Agricultural development and water use in the Central Rift Valley of Ethiopia: A rapid appraisal

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Project:	Data collection for and analysis of smallholder farming in the Ethiopian Central Rift Valley
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University of Twente
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Summary

This report describes the results of an internship in the Central Rift Valley. The internship is part of the project ‘Ecosystems for water, food and economic development in the Ethiopian central rift valley’, executed by the Wageningen University and Research centre, sponsored by the Dutch Ministry of Agriculture, Nature and Food Quality. The project aims at strengthening local authorities in the field of environmental planning. The aim of this research was to collect general data, for example, on demography and agricultural activities and the analysis of data and various agricultural production systems. Special attention was on water use of these systems and other activities in the CRV that consume large amounts of water.

The Ethiopian Central Rift Valley (CRV) is part of the Great African Rift, and encompasses four major lakes on the rift floor and is surrounded by escarpments on the east and west side. It has a semi arid to sub humid climate and is known for its unique ecology, especially birdlife. The natural resources of the area are under enormous pressure due to human influences. During the last decades natural population growth and migration have led to large scale deforestation, increased agricultural activities and an increased cattle population.

One of the developments in the past decades is the introduction and rapid expansion of irrigated agriculture. Smallholder farmer irrigation schemes as well as large scale private and state farms have been established during the last decades. A recent development is the introduction of foreign investment in closed vegetable and flower production systems. Irrigated agriculture, of which mainly smallholder farming, is one of the major water consumers. Because the amount of water extracted for irrigated agriculture is limited to 6,5 % of the evapotranspiration, the influence on the water balance seems limited. Direct extraction from Bulbula river and Lake Abyata however may have contributed to the decreased water levels of Lake Abyata.

Most important source of income for smallholders is still rainfed agriculture and cattle keeping. Both activities have increased rapidly as a result of population growth and have resulted in large scale deforestation. Although the (limited) use of improved seeds and agrochemicals crop yields are low. Low input use, diseases and weather are the major constraints. Depending on the altitude, most important crops are wheat, maize, barley and teff,. Farmers tend to organize into cooperatives and unions, but the level of cooperation could be improved considerably.

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Preface

This report describes a three-months internship in Ethiopia as part of my training at the School of Civil Engineering, University of Twente(UT). This internship was from August 17 to November 17 2006 and contributed to the project 'Ecosystems for water, food and economic development in the Ethiopian Central Rift Valley' of Wageningen University and Research centre. This project is assigned by the agricultural attaché of the Royal Netherlands Embassy in Addis Ababa. In Ethiopia, I have collected and analysed basic information of the study area, the Central Rift Valley, with special focus on data related to water use and management.

First of all I would like to thank Mr. Huib Hengsdijk, project manager of the WUR-team, for his supervision throughout my preparation period, stay in Ethiopia and period of reporting. His quick response to my questions mainly by email facilitated my work. Supervision from the UT was conducted by Ms. Henriette Otter and Mr. Maarten Krol. I want to thank her for setting course and giving me scope to elaborate my internship. Besides I would like to thank the other WUR-team members, Ms. Petra Spliethoff and Mr. Herco Jansen, for sharing their expertise. Special thanks to Ms. Petra Hellegers for support during her stay in Ethiopia.

For my stay in Ethiopia I would especially thank Mr. Geert Westenbrink and Ms. Janny Poley of the Royal Netherlands Embassy, and Mr. Tamiru Alemayehu and Mr. Tibebu Tefere of Addis Ababa University, and furthermore everybody who has enabled me to fulfil my internship.

From the UT Mobility Bureau I would like to thank Ms. Ellen van Oosterzee for her assistance during the preparation of my internship.

