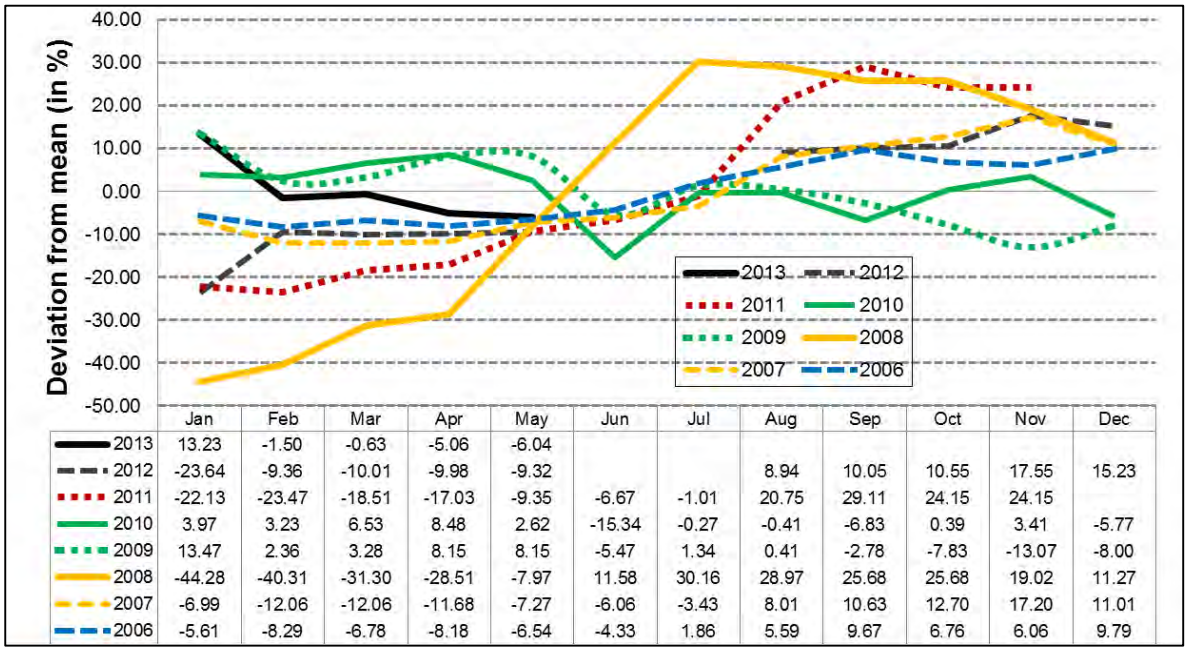
Source: Rashid and Negassa 2011, based on EGTE price data for Addis Ababa

Seasonality of sorghum prices: Figures 5 and 6 chart monthly percentage deviations of sorghum prices from the annual average price at wholesale and retail price level between 2006 and 2013. Price data are extracted from the EGTE data base. Despite the strong seasonality of sorghum entering the markets between December and January there are significant variations in the price pattern from year to year. In theory, prices should be lowest after harvest in Dec/Jan and rise steadily during the rest of the year. Prices seem to top between July and September with the onset of the Belg harvest and then decline. However, sorghum production from the Belg season is miniscule compared to the Meher output, thus it comes at a surprise how strong the dampening influence of the Belg harvest is on prices. Seasonal price variations differ considerably. In some years, for example in 2006, 2009, 2010, the difference between highest and lowest price is just around 10-20% while in other years, 2008, 2001 the price spread reaches 50 -70%. The lack of common pattern in

[8] According to Rashid and Negassa (2011) the simplest measure of variability is the coefficient of variation, which expresses standard deviation as a percentage of means. This measure is not appropriate when there is a trend in the price data or when the data contains high seasonal or irregular fluctuations. The trend component of the data can be eliminated from the coefficient of variation (CV) by using so called Cuddy La Valle index (CLVI). While CLVI accounts for the trend, it fails to account for the seasonality. Therefore, a moving average is used to calculate the coefficient of variation. Coefficient of Variation is the standard deviation over the mean $\mathrm{CV} = \frac{\sigma}{\mu}$, Cuddy Le Valle Index CLVI= $CV\sqrt{(1-R^2)}$,

sorghum prices between 2006 and 2013 is another indication for the poor market integration capacity that is able to smooth out large seasonality in production.

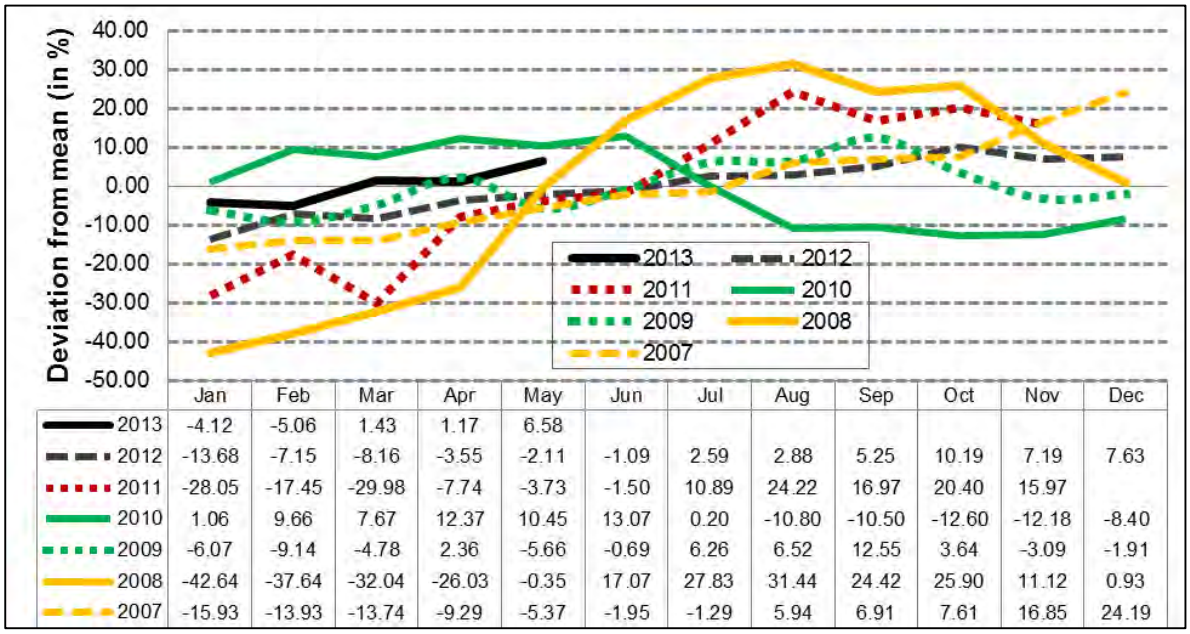
Figure 5: Monthly sorghum wholesale prices (% dev. from annual mean), 2006 – 2013



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	13.23	-1.50	-0.63	-5.06	-6.04							
2012	-23.64	-9.36	-10.01	-9.98	-9.32			8.94	10.05	10.55	17.55	15.23
2011	-22.13	-23.47	-18.51	-17.03	-9.35	-6.67	-1.01	20.75	29.11	24.15	24.15	
2010	3.97	3.23	6.53	8.48	2.62	-15.34	-0.27	-0.41	-6.83	0.39	3.41	-5.77
2009	13.47	2.36	3.28	8.15	8.15	-5.47	1.34	0.41	-2.78	-7.83	-13.07	-8.00
2008	-44.28	-40.31	-31.30	-28.51	-7.97	11.58	30.16	28.97	25.68	25.68	19.02	11.27
2007	-6.99	-12.06	-12.06	-11.68	-7.27	-6.06	-3.43	8.01	10.63	12.70	17.20	11.01
2006	-5.61	-8.29	-6.78	-8.18	-6.54	-4.33	1.86	5.59	9.67	6.76	6.06	9.79

Source: own calculation, based on data from the Ethiopian Grain Trade Enterprise

Figure 6: Monthly sorghum retail prices (% dev. from annual mean), 2007 – 2013



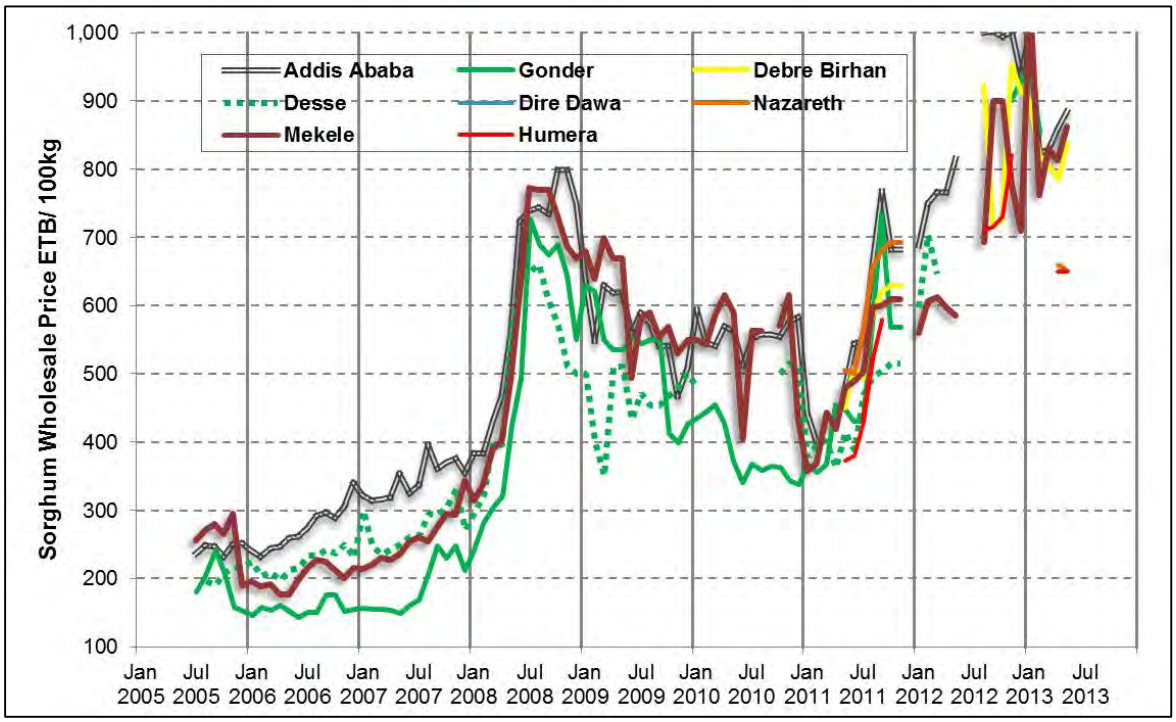
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	-4.12	-5.06	1.43	1.17	6.58							
2012	-13.68	-7.15	-8.16	-3.55	-2.11	-1.09	2.59	2.88	5.25	10.19	7.19	7.63
2011	-28.05	-17.45	-29.98	-7.74	-3.73	-1.50	10.89	24.22	16.97	20.40	15.97	
2010	1.06	9.66	7.67	12.37	10.45	13.07	0.20	-10.80	-10.50	-12.60	-12.18	-8.40
2009	-6.07	-9.14	-4.78	2.36	-5.66	-0.69	6.26	6.52	12.55	3.64	-3.09	-1.91
2008	-42.64	-37.64	-32.04	-26.03	-0.35	17.07	27.83	31.44	24.42	25.90	11.12	0.93
2007	-15.93	-13.93	-13.74	-9.29	-5.37	-1.95	-1.29	5.94	6.91	7.61	16.85	24.19

Source: own calculation, based on data from the Ethiopian Grain Trade Enterprise

Geographic pattern of sorghum prices: Figure 7 shows the markets where seasonal sorghum price data are available: Addis Ababa, Dire Dawa, Nazareth represent the largest consumer markets, Gonder, Mekele, Deese the most important producer markets and Humera, a sorghum cross border point with North Sudan and Eritrea. Addis Ababa and Dire

Dawa have in general the highest prices, at least if compared with Gonder and Desse. Price differences in the country in general thus reflect quite well the perceived flows in domestic trade sorghum from surplus to deficit regions. Mekele stands out as a sorghum producer market where prices are significantly higher than in the other producer markets, namely. Gonder and Desse, but also surpass Addis Ababa and Dire Dawa. Regarding regional price margins, there are periods of small margins, for examples during the extreme price hike starting in 2007, and other periods (2008 and 2010) where prices diverge to a level of more than 50% between markets in rather close proximity (Mekele versus Gonder/Desse).

Figure 7: Spatial price margins for sorghum



Source: own calculation, based on data from the Ethiopian Grain Trade Enterprise

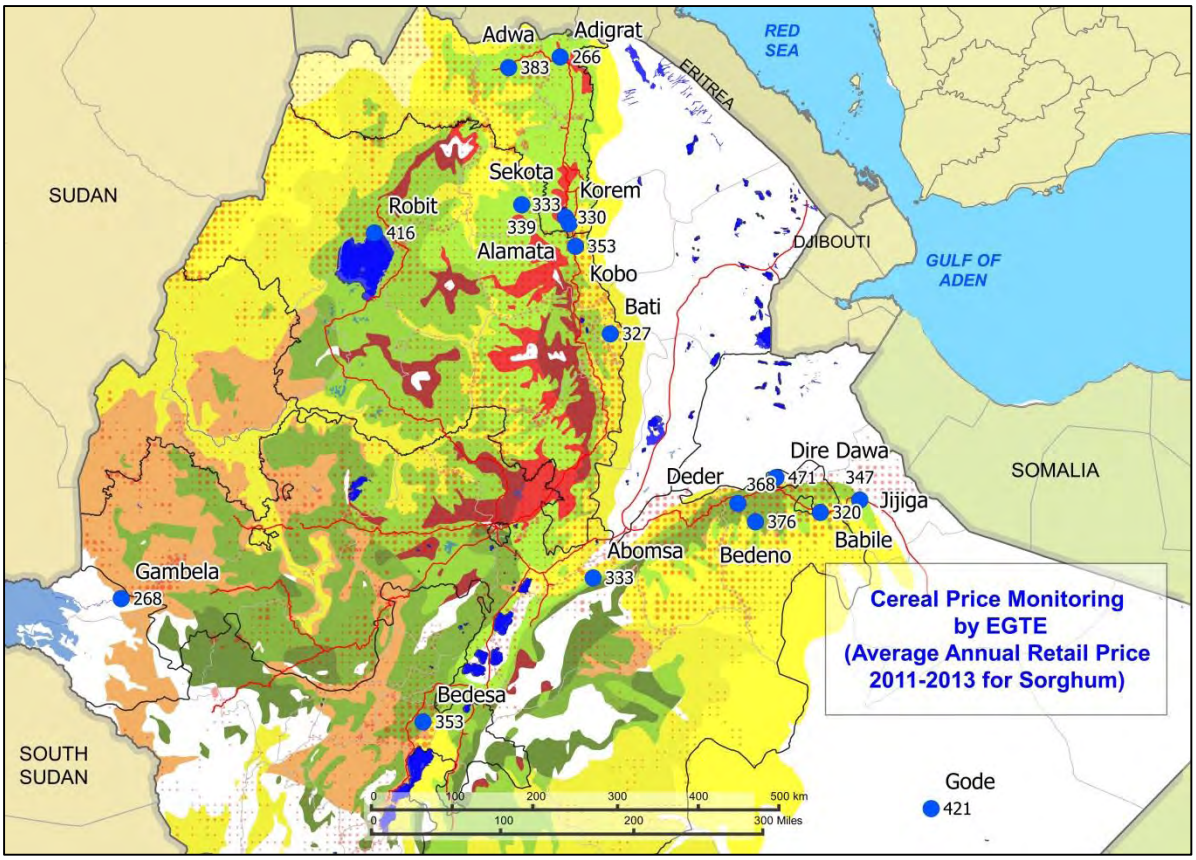
In terms of number of markets and regional coverage, EGTE has a data set that covers more than 20 markets around the country including annual wholesale and retail prices for sorghum. Most of those market places are shown in Map 11 including the AEZ layers that are used in the varietal impact analysis. Most markets are clustered around the major road network where domestic trade takes places. Only a few markets are located directly in the sorghum growing areas. Prices are reported as three year average (2011 – 2013) denominated in USD/mt. Though it is hard to detect a clear price pattern, prices tend to be slightly higher around major consumer centres and in remote areas with poor infrastructure, even in the sorghum growing areas.

Table 43: Retail sorghum prices (average 2011 – 2013) in USD/mt

Market	2011	2012	2013	Av 2011 - 2013	Market	2011	2012	2013	Av 2011 - 2013
Abaala	257	456	316	343	Gambela	283	245	275	268
Abi Adi	277	375	406	353	Gode	526	316	421	421
Abomsa	0	309	358	333	Gordamole	233	333	375	314
Adigrat	234	288	276	266	Hawzien	250	302	335	296
Adwa	357	373	420	383	Jijiga	311	341	389	347
Alamata	269	341	389	333	Karati	294	285	266	282
Babile	287	347	326	320	Kobo	275	377	406	353
Bati	288	338	355	327	Korem	316	330	345	330
Beddenno	361	376	392	376	Merti	234	275	307	272
Bedessa	346	362	352	353	Meti	228	289	311	276
Deder	328	401	375	368	Robit	384	421	442	416
Delo	400	343	249	331	Sekota	269	364	383	339
Dire Dawa	363	511	539	471	Turmi	273	275	273	274
Ebinat	221	293	315	276	Wekro	318	385	424	375

Source: own table, data based on EGTE data set

Map 11: Selected markets of EGTE monitoring of sorghum prices (USD/mt)

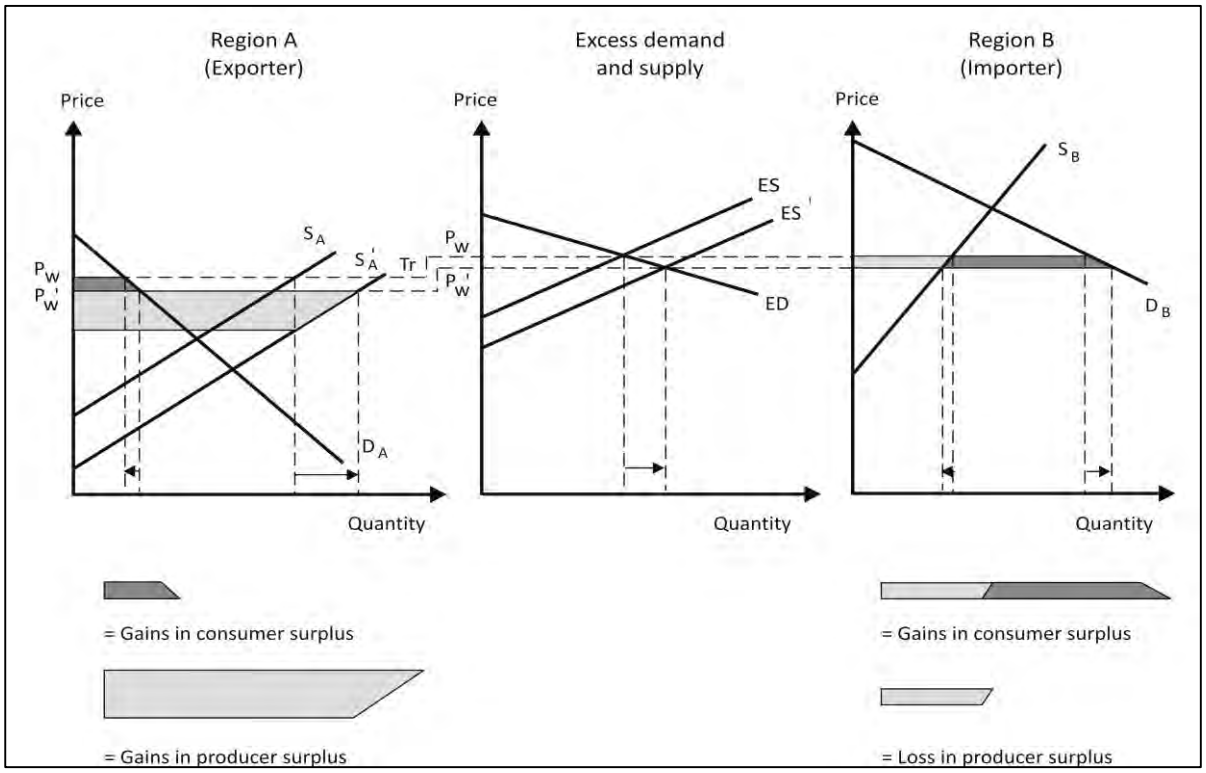


7. Research Impact Assessment: Analytical Framework

7.1. Methodological Framework

The economic effects from the introduction and use of improved varieties are commonly assessed through a cost-benefit analysis or economic surplus approach. The specific characteristics of the Ethiopian markets with connected regional markets and price spill-overs suggest the application of an economic surplus framework similar to that of Davis, Oran, and Ryan (1987) and Alston et al. (1995) used in research evaluation. The impact analysis is carried out within the framework of a partial equilibrium multi-region market model where the economic gains are measured in terms of an increase in producer surplus (PS), consumer surplus (CS) and, in case government interventions are present, in terms of government surplus (GS), see Figure 8. Supply and demand curves are specified for different regions and shifted over time through research induced shifts on the supply side and other shift factors from e.g. exogenous growth. The analytical framework of the market model and the underlying algebra can be thoroughly studied in Alston et al. (1995) and other publications.

Figure 8: Two- market partial equilibrium model with price spill-over



Source: Modified, after Davis et al. (1987, p. 12)

The major specifications to be applied to the Ethiopian sorghum markets can be summarised as follows:

- Linear demand and supply functions define a single commodity market framework with no linkages to other commodity markets via cross-price elasticities.

- Trading activities are basically restricted to the different regional markets within the country, while cross-border trade with neighbouring will be factored in for certain market scenarios and changes the set-up from a closed economy to an open market economy.
- Regional markets are fully interlinked via price spill-over effects. Sorghum is traded in some quantities over long distances between producer and consumer markets. Thus, research induced changes in regional production and prices may affect prices and quantities in other regions.
- The dynamic elements of agricultural research are accounted for: the specific time profiles for technology generation and adoption, variable prices across regional markets, and multiple periods to aggregate annual economic gains over the simulation period and regions.

A standard software package for such a research impact study using the economic surplus concept is the 'DREAM' model. DREAM, or **D**ynamic **R**esearch **E**valuation for **M**anagement, is a stand-alone and menu-driven software package for evaluating the economic impacts of agricultural research and development (R&D). DREAM has been applied to the evaluation of individual projects in a national context as well as to entire commodity sectors at a sub-continental or continental scale. And while it was designed primarily to evaluate options for R&D that is yet to be undertaken (ex-ante assessment), DREAM has also been successfully applied to analysing the effect of past research (ex-post assessments). One of the major advantages is the flexible way of defining the market framework for the model builder. Markets can be specified with no restrictions on the number of markets and for any level: as regional markets for a country-level study or as national markets for an international study. It gives the analyst a great degree of freedom in deciding about the appropriate level of accuracy necessary to capture the spatial heterogeneity in technology adoption and profitability.

7.2. Eight-Stage Process for an Impact Assessment Workshop.

Organising an impact assessment workshop requires careful planning and strict time management. Expert-based data elicitation for a commodity or a project should be conducted within 2-3 full working days, not longer, as experts have a busy schedule and concentration in group work starts fading after 2 days. The composition of the expert group varies with the type of undertaking. For a crop breeding program a group of 5-8 experts suffice with probably 1-2 socio-economists, and the rest breeders and agronomists. To ensure good quality of information the workshop facilitator/impact analyst should build-in some cross-checks and validation procedures and join in the different working group in rotational manner.

The key challenges are controlling the overly optimistic perspective of the experts with regard to varietal performance and the abstract and hypothetical nature of projecting the future market situation and performance of a variety that usually leads to a slow start, heavy discussions and doubts about successful completion of the tasks ahead. Below is a short description of an eight-stage data elicitation process that deals with these challenges and has proven operational for such type of short brainstorming workshop.

1. Hand-outs and presentation

Prior to the workshop, the facilitator/analyst prepares hand-out material and a presentation in the office. The hand-outs contain all necessary commodity information such as prices, production, area cultivated and yields at the lowest administrative level possible, results from adoption and profitability studies and seed production. From experience the hand-outs are heavily used at any stage during group work. An administrative country map with regions, zones and Woreda names is important for defining homogenous impact zones and grouping and selecting administrative units. A presentation should be given at the beginning of the workshop introducing the workshop program, the set-up for group work, methodological background, and the hand-out material.

2. List of improved varieties

The list of varieties to be included depends on the scope of study, whether ex-post or ex-ante, institutional specific or countrywide, variety specific open-pollinating OPV or hybrids. In our case of a countrywide a combined ex-post/ex-ante perspective, the variety list is comprehensive and covers all major varieties (first generation, later generation and varieties still under development and testing.

3. **Impact area boundaries**

The impact area defines the locations and share of national production that will be subject to assessing the varietal performance and modelling the economic implications and market changes. Any production outside the impact areas are not omitted but treated in a different way, usually as a residual market in an impact model without presence of research-induced supply shifts. Depending on a commodity's spread of production and presence of improved varieties across regions it may be necessary to declare all areas as impact region. When production is more clustered and improved varieties confined to certain areas, the impact zone can be limited and thus production in the impact zone becomes a fraction of national production. It is important to note that around 75% - 90% of the impact zones' production should be covered by selecting zones (or other lower-level units) and their compounded production volumes.

4. **Homogeneous impact zonation**

Once the impact area is defined, the next step is to further structure the area into homogeneous impact zones (HIZ) with the idea to simply the assessment process by reducing the number of location specific impact parameters, such as adoption rates and profitability. The experts from EIAR at the workshop in Ethiopia choose agro-ecological zonation rather than administrative boundaries as the appropriate system based on Ethiopia's breeding strategy that is directed towards agro-ecological environments with distinct conditions in altitude, rainfall level and pattern, topography and disease incidence. Regardless of the zonation system – whether administrative or AEZ, impact parameters can be converted in most cases into the appropriate DREAM model structure. However, conversion requires the use of GIS software, the availability of GIS admin and AEZ maps with the necessary sorghum data, based on which admin and AEZ layers are intersect and converted in both directions.

5. Current adoption rates.

Probably the most difficult task is to manage and provide guidelines on assessing current and future adoption rates. Empirical evidence and systematic monitoring of varietal

composition for major food crops is rare in national agricultural statistics. The bulk of information comes from adoption studies commissioned by research institutions, but reported adoption rates are not representative and usually confined to small sampling area. In the absence of sufficient hard evidence, seed production figures from the private and public seed sector can be helpful in providing an initial best-guess. That's the way the workshop was done in Ethiopia for Sorghum.

Clarification of the proper meaning of 'adoption rate' is necessary because the term is used in different way, sometimes as the percentage of households using an improved variety, or share in area cultivated. In an impact study 'adoption rate' should always refer to the share of production as modelling based impact assessment relies on a market framework with prices and quantities as market parameters.

It is useful to define in the first instance a cumulative adoption rate for all improved varieties combined and for each impact zone and then proceed with the individual varieties. In many cases the sum of the individual adoption rates exceeds the prior set cumulative rate by a large margin. This way the cumulative acts a cross-check and benchmark for necessary downward adjustments in the individual adoption rates

6. Future adoption rates

If the planning horizon in the ex-ante study is too long and spans over 20-30 years, experts may find it hard to comprehend the circumstances and feel uneasy in providing an informed judgement about the spread of improved varieties for such a distant future. Therefore, it is advisable to shorten the look forward to 10 years in a first step which comes closer to what breeders and agronomists are familiar with as planning horizon. The experts should discuss the pros and cons, bottlenecks and pushing factors that drive or inhibit adoption rates and conclude the discussion with defining the cumulative adoption rate by zone in 10 years' time. The next steps are those as described under step 5. Once this task is completed, the core adoption information is ready and consists of current and future cumulative and individual adoption rates as shown in Table 44.