Finally I would like to thank Mr. Edwin van der Maden and the other 'Dutch folks' for having a great time in Addis Ababa

List of abbreviations

a.s.l.	Above sea level
CRV	Central Rift Valley
NGO	Non Governmental Organization
WUA	Water Users Association
HGC	Horticulture Growers Cooperative
OIDA	Oromya Irrigation Development Authority
JICA	Japanese International Cooperation Agency
IDE	International Development Enterprise
IBC	Institute of Biodiversity Conservation
WUR	Wageningen University and Research centre
UT	University of Twente
AAU	Addis Ababa University
A&D-office	Agricultural and Development office

Lexicon

Agrochemicals:	the total of pesticides, herbicides and fungicides.
Kebele:	administrative region in a woreda
Smallholder:	owner or tenant of a farm up to 2.5 ha.
Woreda:	administrative region subdivided in kebele’s

1 Introduction

The Ethiopian Central Rift Valley is part of the Great African Rift Valley and is located between 38°00’-39°30’ east longitude and 7°00’-8°30’ north latitude. The CRV has an arid to semi-arid climate, although the highlands on the eastern and western escarpments of the valley are sub-humid. From the escarpments the lakes on the rift floor are fed by rivers, of which Meki and Katar river are the most important. The four major lakes are Lake Ziway, Lage Langano, Lake Abyata and Lake Shala of which the latter is a sub-catchment of the CRV. Lake Ziway and Lake Langano drain to Lake Abyata, a terminal lake, by the Bulbula and Horakelo river, respectively. Lake Abyata and Shala together form a National Park that is primarily created for its aquatic bird life. Until now, only a part of the 87.000 ha park is protected and fenced. The park is heavily threatened by the invading human and cattle population.

In addition to the Shala-Abyata National Park, also the rest of the environment in the CRV is severely affected by human activities. The rapidly growing population has led to an increased claim on natural resources. A large part of the area is heavily deforested for charcoal production and agricultural activities. The agricultural area has increased considerably, while changing agricultural practices have increased further the pressure on the natural resources. Irrigation, fertilizers and agrochemicals have been introduced in the last years. The immense cattle population has led to overgrazing and is a threat to the biodiversity for which the CRV is known.

Furthermore, national and foreign horticultural and floricultural (for export) activities have been introduced in Ethiopia. Thanks to the favorable climate, the geographical location in relation to the European market and the enabling conditions, which the Ethiopian government has created, this sector expands rapidly. So far, the Sher-complex located along Lake Ziway close to the outlet of Bulbula is the only private large-scale horticulture and floriculture farm in the CRV.

The Dutch Ministry of Agriculture, Nature and Food quality has committed itself to contribute to the theme 'Water for food and ecosystems'. As part of this policy issue, a project "Ecosystems for water, food and economic development in the Central Rift Valley of Ethiopia" was formulated in the spring of 2006. As the project was just started a 'quick scan' of the Central Rift Valley was required to collect information and gain knowledge about the area and more specifically about the agricultural production systems in relation to water management. The objective of my internship was to collect information on agricultural production, with special interest in water consumption for irrigation and to gain insight in the overall socio-economic development of the CRV.

This report starts with a description of the goals of my internship (Chapter 2) and the methodological approach (Chapter 3) used during the internship. In Chapter 4 some general characteristics of the CRV are presented. The irrigated farming systems present in the CRV, are described and assessed in terms of water use in Chapter 5. In Chapter 6 rainfed agriculture is described, followed by the cooperation between smallholder farmers in Chapter 7. Conclusions of the internship are described in Chapter 8.

2 Problem definition

The CRV is a fast degrading area, which faces several problems. One of the major problems is the drop of surface water tables, especially in Lake Abyata. During the last decades several potential causes for this drop in lake levels have been mentioned. Water extraction for irrigation has increased rapidly along the Bulbula river and the upstream part of the catchment. Another water user that extracts water directly from Lake Abyata, is the soda ash factory. Furthermore human population has increased, resulting in increased domestic use and a degraded environment.

In the research plan written at the start of my internship the problems in the CRV are described in more detail. Summarizing, the internship consisted of two parts: First, the collection of basic data, such as demography and agricultural activities. The second part consists of analysis of data and various agricultural production systems. Special attention was on water use of these systems and other activities in the CRV that consume large amounts of water.

2.1 Goal of study

The goal of this study is:

1. To collect information about smallholder farming in the CRV with respect to available resources, grown crops, irrigation schemes, input use and costs and benefits, by surveying agricultural offices, smallholders and (nongovernmental) organizations
2. To gain insight in the overall (socio-)economic development of smallholder farming in the CRV.