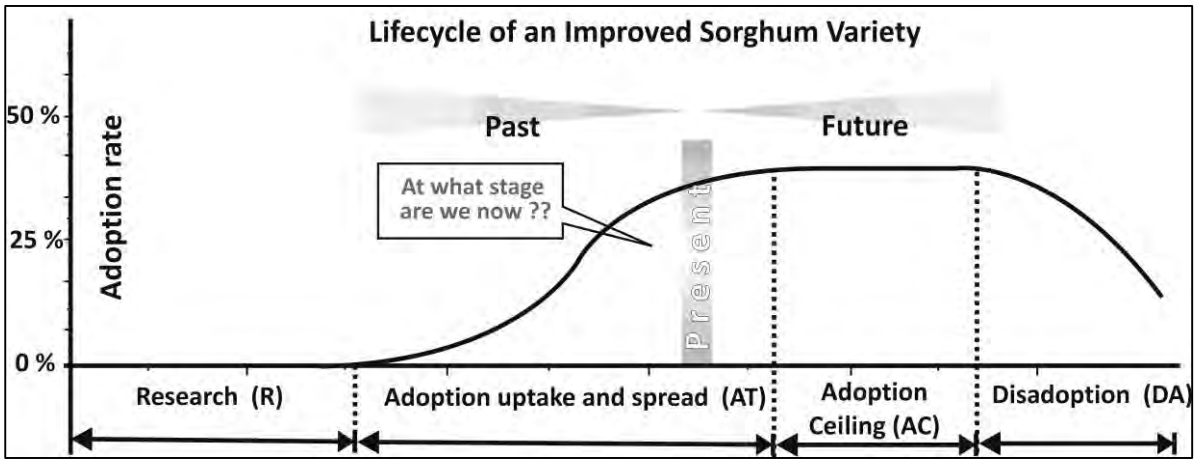
Table 44: Data sheet for current and future adoption rates

current adoption rates							
			Variety				
AEZ	Cumulative rate (target)	Sum of Individual rates	Chiro	Chelenko	Geremew	Dagim	Other varieties (cumulated)
Highland	6	6	2.5	0.5			4
Intermediate altitude	2	2			0.5	0	2.5
future adoption rates (10 years ahead)							
Highland	20	20	7	5			18
Intermediate altitude	10	10			3	3.3	16.3

Source: own table

The final step is to elicit the variety's remaining adoption parameters alongside the lifecycle of a variety as shown in Figure 9. These are: 1) year of release, number of years for adoption uptake (AT), 2) number of years at the maximum adoption level (AC), and eventually 3) beginning and speed of dis-adoption. In some cases, depending on the age of the variety, adoption rate in 10 years' time may not fall into the ceiling period (AC). Then the maximum adoption rate needs to be assessed in addition to the rate in 10 years.

Figure 9: Adoption information by variety



7. Incremental profitability of improved over local varieties

Profitability is the second shift parameter that drives the shift in the supply curve by making production more cost effective or increasing yield and outputs with the same cost structure. Local and improved varieties have a distinct expenditure and revenue structure that is analysed in a partial budget. The task of the experts is to develop partial crop budgets for local and improve varieties and calculate the differences on the revenue and cost side in absolute and relative terms.

Table 45 showcases a fictive example from Ethiopia with a representative local variety that serves as benchmark to measure and compare the profitability of all improved varieties in that region (Highland). The level of accuracy applied to cost items and developing a partial budget that averages the profitability of the local variety mix in a given region or AEZ needs to be discussed prior to start. As sorghum is a labour intensive crop enough attention should be given to the proper assessment and costing of family and hired labour. Caution is necessary when it comes to yield. What should be measured is the potential yield at the farmers' field under normal production circumstances and not yields that have been attained on-station or in on-farm trials.

Another question arises with regard to agronomic practices and input intensity. They can be different between local and improved varieties as farmers may apply more modern inputs and labour to improved varieties. In a simple way the effects of agronomic practices on yield and profitability can be incorporated as model scenarios by defining a range of yield and costs effects, or experts can distinguish between input systems while developing the partial budgets.

Table 45: Partial budgets for profitability comparison of improved varieties

Highland (Ethiopia)		Local variety	Improved variety	Percentage increase over local variety
	Unit		Chiro, Chelenko, Muyra-1, Muyra-2	Chiro, Chelenko, Muyra-1, Muyra-2
Yield	mt/ha	3.10	4.32	DREAM model '% revenue shifts'
Price	USD/mt	368	368	
Revenues	USD/ha	1,142	1,592	**39.4**
Labour costs	USD/ha	369	467	DREAM model % 'cost shifts'
Other costs	USD/ha	16	83	
Total costs	USD/ha	385	550	**14.5**
Gross margin	USD/ha	757	1,041	

Source: own table, based on workshop data

Assessment of adoption rates and profitability can run in parallel when even possible in order to safe time. Experts need be to divided and assigned to two different working groups. Dividing groups by variety is not advisable as it may inflict an assessment bias among varieties. There is a methodological issue if prices for local and improved varieties differ. Improved varieties can achieve higher or lower market prices if they show a better quality (e.g. for brewing) or are inferior for human consumption (e.g. bad taste or colour). So, yields and/or prices act in the same way by driving revenues. The 'DREAM model' does not incorporate price differentials between both varietal groups and asks only for percentage changes in yields and costs. Ignoring price differentials in the 'DREAM' model would underestimate or overestimate research gains. Therefore, instead of percentage yield changes we need to assess and enter the percentage revenue changes in the 'DREAM' model. Calculating the percentage cost increase (decrease) must be done by discounting the differences the value differences between revenues and costs.

8. Research costs

Budgeting research costs has no limits in choosing tailor-made approach that suits the assessment case at hand and differs in almost every respects with other ways of doing it. Costs budgeting can be done at the workshop or assigned by the facilitator/analysts to the experts to be prepared prior or after the workshop. With a county-level exercise like this that takes account of the entire breeding program from the start to the distant future, only a simplified budget approach seems workable that ignores the complexity in the funding structure (e.g. multitude of donors and micro projects) and the time consuming task of reading out historic research budgets form the records.

The approach used in this study is a simple spreadsheet that accounts for the costs of the breeding program at an annual base, see Table 46. It includes the core budget from public funding and a donor component that supplements the budget in carrying out specific research projects. Costs figures are readily available from project funding proposals and the institutions budget department. The annual budget is a blend of real core budget figures plus a theoretical budget that reflects the scale of donor funding to carry out research at full scale.

The research budget for sorghum which was developed by all workshop participants amounts to 365,000 USD/year based on the assumption that staff, equipment and

maintenance costs are fairly similar for each crop breeding program. In a next step, the annual budget is then converted to any previous years by using the annual consumer price index provided by the IMF or other official source as deflator.

Table 46: Annual budget of the Ethiopian sorghum research program

	Birr	USD
Σ Human resource costs	**2,932,736**	**154,355**
1. Casual Labor	1,250,000	65,789
2.Salaries-Scientist *(4 breeder. 0.1 Socio economist, 0.4 agronomist, 0.5 entomology, 0.4 pathology, 0.1)*	1,101,936	57,997
3. Technicians	580,800	30,568
Σ Supply and maintenance	**1,816,458**	**95,603**
4. Field and laboratory supplies	350,740	18,460
5. Office supplies	125,077	6,583
6. Vehicle	592,000	31,158
7. Vehicle maintenance/operation	748,641	39,402
Σ Travel/training	**1,284,557**	**67,608**
8. Domestic Travel	524,837	27,623
9. International Travel	370,000	19,474
10. Meeting and training costs/field days	389,720	20,512
Σ Miscellaneous Costs	**278,290**	**14,647**
11. Communications	50,123	2,638
12. Equipment	228,167	12,009
13. Statutory Variety Release	0	0
Sub-total	**6,312,041**	**332,213**
14. Overhead (10%)	631,204	33,221
Grand total	**6,943,245**	**365,434**

Source: data provided by EIAR

Table 47: Deflated research costs based on historic inflation rates (CPI), in USD

Year	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**
Infl. R	8.1	22.8	33.2	8.1	8.5	44.4	17.2	12.3	12.9	3.3	17.8
Defl RC	365,434	338,119	275,408	206,725	191,169	176,245	122,060	104,113	92,702	82,077	79,489
Year	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**	**1995**	**1994**	**1993**	**1992**
Infl. R	1.7	-8.2	0.7	7.9	0.9	2.4	-8.5	10.0	7.6	3.5	10.5
Defl RC	67,499	66,401	72,362	71,886	66,597	66,007	64,463	70,439	64,022	59,504	57,468
Year	**1991**	**1990**	**1989**	**1988**	**1987**	**1986**	**1985**	**1984**	**1983**	**1982**	**1981**
Infl. R	35.7	5.2	7.8	7.1	-2.4	-9.8	19.1	8.4	-0.7	5.9	6.1
Defl RC	51,994	38,309	36,432	33,790	31,556	32,341	35,859	30,117	30,000	30,000	30,000
Year	**1980**	**1979**	**1978**	**1977**	**1976**	**1975**	**1974**	**1973**	**1972**	**1971**	**1970**
Infl. R	4.5	16.0	14.3	16.7	28.5	6.6	8.6	8.9	-6.1	0.5	10.1
Defl RC	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000

Source: Worldbank data base, data.worldbank.org/; Infl. R=inflation rate, Defl. RC=deflated research costs,

Table 47 shows inflation rates and the annual deflated research budget for Ethiopia between 1970 and 2012. The country experienced over the years roller coaster periods of inflations above 30% with intercepts of years of deflation, mainly driven by food prices movements. High inflation rates would have eroded the value of the sorghum research budget, so the budget was curtailed at a nominal value at 30,000 USD/year starting with 1983. Each sorghum variety in the list is then allocated an equal share from the annual budget during the development stage.

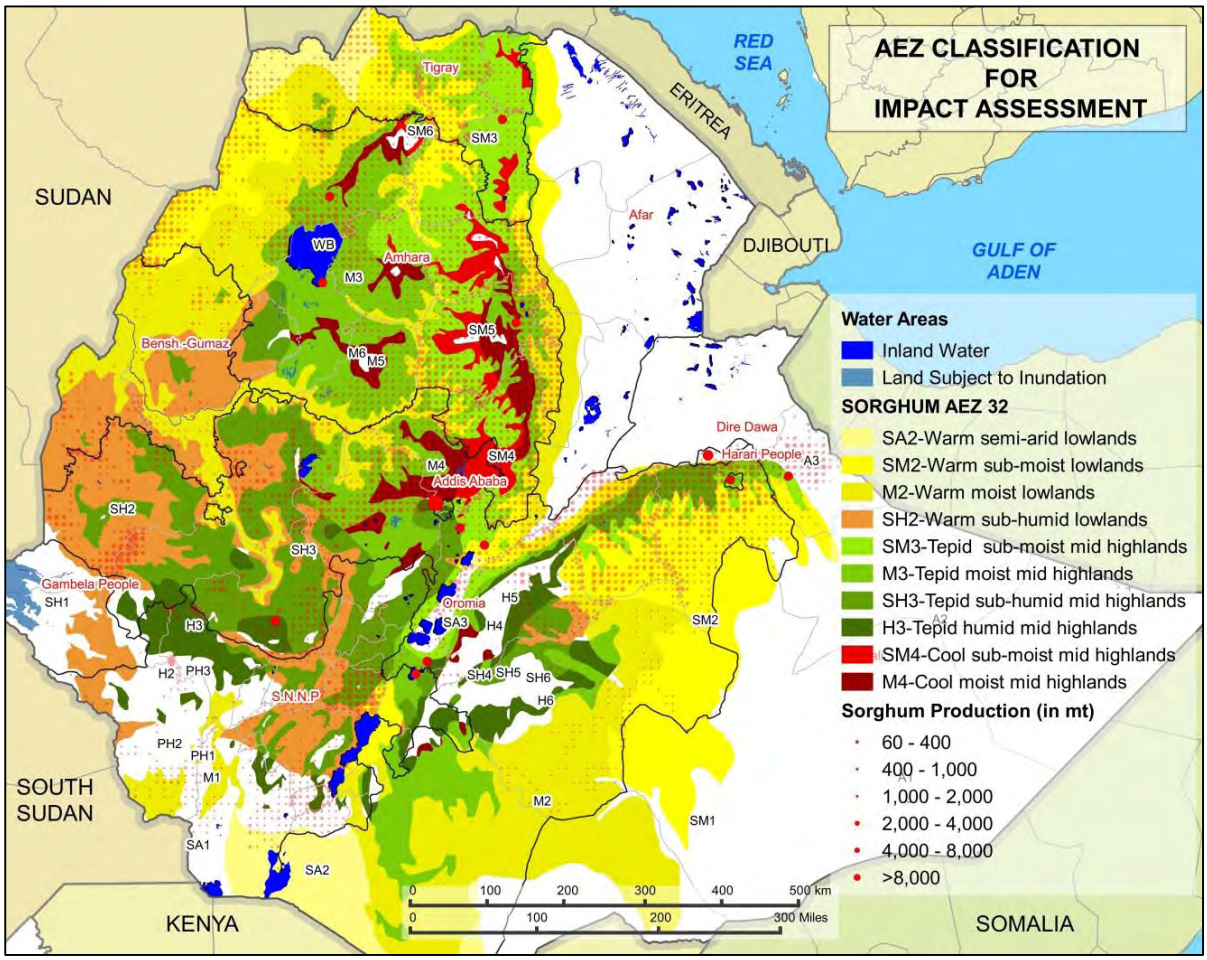
Costs that incurred in years with no reported research activities are partially attributed to the following research period with the justification that those years serve as preparation and baseline research for the next program stage. This approach takes account of what is known from the impact literature as the notion of 'probability of research success'. The probability of research success takes note of the possible failure of generating useful outputs with consequent sunk costs and reduced potential impacts. Mathematically, it enters the impact model as a discounting factor in the product of adoption rates and yield shifts. In this study, all research costs are accounted for 100% regardless of the varietal success. This implies that costs incurred in developing varieties that never made it to the market are fully accounted for as sunk costs and attributed to the varieties that were being released and propagated.

8. Impact Analysis for Improved Sorghum Varieties

8.1. Impact Zones, Sorghum Varieties and Performance Parameters

Impact zones: The extremely diverse eco-systems in Ethiopia prevent a meaningful delineation of homogeneous impact zones alongside administrative boundaries. Regions are too large to consider as homogenous for sorghum (consider the large size of the Oromia and Amhara regions), and zones are too numerous (over 100) and too small to be of practical use to stratify an area of 1.8 Million ha. Ethiopia's breeding program has its strategic orientation across agro-ecological domains while varieties are developed in respective research centres located in each of the domains, EIAR experts favoured the AEZ approach. Based on the availability of a GIS map with the AEZ 32 and AEZ 9 system, EIAR decided to use the AEZ 32 class system - the AEZ 9 system was considered too unspecific - and define the sorghum domains by grouping AEZs with similar features (Table 48).The grouping can also be looked up from Map 12.

Map 12: Agro-ecological zonation for sorghum



Source: Author's Map

In terms of area, the 'dry lowlands' is the domain covering over 36% of Ethiopia, followed by the 'Intermediate Altitude' with round 34%. The 'highlands', marked in red in Map 12, are the smallest with around 2% in area and 3.5 % in population.

Table 48: Sorghum AEZs and cereal production

AEZ Code	Name AEZ	Area	%	Pop.	%	Maize	HH Maize	Sorg-hum	HH Sorg-hum	Millets	HH Millets
Unit		'000 ha		'000		'000 ha	'000	'000 ha	'000	'000 ha	'000
Dry lowlands		**40,785**	**36.3**	**21,871**	**26.8**	**1,853**	**2,677**	**1,566**	**1,725**	**228**	**470**
SA2	Warm semi-arid lowlands	564	0.5	343	0.4	25	35	27	28	5	8
SM2	Warm sub-moist lowlands	11,401	10.2	7,391	9.1	411	831	583	654	70	166
M2	Warm moist lowlands	28,820	25.7	14,137	17.3	1,417	1,811	956	1,044	153	296
Moist Lowlands											
SH2	**Warm sub-humid lowlands**	**10,767**	**9.6**	**8,712**	**10.7**	**935**	**986**	**356**	**580**	**84**	**200**
Intermediate Altitude		**37,842**	**33.7**	**40,187**	**49.3**	**2,665**	**3,556**	**1,526**	**1,986**	**264**	**612**
SM3	Tepid sub-moist mid highlands	6,539	5.8	7,109	8.7	289	638	409	507	37	122
M3	Tepid moist mid highlands	16,548	14.7	14,690	18.0	1,043	1,402	640	701	124	250
SH3	Tepid sub-humid mid highlands	11,636	10.4	13,389	16.4	1,177	1,307	414	672	102	234
H3	Tepid humid mid highlands	3,119	2.8	4,999	6.1	157	210	64	105	2	6
Highlands		**2,248**	**2.0**	**2,889**	**3.5**	**152**	**237**	**126**	**143**	**18**	**40**
SM4	Cool sub-moist mid highlands	548	0.5	777	1.0	16	50	42	50	2	9
M4	Cool moist mid highlands	1,700	1.5	2,112	2.6	136	187	84	93	15	32
Total Sorghum AEZ		91,642	81.6	73,660	90.3	5,606	7,456	3,574	4,435	594	1,323
Rest		20,660	18.4	7,578	9.3	290	375	191	256	6	18

Source: own table

Unlike the geography of sorghum production in Uganda, Tanzania, and Kenya which is very clustered and confined to the semi-dry and dry areas while other regions in those countries are dominated by other cereals such as maize, wheat and rice, Ethiopia is less stratified in the predominance of specific and typical cereal crop. In total, all four sorghum domains cover over 80% of Ethiopia's land area, 90% of population. All other major cereals are grown there as well with shares over 90%. In fact, the domains constitute the core agricultural base, and as a rural society, the majority of the populace.

Sorghum varieties and adoption: Sorghum experts from EIAT developed a list of sorghum varieties that includes all relevant varieties from the start of the National breeding program (70s) until now (Table 49). Relevant varieties are those that have been adopted at a commercially relevant level and with proper seed multiplication and maintenance in place. All those varieties that have been developed but never made it to the market have been set aside. The same holds true for the more recent and varieties under development that exhibit inferior traits compared to those that actively promoted and distributed. In total the list contains 23 varieties that were breed for specific agro-ecological conditions.

Table 49: Complete list of improved sorghum varieties and adoption information

	Begin of Research	Year of release	Year of maximum adoption	Begin of adoption decline	Maximum adoption level in %	Current Adoption Level in %
Highlands					**20**	**6**
1. Chiro	1991	1998	2015	2020	7	2.5
2. Chelenko	1991	2005	2018	2024	5	0.5
3. Muyra-1	1977	2000	2017	2024	4	1.5
4. Muyra-2	1977	2000	2017	2022	4	1.5
Intermediate Altitude					**10**	**2**
1. Baji	1982	1996	2008	2012	0.2	0.25
2. Geremew	1984	2007	2018	2026	3	0.5
3. Birmash	1978	1989	1999	2006	0.25	0.5
4. Dagim	1994	2011	2016	2022	3.3	0
5. Abamelko	1989	2001	2011	2015	0.25	0.25
6. Lalo	2001	2006	2017	2024	3	0.5
Moist lowlands					**4**	**5**
Gambella-1107	1971	1976	1996	2006	4	5
Dry Lowlands (High potential varieties)					**38**	**10.5**
1. Teshale	1972	2002	2018	2022	3	1.5
2. Meko-1	1988	1997	2018	2030	6	2
3. Melkam	1999	2009	2017	2023	5	1.5
4. Dekeba	2005	2012	2017	2027	6	0
5. Girana-1	1995	2007	2017	2022	5	1.5
6. Misikir	1995	2007	2017	2022	3	1
7. 76T1#23	1973	1976	1996	2006	2	3
8. ESH-1	1997	2009	2017	2027	4	0
9. ICSA-15XM4850	2006	2014	2019	2029	4	0
Dry Lowlands (Striga resistant varieties)					**12**	**4.5**
1. Gobiye	1989	2000	2015	2021	6	3
2. Abshir	1989	2000	2015	2020	3	1.25
3. Birhan	1989	2002	2016	2021	3	0.25

Source: own table, based on workshop data

There are four OPV varieties suited for the highlands, all registered and released between 1998 and 2005. Six OPV varieties were breed for the Intermediate altitudes, three of them rather old varieties released between 1989 and 2001, and the other three between 2006 and 2011. There is only one variety for the 'moist lowlands' though the moist lowlands cover a significant part of the sorghum area and production. It is the variety Gambella-1107 released in 1976. Despite its long existence in the market, Gambella-1007 has only captured a small share in the 'moist-lowland' variety mix. There are three groups of improved sorghum varieties for the 'dry lowlands', namely the first seven are OPV varieties with high yield potential, and the last two (ESH-1 and ICSA-15XM4850) are hybrids with even higher yields, and finally three striga resistant varieties.

8.2. Short Profile of Improved Sorghum Varieties

Highland Varieties (>1900 masl)

Chiro

Chiro was released in 1996/97 for the highlands. Unlike the above two, this variety is red-seeded. The special feature if this variety is its sugary stalk, which can be chewed like sugarcane and excellent for animal feed. Its height may be within the range of 185-190 days. The variety can give grain yield of 4.2-5.8 tons/ha. The 100 seeds weight of this variety is 24-3.0g.

Chelenko (ETS 1176)

Chelenko is a red seeded sorghum variety. It was released in 2005 for low land areas of Highlands of Hararghie, ArsiNegele and simaliar areas of altitude 1900-2700 and receiving rainfall of 800-1200 mm. Chelenko grows to the average height of 250-410 cm, matures in 181-207 days, and yields 2.9-6.3 tons/ha under research station conditions. The seed weight of 1000 seed of Chelenko is 36-38 gm.

Muyra-1 (EST-1005)

Muyra-1 is a red seed variety. It was released in 2000 for the highland areas of Hararghe by Haramaya University. Muyra-1 can achieve a yield level between 3-6.5 tons/ha.

Muyra-2 (EST-567)

Muyera-2 is a white seeded variety released in 2001 for the highland areas. It is similar to Muyra-1 released by Haramaya University in terms of maturity. The variety has a yield range between 3-5 tons/ha.

Mid-altitude Varieties (1600 – 1900 masl)

Baji

The name was given by merging the first two letters of Bako and Jimma where it was tested. It was released in the 1996/97 cropping season. This variety looks like Birmash. Its height may be within the range of 139-164cm and matures within 150-180 days. Its yield ranges between 3.1-5.6 tons/ha. The 100 seed weight of this variety is 2.3-2.7g.

Geremew (87 BK-4122)

This variety is a red seeded sorghum variety released in 2007 for Jimma, Bako and similar areas for altitude 1600-1800 masl where there is 1000-1600 mm. The variety matures in 150-160 days, has a height of 170 cm and yields approximately 4.9 tons/ha at the research station. The 1000 seed weight is 41 gm.

Birmash

Birmash was originally released for Birr Valley and similar areas in 1989. It is a red seeded variety with semi compact panicle. Its height may be within the range of 131-233cm and

matures within 150-180 days. It is the highest yielding variety giving up to 6.9 tons/ha in experimental fields. The 100 seed weight of this variety is 1.7-2.6g.

Dagem

Deagimis brown seeded variety released in 2011 for sorghum producing areas at 1,600-1,900 masl and rainfall between 900-1,200 mm. The variety matures within 158 days and yields 2.7-5.4 tons/ha. It is resistance to grain mold and leaf disease. The 1000 seed weight is of Dagem is 22.4 gm.

Aba Melko (Sartu)

Abuare is red to brown seeded variety released in 2001 recommended for the lowland areas of South Western region at 1,600-1,800 masl and requires 1,200-1,600 mm rainfall. The variety matures within 160-180 days and yields up to 7.5 tons/ha onstation and 5.0 tons/ha on farmers' field. It is resistance to major disease and stalk borers. The 1000 seed weight of the variety is 32 gm

Lalo (BRC-245)

Lalo is a brown seeded variety released in 2006 for western Oromia (Bako, Gute, Lalo, Bilo Boshe) altitude1500-1900 and receiving rainfall of 1100-1200 mm. Lalo grows to the average height of 300 cm, matures in 199 days. It gives yield of4.0-5.2 tons/ha at field station and 3.5-4.8 tons/ha on farmers' field. Lalo has the character of stay green after physiological maturity and it is also a popping type. The seed weight of 1000 seed of Homal-1 is 29 gm.

Moist Lowland Varieties

Gambella 1107

Gambella was released in 1976 for the moist lowlands of the country similar to Gambella. It is a white seeded variety with semi compact, semi oval and erect panicle. Its height ranges between 120-200cm. Usually, part of the head is covered by the flag leaf (the peduncle is not well excreted). It has good injera making quality. It matures within 110-130 days and can yield 2,8-5,0 tons/ha. The 100 seed weight of this variety is 2.5-3.3g.

Dry lowland Varieties

Teshale

Teshale was released in 2001/2002 cropping season. It is similar in respects to Meko-1, but it is taller and its peduncle is a bit undulating. It takes only 90 to 120 days to mature. Its height is within 190-200 cm. Teshale can give 2.5-5.0 t ha-1. The 1000 seeds weight of this variety is around 33-36g.

Meko-1

Meko-1 was released in 1997/98 cropping season. It is a white-seeded variety with semi loose and erect panicle. Next to Alemaya 70, this is the best variety for injera making and

keeping quality. Its height ranges from 132 to 169cm. It matures within 90-120 days and yields 2.4-4.9 tons/ha. The 100 seeds weight of this variety is about 2.9-3.7g.

Melkam

Melkam is white seed variety released in 2009, Matures within 175-190 days and has a potential yield of 3.5-5.8 tons/ha.

Dekeba (ICSR 24004)

Dekeba is a white seeded variety released in 2012 for the low altitude areas (below 1,600masl) and low rainfall between 500-800 mm. Dekeba grows at an average height of 136 cm and matures in 119 days. Yields range between 3.7-4.5 tons/ha at the research station and between 2.6-3.7 tons/ha on farmers' field. Dekeba has a good injera quality. The seed weight of 1000 seed of Homal-1 is 27 gm.

Girana-1

This variety is a white seeded variety. It was released in 2007 for low land areas of Wollo from low to mi altitude between 1,450 -1,850 masl and where rainfall averages 600-900 mm. The variety grows at an average height of 135-305 cm, matures in 122 days, and reaches yields up to 4 tons/ha in experimental fields and 3.8 tons/ha on farmers' field. The seed weight of 1000 seed of Girana-1 is 30 gm.

Misikir

Miskiris a yellow seeded variety released in 2007 for the low land areas of the Wollo district in sorghum producing areas with altitudes between 1,450-1,860 and with an annual rainfall between 600-900 mm. Miskir grows 123-191 cm in height and yields around 4 tons/ha in experimental fields and 3.7 tons/ha on farmers' field. The weight of 1000 seed of this variety is 27 gm.

76T1#23

This variety was released in 1979 for the moisture stressed dry lowlands. It is white-seeded with semi compact, semi-oval, and erect panicle. It has some red spots. The glume is red or brown. Its height ranges susceptible to leaf diseases and smuts. Its yield is 2.5-4.5 tons/ha. The 1000 seeds weight of this variety is 27-29g.

ESH-1 and ESH-2

Both varieties are white seeded. They are the first two Ethiopian sorghum hybrids released in 2009. They are released for the dry low land areas and can give yields on experimental fields between 5 to 6 tons/ha and 3.5 to 4.5 tons/ha on farmer's filed.

Gobiye

Melkassa Agricultural Research Center (MARC) released Gubiye in collaboration with the Purdue University, USA, in 1999/2000 cropping season. The seed is white and has a semi loose erect panicle. Its height may reach 110-140cm. It is resistant to striga (a parasitic weed species). Gobiye matures within 90-120 days and can reach a yield level between 1.4-2.7

tons/ha on land previously infested with striga. Moreover, it has a good injera making quality. The 1000 weight of this variety is 29-3.g.

Abshir

Abshir was released in 1999/2000 cropping season with Gubiye. Abshir and Gubiye are sister lines and are similar in all respects. However, Abshir has a relatively poorer threshing quality than Gobiye. Its height may reach 110-140cm. It matures within 90-120 days and gives a grain yield of 1.4-2.4 tons/ha. It is also good for injera making. The 1000 seed weight of this variety is 33-36g.

Birhan (Key # 8566)

Birhan was released in 2002. It's a sister line of Abshir and Gobiye and are similar in all aspects except the seed color, red. It matures within 90-120 days.

8.3. Adoption Information and Profitability

The elicitation of adoption information followed a stepwise procedure similar to the description of the 8-stage elicitation process from the previous chapter. The first step is an assessment of the current spread of improved varieties versus local varieties in terms of production share and differentiated by the four AEZ categories. The official statistical bulletin on farm management practises published by the Central Statistical Agency of Ethiopia CSA CSA reports a very low level of improved sorghum varieties, below 1%[9] at country level. EIAR experts considered the official numbers as too low and re-calculated the current adoption level based on their information on seed production from formal (extension and research centres) and informal sources (exchange between small scale farmers and replanting and commercial farms).