3 Methodology and data

Collection of information and data consisted of formal and informal approaches. Most important were the field visits to the CRV, in total thirteen visits. During these visits farms have been visited and data has been collected in ten administrative units, so called *woreda's* (Table 1). During all visits stakeholders have been interviewed to collect data. For the Woreda Agricultural and Development Offices (A&D-office) a questionnaire has been used (Annex I), while others have been interviewed informally with focus on their specific activities. In Addis Ababa various governmental and non-governmental organisation have been visited (Annex II). In addition, literature has been collected at the AAU, the Royal Netherlands Embassy and other organisations. See Figure 1 for a map of the CRV and the location of the different *woreda's*

Table 1. Visited farms and organisations.

Woreda	Visited
Dugda Bora	• Woreda Agricultural and Development Office
	• Meki-Ziway Irrigation Project
Adami Tulu Jido Kombolcha	• Woreda Agricultural and Development Office
	• Ziway State Farm
	• Sher Complex (AQ Roses and Ziway Roses)
	• Ethio-Flora Farm
	• RVWCDA (Office and Haleku Irrigation Project)
	• Several irrigation schemes near Lake Ziway
	• Soda Ash Factory
Ziway Gugda	• Woreda Agricultural and Development Office
	• OSHO
Tiyo	• Woreda Agricultural and Development Office
	• Ketar Irrigation Scheme
	• Arata Irrigation Development Project
Degeluna Tiyo	• Woreda Agricultural and Development Office
Sodo	• Woreda Agricultural and Development Office
	• EDI drip irrigation project
Meskana	• Woreda Agricultural and Development Office
Mareko	• Woreda Agricultural and Development Office
Arsi Negele	• Woreda Agricultural and Development Office
	• Shala-Abyata National Park
Munessa	• Woreda Agricultural and Development Office
	• Munessa State Farm

The Woreda Agricultural and Development Offices are visited because they have most up-to-date general and agricultural information of the study area. Unless mentioned, all data is from the 2005-2006 cropping season. Information on agrochemical use, however, was often not available and is collected in the field. Water use estimations are made through field observation, measurements and by questioning farmers. Furthermore NGO's are visited because they constructed many of the irrigation schemes. For all visited agricultural production systems information on water use has been collected in order to make a water use comparison.