The Ethiopian extension service ESE, the research centres in Melkassa, Sirinka and Fedis other public institutions like the OSE, and from private seed companies produced around 1,100 mt of improved seed. Over 7,700 mt are from private seed companies, the rest from public sources. 96 % of this seed are varieties for the dry lowlands and the rest for all other three AEZ groups (Table 50).

Own seed production by small-scale farmers (informal source) is estimated at 50 mt. Sorghum area from medium and large scale commercial farms are guessed at 64,000 ha. Seed deliveries from formal and informal sources are enough to grow sorghum on 95,000 ha. That is 5% from the national sorghum area in 2013. By including commercial farms, the area and share of production under improved varieties rise to 160,000 ha and a production share of 8 %.

[9] The Agricultural Census Survey for Smallholders, Meher season 2009/2010 (CSA 2010b) reports that 16,390 ha of sorghum by 72,000 smallholders are under improved varieties. The same report for the season 2010/11 (CSA 2010a) indicate a much small number, only 910 ha by 5,800 smallholders. For medium/large scale commercial farms, the numbers from CSA (CSA 2011) are 100 ha and 680 large farms using improved sorghum seeds.

Table 50: EIAR assessment of current adoption of improved sorghum varieties

	Area under sorghum	Formal Seed (mt)	Seed share	Area from formal seed	Seed saved by small farmers	Area from informal seed	Area formal & informal & commercial	Share of improved varieties
	ha	mt	%	ha	mt	ha	ha	%
Highland	96,186	5	0.5	457	2.52	210	667	**0.69**
Intermediate Altitude	288,558	22	2	1,829	7.56	630	2,459	**0.85**
Moist lowland	288,558	16	1.5	1,372	7.56	630	2,002	**0.69**
Dry lowland	1,250,416	1,054	96	87,800	32.76	2730	90,530	**7.24**
Commercial Farms	64,441						64,441	
Total (excl. C)	1,923,717	1,098	100	91,458	50.4	4200	95,522	**4.97**
Total (incl. C)	1,988,158	1,098	100	91,458	50.4	4200	160,099	**8.05**

Source: EIAR experts at the workshop

The EIAR experts later increased those numbers as they considered farmers seed production as too low. The final levels for current and future adoption can be examined from Table 50. Several reasons are named to justify the optimistic view and strong dynamic they expect in the further spread of improved varieties

- Government commitment / priority for sorghum as food security crop
- Emerging of private seed companies
- Emerging of commercial farms
- climate change that will shift the cultivation away from local late maturing to early maturing improved varieties
- Improved seed and grain market for sorghum (for example the Ethiopian Commodity Exchange/ECX)
- Further improvement in the formal and informal seed system

Sorghum profitability: Sorghum experts from EIAR at the impact assessment workshop agreed to develop partial budgets for each of the geographic location and not to differentiate further by individual variety in each location as they assumed, yields and prices are fairly similar and production costs the same for each variety. Each improved variety in a location is then benchmarked against the profitability of a set of local varieties typical for that location. Within the 'dry lowland' group, profitability of improved open pollinating varieties, hybrids and striga resistant varieties considerably differ as a result of distinct yield potentials under the same crop management. Assumed yields from improved varieties are based on EIAR farmers' field trials but factor in real-world crop management practises that are sub-standard in the use of modern inputs, disease management, harvesting and post-harvest handling. However, as it can be studied from Table 51 yields under improved varieties are assumed 20%-40% higher than of local varieties which reflects the optimistic view of EIAR sorghum experts that the positive trends in yields and use of modern inputs continue to prevail in the future.

Some downward adjustments in the partial budgets had to be made after cross-check with market price data by EGTE. Initial sorghum farm gate prices were set at 9 Birr/kg during the workshop which translates into farm gates prices (9,000 Birr/mt) much higher than wholesale and retail prices during the last few years. As reported from the previous chapter on

sorghum prices, wholesale prices across different markets in Ethiopia vary between 6,000 – 8,000 Birr/mt. during 2011 and 2013 harvest season. Therefore, the impact analysis goes with 7 Birr/kg which is still very high but fits better into the price hierarchy at the different marketing stages.

Based on the EIAR detailed account of all major production costs, some facts about the partial budgets from Table 51 and Table 52 in USD/ha deserve some attention. Profitability of all improved varieties is vastly superior to local varieties across all four locations. In revenue terms, improved varieties outperform local varieties between 40% to 85% which is attained at a moderate rise in production costs between 7% and 25%, mainly from higher labour costs (family plus hired) and higher usage of mineral fertilizer. Yields are highest in the 'Highlands' (4.3 mt/ha) and 'moist lowlands' (3.1 mt/ha) driven by sufficient rainfall. In the drought prone 'dry lowlands' yields are highest for the two hybrid varieties (3.2 mt/ha), 2.7 mt/ha) for OPVs and 1.6 mt/ha for striga resistant varieties. The low yields for striga resistant varieties may be attributed to two effects: (1) a certain genetic trade-off between breeding for resistance and yields and (2) prevalence of striga and damage to yields in locations where those varieties are targeted for.

Table 51: Sorghum gross margins of improved and local varieties (Birr/ha)

	Highland		Intermediate altitude		Moist Lowland		Dry Lowland OPV		Dry Lowland Hybrid		Dry Lowland (Striga Resistant)	
	Name	Type	Name	Type	Name	Type	Name	Type	Name	Type	Name	OPV
	Chiro	OPV	Baji	OPV	Gambella-1107	OPV	Teshale	OPV	ESH-1	Hybrid	Gubiye	OPV
	Chelenko	OPV	Geremew	OPV			Meko-1	OPV	ICSA-15XM4850	Hybrid	Abshir	OPV
	Muyra-1	OPV	Birmash	OPV			Melkam	OPV			Birhan	OPV
	Muyra-2	OPV	Dagim	OPV			Dekeba	OPV				
			Abamelko	OPV			Girana-1	OPV				
			Lalo	OPV			Misikir	OPV				
							76T1#23	OPV				
Gross Margin Calculation(Br/ha)												
Revenue and costs (Birr/ha)	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety
Yield (Kg/ha)	4,320	3,100	2,700	1,944	3,120	2,246	2,700	2,000	3,200	2,000	1,600	1,100
Price(br/kg)	7	7	7	7	7	7	7	6	7	6	7	7
Revenues (Br /ha)	**30,240**	**21,700**	**18,900**	**13,608**	**21,840**	**15,722**	**18,900**	**12,000**	**22,400**	**12,000**	**11,200**	**7,700**
Variable Costs	**10,450**	**7,305**	**9,075**	**6,087**	**8,489**	**6,973**	**8,508**	**5,479**	**8,628**	**5,479**	**6,501**	**4,645**
Seed cost	120	135	120	135	120	135	120	135	240	135	120	135
Fert cost A. Dap (Br/ha)	800	160	800	160	800	160	1,600	400	1,600	400	400	80
B. UREA(Br/ha)	650	0	650	0	650	0	650	163	650	163	156	0
Manure	0	0	0	0	0	0	0	0	0	0	0	0
Pesticides	0	0	0	0	0	0	0	0	0	0	0	0
Labour (Family)	8,400	6,664	7,203	5,580	6,571	6,427	5,870	4,558	5,870	4,558	5,647	4,307
Labour (Hired)	480	346	301	212	348	251	268	223	268	223	179	123
Gross Margin (Br/ha)	**19,790**	**14,395**	**9,825**	**7,521**	**13,351**	**8,749**	**10,392**	**6,521**	**13,772**	**6,521**	**4,699**	**3,055**
DREAM model parameters												
% revenue increase	39.4		38.9		38.9		57.5		86.7		45.5	
% costs increase	14.5		22.0		9.6		25.2		26.2		24.1	

Source; own calculations, based on workshop data

Table 52: Sorghum gross margins of improved and local varieties (USD/ha)

	Highland		Intermediate altitude		Moist Lowland		Dry Lowland OPV		Dry Lowland Hybrid		Dry Lowland (Striga Resistant)	
	Name	Type	Name	Type	Name	Type	Name	Type	Name	Type	Name	OPV
	Chiro	OPV	Baji	OPV	Gambella-1107	OPV	Teshale	OPV	ESH-1	Hybrid	Gubiye	OPV
	Chelenko	OPV	Geremew	OPV			Meko-1	OPV	ICSA-15XM4850	Hybrid	Abshir	OPV
	Muyra-1	OPV	Birmash	OPV			Melkam	OPV			Birhan	OPV
	Muyra-2	OPV	Dagim	OPV			Dekeba	OPV				
			Abamelko	OPV			Girana-1	OPV				
			Lalo	OPV			Misikir	OPV				
							76T1#23	OPV				
Gross Margin Calculation (USD/ha)												
Revenue and costs (USD/ha)	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety	Improved Variety	Local Variety
Yield (mt/ha)	4.32	3.10	2.70	1.94	3.12	2.25	2.70	2.00	3.20	2.00	1.60	1.10
Price (USD/mt)	368	368	368	368	368	368	368	316	368	316	368	368
Revenues (USD/ha)	**1,592**	**1,142**	**995**	**716**	**1,149**	**827**	**995**	**632**	**1,179**	**632**	**589**	**405**
Variable Costs	**550**	**384**	**478**	**320**	**447**	**367**	**448**	**288**	**454**	**288**	**342**	**244**
Seed cost	6	7	6	7	6	7	6	7	13	7	6	7
Fert cost A. Dap	42	8	42	8	42	8	84	21	84	21	21	4
B. UREA	34	0	34	0	34	0	34	9	34	9	8	0
Manure	0	0	0	0	0	0	0	0	0	0	0	0
Pesticides	0	0	0	0	0	0	0	0	0	0	0	0
Labour (Family)	442	351	379	294	346	338	309	240	309	240	297	227
Labour (Hired)	25	18	16	11	18	13	14	12	14	12	9	6
Gross Margin (USD/ha)	**1,042**	**758**	**517**	**396**	**703**	**460**	**547**	**343**	**725**	**343**	**247**	**161**
DREAM model parameters												
% revenue increase	39.4		38.9		38.9		57.5		86.7		45.5	
% costs increase	14.5		22.0		9.6		25.2		26.2		24.1	

Source; own calculations, based on workshop data

8.4. Dream Model Setup

The market structure and specifications in the 'Dream' model are outlined in Table 53. Markets are the four sorghum agro-ecologies where improved varieties have been adopted at a larger scale and/or in which future adoption are likely to take place for the varieties under development. In addition a residual market is added for technical reasons with the aim to capture all the remaining unaccounted production and consumption and, furthermore, to level out the sorghum surplus (around 50,000 mt) that comes from the major producing regions. The size of the residual market is rather small (190,000 mt in production and 240,000 mt in consumption) as most of the sorghum economy is covered by the four agro-ecologies.

Two other markets are added, the 'Import" and Export' market that allow foreign trade in both directions or prohibit foreign trade depending on the chosen elasticity parameters. Export and import markets are set at zero in terms of supply/demand balance and are decoupled from all other markets in the baseline set-up. Thus they do not interfere in the price formation or impact generation within the domestic market group. Market prices are calculated from the EGTE price data set as outlined in the section on spatial price pattern. A single or a group of markets with available sorghum price data are then attributed to each of the four AEZs in order to arrive at representative sorghum prices. However, defining a proper price level for the 'DREAM' model markets somehow remains speculative in light of the large geographical size and pattern of AEZs and limited understanding of sorghum marketing channels across regions. According to IFPRI demand analyses, supply and demand own price elasticities are set at 0.66 for supply and -0.66 for demand for the base run and later modified for sensitivity analyses. The discount rate is set at 5%.

Table 53: The 'DREAM' model configuration of markets and parameters

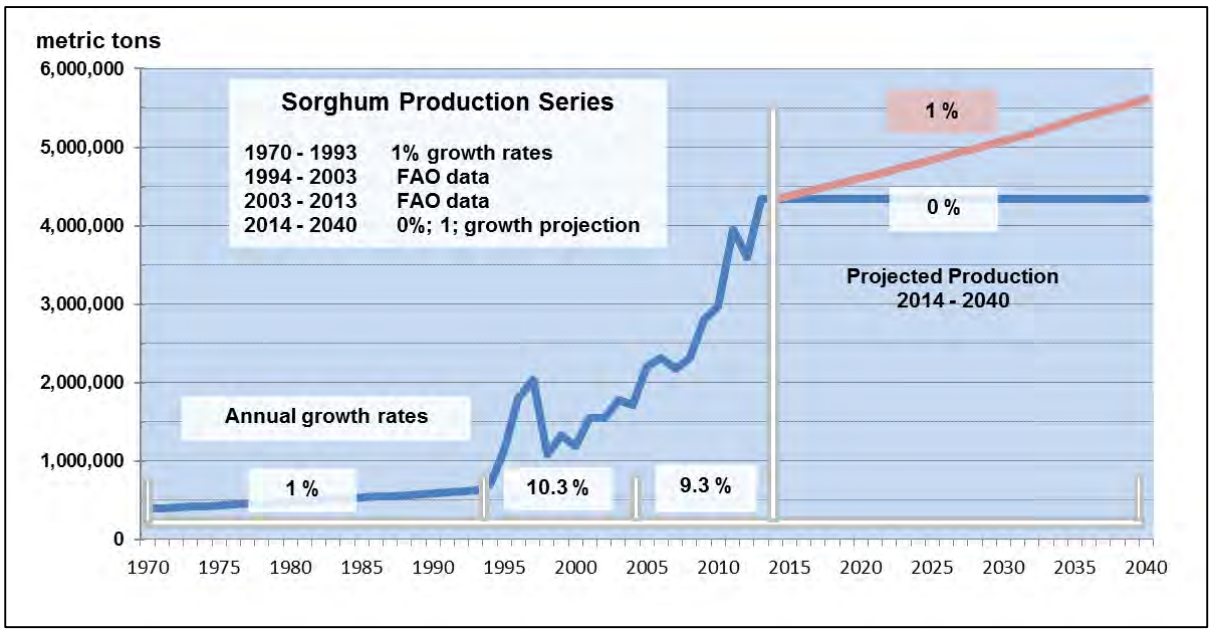
Markets in the DREAM model	Supply	Demand	Surplus / Deficit	Price	Elasticity		Discount rate %	Exogenous growth
Region	mt	mt	mt	USD/mt	Supply	Demand		Supply/Demand
Highland	126,295	127,619	-1,324	338	-0.66	-0.66		(2);(10.3);(9.3),(0)
Intermediate altitude	1,526,092	1,699,942	-173,850	347	-0.66	-0.66		(2);(10.3);(9.3),(0)
Moist lowland	355,516	398,307	-42,790	268	-0.66	-0.66		(2);(10.3);(9.3),(0)
Dry lowland	1,566,067	1,298,497	267,569	335	-0.66	-0.66		(2);(10.3);(9.3),(0)
Residual market	190,535	240,140	-49,605	386				(2);(10.3);(9.3),(0)
Total (2012)	3,764,505	3,764,505	0		-0.66	-0.66	5	
Import market	100,000	100,000	0	240	0	0		
Export market	100,000	100,000	0	400	0	0		
Market size at different years during the ex-post period								
Total (1980)	481,254	481,254	0				5	(2);(10.3);(9.3),(0)
Total (1990)	586,646	586,646	0				5	(2);(10.3);(9.3),(0)
Total (2000)	1,241,411	1,241,411	0				5	(2);(10.3);(9.3),(0)
Total (2010)	3,077,780	3,077,780	0				5	(2);(10.3);(9.3),(0)

Source: own calculations

Exogenous growth: The economic surplus concept requires a proper account of the market size and production and consumption figures at any time in the simulation period. This can be done in different ways. In an ex-ante impact analysis, the simulation process starts at the current year's production and consumption statistics embedded in the market set-up and then adjusted for each consecutive year in the future in line with the exogenous growth parameters of the 'Dream' model. Ex-post analyses are more tedious and time consuming as every variety has its own timeline from the start of breeding until release onto the market. It is mandatory for any ex-post model run to calibrate the model markets in accordance with the official production and consumption statistics at the years under consideration. Failure to account for production trends results in wrong and misleading economic surplus estimates as research impact is sensitive to the size of markets in which research-induced supply shifts occur. Technically, this is done by breaking down the historic time series of production and consumption, if very long, into several time periods of similar growth rates. The results are set of growth rates and time periods that are factored in the DREAM model as a set of exogenous growth parameters.

Unlike Uganda and Kenya, sorghum production in Ethiopia shows distinct periods of very different growth dynamics (Figure 10). FAOSTAT data only cover the period between 1991 and 2013. For those years uncovered, 1971-1990 (ex-post) and 2014-204 (ex-ante) certain assumptions about the annual growth rates need to be made.

Figure 10: FAO sorghum production time series and derived growth rates



Source: own figure, based on FAOSTAT data and own calculation

For the ex-post period, a moderate annual growth rate of 1% was assumed. For the ex-ante period between 2014 and 2040, zero growth was chosen for reasons of modelling convenience and also based on a slowdown in future sorghum growth as available land for further expansion of cereal cultivation may become scarce. However, research impacts are fairly proportional to the market size, e.g. a 2% higher annual growth rate above baseline level will generate approximately 2% higher research impacts per year. Other more optimistic growth scenarios for the future can be easily accommodated by adjusting the

impact figures accordingly. Calculation of annual growth rates for the FAO production series between 1991 and 2013 resulted in two distinct periods: between 1991 and 2004 with an annual growth rate of 10.3 and between 2004 and 2013 a rate of 9.3%. In summary, four growth periods enter the DREAM model:

- 1% annual growth between 1971 and 1991
- 10.3% annual growth between 1991 and 2004
- 9.3% annual growth between 2004 and 2013,
- and 0% annual growth rates for the ex-ante period between 2014 and 2040

The same growth rates apply to domestic demand as well in order to maintain a balanced market for each year.

8.5. Baseline Results

The entire sorghum breeding program in Ethiopia starting in 1971 with the beginning of the variety Gambella-1107 and looking into the future until 2040 generates net research benefits at the magnitude of 762 million USD (Table 54). The compounded and discounted research costs amount to 4.5 million USD. On an annual base[10] net research gains translate into 40 million USD each year, see Table 55. The 'Dry Lowland' market stands out as the major beneficiary with over 670 million USD and capturing 88% of all research gains. The reasons are simply the large number of improved sorghum varieties targeted at the dry lowlands and their level of superiority over local varieties that surpass most other varieties. Research gains which materialize in the 'highlands' and 'moist lowlands' are small and combine around 1.3% only. But so is the area and share in sorghum production in those two regions.

Table 54: Distribution of Economic Surplus by markets ('000 USD)

Market	Producer surplus	Consumer surplus	Total surplus	Research Costs	TS - Costs	Share in total surplus (%)
Highland	6,186	1,011	7,197		2,634	0.9
Intermediate Altitudes	-13,825	101,610	87,785		87,785	11.4
Moist Lowland	509	3,167	3,675		3,675	0.5
Dry Lowland	651,692	10,322	662,014		662,014	86.3
Residual Market	-20,350	26,587	6,236		6,236	0.8
Total	624,212	142,696	766,907	4,564	762,344	

Source: own calculation

[10] In the context of research benefits, annuity applies to a constant annual value of research benefits which is equivalent to the actual but uneven flow of costs and benefits generated from the DREAM model in terms of present value PV if discounted with the same discounting factor and over the same period. The use of annuity instead of simple annual average becomes necessary as the impact assessment involves discounting procedures.

Based on the size and level of sorghum production (1.5 million mt in 2012) which is comparable with the 'dry lowlands', the sorghum breeding program vastly underrepresents the 'intermediate altitude' in terms of variety development and impact. Only 11% of the research gains go to the 'intermediate altitudes" compared to a 40% production share. The reasons can be found in the limited number of suitable improved varieties (only six) and the relatively poor performance of those varieties. Only two of them, 'Lalo' and 'Dagim' varieties show satisfactory Internal Rates of Return above 30%. Another interesting feature is the distribution of research gains by producers and consumers. Around 80% of research gains are captured by producers and only 20% by consumers in terms of higher supply and lower prices. The consumer share is unusually low with 20% if compared with similar studies from Uganda and Tanzania. One possible explanation is the rather high price elasticity of demand of -0.66 taken from IFPRI publications. Though still inelastic, the value is higher than in other countries[11].

Table 55: Annual economic surplus by markets (annuity values in '000 USD)

Market	Annual producer surplus	Annual consumer surplus	Annual total surplus
Highland	320	52	**373**
Intermediate Altitudes	-716	5,262	**4,546**
Moist Lowland	26	164	**190**
Dry Lowland	33,749	535	**34,284**
Residual Market	-1,054	1,377	**323**
Total	32,326	7,390	**39,716**

Source: own calculation

Table 56 summarises model results by different groups of varieties. The picture looks similar -almost identical- to the allocation of research gains by markets. A strong performance can be observed with the 'dry lowland' open pollinating and hybrids. The two hybrids ESH-1 and ICSA-15XM4850, which were released in 2009 and 2014, have the potential of generating in total over 200 million USD. That just falls short of 25% in total research gains.

A closer look at the performance of individual varieties outlined in Table 57 reveals some trends that are familiar with similar impact studies on sorghum varieties conducted for other countries, such as Uganda and Tanzania.

[11] Another possible explanation lies in the peculiarity of the DREAM model as it is built around linear market functions. Elasticity in linear functions is always a point elasticity and causes functions to rotate and change slope significantly if market prices are altered. This implies S &D functions with the same elasticity may look very different in terms of slope and influence price changes from research induced supply shifts.

Table 56: Economic surplus by group of varieties

Variety	Producer surplus	Consumer surplus	Total surplus	Research Costs	TS - Costs	Total surplus (in %)
Unit	000 USD	000 USD	000 USD	000 USD	000 USD	
Highland Var.	5,018	2,137	7,155	902	**6,253**	0.9
Intermediate Altitude Var.	65,931	13,069	79,000	1,113	**77,887**	10.3
Moist Lowland Var.	1,267	2,074	3,341	70	**3,271**	0.4
Sub Total Dry Lowland	551,996	125,416	677,411	2,478	**674,933**	88.3
Dry Lowlands OPV	297,166	68,562	365,728	1,206	**364,521**	47.7
Dry Lowlands Hybrids	174,682	51,684	226,366	1,023	**225,343**	29.5
Dry Lowlands Striga resistant	80,148	5,170	85,318	249	**85,069**	11.1
Total	624,212	142,696	766,907	4,564	**762,344**	100

Source: own table

Table 57: Economic surplus by variety

Variety	Begin of breeding	Year of release	Producer surplus	Consumer surplus	Total surplus	Research Costs	TS - Costs	IRR
Unit			000 USD	000 USD	000 USD	000 USD	000 USD	
Highland								
Chiro	1991	1998	1,065	1,044	2,110	66	2,044	**24.8**
Muyra-1	1991	2000	538	527	1,065	386	680	**8.2**
Muyra-2	1977	2000	497	487	983	386	598	**8.0**
Chelenko	1977	2005	2,918	79	2,996	66	2,931	**24.1**
Intermediate Altitudes								
Birmash	1982	1989	502	465	967	260	707	**12.1**
Baji	1984	1996	315	292	607	225	382	**9.4**
Lalo	1978	2006	37,321	10,562	47,883	89	47,794	**93.6**
Abamelko	1994	2001	1,396	86	1,482	93	1,390	**22.4**
Geremew	1989	2007	9,422	610	10,032	232	9,800	**18.6**
Dagim	2001	2011	16,976	1,054	18,030	214	17,815	**36.4**
Moist Lowland								
Gambella-1107		1976	1,267	2,074	3,341	70	3,271	**25.3**
Dry Lowlands OPV								
76T1#23	1972	1976	6,937	6,877	13,814	42	13,772	**61.8**
Meko-1	1988	1997	70,554	4,571	75,126	81	75,044	**46.7**
Teshale	1999	2002	6,440	6,385	12,825	313	12,511	**16.9**
Girana-1	2005	2007	59,135	3,323	62,458	123	62,335	**55.0**
Misikir	1995	2007	32,927	2,113	35,039	123	34,916	**49.7**
Melkam	1995	2009	45,294	2,932	48,226	156	48,070	**68.6**
Debeka	1973	2012	75,880	42,361	118,241	368	117,873	**104.0**
Dry Lowlands Hybrids								
ESH-1	1997	2009	92,785	6,031	98,816	160	98,656	**62.2**
ICSA-15XM4850	2006	2014	81,897	45,653	127,550	863	126,687	**84.8**
Dry Lowlands Striga Resistant								
Gobiye	1989	2000	41,206	2,662	43,867	78	43,789	**46.3**
Abshir	1989	2000	19,845	1,278	21,123	86	21,037	**40.2**
Birhan	1989	2002	19,098	1,230	20,328	86	20,242	**37.1**

Source: own table

With a few exceptions, improved varieties targeted at the highlands, intermediate highlands, and moist lowlands are performing well on average. However, some varieties in the list are disappointing, at least in economic terms with IRR below 10%. Another tendency is that 1st generation varieties seem to perform not as well as varieties developed and released more recently. There are several reasons for this: (1) dry lowland varieties have higher shift factors (% revenue increase), based on experts' assessment and compared with all other markets; (2) some of the older varieties, for example Muyra-2 and Chelenko (highland), Birmash and Baji (intermediate altitudes) took many years from the laboratory to the market. This does not imply that the breeding process took so long, it may hint also at inactivity in pushing ahead with seed production and market release; (3) based on the long research time gap, assigned research costs during that period is higher compared with the 'fast' varieties; and (4) research gains are proportional with market size which has been much smaller 20-30 years ago before enormous expansion in cereal production that took place during the last 15 years.

Ex-post vs. Ex-ante: A breakdown of the research gains by ex-post and ex-ante can be studied from the Tables 58-60. Less than 20% of the gains (130 million USD) which translates into 7.4 million USD a year have been achieved since the start of the breeding program. The bulk of gains (640 million USD) with an annual return of 43 million USD lie in the future, partly fuelled by the sorghum experts' optimistic view on the adoption dynamic until 2040. The results pinpoint at the long-term nature of the sorghum breeding program in generating the first returns to investments as varietal development and the dynamic in farmers' uptake need time to gain momentum. Moreover, crop breeding program across East Africa suffered at their initial stage from many shortcomings, such as lack of appropriate genetic material, breeding strategies and technologies, and lack of resources and infrastructure to release and promote those varieties at a larger scale. With over 80% of the gains from sorghum breeding lie ahead and enough sorghum varieties with good properties at hand, all concerned stakeholders in the Ethiopian sorghum sector should ensure a proper infrastructure to varietal promotion, seed production, and extension services in the field.