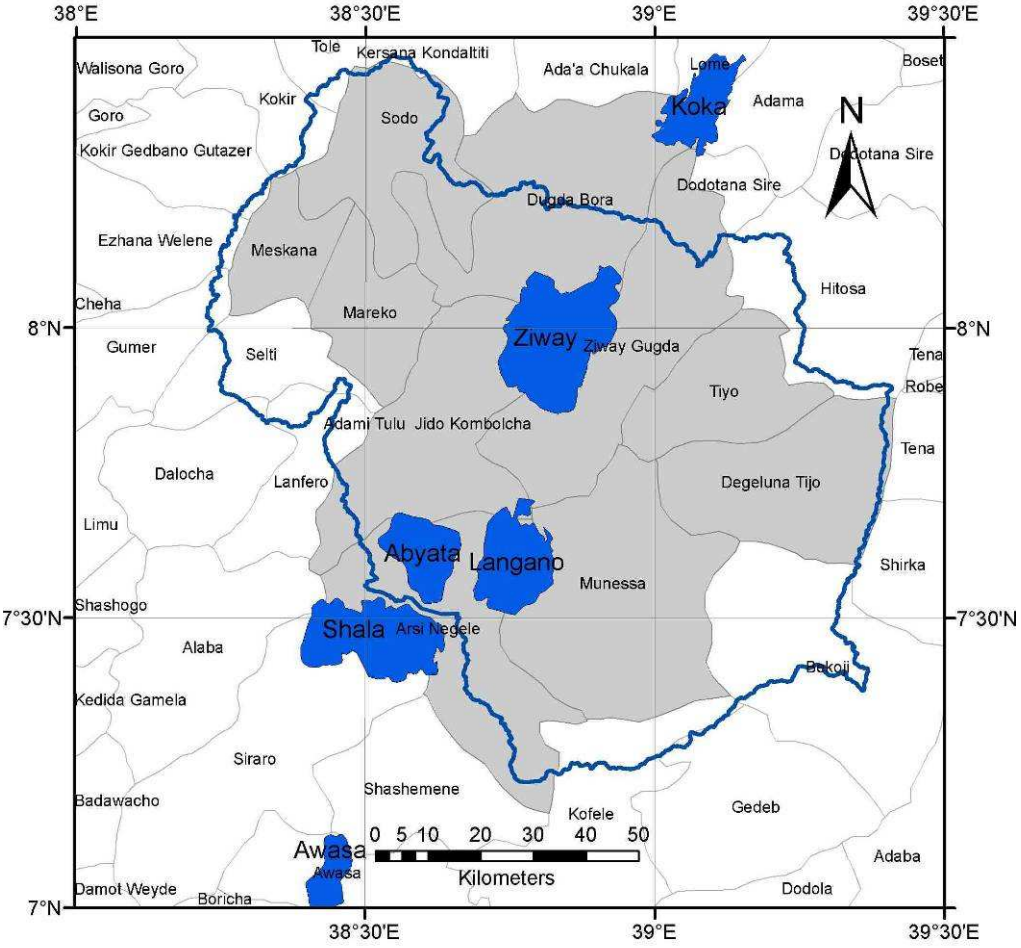


Figure 1. The CRV study area and its *Woreda's*.

4 The Central Rift Valley

Information and data on the CRV is often not readily available. Data is scattered and many organizations do not have a good overview of available information. Furthermore, many general data is not available at all or is not up-to-date. To collect the scattered data available and verify existing data, the CRV has been visited to gather information on some general characteristics. The relation between population, employment, livestock and climate and their impact on the environment is discussed in this Chapter.

4.1 Population

The population in the CRV has increased rapidly in the last decades due to natural population growth and migration to the CRV from other regions. Consequently, pressure on natural resource has increased enormously. Population growth in all *woreda's* is estimated at approximately 3%. The population of each *woreda* is given in Table 2. The population numbers in Table 2 are indicative since the registration of population is poorly developed. The average family size in rural areas varies between 5.3 (Mareko) and 7.5 (Degeluna Tiyo). For other *woreda's*, when data are not available, it is estimated at around 6.

Table 2. Population characteristics in CRV woreda's (July, 2006).

	Total area (ha)	**Rural population**	**Urban population**	**Total population**	**Population density**	
					Own data	IBC (2005)
Dugda Bora	146800	145146	44264	189410	1.3	1.1
Adami Tulu Jido Kombolcha	?	?	?	?	?	1.0
Ziway Gugda	125000	116819	3689	120508	1.0	0.9
Tiyo [1)]	65000	94557	-	94557	1.5	2.8
Degeluna Tiyo	92700	114765	-	114765	1.2	1.3
Meskana [1)]	59700	240373	-	240373	4.0	3.0 [2)]
Mareko	22329	63756	0	63756	2.9	3.0 [2)]
Munessa	121730	165027	14985	180012	1.5	-
Arsi Negele	139587	156954	42393	199347	1.3	-
Sodo [1)]	88533	169469	-	169469	1.9	1.7
Total	**861379**	**1266866**	**105331**	**1372197**	**1.6**	**-**

[1)] Urban population not available
[2)] Average of both Meskana and Mareko
-: Information not available at A&D-office or by IBC.
?: Responsible officer not present at A&D-office during visit.

4.2 Employment

The rural population in the CRV mainly depends on subsistence farming. Besides smallholder farming, some other livelihoods in the CRV can be identified like fishing and employment at large scale farms. On both private and state farms, most employees are female. Additional income is obtained by charcoal production, beekeeping and sand winning from river beds.

One of the major employers in the CRV is the Sher-complex in Ziway. With an average number of 30 up to 40 workers per hectare in floriculture, the Sher-complex creates an important (and still growing) source of employment opportunities in the region. Officers of the A&RD-office in Adami Tulu Jido Kombolcha are partly satisfied with the employment opportunities offered by the Sher-complex, but are afraid for migration of workers from outside the area when more greenhouses are constructed. Farmers at the Sher-complex pay their workers one Birr per hour. A normal working day is 8 hours. Another important employer is the Ziway State Farm. With 186 permanent workers and 3000 seasonal workers they employ about 7 workers per hectare. Seasonal workers at the state farm earn, dependent

on their function, 4 up to 5,5 Birr for a eight hours working day. Although neighbouring the Sher-complex, the state farm assistant manager claims to have no problems with workers switching to Sher. Problems faced by the state farm are theft in the last years and workers that do not show up when productivity on their own plots makes them self-sufficient.
On the eastside of Lake Langano the Munessa State Farm is located. With an area of 2435 ha it employs 120 permanent workers. During the growing season July and August another 500 daily workers are employed for weeding. After harvesting, during October and November, 70 up to 80 additional workers are required for post harvest activities. Other important employers are private farms like Ethio-Flora, located along the Bulbula river, the haricot bean farm north of Lake Ziway and the farms of Mr. Tamiru in the *woreda* Ziway Gugda.

4.3 Livestock

Most animals in the CRV are goats (in the lowland), sheep (in the highland) and cattle, mainly for meat production. Oxen are used as draft animals. In addition, chicken are kept for meat and egg production. For transportation donkeys, mules and horses are kept. The livestock population is large (Table 4) for a number of reasons. Traditionally, the number of animals, mainly cattle, gives farmers social status. For this reason farmers try to keep as many cattle as possible. Furthermore the increased human population has lead to an increase in animals. This has resulted in overgrazing in many parts of the CRV. That a smaller number of healthy cattle can produce more than a large unhealthy population does not always seem to be understood. Because most pasture land is for common use, people do not feel responsible to be the first to reduce their cattle population. Overgrazing adds to soil nutrient depletion and erosion, which is a serious threat in various places of the CRV (Figure 2). Surprisingly, maize residues are often burned instead of used for animal feed.

Beekeeping is an expanding source of income, mainly in the mountain *woreda's*. Traditional beehives are kept by many farmers and the number of the expensive modern variant is increasing (Table 3). Modern beehives are managed both by single farmers and cooperatives. Traditional beehives are made of twigs and are placed in trees (Figure 2), while modern box-shaped beehives are made of board and placed on the ground.

Figure 2. (a) Cattle in Lake Shala-Abyata National Park and (b) traditional beehives.

Table 3. Characteristics of beekeeping (based on information of the A&RD-offices in Tiyo, Degeluna Tiyo and Sodo).

	Number of hives	Production (kg/hive)	Net benefits (Birr/kg)	Costs (Birr/hive)
Modern beehives	551	15 – 20	25 - 35	1350
Traditional beehives	8590	3 -5	15 - 20	10

Table 4. Livestock population in the Central Rift Valley (# = number of animals; D= animal density).

Woreda	Total Area (ha)	Cattle		Goat		Sheep		Donkey		Horse		Mule		Poultry	
		#	D	#	D	#	D	#	D	#	D	#	D	#	D
Dugda Bora & Adam Tuli [1)]	297271	90954	0,31	148251	0,50	26256	0,09	36842	0,12	2219	0.01	1495	0,01	195595	0,66
Ziway Gugda	125000	167797	1,34	71636	0,57	15182	0,12	14813	0,12	3509	0,03	1466	0,01	82739	0,66
Tiyo	6500	99478	1,53	8494	0,13	45237	0,70	11785	0,18	5687	0,09	246	0,00	35044	0,54
Degeluna Tijo	92700	162872	1,76	8512	0,09	86778	0,94	11341	0,12	16382	0,18	1150	0,01	57204	0,62
Meskana	59700	-	-	-	-	-	-		-	-	-	-	-		
Mareko	22329	24986	1,12	20120	0,90	5060	0,23	2271	0,10	385	0,02	144	0,01	16052	0,72
Munessa	121730	156012	1,28	13910	0,11	115795	0,95	10620	0,09	32230	0,26	1054	0,01	60384	0,50
Arsi Negele	139587	320162	2,29	19010	0,14	32303	0,23	21404	0,15	6723	0,05	210	0,00	81344	0,58
Sodo	88533	80389	0,91	17515	0,20	20130	0,23	12549 [2)]	0,14 [2)]	-	-	-	-	53619	0,61
Total/average	**861379**	**1011696**	**1,17**	**159197**	**0,18**	**320485**	**0,37**	**84783**	**0,10**	**64916**	**0,08**	**4270**	**0,00**	**386386**	**0,45**

1) population and density estimation on the basis of Zerihun Woldu (2003)

2) total population of horses, donkeys and mules

-: No information available from A&D-office

4.4 Environmental impact

The demand for cooking fuel has increased as a result of population growth. Since liquid fuels are expensive, use of charcoal is often the only option for the local poor to satisfy their energy demand. In addition, charcoal trading, although illegal, has become an income for many local people. Charcoal is made of acacia trees and its production has caused large-scale deforestation in the last three decades. Consequently, soil retention of precipitation will be reduced and run-off increased resulting in soil erosion and increased sediment transport to and in rivers.
Another cause of increased sediment fluxes, mainly in rivers draining to Lake Ziway, is (illegal) sand winning in the river beds for cement production. Sand is extracted year round from perennial rivers and from seasonal rivers after the rainy season.