Table 58: Research gains in the past and the future (in '000 USD)

	Total Suplus ('000 USD)			%	%
	Ex-post	Ex-ante	Total	Ex-post	Ex-ante
Total	**129,682**	**637,225**	**766,907**	**16.9**	**83.1**
Highland	2,019	5,178	7,197	28.1	71.9
Intermediate Altitudes	14,675	73,110	87,785	16.7	83.3
Moist Lowland	3,250	425	3,675	88.4	11.6
Dry Lowland	108,529	553,486	662,014	16.4	83.6
Residual Market	1,209	5,027	6,236	19.4	80.6

Source: own table

Table 59: Ex-post and ex-ante research gains per year (as annuity value in '000 USD)

Annuity by markets									
	Ex-post			Ex-ante			Total		
Markets	from	to	Annual surplus	from	to	Annual surplus	from	to	Annual surplus
Highland			116			354			373
Intermediate Altitudes			842			4,993			4,546
Moist Lowland	1971-2013		187	2014-2040		29	1971-2040		190
Dry Lowland			6,229			37,799			34,284
Residual Market			69			343			323
Total			7,443			43,517			39,716
Group of varieties	Annuity by group of varieties								
Highland	1977	2013	120			353	1977	2040	375
Intermediate Altitudes	1978	2013	861			4,432	1978	2040	4,152
Moist Lowland	1971	2013	178			17	1971	2040	173
Dry Lowland	1972	2013	6,389	2014-2040		38,716	1972	2040	35,144
Dry Lowlands OPV	1972	2013	4,000			20,252	1972	2040	18,974
Dry Lowlands Hybrids	1997	2013	1,009			14,712	1997	2040	12,901
Dry Lowlands Striga resistant	1989	2013	2,202			3,752	1989	2040	4,652
Total	1971	2013	7,443	2014	2040	43,517	1971	2040	39,716

Source: own calculation

Table 60: Ex-post and ex-ante research gains by variety

		Total Suplus ('000 USD)			%	%
Variety	Year of	Ex-post	Ex-ante	Total	Ex-post	Ex-ante
Highland						
Chiro	1998	618	1,492	2,110	29.3	70.7
Muyra-1	2000	374	691	1,065	35.1	64.9
Muyra-2	2000	374	609	983	38.0	62.0
Chelenko	2005	619	2,377	2,996	20.7	79.3
Intermediate Altitudes						
Birmash	1989	862	105	967	89.2	10.8
Baji	1996	366	241	607	60.3	39.7
Lalo	2006	9,859	38,024	47,883	20.6	79.4
Abamelko	2001	764	719	1,482	51.5	48.5
Geremew	2007	718	9,314	10,032	7.2	92.8
Dagim	2011	1,536	16,493	18,030	8.5	91.5
Moist Lowland						
Gambella-1107	1976	3,096	245	3,341	92.7	7.3
Dry Lowlands OPV						
76T1#23	1976	13,036	778	13,814	94.4	5.6
Meko-1	1997	22,976	52,149	75,126	30.6	69.4
Teshale	2002	3,998	8,827	12,825	31.2	68.8
Girana-1	2007	11,247	51,211	62,458	18.0	82.0
Misikir	2007	6,736	28,303	35,039	19.2	80.8
Melkam	2009	8,552	39,674	48,226	17.7	82.3
Debeka	2012	2,633	115,608	118,241	2.2	97.8
Dry Lowlands Hybrid						
ESH-1	2009	10,935	87,881	98,816	11.1	88.9
ICSA-15XM4850	2014	0	127,550	127,550	0.0	100.0
Dry Lowlands Striga						
Gobiye	2000	15,989	27,878	43,867	36.4	63.6
Abshir	2000	7,974	13,149	21,123	37.7	62.3
Birhan	2002	6,420	13,908	20,328	31.6	68.4

Source: own calculation

BASELINE RESULTS: KEY FINDINGS

- **The economic performance of the Ethiopian sorghum breeding program is impressive. Overall research gains account for 760 million USD between 1971 and 2040. On an annual base that translates into 40 million USD.**
- **There is a strong research bias in favour of the dry lowlands. Most of the research gains are allocated there due to the large number of varieties and their potentials. The breeding program discriminates heavily against the 'intermediate altitudes' that make up around 40% in production and area but receive little attention in the number of varieties and thus a small fraction of the research gains (11%)**
- **The Ethiopian sorghum market favours farmers' more than consumers with the chosen DREAM model set up and elasticity values. 80% of the gains are captured by producers. Price changes from improved varieties and expanded production are marginal compared with no-research.**
- **Older, first generation varieties tend to be economically inferior with lower IRR (8-20%) and higher research costs than more recently developed varieties. This reflects the challenging environment and learning process in a breeding program that took off in the 70s in east Africa.**
- **Underperforming varieties, low adoption rates, slow breeding process and time delays in market release are reasons to explain the rather low share of ex-post research gains (only 20%) while over 80% of the research gains (600 million USD) occur in the future until 2040.**

8.6. Modelling Scenarios and Sensitivity Analysis

A set of sensitivity analyses/scenarios are carried out to test the robustness of model results with regard to certain impact parameters and value ranges. This way part of the uncertainty surrounded in the experts' assumptions and assessment can be treated and simulated. In addition, model scenarios can incorporate different assumptions regarding the market environment in which a commodity is produced and traded and conduct a comparative analysis based on their economic and distributional consequences. Here two sets of scenarios are developed which correspond directly to ICRISAT's areas of interventions (Table 36).

One set of scenarios tests different adoption and yield levels that are attainable from the genetic potential of improved varieties, better agronomic practices and promotion of improved varieties. The second set comprises market and trade scenarios for the domestic markets and trade with neighbouring countries which are related and part of ICRISAT's IMOD strategy and value chains.

Table 61: Linking ICRISAT's areas of interventions with model scenarios

ICRISAT	Breeding & Agronomy		IMOD Strategy (Inclusive Market Oriented Development)		
Research Outcome	Development of superior germplasm	Exploit genetic yield potential	Up-scale spread of improved varieties across locations	Improve market linkages and efficiency	Improve demand from foreign markets
Promoting activities	draught resistance, early maturing Var.	Agronomic best- practise and modern inputs	e.g. seed multiplication and quality	Linking poor farmers with markets, product innovations.	Specialised var.with high foreign demand (e.g. for brewing)
DREAM model scenarios					
Scenario type	Base Run	Adoption and yields		Markets and trade	
Model parameters		Variation in the yield levels	Variation in the adoption rates	Variation in domestic price elasticity	Variation in price elasticity of foreign demand

Source: own table

Markets and trade scenarios

Three different market scenarios are tested in addition to the baseline (Table 62). Each scenario is defined by a set of price elasticity parameters for the domestic market and cross-border trade (foreign supply and demand).

- Scenario 1 (high market integration) portrays an improved market situation: preference for sorghum products strengthen (η_p at -1.5) and production becomes more price responsive (ε_p= 1.5)., e.g. from a shift in relative cereal prices in favour of sorghum, better market linkages of farmers, higher share in market sales and less home consumption. No cross-border trade allowed
- Scenario 2a opens up cross border trade by allowing imports at a commercial base. Foreign export supply to Ethiopia is assumed to be medium with price elasticity of foreign supply (ε_{im}) set at 1.5.
- Scenario 2b is similar to scenario 2a except that sorghum exports are opened up while imports are prohibited. Foreign demand for Ethiopian sorghum is set at medium level (η_e set at -1.5). Any reduction in the price of sorghum in Ethiopia from surplus production from improved varieties triggers a high demand from foreign buyers.
- Scenario 3 represents a complete liberalisation in cross-border trade. Sorghum export supply and import demand are set at medium level (+-1.5).

Table 62: Configuration of price elasticity parameters for the trade scenarios

	Trade regime	Baseline (0)	High domestic market integration (1)	Cross-border trade		
				Imports allowed (2)	Exports allowed (3)	Free trade (imports and exports allowed) (4)
Domestic Market	(ε_p)	0.66	1.5	0.66	0.66	
	(η_p)	-0.66	-1.5	-0.66	-0.66	
Foreign Markets	(ε_{im})	0	0	**1.5**	0	**1.5**
	(η_{ex})	0	0	**0**	**-1.5**	**-1.5**

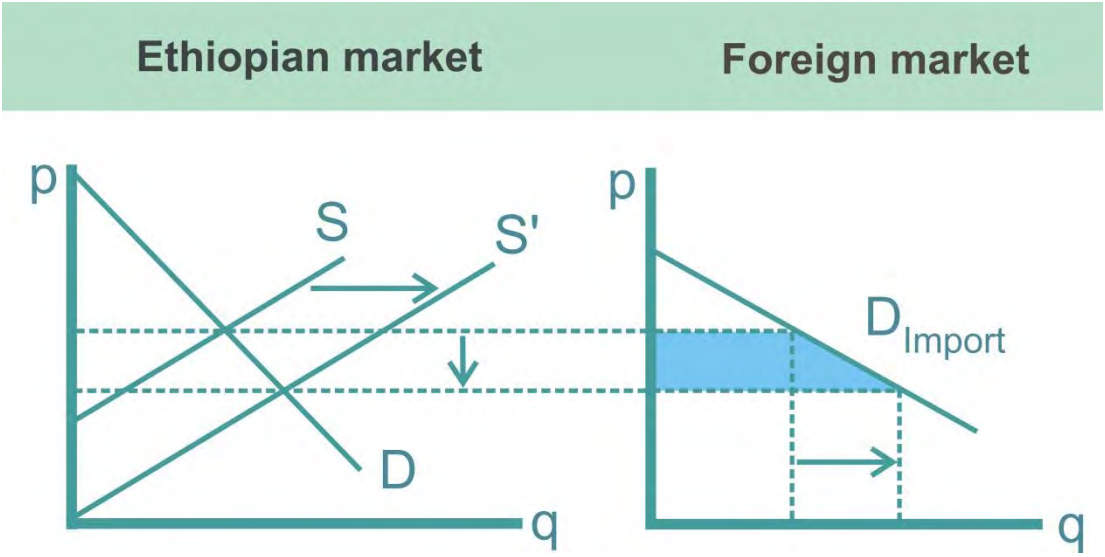
Source: own table

Why does cross-border trade matters for sorghum breeders?

Introducing foreign trade into the DREAM has several implications for the Ethiopian market, the prices for sorghum and the distribution of the research gains. The foreign market as depicted in the diagram below creates additional demand for Ethiopian sorghum from foreign buyers. Adoption of improved varieties induce the domestic supply to shift outwards (research shift) as a consequence of higher yields and production compared to local varieties. Prices in all parts of Ethipia regardless of adoption or non-adoption regions, consumer or producer markets fall. Lower prices make Ethiopia sorghum more attractive and increases demand from foreign buyers.

The effects of cross-border trade for sorghum producers are twofold: a) they gain from additional production and market opportunities provided by foreign buyers and b) from lower price pressure in the local market as some part of production is sold to the foreign market. Both effects combined create significant benefits to farmers. Ethiopian sorghum consumers on the other hand loose from higher market prices and reduced consumption as it would be without cross-border trade. Part of local consumption is replaced by foreign demand in terms of sorghum exports. As a consequence consumers face significant economic losses.

Cross-border trade creates additional gains in the importing country for consumers in terms of lower import prices and higher consumption levels. But these 'spill-over' effects are not accounted for in the analysis as they occur outside the Ethiopian border.



Model results from trade scenarios

Inspection of the results from the market and trade scenarios shows that market performance as well as trade regimes has little influence on the overall size of the research gains. The difference in total economic surplus between the least (export or imports allowed) and the most favourable scenario (complete free trade) is only 7%. The trade regime is also fairly neutral in the allocation of research gains across markets. The most sensitive reaction is on the consumer side. Some results in Table 63 are surprising and counterintuitive at first sight. A closer look at the import scenario (2a) shows increased producer surplus despite some import volumes, though common sense is that domestic producers loose part of the market and revenues if some production is replaced by cheaper imports. There are basically

two explanations for the positive effects on producers and strong negative effects on consumers from imports.

Table 63: Results from market & Trade Scenario ('000 USD)

Economic Surplus (in '000 USD)	Baseline (0)	High market integration (1)	Cross-border trade import or export liberalisation (2a&b)	Cross-border trade liberalisation (3)	Spread in %
TS	766,907	770,334	764,291	816,221	6.8
PS	624,212	635,276	651,663	671,213	7.5
CS	142,696	135,058	112,627	145,008	28.8
Highland	7,197	7,488	7,254	7,664	6.5
Intermediate Altitudes	87,785	82,912	67,464	90,290	33.8
Moist Lowland	3,675	4,227	3,092	3,788	36.7
Dry Lowland	662,014	671,691	686,373	708,931	7.1
Residual Market	6,236	4,016	107	5,547	5753.7
Total	766,907	770,334	764,291	816,221	

Source: own table

First, research gains are generated from comparison between local varieties (without research) and improved varieties (with research case). Imports do affect farmers' sectoral income share but that is valid for the 'with'- and 'without' research case. **Second**, imports increase the size of the sorghum economy and thus all research gains within its boundary. Third, the 'dream' model operates with fixed price wedges across markets. There is no embedded mechanism to level out prices when markets become bigger. The fixed price wedges are responsible for losses in consumer surplus as additional local production from improved varieties substitute for imports (neg. price elasticity) that are cheaper than any domestic production. Thus, consumers pay more for sorghum in the market. The modest Increase in economic surplus in the free-trade scenario -though rather modest - underlines the general hypothesis of the 'gains from trade' in a liberalized trade regime. Many of the positive factors from free trade cannot be captured in a market model that is as simple as the 'Dream' model

Adoption and yield scenarios

Adoption rates and yields are the two key impact factors that determine the size of the research induced supply shift and thus the magnitude of the welfare gains. In the elicitation process, adoption rates and yield effects are subject to a multitude of different assumptions on which future trends in those variables are based on. In the absence of quantitative forecasting methods (lack of adoption time series), the best way to capture the surrounding uncertainties is to conduct sensitivities analyses and test the robustness of the impact results for a range of likely values for adoption rate and yield effects. Because of the rather

elevated scale in adoption and yields, only the downside of the value range is tested with adoption rates and yield levels reduced to 50% of their original values.

Table 64-66 summarize the major findings. Higher adoption rates and yields simply reduce the impact dynamic without changing much in the distribution pattern between consumers and producers and between regions. In general a 50% cut in yields reduces the IRR and research gains more than a comparable 50% cut in adoption rates. But this depends on the particular shape of the adoption curve and the composition of the costs and revenue in a partial budget. The severity of cutting down on adoption levels versus yield expectations on the IRR and research gains is striking. The effects of a 50% reduction in yield and thus revenues on the profitability are much higher than for adoption rates. This steams from the fact that a 50% decline in yields/revenue causes a more than 50% reduction in the shift factor. The shift factor for profitability is the simple sum of .the percentage change in revenue minus the percentage change in costs. The higher the share of input costs is in relation to revenues, the bigger impact lower yields and revenues have on the shift factor

From a researcher's viewpoint, lower than expected adoption rates do not constitute as much of a risk to the performance of a breeding program than lackluster yields, esp. in a medium-level input system when costs for seed and fertilizer are significant investments. In economic terms, yield failures pose greater risk than disappointing adoption rates in more advanced and cash driven crop management systems. The implication for economists who are in charge of impact studies are that profitability calculus for improved varieties should be based on a solid and careful estimation where all adverse factors of the farmers' environment should be taken account of and valued.

Table 64: Economic surplus from lower adoption rates and yield levels

	Baseline	Adoption rate - 50%	% in total surplus	Yield decline 50%	% in total surplus
Total surplus	766,907	383,164	50.0	173,893	22.7
Producer surplus	624,212	311,482	49.9	138,511	22.2
Consumer surplus	142,696	71,682	50.2	35,382	24.8

Source: own table

Table 65: Economic surplus from lower adoption rates and yield levels by region

	Adoption rate – 50%			Yield decline 50%		
	Total surplus	Producer surplus	Consumer surplus	Total surplus	Producer surplus	Consumer surplus
Highland	3,592	3,083	509	1,881	1,643	238
Intermediate Altitudes	44,883	-6,298	51,181	6,584	-19,488	26,072
Moist Lowland	1,837	243	1,594	844	114	730
Dry Lowland	329,939	324,743	5,196	163,324	160,928	2,397
Residual Market	2,913	-10,289	13,203	1,260	-4,685	5,946
Total	383,164	311,482	71,682	173,893	138,511	35,382

Source: own table

Table 66: Internal Rate of Return IRR

Group	Variety	Baseline	Adoption rate -50%	Yield decline 50%
Highland	Chiro	24.8	19.8	15.7
	Muyra-1	8.2	6.1	4.1
	Muyra-2	8	5.8	3.9
	Chelenko	24.1	20.2	16.7
Intermediate Altitude	Birmash	12.1	9.2	5.2
	Baji	9.4	7.6	5.7
	Lalo	93.6	77.4	35.8
	Abamelko	22.4	19.6	3.4
	Geremew	18.6	16	7.3
	Dagim	36.4	31.5	14.1
Moist Lowland	Gambella-1107	25.3	20.4	17.8
Dry Lowland OPV	76T1#23	61.8	48.6	36.7
	Meko-1	46.7	40.7	34.3
	Teshale	16.9	14.6	11.9
	Girana-1	55	48.2	40.6
	Misikir	49.7	43.1	35.7
	Melkam	68.6	59.2	48.8
	Debeka	104	86.7	68.2
Dry Lowland Hybrids	ESH-1	62.2	54.5	50.5
	ICSA-15XM4850	84.8	69.5	61.7
Dry Lowland Striga resistant	Gobiye	46.3	40.4	28.6
	Abshir	40.2	34.6	23.6
	Birhan	37.1	32.2	22.2

Source:

9. Geography of Research Gains and Poverty Implication

Breeding program in dryland cereals that are conducted by ICRISAT and its NARS partners in ESA countries are aimed at providing resource poor farmers in remote areas with better agronomic practices and high performing varieties that help increase and stabilize agricultural income. Poverty comes along with Sorghum as it is grown to a large extent in dry and semi-dry areas with a high prevalence of poverty and underdevelopment. This section gives fresh and quantitative evidence to the notion of sorghum as a 'poor man's crop and assess how successful and inclusive the Ethiopian sorghum breeding program has been in generating economic benefits for the rural and urban 'poor'. The analysis cannot come up with advanced conclusions regarding the scale of poverty eradication from those improved varieties, but allows a general assessment whether the breeding programs has been neutral or have a 'poor' or' non-poor' bias in the flow of research benefits depending on the regional allocation of research gains and match with the poverty hotspots.

9.7. Analytical Approach in Assessing the Spatial Pattern of Research Gains

There are several dimensions of poverty that influence the effectiveness of breeding programs towards pro-poor objectives and generation of the desired impacts for the 'poor's households. The 'macro' dimension is the general level of poverty in Ethiopia and poverty disparities between regions that determine how effective location specific varieties and regional priorities are in addressing the 'pro-poor agenda'. The 'meso' dimension of poverty refers to sector specific poverty profile, for example the poverty level of sorghum growers in comparison with maize or vegetable growers, or market prices attainable by the 'poor' versus better off farmers selling larger quantities. The third dimension comprises farm level decisions that are specific to the farmers' wealth status and resource endowment, such as crop management practises, level of input use, adoption of improved varieties, and others. The ideal would be to have sufficient information about all three dimensions. However, with regard to macro-level poverty, Ethiopia is well researched but lacks the regional depth. Most studies report poverty indicators for regions, occasionally for zones and never at woreda level. Analyses about poverty levels in certain commodity sectors and performance in the market place are rare. The same applies to farming practises, and profitability in cereal production. In the absence of reliable information, this analysis as well as the elicitation process for the DREAM model makes no attempt to differentiate farming practises, market prices, partial budgets and adoption behaviour between the 'poor' and 'non-poor'.

A simplistic but feasible approach is chosen that tries to trace the allocation of research gains towards different regions and compare them with the region specific poverty rate. If research gains have a regional bias towards richer regions like the Oromia region then the program's impact tends to underrepresent the 'poor's share in comparison with the national average. Research gains can be looked at from the producers' angle (in terms of producer surplus and from the consumer side (in terms of consumer surplus). The poverty rate may be very different depending on income elasticity, if for example sorghum consumption has a very strong bias towards the 'poor' or not.

Recover spatial details from the 'Dream' Model. The regional distribution of research gains is hard to trace from the DREAM model at a meaningful level of detail as results are highly aggregated alongside the market specifications. However, there are ways to recover

some of the spatial details that are embedded in the production and consumption data sets. The solution is to translate the research gains from the DREAM model into per units of production and consumption across all markets. The per-unit value is almost constant as research gains, namely producer and consumer surplus, grow linear with the level of production and consumption. With known per-unit values (USD surplus/mt), research gains can then be attributed to any region and administrative level with known production and consumption figures. Table 67 contains all per-unit values disaggregated by markets, producer and consumer level, ex-post and ex-ante period from the aggregated economic surplus figures and annual surplus expressed as annuity.

Table 67: Research gains in per unit of production and consumption

Market/AEZ	Ex-post period (1971 - 2013)		Ex-ante period (2014 – 2040)	
	Producer surplus	Consumer surplus	Producer surplus	Consumer surplus
	USD/mt of production	USD/mt of consumption	USD/mt of production	USD/mt of consumption
Aggregated surplus				
Total	**94.3**	**17.7**	**136.8**	**32.5**
Highland	40.1	11.8	36.6	4.3
Intermediate altitude	12.4	17.0	-12.9	54.6
Moist lowland	16.5	11.8	-3.7	4.3
Dry lowland	215.5	11.8	349.8	4.3
Residual market	-64.9	67.8	-86.8	89.8
Annuity (surplus per mt/year)				
Annual ES(USD)/mt	**Ex-post (1971 - 2013)**		**Ex-ante 2014 - 2040**	
Total	**5.4**	**1.0**	**9.3**	**2.2**
Highland	2.3	0.7	2.5	0.3
Intermediate altitude	0.7	1.0	-0.9	3.7
Moist lowland	0.9	0.7	-0.2	0.3
Dry lowland	12.4	0.7	23.9	0.3
Residual market	-3.7	3.9	-5.9	6.1

Source: own calculations

9.8. Prevalence of Poverty in Ethiopia

Trends in national poverty: Using real per adult consumption expenditure, the levels of total, rural and urban poverty indices for 1995/1996, 1999/00, 2004/2005 and 2010/11 are provided in Table 68. Compared to 2004/05, poverty has declined substantially from 38.7% to 29.6%, but limited to the incidence (head count) and depth of poverty (poverty gap). The 2010/11 poverty head count index (incidence of poverty) is lower than the index for 2004/05 by 24% while the poverty gap is lower by 5.5% indicating a substantial decline in poverty during the five-year period ending in 2010/11. Moreover, the decline in poverty is also much higher after 2004/05 than after 2004/05. In general, rural poverty still remains higher (30%.4) than urban poverty (25.7%) in the newest household and income survey from 2010/11. Much of the decline in national poverty in 2010/11 can be attributed to a decline in urban poverty in contrast to the decline in poverty in 2004/05 which was mainly due to a decline in rural poverty. The 2010/11 rural poverty head count and poverty gap are lower than that of 2004/05 by 23% and 5.5%, respectively, but poverty severity of 2010/11 is higher than of 2004/05 by 17% indicating that inequality in rural started to rise. The

preliminary analysis indicates that there has been a decline in the proportion of rural people who are below the poverty line and the average gap of the poor from the poverty line, but no improvement in the distribution of income among the rural poor. The Ministry of Finance and Economic Development of Ethiopia (Federal Democratic Republic of Ethiopia 2013) attributes the decline in rural poverty to the wide-ranging and multi-faceted pro-poor programs that have been implemented in rural areas such as extension of improved agricultural technologies and farming practices, commercialization of smallholder farming agriculture, rural infrastructural development and a range of food security programs (productive safety net programs, provision of credit, and so on). The same ministry argues that the decline in urban poverty incidence and gap could be attributed to the pro-poor activities undertaken in urban areas since 2005 including the on-going efforts waged by the government to creating favourable environment for private sector investment, job creations and distribution of subsidized basic food items provided to the urban poor in times of inflation over the last five years.

Table 68: Trends of national and rural/urban poverty[12]

	Poverty indices over time				Change (%)	
	1995/96	1999/00	2004/05	2010/11	2004/05 over 1999/00	2010/11 over 2004/05
National						
Head count index	**0.455**	**0.442**	**0.387**	**0.296**	**-12.4*** **	**-23.5*** **
Poverty gap index	0.129	0.119	0.083	0.078	-30***	-5.5*
Poverty severity index	0.051	0.045	0.027	0.031	-39.8***	14.4***
Rural						
Head count index	0.475	0.454	0.393	0.304	-13.4***	-22.7***
Poverty gap index	0.134	0.122	0.085	0.080	-30.***8	-5.5NS
Poverty severity index	0.053	0.046	0.027	0.032	-40.6***	17.0*
Urban						
Head count index	0.332	0.369	0.351	0.257	-4.7***	-26.9***
Poverty gap index	0.099	0.101	0.077	0.069	-23.6***	-10.1***
Poverty severity index	0.041	0.039	0.026	0.027	-33.5***	5.1***

Source: FDRE 2013, based on HICE survey of 1995/96, 1999/00, 2004/05 and 2010/11. Note: *** Significant at 1 %; ** significant at 5 %; * significant at 10 %; NS=Not significant.

[12] The Development and Poverty Report of the Federal Democratic Republic of Ethiopia(2013) applies three types of poverty measures:
Incidence of poverty (headcount index).This is the share of the population whose income or consumption is below the poverty line, that is, the share of the population that cannot afford to buy a basic basket of goods.
Depth of poverty (poverty gap).This provides information regarding how far households are far from the poverty line. This measure captures the mean aggregate income or consumption shortfall relative to the poverty line across the whole population. It is obtained by adding up all the shortfalls of the poor (assuming that the non-poor have a shortfall of zero) and dividing the total by the population. In other words, it estimates the total resources needed to bring all the poor to the level of the poverty line (divided by the number of individuals in the population).
Poverty severity (squared poverty gap). This takes into account not only the distance separating the poor from the poverty line (the poverty gap), but also the inequality among the poor, that is, a higher weight is placed on those households further away from the poverty line.

Status of regional poverty: The regional distribution of total and food poverty in Ethiopia and trends in this distribution are shown in Table 69. In 2010/11, poverty head count index is the highest in Afar (36.1%) followed by Somali (32.8%) and Tigray (31.8%), while poverty estimates are lowest in Harari (11 %) followed by Addis Ababa (28.1 %) and Dire Dawa (28.3 %). Considering only the large rural regions, the poverty disparity between the poorest (Afar, 36% total and 41% rural) and the richest region (Oromia, 29% total and 29% rural) is not as pronounced as in many other sorghum growing nations in the ESA region. It seems the disparity has even declined between 1995 and 2010. Some of the largest regions (Amhara, Tigray, and S.N.N.P) in terms of land area and agricultural production have been able to nearly cut poverty rate in half over the last 20 years.