Figure 3. Sand winning in Meki River, Dugda Bora *woreda.*

The effect of regional deforestation on the microclimate is hard to determine. Although it is clear that it can affect temperature and precipitation on both regional and larger scale as for example has been shown by the African Monsoon Multidisciplinary Analyses (AMMA) in Western Africa. Worldwide discussion on this subject is on-going and the relationship between deforestation and climate change is still poorly understood. However, it is clear that the deforestation has reduced the area with acacia woodland rapidly during the last years (Asfaw, 1997).

4.5 Climate

The CRV climate can be divided into two zones. The lowland zone surrounding the lakes is arid or semi arid and the highlands are humid to dry sub humid. In Figure 4 the mean monthly temperature at Ziway (lowland) station is presented. Data on temperature for other stations is not available. In Figure 5 the rainfall for both lowland and highland areas of four stations is presented.

Figure 4. Mean monthly temperature at Ziway station (lowland), 1996-2005.

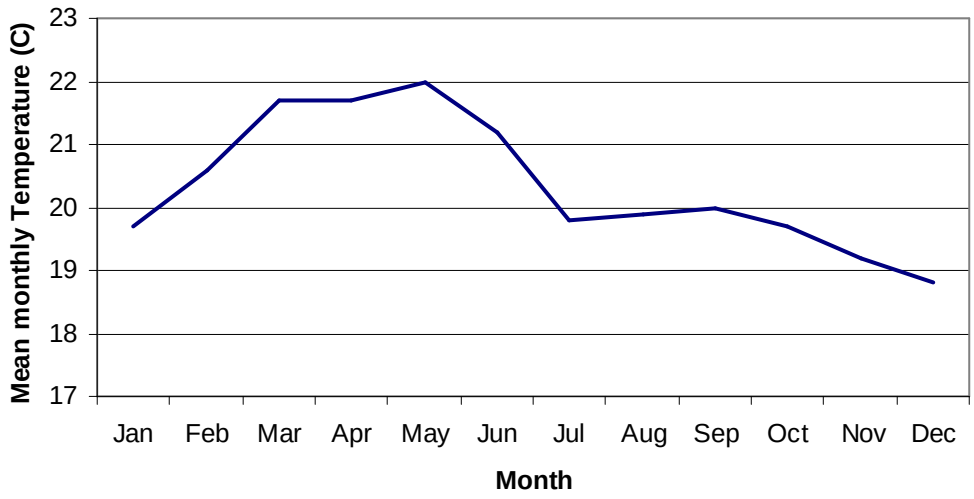
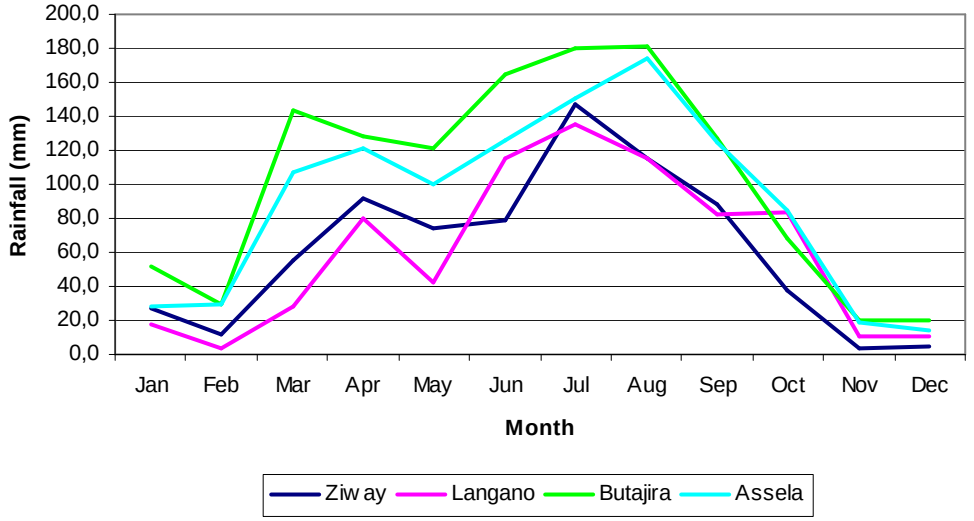


Figure 5. Mean monthly rainfall at two lowland (Ziway, Langano) and two highland (Butajira, Assela) stations during 1996-2005.