Table 69: Trends of regional poverty headcount indices by region

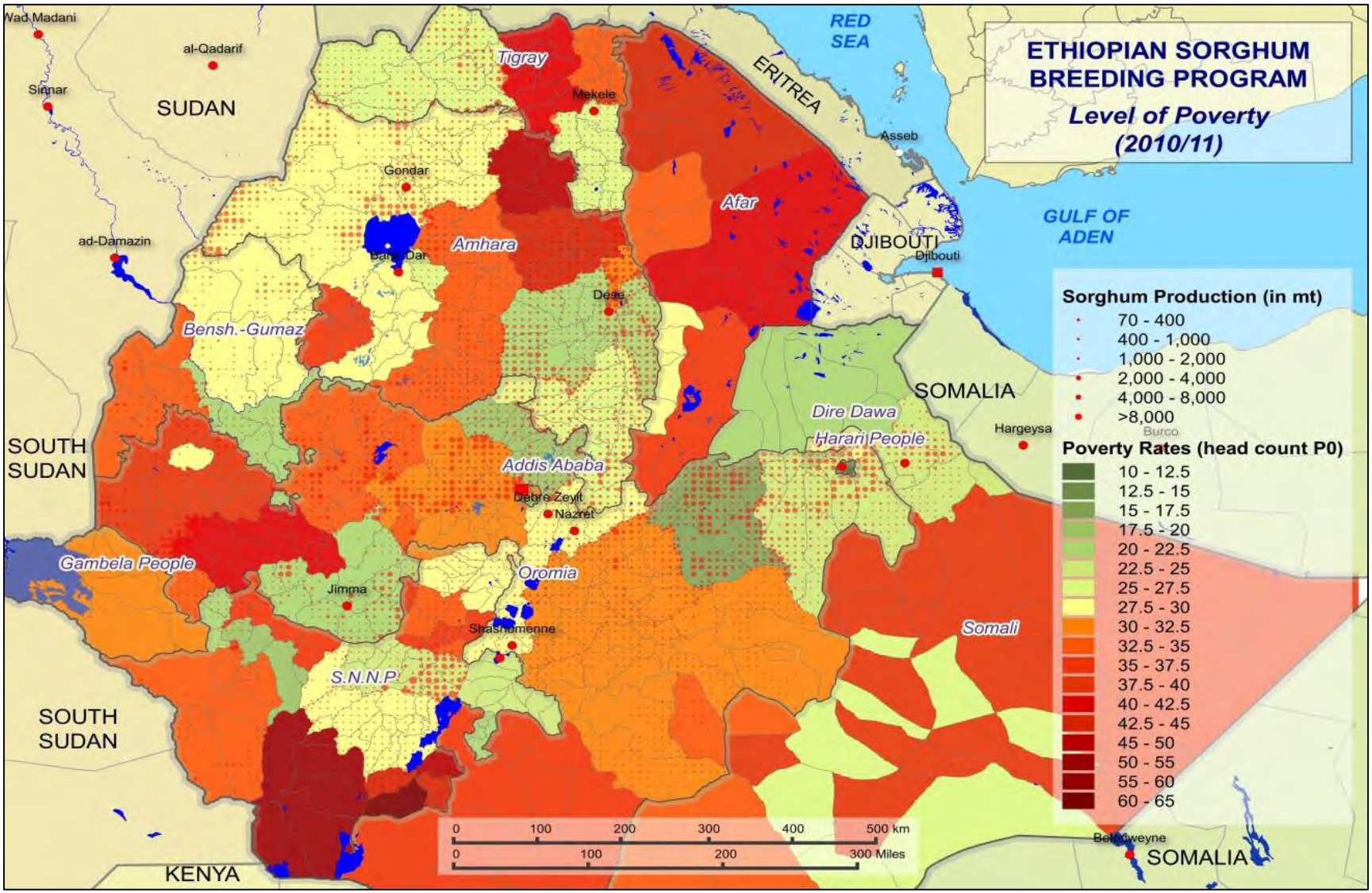
	1995/96			1999/2000			2004/05			2010/11		
Region	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Tigray	0.579	0.457	0.561	0.616	0.607	0.614	0.510	0.367	0.485	0.365	0.137	0.318
Afar	0.518	-	0.331	0.680	0.268	0.56	0.429	0.279	0.366	0.411	0.237	0.361
Amhara	0.567	0.373	0.543	0.429	0.311	0.418	0.404	0.378	0.401	0.307	0.292	0.305
Oromia	0.347	0.276	0.340	0.404	0.359	0.399	0.372	0.346	0.370	0.293	0.248	0.287
Somale	0.346	-	0.309	0.441	0.261	0.379	0.452	0.353	0.419	0.351	0.231	0.328
B.B.G	0.476	0.345	0.468	0.558	0.289	0.54	0.458	0.345	0.445	0.301	0.213	0.289
SNNP	0.565	0.459	0.558	0.517	0.402	0.509	0.382	0.383	0.382	0.300	0.258	0.296
Gamb.	0.418	0.244	0.343	0.546	0.384	0.505	Na	na	na	0.325	0.307	0.320
Harari	0.133	0.291	0.22	0.149	0.35	0.258	0.206	0.326	0.270	0.105	0.117	0.111
AA	0.404	0.300	0.302	0.271	0.362	0.361	0.299	0.326	0.325	…	0.281	0.281
DD	0.366	0.246	0.295	0.332	0.331	0.331	0.398	0.329	0.352	0.142	0.349	0.283
Total	**0.475**	**0.332**	**0.455**	**0.454**	**0.369**	**0.442**	**0.393**	**0.351**	**0.387**	**0.304**	**0.257**	**0.296**

Source: Federal Democratic Republic of Ethiopia 2012, based on HICE survey of 1995/96, 1999/00, 2004/05 and 2010/11

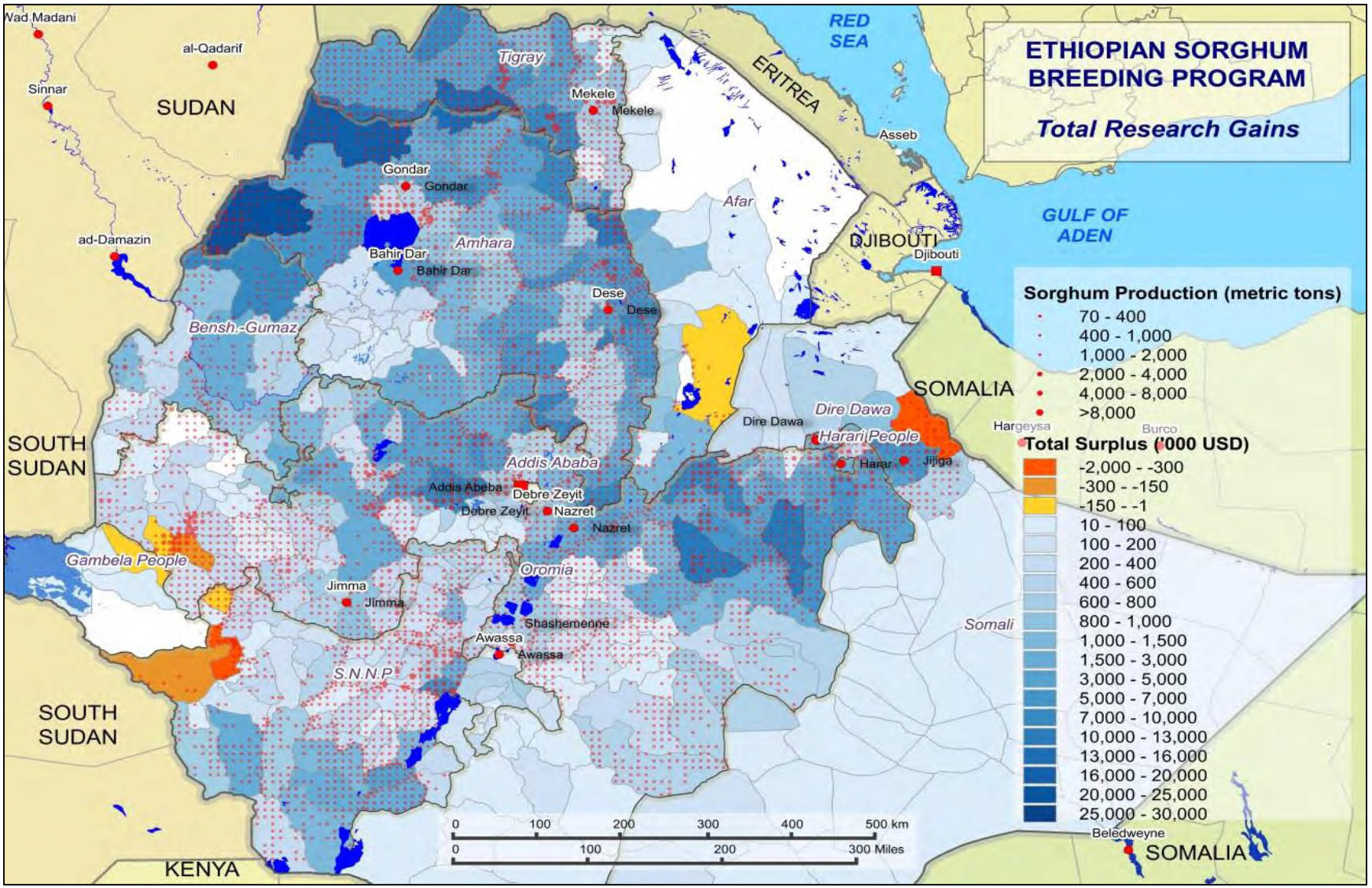
9.9. Geographic Distribution of Research Gains by Woreda

Thanks to ICRISAT's GIS data base on dryland cereals for ESA countries, together with the per-unit values of research gains from Table 67, is possible to sketch the geographic allocation of research gains from the Ethiopian sorghum breeding program for each woreda (see Maps 14 to 16) A look at the Map 14 shows that the regional distribution of the research gains (in total economics surplus) follows closely the level of sorghum production though the consumption side is part of the overall gains. As shown in Table 54, consumer surplus is only a fraction of the size of producer gains. Another explanation is that the location of consumption overlaps to a large extent with the production areas. There are some pockets of negative research gains in the north and south where some sorghum production are located but without any improved variety, causing losses in producer surplus, combined with a low rate of consumption and consumer surplus. The same effect can be studied from the Map 15 that highlights the regional distribution in producer surplus.

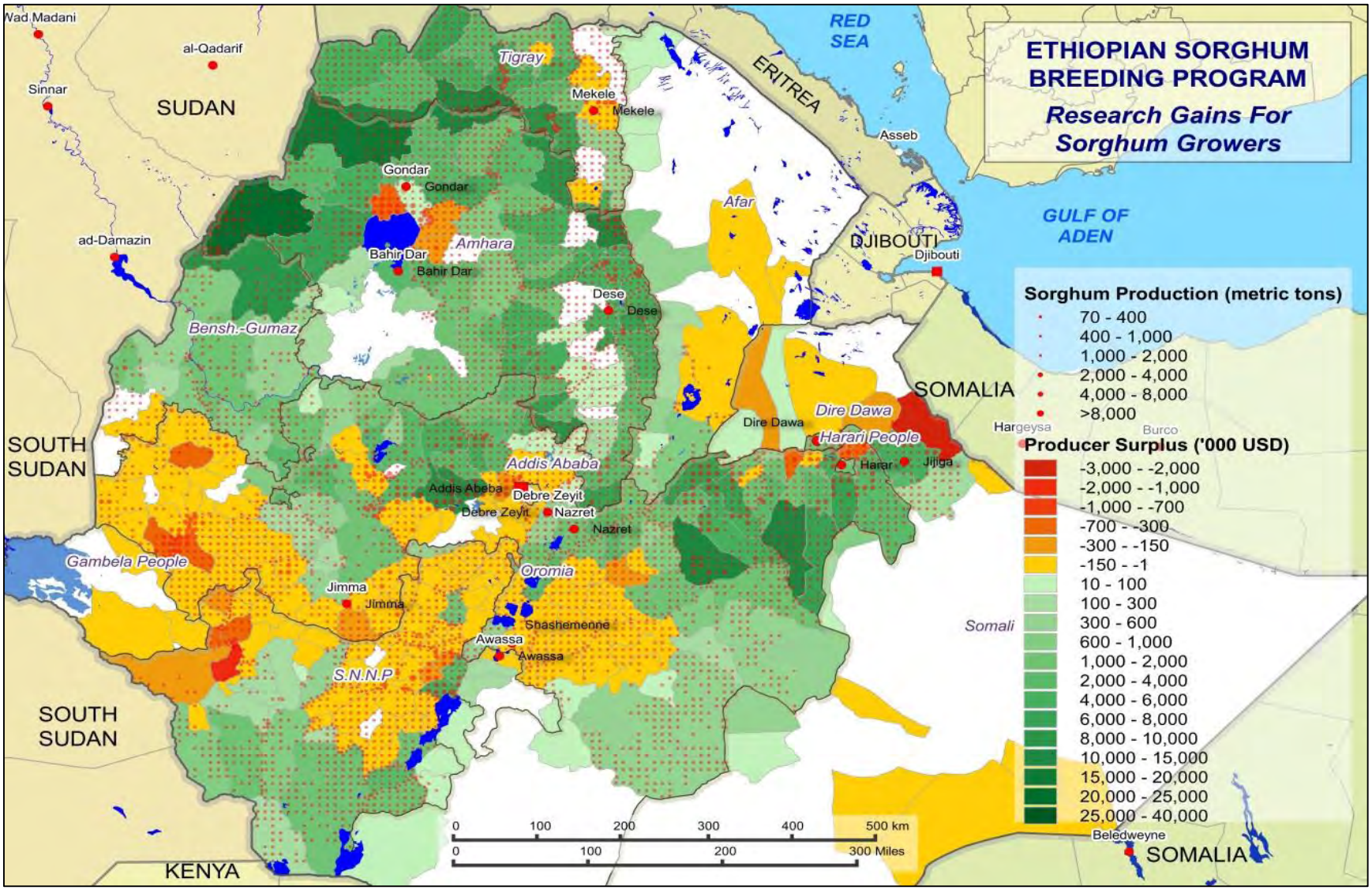
Map 13: Regional poverty levels (head count P_0, 2010/11)



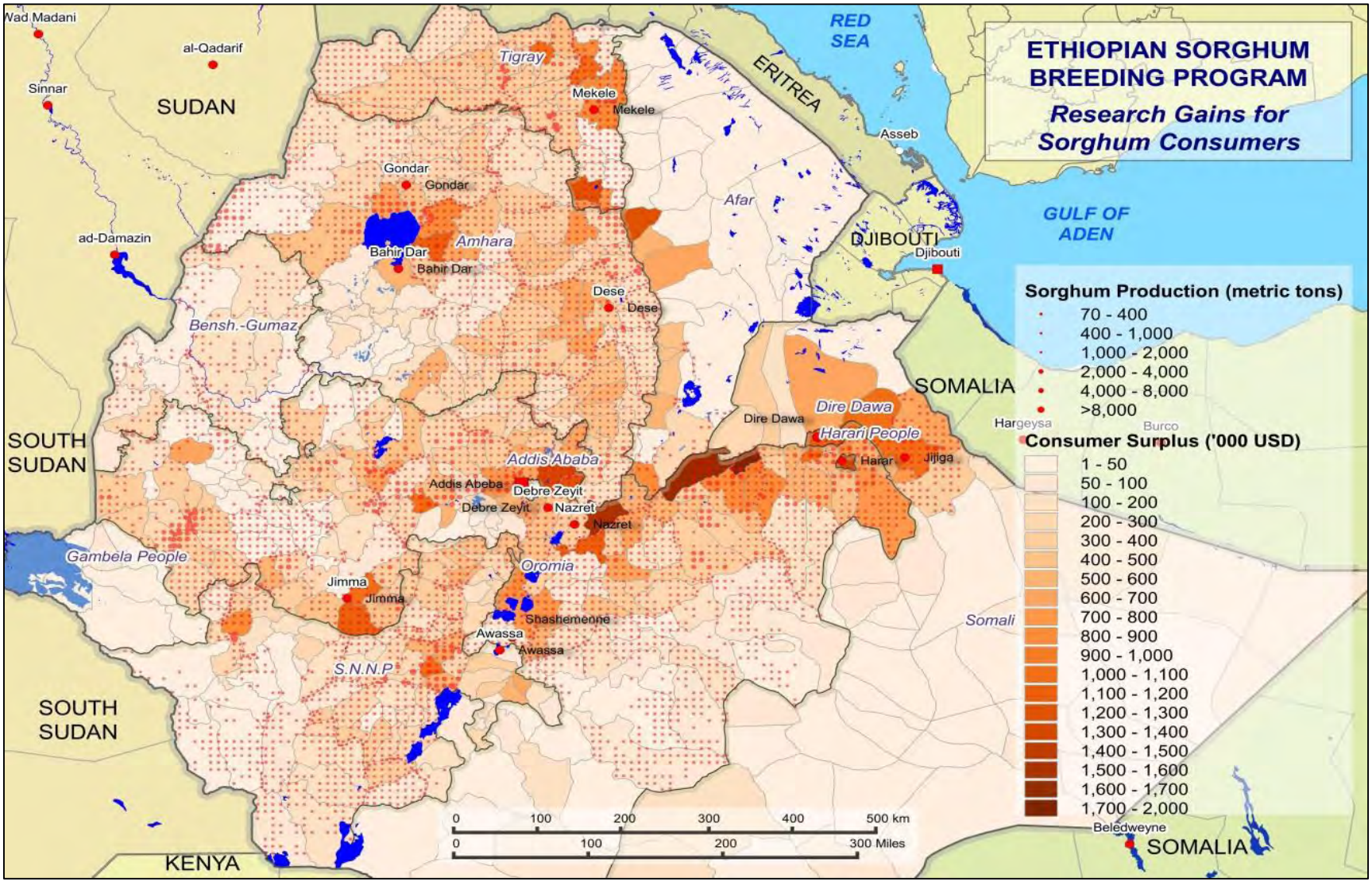
Map 14: Regional distribution of research gains (total economic surplus)



Map 15: Regional distribution of research gains (producer surplus)



Map 16: Regional distribution of research gains (consumer surplus)



9.10. Poverty Indicators in the Sorghum Sector

This section looks at the incidence of poverty inside the sorghum sector. Similar impact studies from Uganda and Tanzania found a slightly elevated poverty level in the sorghum economy compared to other cereals and above national average of rural poverty. Sorghum production in those countries are more clustered and located in poverty hotspots. On the demand side, sorghum in Uganda and Tanzania is mainly consumed in rural areas, as it is the case in Ethiopia but show a much stronger negative correlation between household income and per captia consumption. From the data, some indicators are fairly easy to derive: e.g. absolute numbers and share of production, consumption, rural households, and person within from the 'poverty' cluster. The analysis is derived from the following data:

- Sorghum production and consumption at woreda level from the IFPRI 'MapSpam' spatial crop data set (updated with the official production statistics from the Central Statistical Agency CSA). Consumption level by woreda from the ICRISAT's cereal consumption analysis
- Demographic data (population census 2012, number of household by crop type) at woreda level from CSA.
- Poverty indicators (P_0, P_1, P_2) from different years, 204/05 and 2010/11, from the Ministry of Finance and Development. The 2004/05 poverty data report on zonal level while all other sources only give the regional indicators. The 2004/05 was applied and then each poverty value adjusted to match the newest 2010/11 data from the regions. In a next step, each woreda was then assigned the zonal poverty value it belongs to. Thus, no further distinction could be made beyond zonal level due to the absence of woreda level data.
- Some simplifying assumptions are made: same level of poverty for all household types (maize, sorghum or millet producing households) and no differentiation in sorghum economics (yields, prices, input costs).

Table 70 highlights the share of production and consumption from poor producers and consumers. Some of the findings are surprising. Poverty in the Ethiopian sorghum sector persists but is not higher in terms of production share than the national poverty rate at around 29% and rural poverty rate at 30%. The share of sorghum production, consumption, number of sorghum growing households within the poverty cluster is around 29% under the simplifying assumption made in the analysis. The reasons for the rather low 'poverty footprint' in the sorghum sector are mainly (1) widespread cultivation across regions and agro-ecological zones incl. wealthy regions, (2) the low regional poverty disparity, and (3) moderately negative income elasticity in sorghum consumption that softens the strong divide in sorghum consumption between rural-urban and poor-rich which is common in other ESA countries. However, more empirical research is needed to investigate differences in the household characteristics, adoption behaviour and profitability of improved sorghum varieties alongside various wealth clusters that helps to arrive at more accurate macro picture of poverty persisting in the sorghum sector.

Based on the production level in 2012, around 1 million tons of sorghum comes from poor farmers and the same amount is consumed by poor consumers. The poverty share in production fairly reflects the general poverty level in the regions. What drives the share down

is particularly the large production in the Oromia region whose poverty level at 28% in 2010/11 is below national average. The same applies to the consumption side.

Table 70: Poverty in the Ethiopian sorghum sector: production and consumption

2012	Production	Production by the ‚poor'	%	Consumption	Consumption by poor	%
UNIT	**000 mt**	**000 mt**		**000 mt**	**000 mt**	
TOTAL	**3,765**	**1,082**	**28.7**	**3,765**	**1,082**	**28.8**
Addis Ababa	10	3	28.6	3	1	28.1
Afar	38	13	34.6	89	30	33.6
Amhara	1,293	383	29.6	894	268	30.0
Benshangul-Gumaz	118	33	27.9	106	31	28.9
Dire Dawa	20	6	28.3	17	5	28.3
Gambela Peoples	3	1	32.3	5	1	32.0
Harari People	6	1	11.1	43	5	11.1
Oromia	1,493	405	27.1	1,552	419	27.0
Somali	76	19	24.4	98	26	26.5
Southern Nations, Nationalities and Peoples	304	93	30.4	521	154	29.6
Tigray	402	127	31.6	437	143	32.7

Source: own calculations

Table 71 shows the number of sorghum growing households and persons. In 2012, 4.7 million households are classified as sorghum growing households by the Agricultural Sample Survey 2010/11 (CSA 2011). Assuming an average household size of 5 persons, the total number of persons involved in sorghum production adds up to 23.5 million. Both figures seem to be overstated if compared with the total number of households and population size of Ethiopia at around 85 million in 2012. Some validation is needed on the part of rural households and division by crop type.

Table 71: Scale of poverty in the Ethiopian sorghum sector: households and people

	Number of sorghum growing households	Number of ‚poor' sorghum growing households	people in the sorghum growing households	‚Poor' people in sorghum growing households
UNIT	'000	'000	'000	'000
TOTAL	**4,707**	**1,396**	**23,536**	**6,978**
Addis Ababa	9	3	46	14
Afar	43	15	214	75
Amhara	1,421	431	7,105	2,155
Benshangul-Gumaz	149	43	745	216
Dire Dawa	26	7	131	37
Gambela Peoples	7	2	36	12
Harari People	6	1	28	3
Oromia	1,914	521	9,570	2,605
Somali	71	18	357	89
Southern Nations, Nationalities and Peoples	617	203	3,085	1,017
Tigray	444	151	2,220	755

Source: own calculations

9.11. 'Poverty' Inclusiveness of the Sorghum Breeding Program

As stated in the previous section, no distinction was made between the sorghum economics of 'poor' and non-poor famers. Consequently, the gains from improved sorghum varieties are equally distributed among the different type of households regardless of farm size and income status. Research gains per household are not easy to come by as market size, number of adopters, and annual research costs and gains change every year. However, Table 72 summarizes the results from a calculation that tries to derive a meaningful economic value for the ex-ante period on a per-household base. The figures per household should not be understood as farmers' income gains but are rather macroeconomic valuation of the returns to public investment in breeding broken down for each household in the sorghum sector. The effects on farmers' income can be directly retrieved from the gross margin table as changes in revenues and costs on a per-ha base. Aggregated economic surplus figures between 2013 and 2040 are referenced with the current number of sorghum growing households (around 4.7 million), current adopting households (336,100) based on the median adoption level between 2013 and 2040 and the number of adopting households (1.1 million) at the maximum adoption levels (50% for the dry lowlands, 4% moist lowlands, 10% intermediate altitudes and 20% for the highlands).

Table 72: Returns to investment in the ex-ante period (2013-2040 by household

Sorghum Households	Number of households	Producer surplus per household	Producer surplus per household	Total surplus per household
Unit		USD	USD	USD
All households	4,707,299	108.8	26.2	134.9
Current adopting households	336,103	1,523.3	366.7	1,890.0
All adoption households at maximum adoption levels	1,113,030	460.0	110.7	570.7

Source: own calculations

As a simple measure of inclusiveness for the Ethiopian breeding program and varieties released we can calculate the numbers of poor households and persons in these households that are reached according to the EIAR sorghum experts' assessment of regional adoption rates throughout the entire period. Table 73 shows the results broken down in the three time periods, 'ex-post (1971 – 2012), current (2013), and ex-ante (2014 – 2040). Calculations are based on ex-post median adoption rate, current adoption rate for 2013 and maximum adoption rates for the ex-ante period. From the ex-post perspective, the Ethiopian sorghum breeding program has shown limited impact so far in reaching out to the rural 'poor'. Only 50,000 'poor' households (approx. 250,000 'poor' people) have been reached on average between 1971 and 2013 as a result of limited number of varieties and adoption rates far below 5%. However, the prospects for the future are excellent. At the current adoption rate, improved sorghum varieties are grown among 100,000 poor farmers (around 500,000 people). Under the assumption of a 'double poverty rate' of sorghum growers compared to national average these numbers increase to 200,000 'poor' households with over one million 'poor' people

If the spread of improved varieties reaches the level experts predict in this study (around 50%) future, the number of beneficiaries in the poor cluster can reach between 1.6 million and 3.3 million people, and between 330,000 and 660,000 households. This amounts to 7 – 14% of the national 'poor' population of 25 million (2013).

Table 73: How inclusive is the Ethiopian sorghum breeding program for the 'poor'?

	Number of adopting households	'Conservative' estimation		Double poverty rate for sorghum growing households	
		Number of 'poor' adoption households	Number of ‚poor' persons	Number of 'poor' adoption households	Number of ‚poor' persons
	Ex-post period (1971 – 2013)				
TOTAL	**69,664**	**25,474**	**127,368**	**50,947**	**254,736**
Addis Ababa	58	16	79	32	159
Afar	655	276	1,378	551	2,755
Amhara	28,047	9,819	49,096	19,638	98,192
Benshangul-Gumaz	2,557	1,152	5,760	2,304	11,519
Dire Dawa	267	93	465	186	929
Gambela People	23	9	43	17	87
Harari People	123	14	68	27	137
Oromia	23,756	7,693	38,467	15,387	76,933
Somali	930	393	1,963	785	3,925
Southern Nations, Nationalities and Peoples	3,473	1,341	6,706	2,682	13,412
Tigray	9,773	4,669	23,343	9,337	46,687
	Current 2013				
TOTAL	**336,103**	**100,029**	**500,147**	**200,059**	**1,000,294**
Addis Ababa	227	68	341	136	682
Afar	2,915	1,021	5,105	2,042	10,209
Amhara	124,129	37,552	187,758	75,103	375,515
Benshangul-Gumaz	12,110	3,374	16,872	6,749	33,745
Dire Dawa	1,472	417	2,083	833	4,166
Gambela Peoples	234	76	378	151	756
Harari People	493	55	274	110	548
Oromia	119,439	31,339	156,697	62,679	313,394
Somali	3,888	1,062	5,310	2,124	10,620
Southern Nations, Nationalities and Peoples	29,160	10,879	54,394	21,758	108,789
Tigray	42,035	14,187	70,935	28,374	141,871
	Ex-ante period (2014 – 2040)				
TOTAL	**1,113,030**	**330,829**	**1,654,147**	**661,659**	**3,308,294**
Addis Ababa	992	295	1,477	591	2,955
Afar	9,780	3,428	17,138	6,855	34,275
Amhara	434,079	131,354	656,768	262,707	1,313,536
Benshangul-Gumaz	33,545	9,175	45,876	18,350	91,751
Dire Dawa	5,070	1,435	7,174	2,869	14,347
Gambela Peoples	191	62	308	123	617
Harari People	1,731	192	960	384	1,921
Oromia	378,026	97,650	488,248	195,299	976,496
Somali	13,284	3,617	18,085	7,234	36,170
Southern Nations, Nationalities and Peoples	90,082	34,214	171,072	68,429	342,145
Tigray	146,252	49,408	247,040	98,816	494,081

Source own calculations

POVERTY INCLUSIVESS: KEY FINDINGS

- **Ethiopia has achieved tremendous success in poverty eradication over the last 15 years, from a 45% poverty rate (head count) in 1995 down to 29.6% in 2010. Regional poverty disparity is much less pronounced compared to other ESA countries and varies between 36% in Afar, the poorest region, and 29% in Oromia, the richest region ('Addis Ababa" and 'Dire Dawa' are excluded as they are urban clusters)**
- **Poverty in the Ethiopian sorghum sector persists but is not higher than the national poverty rate. The percentage of sorghum production, consumption, and sorghum growing households in the poverty cluster is around 29% under the simplifying assumption made in the analysis. More empirical research is needed to investigate differences in household characteristics, adoption behaviour and profitability of improved sorghum varieties alongside various wealth clusters**
- **The reasons for the rather low 'poverty footprint' in the sorghum sector are mainly (1) widespread cultivation across regions and agro-ecological zones incl. wealthy regions, (2) the low regional poverty disparity, and (3) moderately negative income elasticity in sorghum consumption that softens the strong divide in sorghum consumption between rural-urban and poor-rich which can be observed in other ESA countries.**
- **From the ex-post perspective, the Ethiopian sorghum breeding program has shown limited impact so far in reaching out to the rural 'poor'. Only 50,000 'poor' households (approx. 250,000 'poor' people) have been reached on average between 1971 and 2013 as a result of limited number of varieties and adoption rates far below 5%**
- **<u>However, the prospects for the future are excellent</u>. At the current adoption rate, improved sorghum varieties are grown among 100,000 poor farmers (around 500,000 people). Under the assumption of a 'double poverty rate' of sorghum growers compared to national average these numbers increase to 200,000 'poor' households with over one million 'poor' people**
- **If the spread of improved varieties reaches the level experts predict in this study (around 50%) future, the number of beneficiaries in the poor cluster can reach between 1.6 million and 3.3 million people, and between 330,000 and 660,000 households. This amounts to 7 – 14% of the national 'poor' population of 25 million (2013).**
- **From a macro-economic perspective, the returns to investment are considerable from the available set of improved varieties, most of them are high potential and already ready for release and systematic propagation. Total expected gains (total economic surplus) compounded until 2040 amount to 135 USD for all sorghum growing households, 1,890 USD for current adopting households and 570 USD for the 1.1 million households that are expected to become adopters.**

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Annex

Table: A-1: Land use development between 2000-2011 (in '000 ha)

	Agr. area irrigated	Agr. area organic, total	Agr. area	Arable land and permanent crops	Arable land	Country area	Fallow land	Forest area	Land area	Perm.crops	Temporary crops
2011	182	140	35,683	15,683	14,565	110,430	615	12,155	100,000	1,118	12,241
2010	154	137	34,985	14,985	13,948	110,430	635	12,296	100,000	1,037	11,917
2009	164	123	34,513	14,513	13,606	110,430	635	12,437	100,000	907	11,587
2008	180	100	35,077	15,077	14,038	110,430	1,165	12,578	100,000	1,039	11,343
2007	135	140	34,219	14,219	13,396	110,430	1,444	12,718	100,000	823	10,965
2006	135	113	33,691	13,691	12,923	110,430	1,398	12,859	100,000	768	10,525
2005	147		33,101	13,101	12,364	110,430	1,369	13,000	100,000	737	10,151
2004	121		31,607	11,607	10,928	110,430	1,076	13,141	100,000	679	8,975
2003	121		31,607	11,607	10,928	110,430	1,076	13,282	100,000	679	8,975
2002	99		30,268	10,268	9,600	110,430	840	13,423	100,000	668	8,055
2001			31,409	11,409	10,712	110,430		13,564	100,000	697	
2000			30,662	10,662	10,000	110,430		13,705	100,000	662	

Table: A-2: Demographic dynamics of Ethiopia, 1993-2012 ('000 persons)

	Total Population (1000)	Urban population (1000)	Rural population (1000)	Agricultural population (1000)	Non-agricultural population (1000)	Female economically active population in Agr (1000)	Male economically active population in Agr (1000)
Annual growth rate	**2.56**	**3.87**	**2.33**	**1.97**	**5.12**	**3.28**	**2.67**
2012	86,539	14,749	71,790	65,983	20,556	15,063	18,079
2011	84,734	14,271	70,464	65,076	19,658	14,741	17,662
2010	82,950	13,820	69,129	64,158	18,792	14,407	17,250
2009	81,188	13,398	67,790	63,231	17,957	14,062	16,843
2008	79,446	12,999	66,447	62,294	17,152	13,704	16,442
2007	77,718	12,612	65,106	61,342	16,376	13,337	16,046
2006	75,993	12,225	63,768	60,362	15,631	12,960	15,570
2005	74,264	11,829	62,435	59,358	14,906	12,677	15,275
2004	72,527	11,420	61,107	58,326	14,201	12,271	14,890
2003	70,784	11,001	59,783	57,265	13,520	11,864	14,509
2002	69,041	10,581	58,460	56,179	12,862	11,456	14,134
2001	67,304	10,169	57,135	55,075	12,229	11,049	13,766
2000	65,578	9,771	55,807	53,957	11,621	10,643	13,406
1999	63,869	9,390	54,479	52,831	11,038	10,241	13,053
1998	62,174	9,022	53,152	51,693	10,481	9,895	12,716
1997	60,482	8,661	51,821	50,536	9,945	9,546	12,380
1996	58,774	8,298	50,476	49,347	9,427	9,192	12,040
1995	57,042	7,929	49,113	48,118	8,925	8,832	11,693
1994	55,281	7,552	47,729	46,844	8,437	8,465	11,339
1993	53,502	7,173	46,330	45,536	7,966	8,152	10,967

Table A-3: Sorghum area 2001/02 – 2011/12 by zone (in ha)

Region	Zone	2001/02	2007/08	2008/09	2010/11	2011/12	% of total Area (5y av)	Annual growth rate (2001/02-2011/12
	TOTAL	1,164,882	1,531,533	1,613,136	1,897,734	1,923,178	100.0	5.1
AM	North Gondar (Semen) Zone	128,310	176,170	203,500	201,936	238,262	11.9	6.4
ORO	East Hararge (Misrak) Zone	78,392	125,620	137,163	133,752	145,771	7.9	6.4
AM	North Shewa (Semen) Zone	90,740	106,019	110,076	161,303	132,426	7.4	3.9
ORO	West Hararge (Mirab) Zone	91,615	105,736	117,513	124,808	122,384	6.9	2.9
AM	South Wello (Debub) Zone	60,143	41,039	32,974	92,223	97,731	3.8	5.0
AM	North Wello (Semen) Zone	48,113	42,516	43,834	82,172	90,239	3.8	6.5
ORO	West Shewa (Mirab) Zone	46,011	81,212	61,115	77,758	87,503	4.5	6.6
ORO	Jimma Zone	34,547	66,896	72,486	62,236	71,844	4.0	7.6
TIG	North Western Tigray Zone	36,151	54,973	54,237	65,368	65,246	3.5	6.1
TIG	Central Tigray (Mehakelegnaw) Zone	30,788	32,679	48,552	55,154	57,235	2.8	6.4
ORO	East Wellega (Misrak) Zone	25,050	52,840	55,902	51,173	53,901	3.1	8.0
ORO	West Wellega (Mirab) Zone	44,585	44,082	43,109	55,926	51,207	2.8	1.4
ORO	North Shewa (Semen) Zone	45,480	26,107	28,230	62,752	48,779	2.4	0.7
TIG	Western Tigray (Mirabawi) Zone	18,075	46,851	45,806	39,028	44,940	2.6	9.5
TIG	Southern Togray (Debubawi) Zone	27,079	33,095	27,402	53,138	43,010	2.3	4.7
AM	South Gondar (Debub) Zone	17,663	30,287	43,422	37,857	41,794	2.2	9.0
ORO	Illu Aba Bora Zone	21,335	51,607	45,686	38,731	41,351	2.6	6.8
AM	East Gojjam (Misrak) Zone	19,852	41,874	28,257	35,034	40,544	2.1	7.4
AM	Waghemira Zone	15,011	18,967	29,488	39,997	40,337	1.9	10.4
ORO	Arsi Zone	24,330	25,475	33,801	33,904	38,072	1.9	4.6
AM	Oromia Zone	24,703	28,289	33,440	34,719	36,799	1.9	4.1
ORO	Kelem Welega Zone		31,515	31,939	30,680	32,017	1.8	
SOL	Jigjiga Zone	20,604	31,846	19,801	32,639	26,493	1.6	2.5
BG	Metekel Zone	18,158	19,763	17,847	29,681	26,200	1.4	3.7
BG	Asossa Zone	25,011	24,384	24,318	23,235	22,290	1.4	-1.1
ORO	Bale Zone	11,004	10,668	24,011	9,264	18,602	0.9	5.4
SNNP	Bench Maji Zone	3,855	8,788	11,640	11,995	16,071	0.7	15.3
SNNP	Keffa Zone	8,173	17,313	16,030	11,341	15,105	0.9	6.3
SNNP	South Omo (Debub) Zone	13,581	10,476	9,447	9,803	14,781	0.6	0.9
SNNP	Gamo Gofa Zone	11,626	4,823	9,088	11,661	12,319	0.6	0.6
ORO	Horo Gudru Welega Zone		6,632	8,571	15,128	10,684	0.6	
SNNP	Silti Zone		8,614	10,110	9,684	10,219	0.6	
SNNP	Konso Special Wereda	18,274	12,283	8,324	8,998	9,947	0.6	-5.9
BG	Kemashi Zone	9,207	12,269	13,228	10,979	8,865	0.7	-0.4
SNNP	Derashe Special Wereda	13,078	7,699	5,852	6,812	8,228	0.4	-4.5
SNNP	Gurage Zone	10,040	4,250	5,929	6,660	7,520	0.4	-2.8
SNNP	Sheka Zone	4,725	7,355	7,510	8,177	7,400	0.4	4.6
SNNP	Hadiya Zone	7,114	7,048	9,097	7,156	7,338	0.4	0.3
ORO	East Shewa (Misrak) Zone	11,592	8,011	5,625	21,064	6,356	0.6	-5.8

ORO	South West Shewa Zone		4,031	5,060	6,940	4,740	0.3	
TIG	Eastern Tigray (Misrakawi) Zone	1,966	2,907	4,030	4,190	4,712	0.2	9.1
ORO	West Arsi Zone		3,648	4,651	6,754	4,208	0.3	
AM	Bahir Dar Special Zone		2,664	2,791	3,513	3,556	0.2	
SNNP	Alaba Special Wereda		3,751	4,136	3,084	3,167	0.2	
SNNP	Dawro Zone	4,521	2,258	4,417	2,858	3,102	0.2	-3.7
BG	Mao Komo Special Zone		2,575	2,462	2,681	2,767	0.2	
SNNP	Kembata Tembaro Zone	5,921	2,212	3,140	3,134	2,690	0.2	-7.6
GAM	Mezhenger Zone		2,146	2,300	2,388	2,670	0.1	
SOL	Shinile Zone	819	1,942	2,115	1,913	1,844	0.1	8.5
SNNP	Konta Special Wereda	1,224	1,700	1,790	1,521	1,254	0.1	0.2
SNNP	Woloyita Zone	3,224	1,458	1,702	1,542	1,099	0.1	-10.2
SNNP	Yem Special Wereda	616	1,041	1,588	1,764	778	0.1	2.4
SNNP	Basketo Special Wereda	594	169	352	414	385	0.0	-4.2
SNNP	Burji Special Wereda	932	305	235	361	306	0.0	-10.5
AFF	Zone 1	64					0.0	-100.0
AFF	Zone 2						0.0	
AFF	Zone 3	1,341					0.0	-100.0
AFF	Zone 4						0.0	
AFF	Zone 5						0.0	
AM	West Gojjam (Mirab) Zone	3,144	2,184				0.1	-100.0
AM	Awi Zone	7,540	9,125				0.5	-100.0
BG	Pawe Special Zone		839	1,052			0.1	
GAM	Agnewak Zone		927	1,309	941		0.1	
GAM	Nuwer Zone						0.0	
GAM	Etang Special Zone		5	127	199		0.0	
ORO	Borena Zone	3,456						-100.0
ORO	Guji Zone							
ORO	Adama Special Zone							
ORO	Jima Special Zone							
ORO	Burayu Special Zone							
SOL	Degehabur Zone							
SOL	Warder Zone							
SOL	Korahe Zone							
SOL	Fik Zone							
SOL	Gode Zone							
SOL	Afder Zone							
SOL	Liben Zone							
TIG	Mekele Special Zone							
SNNP	Sidama Zone	1,323			687			-100.0
SNNP	Gedeo Zone	48						-100.0
SNNP	Amaro Special Wereda	228	112					-100.0
SNNP	Hawassa City Transitional Administration							
SNNP	Keficho Shekicho Zone							
SNNP	Semen Omo Zone							

Source:

Table A-4: Sorghum production 2001/02 – 2011/12 by zone (mt)

Region	Zone	2001/02	2007/08	2008/09	2010/11	2011/12	% of total Prod (5y av)	Annual growth rate (2001/02-2011/12
	TOTAL	1,565,203	2,677,744	2,801,368	3,959,897	3,949,884	100.0	9.7
AM	North Gondar (Semen) Zone	161,791	264,506	379,000	450,671	455,536	11.6	10.9
ORO	East Hararge (Misrak) Zone	95,436	357,842	186,523	272,469	287,702	8.2	11.7
AM	North Shewa (Semen) Zone	119,118	165,322	175,146	372,917	268,585	7.3	8.5
ORO	West Hararge (Mirab) Zone	135,139	253,262	176,987	244,446	284,066	7.2	7.7
AM	South Wello (Debub) Zone	81,449	67,514	43,585	213,324	219,497	4.1	10.4
AM	North Wello (Semen) Zone	67,381	89,312	72,190	191,166	173,175	3.9	9.9
ORO	West Shewa (Mirab) Zone	80,092	119,865	101,068	191,458	263,012	5.0	12.6
ORO	Jimma Zone	48,543	101,157	114,976	105,460	123,630	3.3	9.8
TIG	North Western Tigray Zone	58,532	83,824	100,433	144,929	144,000	3.5	9.4
TIG	Central Tigray (Mehakelegnaw) Zone	38,103	44,961	73,913	129,518	100,460	2.6	10.2
ORO	East Wellega (Misrak) Zone	50,699	87,140	103,578	124,604	127,056	3.3	9.6
ORO	West Wellega (Mirab) Zone	69,133	76,005	73,212	115,064	109,063	2.8	4.7
ORO	North Shewa (Semen) Zone	55,140	36,585	50,844	133,610	83,964	2.3	4.3
TIG	Western Tigray (Mirabawi) Zone	29,266	77,445	79,735	101,186	131,419	2.9	16.2
TIG	Southern Togray (Debubawi) Zone	63,452	60,482	43,978	81,181	87,467	2.0	3.3
AM	South Gondar (Debub) Zone	14,655	36,774	56,023	63,416	67,503	1.7	16.5
ORO	Illu Aba Bora Zone	28,450	83,783	91,809	101,656	95,108	2.8	12.8
AM	East Gojjam (Misrak) Zone	23,690	70,653	54,331	63,478	74,707	2.0	12.2
AM	Waghemira Zone	13,189	23,891	42,484	72,097	71,231	1.6	18.4
ORO	Arsi Zone	50,206	45,322	87,102	93,107	96,874	2.4	6.8
AM	Oromia Zone	31,136	47,676	50,501	65,847	76,742	1.8	9.4
ORO	Kelem Welega Zone	0	78,084	73,399	70,606	74,061	2.2	
SOL	Jigjiga Zone	27,100	31,233	32,273	46,623	74,270	1.4	10.6
BG	Metekel Zone	25,114	30,219	31,547	46,808	48,166	1.2	6.7
BG	Asossa Zone	25,547	36,009	35,003	35,878	38,283	1.1	4.1
ORO	Bale Zone	7,669	18,001	41,618	14,286	29,470	0.8	14.4
SNNP	Bench Maji Zone	5,667	16,590	21,390	22,832	24,631	0.6	15.8
SNNP	Keffa Zone	10,366	31,241	23,465	23,058	22,203	0.7	7.9
SNNP	South Omo (Debub) Zone	12,902	8,563	15,132	18,173	24,636	0.5	6.7
SNNP	Gamo Gofa Zone	10,717	4,642	12,547	13,580	17,976	0.4	5.3
ORO	Horo Gudru Welega Zone	0	9,948	16,258	34,859	20,783	0.6	
SNNP	Silti Zone		13,035	14,690	14,397	17,313	0.4	
SNNP	Konso Special Wereda	7,691	12,464	11,124	7,490	9,522	0.3	2.2
BG	Kemashi Zone	16,378	24,079	22,401	29,308	19,213	0.7	1.6
SNNP	Derashe Special Wereda	8,714	8,346	10,297	5,410	14,824	0.3	5.5
SNNP	Gurage Zone	10,139	5,964	9,361		12,531	0.3	2.1
SNNP	Sheka Zone	8,318	13,748	15,291	21,456	17,174	0.5	7.5
SNNP	Hadiya Zone	6,577	8,235	14,251	10,074	13,175	0.3	7.2
ORO	East Shewa (Misrak) Zone	14,424	16,374	8,430	48,912	7,648	0.6	-6.1

ORO	South West Shewa Zone	0	4,398	9,250	9,606	7,371	0.2	
TIG	Eastern Tigray (Misrakawi) Zone	2,996	4,205		9,579	10,332		13.2
ORO	West Arsi Zone	0	5,297	9,816		8,931		
AM	Bahir Dar Special Zone	0	4,211	4,038	6,092	6,002	0.2	
SNNP	Alaba Special Wereda		5,382	6,534	5,799	4,927	0.2	
SNNP	Dawro Zone	4,071	2,296	5,412	3,912	4,973	0.1	2.0
BG	Mao Komo Special Zone	0	3,789	3,784	5,614	5,159	0.1	
SNNP	Kembata Tembaro Zone	5,451	2,446	5,469	4,820	5,387	0.1	-0.1
GAM	Mezhenger Zone	0	3,538	3,676	5,862	4,126	0.1	
SOL	Shinile Zone	1,031	2,641	3,148	1,757	1,397	0.1	3.1
SNNP	Konta Special Wereda	1,285	2,143	2,690	2,491	1,984	0.1	4.4
SNNP	Woloyita Zone	2,696		2,231	1,636	1,353	0.1	-6.7
SNNP	Yem Special Wereda	627	1,121	2,245	2,316	930	0.0	4.0
SNNP	Basketo Special Wereda	634	187	520	605	464	0.0	-3.1
SNNP	Burji Special Wereda	597	149	346	455	298	0.0	-6.7
AFF	Zone 1	82						-100.0
AFF	Zone 2							
AFF	Zone 3	1,012						-100.0
AFF	Zone 4							
AFF	Zone 5							
AM	West Gojjam (Mirab) Zone	3,498	3,276					
AM	Awi Zone	10,055						-100.0
BG	Pawe Special Zone	0	1,272	2,015			0.0	
GAM	Agnewak Zone	0	1,587	2,108	1,927		0.1	
GAM	Nuwer Zone	0						
GAM	Etang Special Zone	0	2	247	426		0.0	
ORO	Borena Zone	653						-100.0
ORO	Guji Zone							
ORO	Adama Special Zone							
ORO	Jima Special Zone							
ORO	Burayu Special Zone							
SOL	Degehabur Zone							
SOL	Warder Zone							
SOL	Korahe Zone							
SOL	Fik Zone							
SOL	Gode Zone							
SOL	Afder Zone							
SOL	Liben Zone							
TIG	Mekele Special Zone							
SNNP	Sidama Zone							
SNNP	Gedeo Zone							
SNNP	Amaro Special Wereda							
SNNP	Hawassa City Transitional Administration							
SNNP	Keficho Shekicho Zone							
SNNP	Semen Omo Zone							

Source:

Table A-5: Sorghum yields 2001/02 – 2011/12 by zone (mt/ha)

Region	Zone	2001/02	2007/08	2008/09	2010/11	2011/12	5 Y Av. 2007/08 - 2011/12	Annual growth rate (2001/02-2011/12
	TOTAL	1.34	1.75	1.74	2.09	2.05	1.91	4.33
AM	North Gondar (Semen) Zone	1.26	1.50	1.86	2.23	1.91	1.88	4.25
ORO	East Hararge (Misrak) Zone	1.22	2.85	1.36	2.04	1.97	2.05	4.95
AM	North Shewa (Semen) Zone	1.31	1.56	1.59	2.31	2.03	1.87	4.45
ORO	West Hararge (Mirab) Zone	1.48	2.40	1.51	1.96	2.32	2.05	4.64
AM	South Wello (Debub) Zone	1.35	1.65	1.32	2.31	2.25	1.88	5.19
AM	North Wello (Semen) Zone	1.40	2.10	1.65	2.33	1.92	2.00	3.20
ORO	West Shewa (Mirab) Zone	1.74	1.48	1.65	2.46	3.01	2.15	5.61
ORO	Jimma Zone	1.41	1.51	1.59	1.69	1.72	1.63	2.05
TIG	North Western Tigray Zone	1.62	1.52	1.85	2.22	2.21	1.95	3.15
TIG	Central Tigray (Mehakelegnaw) Zone	1.24	1.38	1.52	2.35	1.76	1.75	3.56
ORO	East Wellega (Misrak) Zone	2.02	1.65	1.85	2.43	2.36	2.07	1.54
ORO	West Wellega (Mirab) Zone	1.55	1.72	1.70	2.06	2.13	1.90	3.22
ORO	North Shewa (Semen) Zone	1.21	1.40	1.80	2.13	1.72	1.76	3.57
TIG	Western Tigray (Mirabawi) Zone	1.62	1.65	1.74	2.59	2.92	2.23	6.09
TIG	Southern Togray (Debubawi) Zone	2.34	1.83	1.60	1.53	2.03	1.75	-1.41
AM	South Gondar (Debub) Zone	0.83	1.21	1.29	1.68	1.62	1.45	6.89
ORO	Illu Aba Bora Zone	1.33	1.62	2.01	2.62	2.30	2.14	5.60
AM	East Gojjam (Misrak) Zone	1.19	1.69	1.92	1.81	1.84	1.82	4.44
AM	Waghemira Zone	0.88	1.26	1.44	1.80	1.77	1.57	7.23
ORO	Arsi Zone	2.06	1.78	2.58	2.75	2.54	2.41	2.12
AM	Oromia Zone	1.26	1.69	1.51	1.90	2.09	1.79	5.16
ORO	Kelem Welega Zone		2.48	2.30	2.30	2.31	2.35	
SOL	Jigjiga Zone	1.32	0.98	1.63	1.43	2.80	1.71	7.86
BG	Metekel Zone	1.38	1.53	1.77	1.58	1.84	1.68	2.89
BG	Asossa Zone	1.02	1.48	1.44	1.54	1.72	1.54	5.33
ORO	Bale Zone	0.70	1.69	1.73	1.54	1.58	1.64	8.56
SNNP	Bench Maji Zone	1.47	1.89	1.84	1.90	1.53	1.79	0.42
SNNP	Keffa Zone	1.27	1.80	1.46	2.03	1.47	1.69	1.49
SNNP	South Omo (Debub) Zone	0.95	0.82	1.60	1.85	1.67	1.48	5.78
SNNP	Gamo Gofa Zone	0.92	0.96	1.38	1.16	1.46	1.24	4.70
ORO	Horo Gudru Welega Zone		1.50	1.90	2.30	1.95	1.91	
SNNP	Silti Zone		1.51	1.45	1.49	1.69	1.54	
SNNP	Konso Special Wereda	0.42	1.01	1.34	0.83	0.96	1.04	8.56
BG	Kemashi Zone	1.78	1.96	1.69	2.67	2.17	2.12	1.99
SNNP	Derashe Special Wereda	0.67	1.08	1.76	0.79	1.80	1.36	10.46
SNNP	Gurage Zone	1.01	1.40	1.58	0.00	1.67	1.16	5.14
SNNP	Sheka Zone	1.76	1.87	2.04	2.62	2.32	2.21	2.80
SNNP	Hadiya Zone	0.92	1.17	1.57	1.41	1.80	1.48	6.86
ORO	East Shewa (Misrak) Zone	1.24	2.04	1.50	2.32	1.20	1.77	-0.34
ORO	South West Shewa Zone		1.09	1.83	1.38	1.55	1.46	
TIG	Eastern Tigray (Misrakawi) Zone	1.52	1.45		2.29	2.19	1.98	3.70

ORO	West Arsi Zone		1.45	2.11		2.12	1.89	
AM	Bahir Dar Special Zone		1.58	1.45	1.73	1.69	1.61	
SNNP	Alaba Special Wereda		1.43	1.58	1.88	1.56	1.61	
SNNP	Dawro Zone	0.90	1.02	1.23	1.37	1.60	1.30	5.94
BG	Mao Komo Special Zone		1.47	1.54	2.09	1.86	1.74	
SNNP	Kembata Tembaro Zone	0.92	1.11	1.74	1.54	2.00	1.60	8.08
GAM	Mezhenger Zone		1.65	1.60	2.45	1.55	1.81	
SOL	Shinile Zone	1.26	1.36	1.49	0.92	0.76	1.13	-4.96
SNNP	Konta Special Wereda	1.05	1.26	1.50	1.64	1.58	1.50	4.19
SNNP	Woloyita Zone	0.84	0.00	1.31	1.06	1.23	0.90	3.95
SNNP	Yem Special Wereda	1.02	1.08	1.41	1.31	1.20	1.25	1.64
SNNP	Basketo Special Wereda	1.07	1.11	1.48	1.46	1.21	1.31	1.22
SNNP	Burji Special Wereda	0.64	0.49	1.47	1.26	0.98	1.05	4.30
AFF	Zone 1	1.29						-100.00
AFF	Zone 2							
AFF	Zone 3	0.75						-100.00
AFF	Zone 4							
AFF	Zone 5							
AM	West Gojjam (Mirab) Zone	1.11	1.50				1.50	-100.00
AM	Awi Zone	1.33	0.00				0.00	-100.00
BG	Pawe Special Zone		1.52	1.92			1.72	
GAM	Agnewak Zone		1.71	1.61	2.05		1.79	
GAM	Nuwer Zone							
GAM	Etang Special Zone		0.38	1.95	2.14		1.49	
ORO	Borena Zone	0.19						-100.00
ORO	Guji Zone							
ORO	Adama Special Zone							
ORO	Jima Special Zone							
ORO	Burayu Special Zone							
SOL	Degehabur Zone							
SOL	Warder Zone							
SOL	Korahe Zone							
SOL	Fik Zone							
SOL	Gode Zone							
SOL	Afder Zone							
SOL	Liben Zone							
TIG	Mekele Special Zone							
SNNP	Sidama Zone							
SNNP	Gedeo Zone							
SNNP	Amaro Special Wereda							
SNNP	Hawassa City Transitional Administration							
SNNP	Keficho Shekicho Zone							
SNNP	Semen Omo Zone							

Table A-6: Population and cereal production by Woreda (2012)

Region	Woreda	Pop 2012	HH Maize	HH Sorghum	Area Maize	Prod Maize	Area Sorghum	Prod Sorghum	Cons Sorghum
	Unit	**Head**			**ha**	**mt**	**ha**	**mt**	**mt**
Addis	WEREDA 01	73,346	8	3	4	9	2	3	55
Addis	WEREDA 02	73,346	8	3	4	9	2	3	55
Addis	WEREDA 03	114,338	22	9	11	24	4	7	86
Addis	WEREDA 04	166,782	10	4	5	11	2	4	125
Addis	WEREDA 07	166,782	15	7	8	17	3	6	125
Addis	WEREDA 09	73,346	17	6	9	18	3	5	55
Addis	WEREDA 13	73,346	7	2	3	7	1	1	55
Addis	WEREDA 14	114,338	10	3	5	10	2	2	86
Addis	WEREDA 18	161,900	29	11	15	33	6	10	122
Addis	WEREDA 22	166,782	26	11	13	29	6	10	125
Addis	WEREDA 05	114,338	10	4	5	11	2	4	86
Addis	WEREDA 06	166,782	10	4	5	11	2	4	125
Addis	WEREDA 20	161,900	20	9	10	24	4	8	122
Addis	WEREDA 21	146,173	26	10	13	29	5	9	110
Addis	WEREDA 23	161,900	33	15	17	38	7	13	122
Addis	WEREDA 24	165,215	3,899	3,568	1,605	6,260	1,662	6,100	124
Addis	WEREDA 17	73,330	48	26	25	60	11	21	55
Addis	WEREDA 19	165,215	78	32	37	92	16	36	124
Addis	WEREDA 28	166,680	501	1,865	84	138	968	1,428	125
Addis	WEREDA 11	184,232	446	2,056	93	146	1,058	1,578	138
Addis	WEREDA 12	124,362	20	3	4	8	1	2	93
Addis	WEREDA 15	92,031	23	9	12	25	4	8	69
Addis	WEREDA 16	89,876	10	3	5	10	2	2	67
Addis	WEREDA 08	184,232	57	473	29	49	236	295	138
Addis	WEREDA 10	111,422	274	801	51	85	416	608	84
Addis	WEREDA 25	153,320	19	7	8	19	3	8	115
Addis	WEREDA 26	73,330	1,668	216	843	2,282	102	169	55
Addis	WEREDA 27	73,330	86	38	40	101	17	41	55
Afar	Afambo	68,462	130	6	66	45	3	8	104
Afar	Aysaita	68,462	554	16	280	209	8	21	104
Afar	Chifra	92,805	9,882	3,431	3,425	2,413	1,466	3,540	9,473
Afar	Dubti	92,805	382	10	193	150	5	12	140
Afar	Elidar	19,842	0	0	0	0	0	0	30
Afar	Mille	92,805	2,613	164	1,321	1,012	82	123	140
Afar	Abala	24,946	6,358	149	2,421	4,126	68	197	38
Afar	Afdera	34,770	0	0	0	0	0	0	53
Afar	Berahle	34,770	5,411	226	1,499	2,101	79	100	53
Afar	Dallol	114,142	4,662	1,089	948	1,288	348	614	173
Afar	Erebti	24,946	0	0	0	0	0	0	38
Afar	Koneba	114,142	2,398	694	536	797	205	276	173
Afar	Megale	24,946	7,017	166	2,783	5,013	76	257	38
Afar	Amibara	36,264	6,459	12,772	2,412	4,166	5,859	8,353	3,702
Afar	Argoba Special	13,203	2,649	3,120	676	892	1,794	4,348	1,348
Afar	Awash Fentale	130,626	5,383	4,205	2,476	5,790	1,737	2,857	13,334
Afar	Bure Mudaytu	80,889	265	208	134	85	104	112	122
Afar	Dulecha	13,203	599	371	303	262	185	200	20
Afar	Gewane	72,744	460	672	232	127	333	259	110
Afar	Ewa	92,805	5,615	2,561	1,465	2,069	1,103	2,954	9,473
Afar	Gulina	228,908	8,611	3,158	2,347	5,262	1,343	4,233	23,367
Afar	Habru	92,805	486	8	246	254	4	1	140
Afar	Teru	24,946	54	3	27	28	1	1	38
Afar	Yalo	44,833	8,541	58	3,690	8,672	27	73	68
Afar	Artuma	58,733	1,948	1,928	529	371	971	1,911	5,995
Afar	Dewe	58,733	1,514	1,091	588	381	548	1,027	5,995
Afar	Fursi	58,733	1,818	2,056	512	397	1,036	2,257	5,995
Afar	Simurobi Gele'alo	80,889	3,189	3,523	792	706	1,956	3,555	8,257
Afar	Telalak	72,744	1,673	1,086	614	485	547	1,064	110
AM	Minjarna Shenkora	132,334	59,626	17,375	9,847	31,179	9,618	22,466	8,045
AM	Mojana Wadera	147,722	5,123	7,547	730	1,030	4,538	9,185	8,981
AM	Moretna Jiru	181,388	4,495	7,227	548	774	4,368	8,707	11,028
AM	Siya Debirna Wayu & Ensaro	110,667	7,837	31,642	821	1,269	18,913	31,712	6,728
AM	Tarmaber	140,904	3,066	4,692	374	561	2,836	5,835	8,566
AM	Weremo Wajetuna Mida	100,091	11,784	14,145	1,130	2,183	6,721	15,287	6,085
AM	Bugna	221,702	17,714	30,194	926	1,064	12,711	16,534	13,478
AM	Fogera	300,121	30,818	18,403	5,303	19,828	6,071	12,725	18,246
AM	Kemekem	221,702	54,598	31,153	9,132	28,182	12,095	20,921	13,478
AM	Lay Gayint	221,702	27,968	8,983	3,741	9,772	3,133	3,918	2,132
AM	Simada	261,077	27,522	8,137	4,386	11,052	2,700	3,303	2,510
AM	Tach Gayint	143,701	18,864	6,503	2,470	5,900	2,229	2,696	8,736
AM	Amba Sel	186,269	16,896	23,340	1,183	1,970	8,854	19,733	11,324
AM	Debre Sina	214,637	28,971	23,062	2,981	9,096	8,203	18,966	13,049
AM	Dessie	271,683	651	814	50	106	291	622	2,612
AM	Dessie Zuria	214,637	21,786	21,431	1,699	4,502	7,893	17,489	13,049
AM	Jama	100,091	19,639	24,262	1,686	3,860	9,746	21,935	6,085
AM	Kalu	122,624	40,907	36,967	3,330	7,750	14,654	31,579	7,455

AM	Kelela	214,637	20,878	23,996	1,642	4,498	8,930	21,558	13,049
AM	Kombolcha	271,683	4,486	10,948	750	2,223	3,972	8,163	16,517
AM	Kutaber	214,637	9,164	9,076	702	1,347	3,249	6,549	13,049
AM	Legambo	214,637	7,708	7,638	590	1,475	2,734	5,263	13,049
AM	Mekdela	261,077	11,880	10,860	895	1,870	3,985	6,397	15,872
AM	Sayint	214,637	24,475	24,788	2,100	5,341	8,823	17,704	13,049
AM	Ankesha	292,622	30,674	0	11,150	32,760	0	0	2,814
AM	Banja	132,009	44,473	0	15,558	44,083	0	0	1,269
AM	Dangila	331,988	70,800	631	26,152	83,508	406	552	3,192
AM	Fagta Lakoma	331,988	49,501	0	17,152	51,773	0	0	3,192
AM	Guangua	132,009	56,119	727	19,195	68,624	449	788	1,269
AM	Bahir Dar	148,224	4,073	3,814	1,048	2,648	2,033	3,456	9,011
AM	Awabel	134,787	53,410	11,152	11,088	32,217	3,879	7,489	8,194
AM	Baso Liben	156,726	22,973	9,131	5,261	13,994	3,206	5,997	9,528
AM	Bibugn	331,928	39,639	1,929	11,855	31,002	670	1,196	3,192
AM	Debay Telatgen	272,245	35,912	6,068	7,633	21,746	2,109	3,663	2,618
AM	Debre Marqos	333,133	5,775	1,400	1,227	4,166	487	1,089	3,203
AM	Dejen	134,787	30,666	6,706	6,398	17,049	2,331	4,211	8,194
AM	Enarj Enawga	272,245	45,307	9,329	8,846	25,883	3,252	5,391	16,551
AM	Enbise Sar Midir	261,077	39,852	17,429	7,352	20,901	6,102	11,644	15,872
AM	Enemay	134,787	43,380	8,484	9,220	26,406	2,948	4,967	8,194
AM	Goncha Siso Enese	401,760	34,470	7,305	7,277	20,412	2,536	4,267	3,863
AM	Guzamn	333,133	40,374	9,511	8,655	24,556	3,306	7,242	20,253
AM	Hulet Ej Enese	331,928	52,589	7,275	12,353	34,137	2,515	4,524	3,192
AM	Machakel	123,745	31,313	8,669	8,237	17,817	3,047	7,346	7,523
AM	Shebel Berenta	165,492	31,187	9,144	5,334	14,215	3,216	5,227	10,061
AM	Addi Arkay	165,217	23,484	48,957	3,820	7,077	29,344	51,249	10,044
AM	Alefa	296,626	38,758	16,550	8,346	29,163	9,970	21,787	18,034
AM	Belesa	169,253	49,142	31,981	8,257	18,459	16,195	20,154	10,290
AM	Beyeda	78,289	18,576	14,596	2,718	3,708	8,192	12,836	4,760
AM	Chilga	159,031	16,434	11,788	2,849	6,536	7,093	14,544	9,668
AM	Dabat	165,217	11,119	14,125	1,928	3,855	8,499	8,497	10,044
AM	Debarq	165,217	10,887	22,530	1,884	2,619	13,555	11,269	10,044
AM	Dembia	159,031	20,619	16,739	3,995	9,251	10,072	23,827	9,668
AM	Gonder	172,596	3,748	2,230	650	1,209	1,342	1,534	1,660
AM	Gonder Zuria	159,031	46,539	33,987	8,155	22,303	17,728	31,384	9,668
AM	Janamora	165,217	18,909	13,396	3,264	3,831	8,014	6,306	10,044
AM	Lay Armacheho	159,031	22,407	13,306	3,884	7,348	8,006	9,065	9,668
AM	Metema	143,127	7,287	4,577	1,263	5,110	2,754	8,595	8,701
AM	Quara	41,644	42,690	34,011	8,069	32,135	20,527	58,277	2,532
AM	Sanja	165,217	30,737	38,034	5,247	18,746	22,856	57,798	10,044
AM	Wegera	159,031	28,736	16,863	4,982	9,786	10,146	11,913	9,668
AM	Angolela Tera	119,424	2,965	13,208	320	559	7,902	15,445	7,260
AM	Ankober	119,424	6,194	9,653	974	1,400	5,769	13,686	7,260
AM	Antsokia Gemza	69,268	5,595	6,549	653	1,223	3,717	6,998	4,211
AM	Asagirt	119,424	3,450	5,935	421	799	3,587	12,541	7,260
AM	Berehet	119,424	5,680	6,399	756	1,929	3,849	13,831	7,260
AM	Debre Berhan	151,013	378	607	46	73	367	789	1,452
AM	Debre Berhan Zuria	165,922	5,158	10,837	621	942	6,530	12,691	10,087
AM	Efratana Gidim	181,388	12,556	11,794	1,655	2,795	6,795	15,294	11,028
AM	Gera Midirna Keya Gabriel	145,251	13,931	20,288	1,470	2,593	10,345	21,147	8,831
AM	Gishe Rabel	145,251	6,772	6,098	690	1,294	3,161	5,887	8,831
AM	Hagere Mariamna Kesem	166,680	8,860	8,795	1,048	2,843	5,302	11,533	10,133
AM	Kewet	147,722	6,706	9,331	839	1,208	5,632	11,398	8,981
AM	Lay Betna Tach Bet	100,091	9,231	24,228	978	1,478	13,925	25,561	6,085
AM	Mama Midirna Lalo	181,388	5,175	8,153	631	907	4,927	9,899	11,028
AM	Dawunt Delanta	143,701	19,519	30,482	1,106	1,727	12,465	20,516	8,736
AM	Gidan	232,220	11,915	20,500	615	823	8,603	13,711	14,118
AM	Guba Lafto	196,506	13,032	24,259	709	863	10,001	20,101	11,947
AM	Kobo	183,626	21,539	30,914	1,629	3,351	13,052	41,382	11,164
AM	Meket	232,220	23,803	25,125	1,570	2,354	10,409	14,564	14,118
AM	Tehuledere	150,439	15,312	21,703	1,098	2,099	8,409	23,002	9,146
AM	Wadla	196,506	10,897	18,674	660	826	7,657	11,983	11,947
AM	Weldiya	187,349	837	1,989	43	45	830	2,371	1,801
AM	Artuma Fursina	80,889	14,967	18,252	1,723	2,773	9,323	19,744	4,918
AM	Bati	122,624	19,586	23,374	1,926	2,351	10,326	21,510	7,455
AM	Dawa Chefa	72,744	26,542	23,308	2,760	5,022	10,738	22,847	4,423
AM	Jile Timuga	138,563	7,508	6,981	930	1,486	3,621	8,599	8,424
AM	Debre Tabor	308,536	2,430	1,176	396	1,185	388	704	2,967
AM	Dera	331,928	35,776	14,819	7,776	24,667	6,447	11,746	20,180
AM	Ebenat	221,702	29,283	13,304	4,660	11,236	4,808	5,834	13,478
AM	Esite	331,928	29,680	8,416	5,261	14,318	2,785	4,006	3,192
AM	Farta	221,702	23,158	9,251	3,772	11,904	3,052	5,240	13,478
AM	Tehuledere	150,439	15,312	21,703	1,098	2,099	8,409	23,002	9,146
AM	Tenta	214,637	8,618	8,160	636	1,239	3,021	4,467	13,049
AM	Wegde	169,770	32,956	25,831	3,117	9,354	9,284	20,753	10,321
AM	Were Ilu	214,637	8,573	7,712	683	2,022	2,874	5,791	13,049
AM	Werebabu	92,805	17,389	19,870	1,642	2,511	7,534	20,387	5,642
AM	Dehana	221,702	7,134	13,627	514	592	6,087	7,408	13,478
AM	Sekota	119,049	35,990	39,519	2,305	3,642	18,057	33,721	7,238
AM	Zikuala	78,289	11,943	16,290	1,172	1,604	8,079	14,910	4,760
AM	Achefer	268,375	108,979	702	47,025	159,013	422	746	2,581
AM	Adet	331,928	85,677	2,036	34,526	104,018	692	1,190	3,192

AM	Bahir Dar Zuria	296,626	105,631	9,960	40,983	133,564	5,279	11,481	18,034
AM	Bure Wemberma	123,745	37,792	56	16,145	43,439	20	18	1,190
AM	Dega Damot	123,745	42,540	1,430	14,923	36,857	497	902	1,190
AM	Dembecha	123,745	15,502	754	5,674	13,379	262	614	1,190
AM	Jabi Tehnan	123,745	24,292	0	11,588	29,025	0	0	1,190
AM	Merawi	331,928	60,686	0	27,284	81,841	0	0	3,192
AM	Quarit	331,928	36,166	848	15,216	38,894	295	513	3,192
AM	Sekela	331,988	20,615	0	9,420	25,209	0	0	3,192
BG	Asosa	65,619	7,883	11,317	1,499	3,319	3,386	4,530	8,961
BG	Bambasi	65,619	48,442	40,202	9,571	26,804	11,693	20,478	8,961
BG	Komesha	100,919	4,446	6,094	846	1,923	1,824	2,593	13,781
BG	Kurmuk	18,702	5,224	7,098	994	2,705	2,124	3,749	2,554
BG	Menge	18,702	2,092	2,583	398	899	773	958	2,554
BG	Oda Godere	18,702	3,862	4,120	908	3,373	1,400	4,390	2,554
BG	Sherkole	10,773	1,920	2,014	448	1,223	712	1,165	1,471
BG	Tongo Sp. Wereda	65,619	13,744	7,174	2,701	8,274	2,093	5,626	8,961
BG	Agelo Meti	56,141	5,065	5,643	1,737	2,723	2,293	3,504	7,666
BG	Belo Jegonfoy	10,386	16,802	9,478	9,196	39,702	4,062	10,524	1,418
BG	Kamashi	10,386	3,122	3,123	999	2,358	1,180	2,039	1,418
BG	Sirba Abay	18,702	5,723	5,777	1,791	5,854	2,582	6,421	2,554
BG	Yaso	28,778	12,035	4,873	6,460	27,282	2,333	4,348	3,930
BG	Bulen	41,644	2,461	1,889	813	2,137	1,192	1,681	5,687
BG	Dangur	41,644	24,549	24,585	7,209	23,477	15,370	31,926	5,687
BG	Dibate	28,778	22,804	1,705	7,589	31,697	1,063	1,616	3,930
BG	Guba	41,644	2,164	1,590	697	2,821	994	2,263	5,687
BG	Mandura	41,644	9,992	2,320	3,307	13,721	1,494	2,397	5,687
BG	Pawe	41,644	2,360	893	756	1,757	575	884	5,687
BG	Wembera	41,644	8,535	6,596	2,822	8,749	4,022	7,098	5,687
Dire Dawa	Dire Dawa	96,974	11,952	26,275	1,783	5,962	10,573	19,825	16,947
GAM P	Akobo	33,242	75	9	7	9	2	4	393
GAM P	Gambela	18,599	6,391	6,715	2,048	3,132	1,741	2,606	1,099
GAM P	Itang	56,482	41	0	4	2	0	0	667
GAM P	Jikawo	33,242	28	2	3	2	1	1	393
GAM P	Abobo	56,482	30	23	12	19	6	6	667
GAM P	Dima	20,201	0	0	0	0	0	0	239
GAM P	Godere	18,599	1,225	206	457	571	57	59	220
GAM P	Gog	9,303	352	264	97	316	104	278	549
GAM P	Jor	33,242	8	0	1	1	0	0	393
Harari People	Harar/Hundene	230,389	5,813	5,521	1,065	3,204	2,003	5,733	42,486
ORO	Amigna	154,979	22,867	8,955	6,855	19,611	2,840	7,246	11,369
ORO	Aseko	130,626	4,368	1,949	1,310	3,695	618	2,554	9,583
ORO	Bekoji	246,897	2,760	1,851	831	1,086	588	711	2,284
ORO	Chole	154,979	3,977	1,746	1,192	3,280	554	1,646	1,434
ORO	Degeluna Tijo	143,213	1,953	1,146	586	817	363	499	1,325
ORO	Dodotana Sire	385,566	34,845	11,480	10,806	21,277	3,522	7,154	28,286
ORO	Gedeb	246,897	2,967	1,728	893	1,577	549	1,009	2,284
ORO	Gololcha	74,577	11,995	4,955	3,601	12,546	1,609	5,356	5,471
ORO	Hitosa	126,110	5,688	2,443	1,705	3,606	775	1,788	1,167
ORO	Jeju	154,979	22,495	9,812	7,165	16,975	2,995	12,443	11,369
ORO	Kofele	121,281	24,413	4,529	6,778	15,095	1,395	3,217	8,897
ORO	Merti	154,979	25,311	12,368	7,913	18,582	3,879	12,756	11,369
ORO	Munessa	158,634	15,063	5,370	4,516	12,062	1,703	3,763	11,638
ORO	Robe	126,110	19,724	8,247	5,915	16,921	2,616	5,889	9,252
ORO	Seru	163,712	30,696	11,248	9,193	26,587	3,606	9,184	12,010
ORO	Shirka	143,213	9,894	4,426	2,970	7,914	1,404	2,812	10,506
ORO	Sude	126,110	10,845	6,235	3,251	8,950	1,977	6,681	9,252
ORO	Tena	126,110	4,515	1,969	1,354	3,290	624	1,278	1,167
ORO	Tiyo	241,433	3,860	1,870	1,157	2,885	593	1,397	2,234
ORO	Ziway Gugda	188,455	25,248	10,016	8,051	24,027	3,082	8,271	13,825
ORO	Adaba	175,518	1,908	1,055	595	775	341	365	1,624
ORO	Agarfa	228,918	2,085	821	650	770	266	241	2,118
ORO	Berbere	85,824	2,407	913	751	1,281	296	261	794
ORO	Dodola	121,281	3,610	1,375	1,124	1,827	444	912	1,122
ORO	Gasera	92,106	6,571	2,331	2,037	5,748	752	1,615	852
ORO	Ginir	191,556	4,477	1,812	1,396	2,407	587	777	1,772
ORO	Goba	134,789	2,456	1,095	766	1,548	355	450	1,247
ORO	Gololcha	48,798	11,995	4,955	3,601	12,546	1,609	5,356	3,580
ORO	Goro	52,794	13,304	6,673	4,364	13,421	1,822	3,479	3,873
ORO	Guradamole	52,794	7,247	2,999	2,436	3,811	1,093	1,200	3,873
ORO	Kokosa	121,281	21,985	753	5,326	12,377	243	281	1,122
ORO	Legehida	60,920	17,980	8,983	5,199	9,805	2,987	5,064	4,469
ORO	Meda Welabu	187,575	15,147	5,271	4,676	8,705	1,706	2,260	1,735
ORO	Mennana Arena Buluk	85,824	9,705	3,385	3,026	5,679	1,096	1,263	794
ORO	Nenesebo	121,281	7,618	515	1,501	4,698	167	159	1,122
ORO	Rayitu	40,820	6,372	2,478	1,989	2,949	803	1,144	2,995
ORO	Seweyna	34,931	5,988	2,300	1,867	3,077	744	1,136	2,563
ORO	Sinanana Dinsho	134,789	5,842	2,310	1,822	3,228	748	814	1,247
ORO	Adolana Wadera	131,627	1,941	245	477	1,907	79	77	1,218
ORO	Arero	119,168	6,823	0	1,417	3,938	0	0	1,103
ORO	Bore	112,460	4,967	0	769	4,770	0	0	1,041
ORO	Dire	48,459	6,288	0	1,283	2,369	0	0	448
ORO	Gelana Abaya	264,238	28,912	1,124	4,664	17,152	199	308	2,445
ORO	Hagere Mariam	136,589	13,115	0	2,313	8,421	0	0	1,264

ORO	Liben	42,726	1,587	259	400	797	84	101	395
ORO	Moyale	119,168	3,942	0	996	2,886	0	0	1,103
ORO	Odo Shakiso	538,617	1,272	0	259	790	0	0	4,983
ORO	Teltele	82,308	6,568	852	1,434	3,026	201	206	762
ORO	Uraga	112,460	1,809	0	226	778	0	0	1,041
ORO	Yabelo	54,446	5,562	0	1,135	3,250	0	0	504
ORO	Babile	176,136	22,065	17,996	4,659	13,885	6,620	14,518	12,922
ORO	Bedeno	247,131	18,207	17,379	3,337	10,960	6,306	12,184	18,130
ORO	Deder	161,774	13,654	12,572	2,545	6,952	4,588	7,619	11,868
ORO	Fedis	244,745	25,362	35,861	4,703	14,846	13,068	24,184	17,955
ORO	Girawa	239,609	31,520	31,841	5,777	14,685	11,553	20,377	17,578
ORO	Golo Odo	102,385	65,572	45,695	12,444	32,538	16,760	35,232	7,511
ORO	Goro Gutu	96,974	12,164	10,212	2,277	5,510	3,732	6,092	7,114
ORO	Gursum	185,522	11,702	11,513	2,610	6,807	4,427	11,799	13,610
ORO	Haro Maya	244,745	27,790	26,969	4,979	18,215	9,910	22,017	17,955
ORO	Jarso	115,807	9,637	13,883	1,885	4,837	4,793	8,808	8,496
ORO	Kersa	239,609	25,763	19,538	7,767	27,041	5,992	10,459	17,578
ORO	Kombolcha	115,807	4,486	10,948	750	2,223	3,972	8,163	8,496
ORO	Kurfa Chele	239,609	13,395	11,444	2,455	8,897	4,152	6,636	17,578
ORO	Malka Balo	404,597	22,893	21,949	4,279	12,107	8,006	16,447	29,682
ORO	Meta	96,974	18,326	14,698	3,363	10,506	5,333	8,241	7,114
ORO	Meyu	244,745	36,465	22,103	6,855	18,700	8,129	15,777	17,955
ORO	Ada'a Chukala	188,455	17,029	6,709	9,626	36,760	1,712	3,764	13,825
ORO	Adama	188,455	21,647	10,947	9,800	25,654	2,940	5,755	13,825
ORO	Adami Tulu Jido Kombolcha	188,455	19,471	9,693	9,146	36,334	2,609	6,435	13,825
ORO	Akaki	126,087	8,116	5,042	4,587	17,500	1,289	2,660	9,250
ORO	Arsi Negele	158,634	11,016	5,530	5,969	22,817	1,426	2,890	11,638
ORO	Boset	385,566	42,198	15,487	14,805	40,720	5,191	13,035	28,286
ORO	Dugda Bora	188,455	27,488	16,639	12,417	44,187	4,345	10,842	13,825
ORO	Fentale	130,626	21,250	8,598	7,964	23,509	2,557	7,170	9,583
ORO	Gimbichu	334,822	23,182	16,637	7,919	30,075	5,087	10,062	24,563
ORO	Lome	188,455	16,795	5,184	5,509	21,176	1,792	4,140	13,825
ORO	Shashemene	246,897	6,914	2,478	3,435	12,125	648	951	2,284
ORO	Siraro	207,748	28,889	8,236	10,908	35,814	1,976	2,558	1,922
ORO	Abay Chomen	162,697	3,983	2,592	2,646	8,132	1,201	2,546	1,505
ORO	Abe Dongoro	53,339	2,894	2,022	1,923	6,051	937	2,183	3,913
ORO	Amuru	10,386	9,934	4,149	5,663	17,392	1,914	4,776	762
ORO	Bila Seyo	140,892	21,589	12,986	12,732	47,395	5,964	16,523	10,336
ORO	Diga	141,485	8,031	4,807	5,272	16,183	2,226	4,967	10,380
ORO	Gida Kiremu	10,386	5,034	3,161	3,340	10,373	1,464	3,428	762
ORO	Guduru	162,697	19,712	11,806	11,922	45,293	5,248	13,344	11,936
ORO	Guto Wayu	225,914	15,498	9,890	10,296	34,393	4,583	11,609	16,573
ORO	Ibantu	10,386	792	521	508	1,381	241	467	762
ORO	Jarti	162,697	8,860	5,729	5,785	21,519	2,595	6,627	11,936
ORO	Jimma Arjo	135,271	5,223	2,876	3,412	9,159	1,302	2,257	1,252
ORO	Jimma Horo	162,697	20,707	13,007	13,671	57,715	6,022	16,705	11,936
ORO	Jimma Rare	162,697	4,590	3,333	2,964	11,383	1,539	3,668	11,936
ORO	Leka Dulcha	135,271	5,637	3,160	3,745	11,741	1,464	2,870	9,924
ORO	Limu	10,386	34,193	18,047	13,889	63,143	4,148	8,146	762
ORO	Nunu Kumba	91,177	3,889	2,272	2,364	6,534	922	1,717	6,689
ORO	Sasiga	225,914	18,333	11,236	11,823	47,601	5,198	15,314	16,573
ORO	Sibu Sire	140,892	13,298	8,032	8,834	30,009	3,721	8,734	10,336
ORO	Wama Bonaya	225,914	12,223	8,499	6,956	24,901	3,240	7,574	16,573
ORO	Ale	101,387	3,701	3,233	1,443	2,905	845	2,175	7,438
ORO	Bedele	116,228	5,390	3,757	2,207	6,170	992	1,481	1,075
ORO	Borecha	61,165	5,915	3,164	2,458	8,477	832	1,454	4,487
ORO	Bure	111,902	84,337	59,970	30,984	93,770	15,669	35,503	8,209
ORO	Chora	116,228	7,509	4,437	3,054	8,613	1,139	1,680	1,075
ORO	Darimu	152,911	104,751	49,532	34,347	122,912	13,109	32,015	11,218
ORO	Dedesa	115,682	4,079	1,869	1,668	6,556	482	786	1,070
ORO	Dega	73,236	2,264	2,041	926	2,445	527	818	678
ORO	Gechi	115,682	8,726	3,897	3,593	13,144	1,019	1,639	1,070
ORO	Metu	101,387	11,312	7,956	4,626	12,863	2,052	4,544	7,438
ORO	Nono	18,599	13,251	7,734	4,997	13,340	2,742	6,216	1,364
ORO	Supena Sodo	147,412	1,473	1,450	576	1,053	376	463	1,364
ORO	Yayu	115,682	3,899	2,442	1,591	3,651	628	940	1,070
ORO	Dedo	306,671	38,515	31,544	15,734	39,702	7,922	9,874	22,498
ORO	Gera	115,682	27,779	12,378	11,294	24,243	3,145	5,349	8,487
ORO	Goma	115,682	14,799	6,882	5,972	12,550	1,753	2,474	8,487
ORO	Kersa	250,131	25,763	19,538	7,767	27,041	5,992	10,459	18,350
ORO	Limu Kosa	61,165	28,255	19,658	11,000	33,166	5,128	7,950	4,487
ORO	Limu Seka	81,418	22,301	17,189	10,254	34,709	4,948	10,971	5,973
ORO	Mana	157,943	9,553	7,224	3,855	10,143	1,840	2,619	1,461
ORO	Omonada	153,711	56,242	40,136	22,633	69,874	10,211	16,412	11,276
ORO	Seka Chekorsa	141,556	21,564	13,652	8,702	19,962	3,477	4,496	10,385
ORO	Sekoru	153,711	44,196	30,444	16,344	54,184	7,413	13,191	11,276
ORO	Setema	116,228	37,113	22,867	14,999	49,361	5,831	10,511	8,527
ORO	Sigmo	115,343	21,885	14,383	8,831	19,739	3,664	9,489	8,462
ORO	Tiro Afeta	153,711	30,482	21,182	12,140	42,639	5,358	9,724	11,276
ORO	Abichuna Gne'a	165,922	2,029	10,068	184	278	5,944	9,481	12,172
ORO	Berehna Aleltu	334,822	31,145	16,448	3,827	10,034	7,515	13,743	24,563
ORO	Degem	110,667	4,716	13,062	494	759	7,475	11,699	8,119
ORO	Dera	103,725	35,776	14,819	7,776	24,667	6,447	11,746	7,609
ORO	Gerar Jarso	110,667	4,370	21,127	374	590	12,429	20,527	8,119

ORO	Hidabu Abote	156,726	2,192	6,972	173	215	4,013	6,794	11,498
ORO	Kembibit	166,680	3,375	13,813	293	460	8,099	14,094	12,228
ORO	Kuyu	201,565	11,587	9,225	920	1,890	4,941	9,053	14,787
ORO	Mulona Sululta	166,680	6,412	12,217	772	1,627	6,320	12,608	12,228
ORO	Wara Jarso	103,725	8,570	7,913	984	1,534	3,855	5,300	7,609
ORO	Wuchalena Jido	110,667	4,349	11,270	348	480	6,462	9,914	8,119
ORO	Yaya Gulelena Debre Libanos	110,667	2,921	9,640	230	335	5,558	8,595	8,119
ORO	Anchar	130,626	17,470	11,685	4,839	18,267	4,759	10,063	9,583
ORO	Boke	171,965	46,924	45,340	12,165	33,280	18,211	40,321	12,616
ORO	Chiro	404,597	31,708	35,439	8,783	25,425	14,434	34,980	29,682
ORO	Darolebu	190,202	44,524	32,729	12,448	46,893	13,092	36,714	13,953
ORO	Doba	404,597	17,088	19,465	4,514	11,371	7,832	16,419	29,682
ORO	Goba Koricha	171,965	14,289	14,395	3,958	14,137	5,863	14,466	12,616
ORO	Habro	171,965	14,729	14,772	4,080	14,365	6,017	14,852	12,616
ORO	Kuni	171,965	22,365	24,611	5,813	16,709	9,894	23,448	12,616
ORO	Mesela	404,597	14,212	15,930	3,565	7,044	6,335	10,999	29,682
ORO	Mieso	404,597	37,661	42,486	10,422	33,803	17,296	43,237	29,682
ORO	Tulo	404,597	10,186	13,009	2,821	5,948	5,298	9,011	29,682
ORO	Adda Berga	184,232	11,873	11,345	4,188	12,498	5,071	12,129	13,515
ORO	Alem Gena	126,087	9,855	4,110	3,674	12,360	1,776	7,184	9,250
ORO	Ambo	234,608	29,249	22,620	10,482	36,351	9,978	34,113	17,211
ORO	Ameya	162,814	3,297	1,964	1,160	3,383	843	2,732	1,506
ORO	Bako Tibe	234,608	12,942	7,895	4,933	17,876	3,507	12,537	17,211
ORO	Becho	61,398	123	29	44	92	13	24	568
ORO	Cheliya	81,418	20,759	14,145	7,439	25,562	6,239	22,108	5,973
ORO	Dano	81,418	17,506	11,838	6,510	22,653	4,357	14,187	5,973
ORO	Dawo	79,532	6,763	3,993	2,423	8,797	1,761	4,374	5,835
ORO	Dendi	79,532	41,622	27,967	14,916	50,800	12,336	34,265	5,835
ORO	Ejere (Addis Alem)	198,638	13,446	8,186	4,819	15,495	3,611	8,109	14,572
ORO	Ginde Beret	149,349	17,804	15,098	5,612	15,876	6,381	17,340	10,956
ORO	Ilu	61,398	5,536	3,269	1,984	7,778	1,442	3,997	4,504
ORO	Jeldu	201,565	19,506	12,437	6,990	21,532	5,486	13,777	14,787
ORO	Kersana Kondaltiti	188,455	21,600	3,286	8,010	18,836	1,362	3,029	1,744
ORO	Kokir	150,984	3,363	824	1,183	1,435	321	329	1,397
ORO	Meta Robi	201,565	27,431	18,073	7,516	23,055	8,233	22,744	14,787
ORO	Nono	81,418	13,251	7,734	4,997	13,340	2,742	6,216	5,973
ORO	Tikur	234,608	11,945	9,120	4,281	14,503	4,023	13,806	17,211
ORO	Tole	126,087	94	21	34	70	9	19	1,167
ORO	Walisona Goro	72,854	3,913	369	1,330	1,839	143	167	674
ORO	Walmara	184,232	13,443	13,249	4,750	17,817	5,892	19,743	13,515
ORO	Wenchi	119,766	3,565	2,722	1,278	4,655	1,201	4,461	8,786
ORO	Anfilo	122,521	17,252	9,534	3,595	11,199	2,666	6,229	8,988
ORO	Ayra Guliso	152,911	3,800	2,555	793	1,608	715	994	1,415
ORO	Begi	65,619	43,353	28,085	8,708	25,094	8,066	17,083	4,814
ORO	Boji	11,139	3,975	3,234	846	2,197	925	1,430	817
ORO	Dale Sadi	152,911	21,271	9,401	6,077	21,032	2,548	5,856	11,218
ORO	Ganji	111,105	0	0	0	0	0	0	1,028
ORO	Gawo Dale	122,521	55,236	27,760	15,670	50,931	7,518	15,823	8,988
ORO	Gidami	122,521	17,328	11,318	3,607	13,226	3,169	8,706	8,988
ORO	Gimbi	73,236	5,820	4,462	1,802	4,308	1,554	3,198	5,373
ORO	Haru	73,236	2,407	1,471	502	1,275	411	755	678
ORO	Hawa Welele	122,521	82,920	41,048	21,297	73,130	11,215	26,051	8,988
ORO	Jarso	177,894	9,637	13,883	1,885	4,837	4,793	8,808	13,050
ORO	JimmaHoro	122,521	530	342	111	176	96	121	1,134
ORO	Lalo Asabi	141,485	459	417	96	236	117	177	1,309
ORO	LaloKillie	130,881	11,974	3,749	2,498	8,962	1,050	2,400	9,602
ORO	Mana Sibu	18,968	29,016	22,365	5,886	17,089	6,389	11,229	1,392
ORO	Nejo	18,968	18,793	13,165	4,111	10,084	3,825	6,621	1,392
ORO	Nole Kaba	147,412	2,971	1,934	627	1,687	540	888	1,364
ORO	Sayo	76,984	58,187	39,374	14,525	47,772	10,751	24,668	5,648
ORO	Yobdo	147,412	0	0	0	0	0	0	1,364
SNNP	Amaro	220,030	13,986	692	1,543	3,385	109	192	5,232
SNNP	Basketo	289,572	8,961	3,685	1,110	2,189	319	380	6,886
SNNP	Bench	50,065	11,969	17,635	3,482	6,638	5,881	12,046	2,306
SNNP	Bero	50,065	1,145	735	317	774	291	330	1,191
SNNP	Maji	49,709	7,129	9,142	1,957	5,715	3,485	5,644	2,289
SNNP	Meanit Goldiiya	49,709	5,924	3,084	2,244	5,890	1,072	846	1,182
SNNP	Menit Shasha	50,065	2,643	1,948	852	2,304	708	573	1,191
SNNP	Sheka	20,201	4,544	7,398	1,257	2,367	2,919	5,957	930
SNNP	Shewa Bench	50,065	5,947	2,682	2,161	3,974	977	708	1,191
SNNP	Surma	31,736	5,820	4,602	1,612	4,541	1,821	2,684	1,462
SNNP	Burji	136,589	8,147	2,173	1,536	3,984	389	414	3,248
SNNP	Gena Bosa	128,654	17,259	14,300	6,256	20,145	2,880	4,053	5,925
SNNP	Isara	128,654	1,913	1,399	627	1,188	214	328	3,059
SNNP	Loma Bosa	348,656	9,641	6,127	2,815	6,186	1,485	2,474	8,291
SNNP	Mareka Gena	128,654	966	1,083	316	512	163	189	3,059
SNNP	Tocha	128,674	1,475	1,848	483	829	279	382	3,060
SNNP	Dirashe	220,030	19,498	18,434	7,302	16,321	6,260	10,334	10,134
SNNP	Arba Minch Zuria	220,030	16,663	13,553	4,962	14,058	2,918	4,710	10,134
SNNP	Bonke	220,030	20,695	7,568	6,049	20,237	1,465	2,933	5,232
SNNP	Boreda	220,030	16,006	6,564	4,286	10,513	1,855	2,489	5,232
SNNP	Chencha	220,030	8,715	2,985	2,446	6,221	527	660	5,232
SNNP	Daramalo	106,481	2,937	1,617	824	2,597	286	355	2,532
SNNP	Dita	220,030	6,370	2,225	1,788	4,670	393	503	5,232

SNNP	Gofa Zuria	289,572	20,466	5,355	5,799	12,607	927	1,319	6,886
SNNP	Kemba	289,572	25,294	12,009	7,165	21,317	2,476	4,602	6,886
SNNP	Kucha	123,303	13,669	6,387	3,545	9,166	1,903	3,720	5,679
SNNP	Melekoza	72,912	16,371	4,923	4,255	8,370	778	1,227	1,734
SNNP	MirabAbaya	220,030	11,256	4,004	3,136	8,370	707	953	5,232
SNNP	Ubadebretsehay	289,572	11,784	5,502	3,228	7,079	1,083	1,370	6,886
SNNP	Zala	233,302	4,863	1,863	1,365	3,778	329	398	5,548
SNNP	Bule	112,460	6,273	0	627	1,697	0	0	2,674
SNNP	Kochere	150,744	19,311	0	1,955	6,288	0	0	3,585
SNNP	Wenago	112,460	12,710	0	1,290	3,306	0	0	2,674
SNNP	Yirgachefe	112,460	6,804	0	680	1,550	0	0	2,674
SNNP	Akililna Mohr	227,538	3,717	1,121	1,042	2,265	235	195	5,411
SNNP	Alicho Woriro	333,215	8,853	3,274	2,337	7,759	543	841	7,924
SNNP	Cheha	333,215	5,314	2,324	1,489	5,677	487	927	7,924
SNNP	Dalocha	111,740	5,758	1,639	1,613	6,778	342	673	2,657
SNNP	Endagagn	399,292	8,555	3,651	2,158	7,451	534	920	9,495
SNNP	Enemorina Eaner	399,292	14,611	4,295	4,119	12,560	883	1,170	9,495
SNNP	Ezha	333,215	6,136	1,751	1,720	3,899	367	300	7,924
SNNP	Goro	93,905	13,304	6,673	4,364	13,421	1,822	3,479	4,325
SNNP	Gumer	333,215	16,276	5,349	4,455	15,853	1,017	1,629	7,924
SNNP	Kokir Gedbano Gutazer	319,821	5,441	1,336	1,627	3,066	322	288	7,605
SNNP	Lanfero	158,634	3,693	777	1,260	6,877	176	313	3,772
SNNP	Meskanena Mareko	158,634	9,461	4,129	3,186	12,418	926	1,456	3,772
SNNP	Selti	158,634	4,195	1,212	1,176	4,196	254	385	3,772
SNNP	Sodo	188,455	32,148	10,306	11,187	37,544	2,601	5,030	8,680
SNNP	Badawacho	207,748	28,718	19,711	5,209	14,223	3,641	5,131	9,568
SNNP	Limu	399,292	34,193	18,047	13,889	63,143	4,148	8,146	18,390
SNNP	Misha	399,292	19,274	12,629	3,967	9,969	1,231	2,207	9,495
SNNP	Soro	89,918	25,517	16,741	4,755	11,844	1,425	2,824	4,141
SNNP	Bita	215,010	10,469	17,201	4,044	6,447	4,566	9,479	9,903
SNNP	Chena	49,709	8,092	1,763	3,560	7,469	509	391	1,182
SNNP	Cheta	103,776	835	761	364	658	172	155	2,468
SNNP	Decha	49,709	5,912	2,900	2,524	7,187	758	519	1,182
SNNP	Gelila	289,572	10,043	4,385	1,983	3,019	735	1,072	6,886
SNNP	Hamer	82,308	7,841	9,403	2,010	3,810	2,257	3,931	3,791
SNNP	Kuraz	31,736	2,838	4,124	728	982	990	1,330	1,462
SNNP	Selamgo	49,709	10,535	9,629	2,737	5,179	2,504	3,453	2,289
SNNP	Boloso Sore	348,656	25,608	17,304	4,358	13,205	8,098	13,385	16,058
SNNP	Damot Gale	207,748	30,071	14,371	5,135	14,746	6,711	12,402	9,568
SNNP	Damot Weyde	207,748	37,110	17,824	7,429	22,505	8,042	18,164	9,568
SNNP	Humbo	428,363	34,836	28,042	5,975	17,369	13,240	30,172	19,729
SNNP	Kindo Koysha	195,309	14,885	13,409	2,646	6,522	6,249	17,265	8,995
SNNP	Ofa	138,732	15,110	13,686	2,802	7,336	6,328	16,459	6,390
SNNP	Sodo Zuria	348,656	31,394	15,904	5,354	14,618	7,571	16,242	16,058
SNNP	Yem	399,292	16,892	8,309	4,238	7,953	1,436	1,717	9,495
SNNP	Gesha Daka	215,010	2,540	4,821	1,185	1,929	1,176	2,318	5,113
SNNP	Gewata	215,010	5,535	4,426	2,610	7,590	1,070	1,541	5,113
SNNP	Gimbo	103,776	1,195	663	524	1,081	164	68	2,468
SNNP	Menjiwo	141,556	6,303	7,441	2,899	8,109	1,738	1,363	3,366
SNNP	Sylem	101,387	18,090	18,619	8,277	18,566	4,527	9,954	4,670
SNNP	Telo	103,776	195	313	92	127	76	39	2,468
SNNP	Alaba	158,634	4,883	4,242	1,218	3,846	452	679	3,772
SNNP	Angacha	197,001	8,885	8,142	1,477	4,294	699	1,423	4,685
SNNP	Kacha Bira	348,656	6,404	8,053	951	2,743	901	1,847	8,291
SNNP	Kedida Gamela	261,922	15,692	15,139	2,746	7,387	1,294	2,147	6,228
SNNP	Omo Sheleko	348,656	6,015	5,430	1,067	2,999	483	882	8,291
SNNP	Konso	54,446	26,970	27,455	8,087	13,053	6,753	6,896	2,508
SNNP	Ela (Konta)	103,776	12,800	11,007	4,894	13,544	2,308	2,438	4,780
SNNP	Anderacha	25,185	468	1,176	117	259	329	293	599
SNNP	Masha	25,185	2,029	4,915	590	1,821	1,388	3,172	1,160
SNNP	Yeki	50,065	10,691	17,367	4,018	6,658	4,642	9,600	2,306
SNNP	Aleta Wendo	378,535	35,459	0	4,166	13,211	0	0	9,001
SNNP	Arbe Gona	428,363	54,571	130	6,952	19,795	42	34	10,186
SNNP	Aroresa	131,627	17,201	164	2,388	8,717	53	70	3,130
SNNP	Awasa	121,281	71,407	669	9,854	34,571	202	460	2,884
SNNP	Bensa	187,961	28,833	121	3,647	11,725	39	32	4,470
SNNP	Dale	378,535	53,086	588	6,281	21,349	280	961	9,001
SNNP	Dara	112,460	15,061	0	1,717	6,270	0	0	2,674
SNNP	Hulla	378,535	48,530	0	5,702	19,166	0	0	9,001
SNNP	Shebedino	428,363	65,715	1,352	8,265	29,127	513	872	10,186
SNNP	Bako Gazer	82,308	26,120	17,243	6,969	13,011	3,989	6,284	3,791
SNNP	Bena	82,308	13,243	11,410	3,429	6,600	2,738	5,230	3,791
SOM	Bare	51,614	35	28	17	31	14	24	360
SOM	Chereti	89,170	110	42	50	37	21	22	622
SOM	Debeweyin	53,840	4	2	2	2	1	1	376
SOM	Denan	42,998	0	0	0	0	0	0	300
SOM	Dihun	51,974	12	7	6	5	3	5	363
SOM	Dolobay	89,170	5	5	2	5	2	4	622
SOM	East Imi	51,614	27	14	14	19	7	12	360
SOM	Elkere	51,614	282	221	143	86	110	64	360
SOM	Aware	129,257	0	0	0	0	0	0	902
SOM	Degehabur	30,962	0	7	0	0	4	10	216
SOM	Degehamedo	176,136	3	2	2	9	1	4	1,230
SOM	Misrak Gashamo	129,257	0	0	0	0	0	0	902
SOM	Babile	202,325	22,065	17,996	4,659	13,885	6,620	14,518	19,507

SOM	Gursum	185,522	11,702	11,513	2,610	6,807	4,427	11,799	17,887
SOM	Hareshen	129,257	23	52	12	67	26	121	902
SOM	Jijiga	202,325	14,803	20,021	7,974	22,586	10,186	29,727	19,507
SOM	Kebribeyah	44,424	2,323	2,679	1,251	3,229	1,365	4,230	4,283
SOM	Teferi Ber	58,048	24,913	16,414	13,419	35,024	8,354	21,461	5,597
SOM	Dolo Odo	89,170	1,038	0	293	204	0	0	622
SOM	Filtu	296,006	4,462	122	1,271	1,959	39	36	2,066
SOM	Moyale	42,726	3,942	0	996	2,886	0	0	298
SOM	Afdem	36,264	3,524	2,882	652	1,696	1,052	1,805	3,496
SOM	Ayisha	58,048	6	1	1	0	0	1	405
SOM	Dembel	115,807	868	5,353	160	341	1,942	2,291	11,166
SOM	Erer	17,118	3,861	3,149	643	1,768	1,200	1,579	1,650
SOM	Miesso	36,264	1,610	1,672	343	379	633	710	3,496
SOM	Shinile	58,048	111	1,294	15	20	555	952	5,597
SOM	Adadle	51,614	4	14	2	4	7	7	360
SOM	Afder	51,614	36	31	18	6	15	11	360
SOM	Ferfer	62,190	0	0	0	0	0	0	434
SOM	Fik	176,136	27	19	14	16	10	14	1,230
SOM	Gerbo	51,974	0	0	0	0	0	0	363
SOM	Gode	51,614	9	16	5	8	8	9	360
SOM	Goro Baqaqsa	40,820	589	327	298	243	163	74	285
SOM	Gudis	42,998	14	8	7	7	4	7	300
SOM	Guradamole	40,820	7,247	2,999	2,436	3,811	1,093	1,200	3,936
SOM	Hamero	176,136	0	0	0	0	0	0	1,230
SOM	Kebridehar	53,840	16	8	8	8	4	3	376
SOM	Kelafo	99,977	40	24	20	36	12	25	698
SOM	Lagahida	176,136	1,562	784	367	933	325	393	1,230
SOM	Meyumuluka	176,136	4,946	3,898	1,298	3,779	1,668	1,866	1,230
SOM	Mustahil	62,190	18	18	9	18	9	14	434
SOM	Segeg	51,974	1	0	0	0	0	0	363
SOM	Selahad	51,974	316	179	123	98	75	46	363
SOM	Shekosh	122,637	5	2	2	3	1	2	856
SOM	Shilabo	53,840	0	0	0	0	0	0	376
SOM	West Imi	51,614	27	15	14	18	8	12	360
SOM	Boh	131,476	0	0	0	0	0	0	918
SOM	Danot	122,637	0	0	0	0	0	0	856
SOM	Geladin	122,637	0	0	0	0	0	0	856
SOM	Warder	53,840	0	0	0	0	0	0	376
TIG	Adwa	148,405	16,195	13,251	2,004	2,694	4,690	6,010	17,614
TIG	Ahferom	148,405	21,768	20,841	2,461	4,043	6,397	10,821	17,614
TIG	Degua Temben	119,049	21,243	13,525	2,525	4,178	4,741	6,365	14,130
TIG	Kola Temben	113,479	27,266	22,083	3,331	7,043	7,845	14,293	13,468
TIG	Laelay Maychew	113,479	13,187	9,651	1,632	2,339	3,416	4,003	13,468
TIG	Mereb Lehe	125,876	11,673	9,773	1,440	1,792	3,494	4,036	14,940
TIG	Naeder Adet	113,479	25,529	22,186	3,124	7,108	8,166	17,477	13,468
TIG	Tahtay Maychew	113,479	20,035	19,272	2,392	4,788	7,473	15,701	13,468
TIG	Tanku Abergele	119,049	30,745	46,213	3,653	7,733	19,939	32,029	14,130
TIG	Werie Lehe	113,479	26,596	22,463	3,052	7,210	7,070	16,679	13,468
TIG	Atsbi Wenberta	143,577	12,059	5,035	1,392	2,242	1,642	3,705	17,041
TIG	Erob	59,650	1,118	437	99	109	75	159	523
TIG	Ganta Afeshum	148,405	10,009	8,382	905	1,645	1,975	4,377	17,614
TIG	Gulomahda	176,436	7,480	5,914	672	862	1,378	2,028	1,547
TIG	Hawzen	148,405	13,998	10,535	1,278	2,988	2,507	6,806	17,614
TIG	Saesi Tsaedaemba	114,142	8,079	2,530	852	1,427	522	1,222	1,001
TIG	Wukro	119,448	11,327	10,578	894	1,768	3,660	6,552	14,177
TIG	Mekele	149,323	766	124	74	77	55	172	1,309
TIG	Alamata	232,220	12,853	11,830	920	1,953	5,145	17,641	27,562
TIG	Ambalaje	119,049	8,974	422	786	1,265	188	513	1,044
TIG	Endamehoni	176,998	10,271	455	831	1,441	203	616	1,552
TIG	Enderta	119,049	21,499	10,076	2,719	4,600	4,239	9,067	14,130
TIG	Hintalo Wajirat	119,049	19,932	1,247	2,890	4,579	557	1,673	1,044
TIG	Ofla	176,998	12,474	4,942	1,012	1,849	2,231	3,541	21,007
TIG	Raya Azebo	113,011	14,458	928	1,943	4,236	414	1,854	991
TIG	Samre	119,049	41,496	39,479	3,808	5,763	17,478	27,429	14,130
TIG	Asegede Tsimbela	129,511	6,549	7,782	605	1,919	4,443	14,042	15,371
TIG	Kafta Humera	110,486	5,849	5,626	583	1,870	3,226	10,163	13,113
TIG	Laelay Adiyabo	105,124	4,955	6,876	458	1,247	3,926	11,269	12,477
TIG	Medebay Zana	113,479	17,993	20,543	2,030	4,963	8,859	23,022	13,468
TIG	Tahtay Adiyabo	129,511	10,972	12,810	1,014	3,025	7,314	17,288	15,371
TIG	Tahtay Koraro	129,511	5,303	6,987	490	1,488	3,989	13,524	15,371
TIG	Tsegede	165,217	8,642	26,163	1,213	5,249	15,638	38,952	19,609
TIG	Tsilemti	129,511	18,554	38,570	2,646	6,047	22,457	46,598	15,371
TIG	Welkait	129,511	6,502	6,458	614	2,351	3,690	11,964	15,371

Table A-7: Gross production value (constant 2004-2006 million US$)

	Sorghum	Maize	Wheat	Barley	Millet	Rice, paddy
	Gross Production Value (constant 2004-2006 million US$) (USD)					
Annual growth rate 2000-2011	**11.57**	**5.80**	**7.92**	**7.06**	**6.42**	**17.72**
Annual growth rate 1993-1999	**13.37**	**11.73**	**4.25**	**3.40**	**18.91**	**5.82**
2011	690.18	665.24	581.09	320.10	110.83	13.66
2010	517.87	519.95	625.85	328.95	91.52	15.59
2009	488.78	524.67	516.37	285.53	97.82	10.79
2008	403.67	503.85	501.20	254.10	84.57	3.69
2007	378.84	445.19	451.56	238.79	69.31	1.70
2006	403.15	537.63	565.50	264.92	87.32	1.81
2005	383.49	521.91	469.41	262.79	69.38	1.70
2004	299.42	387.75	442.91	258.50	58.12	1.81
2003	310.99	366.08	329.26	204.34	53.27	1.97
2002	269.50	376.98	294.58	222.42	53.45	2.12
2001	269.93	440.06	324.77	191.11	55.20	2.33
2000	207.07	357.95	251.36	151.07	55.88	2.27
1999	232.57	377.85	233.94	180.82	66.75	2.12
1998	188.80	312.77	232.53	184.67	45.32	1.97
1997	355.63	398.45	222.37	179.10	51.71	1.81
1996	315.07	422.16	236.51	211.41	42.54	2.31
1995	198.82	265.46	220.51	185.26	26.90	1.66
1994	122.46	186.28	163.35	164.51	30.84	1.50
1993	109.51	194.25	182.23	147.99	23.61	1.51

Table A-8: Cereal exports in Ethiopia (1993-2010)

	Maize		Sorghum		Wheat		Millet		Barley	
	mt	000 USD	mt	000 USD	mt	000 USD	mt	000 USD	mt	000 USD
2010	35,994	9,810	21,786	7,202	5	5	12	7	17	18
2009	0	0	0	0	1	1	16	18	25	37
2008	0	0	2,224	635	35	124	41	27	88	46
2007	17	9	2,402	514	1	1	93	48	141	75
2006	672	128	1,371	284	0	0	139	69	51	28
2005	2,606	453	13,420	3,559	195	29	5	2	9	3
2004	11,086	1,787	1,760	320	54	12	28	11	147	54
2003	746	101	1,412	415	58	16	625	204	82	29
2002	12,848	1,858	1,198	196	94	15	8,904	329	103	43
2001	1,327	217	118	36			50	25	9	4
2000	385	83	1,051	266	2	1	156	74	30	13
1999	979	236	408	102	20	8	80	3	25	11
1998	1,701	329	239	53	20	13	76	4	16	6
1997	0	0	63	18	0	0	0	0	0	0
1996	0	0	63	18	0	0	0	0	0	0
1995	0	0	63	18	0	0	0	0	0	0
1994	0	0	49	17	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0

Table A-9: Cereal imports in Ethiopia (1993-2010)

	Maize		Sorghum		Wheat		Millet		Barley	
	mt	000 USD	mt	000 USD	mt	000 USD	mt	000 USD	mt	000 USD
2010	29,222	11,700	351,734	123,000	1,698,234	475,000	3	3	41	18
2009	54,466	22,000	268,640	95,000	1,735,594	490,000	1	3	0	0
2008	36,050	14,891	252,697	84,503	1,100,050	465,194	5	7	1	2
2007	31,912	14,000	16,468	3,300	600,238	210,000	1	1	0	0
2006	60,271	25,000	1,088	220	526,206	135,000			0	0
2005	30,436	10,500	2,861	400	862,146	224,444		1	0	0
2004	11,347	7,713	4,606	895	575,020	176,643	1		0	0
2003	11,582	5,049	24,416	4,807	1,603,103	362,391	0	0	0	0
2002	3,189	1,341	10,000	2,000	657,000	98,500	0	0	0	0
2001	23,500	8,500	8,500	1,800	1,031,000	150,000			5,775	1,319
2000	18,300	6,500	7,400	1,510	1,164,000	163,000			4,984	998
1999	35,000	4,700	49,000	10,000	550,000	77,000			5,000	1,024
1998	30,000	4,300	50,000	10,000	463,000	81,000				
1997	26,800	3,500	10,000	2,400	187,200	34,400	0	0	0	0
1996	20,500	3,000	50,000	11,500	295,000	76,000	0	0	0	0
1995	24,500	3,100	100,354	22,723	509,500	132,000	0	0	0	0
1994	36,300	4,900	102,875	23,000	553,583	129,613	0	0	2,015	685
1993	21,000	2,700	19,900	4,500	358,100	56,800	1	29	0	0

Table A-10: Cereal utility balances for cereals (2000-2009)

	Maize										
	Domestic supply quantity	Export Quantity	Feed	Food supply quantity	Import Quantity	Other Util	Proc-essing	Production	Seed	Stock Variation	Waste
2009	3,954,408	0	120,000	3,592,093	57,245		427	3,897,163	44,306	0	197,581
2008	3,849,574	11	120,000	3,466,701	73,145		27,942	3,776,440	44,306	0	190,624
2007	3,520,731	18	100,000	3,200,334	33,954		277	3,336,795	44,185	150,000	175,935
2006	3,590,657	672	120,000	3,223,417	61,699		383	4,029,630	42,363	-500,000	204,495
2005	3,440,255	2,606	120,000	3,084,776	30,992		210	3,911,869	38,153	-500,000	197,115
2004	2,981,022	11,191	90,000	2,693,587	35,900		299	2,906,314	48,753	50,000	148,383
2003	3,071,394	746	80,000	2,796,068	88,260		514	2,743,880	45,039	240,000	149,773
2002	3,058,953	12,860	70,000	2,790,677	6,258		61	2,825,555	44,778	240,000	153,437
2001	3,029,098	1,339	70,000	2,755,164	32,107		173	3,298,330	37,669	-300,000	166,092
2000	3,031,419	385	70,000	2,763,002	28,864		38	2,682,940	47,317	320,000	151,062
	Sorghum										
	Domestic supply quantity	Export Quantity	Feed	Food supply quantity	Import Quantity	Other Util	Proc-essing	Production	Seed	Stock Variation	Waste
2009	3,239,906	0		2,045,537	268,640	1,000,000		2,971,266	32,374	0	161,995
2008	2,566,514	2,224		1,955,704	252,697	450,000		2,316,041	32,374	0	128,437
2007	2,187,665	2,402		1,847,491	16,468	200,000		2,173,599	30,671	0	109,503
2006	2,312,758	1,371		1,867,765	1,088	300,000		2,313,041	29,286	0	115,706
2005	2,189,682	13,420		1,800,166	2,861	250,000		2,200,241	29,361	0	110,155
2004	1,760,757	1,760		1,642,388	4,606	0		1,717,911	30,244	40,000	88,126
2003	1,807,287	1,412		1,690,623	24,416	0		1,784,283	26,229	0	90,435
2002	1,695,032	1,198		1,583,504	10,000	0		1,546,230	26,717	140,000	84,812
2001	1,657,102	118		1,551,590	8,500	0		1,548,720	22,651	100,000	82,861
2000	1,564,429	1,051		1,458,972	7,400	0		1,188,080	27,184	370,000	78,274
	Wheat										
	Domestic supply quantity	Export Quantity	Feed	Food supply quantity	Import Quantity	Other Util	Proc-essing	Production	Seed	Stock Variation	Waste
2009	4,930,218	1,103		2,870,653	1,855,344	1,700,000	4	3,075,644	119,000	333	240,562
2008	3,580,975	1,020		2,784,923	1,119,265	500,000	4	2,463,064	117,850	-333	178,156
2007	2,826,610	1,084		2,585,899	605,598	0	13	2,219,095	99,730	3,000	140,967
2006	3,315,517	437		2,547,075	533,895	500,000	4	2,779,058	103,174	3,000	165,263
2005	3,182,767	785		2,417,996	871,690	500,000	4,153	2,306,862	102,168	5,000	158,450
2004	2,760,689	388		2,513,184	579,474	0	9	2,176,603	109,913	5,000	137,581
2003	3,285,014	281		2,521,929	1,683,202	500,000	0	1,618,093	102,025	-16,000	161,060
2002	2,562,321	345		2,353,452	675,021	0	0	1,447,645	81,637	440,000	127,232
2001	2,481,394	180		2,279,604	1,065,553	0	0	1,596,020	70,439	-180,000	131,351
2000	2,201,373	493		1,997,149	1,226,596	0	0	1,235,270	84,260	-260,000	119,964