Precipitation in the highland areas is higher than in the lowland areas. A dry period can be identified from the end of October till the beginning of March, which makes two cropping seasons in rainfed agriculture impossible. The irregular distribution of rainfall over the year is the biggest constraint for agriculture, because cumulative rainfall over the year is quite high (89% of annual precipitation in the Netherlands).

5 Irrigated farming systems

The irrigated area has increased rapidly during the last years. Thanks to support of NGO's, governmental institutions and private investors smallholder farmers are able to practice irrigated agriculture to improve their income situation. Furthermore large-scale private farms have started production of vegetables, fruits and flowers. A third agricultural production system is the Ziway State farm, which produces seeds, vegetables and fruits. A classification of irrigated agriculture into four production systems has been made (Hengsdijk & Jansen, 2006).

- Smallholder open-field vegetable and fruit production systems
- Closed-vegetable and flower production systems on private farms.
- Open-field vegetable and fruit production systems on state farms.
- Open-field vegetable and fruit production systems on private farms.

These production systems use irrigation water to enable or increase crop production. The way farmers irrigate depends on the used irrigation system, the frequency of irrigation sessions and the grown crops. Total water use for each production system in the CRV depends on the total area covered by each system and the intensity of use during the year (i.e. the number and length of cropping seasons, and irrigation management).

5.1 Open-field vegetable and fruit production systems on smallholder farms

Farming is by far the most important livelihood strategy for the rural population. In addition to rainfed agriculture and livestock husbandry, in some areas vegetables and fruits are grown under irrigation. Irrigation management of smallholders differs within the CRV. The first difference can be made between the Rift floor and the highland areas on the eastern and western escarpment. Conditions in the highlands differ from those in the Rift floor because of micro-climatological differences. The escarpments have higher precipitation and lower temperatures, resulting in different cropping patterns, differences in productivity and irrigation management.

In the *woreda's* located in the Rift floor (Dugda Bora, Adami Tulu Jido Kombolcha, Ziway Gugda and Arsi Negele) the major crops are tomato, onion, green pepper and cabbage. Furthermore some crops are grown on smaller scale, like potato, or in specific regions, like papaya in Dugda Bora. In highland *woreda's* (Tiyo, Degeluna Tiyo, Sodo, Mareko, Meskana and Munessa) crops like potato, onion, carrot, beetroot, garlic and sugar cane are mostly grown. See Table 5 for the area of irrigated crops on smallholder farms. The total area in Table 5 does not correspond with the total irrigated area in the CRV. In Table 5 only part of the area of the major crops are recorded for the 2006/2007 cropping season. The percentages however, give a good indication of the irrigated crops grown and their importance in the CRV.

Table 5. Irrigated crop area in the CRV.

	Area (ha)	Percentage of total
Onion	2525	37
Tomato	1923	28
Potato	1178	17
Green pepper	437	6
Cabbage	367	5
Papaya	280	4
Carrot	81	1
Beetroot	75	1
Sugar cane	32	0,5
Haricot bean	5	0,1
Total	**6903**	**100**

In highland areas, the major water sources for irrigation are the rivers running towards the lakes in the Rift floor. Only in the Mareko *woreda* boreholes are used for both irrigation and other use. Here, irrigation water is only used for the production of seedlings that are transplanted in rainfed plots at the beginning of the rainy season. Major rivers, including their tributaries, used for irrigation are the Meki river on the western and the Katar river on the eastern escarpment. Both rivers drain to Lake Ziway. In the south of the CRV rivers that drain to Lake Langano and Lake Abyata are used for irrigation. In the highland water is diverted from rivers using channels (Figure 6) which transport water to reservoirs from where it is distributed over the plots.

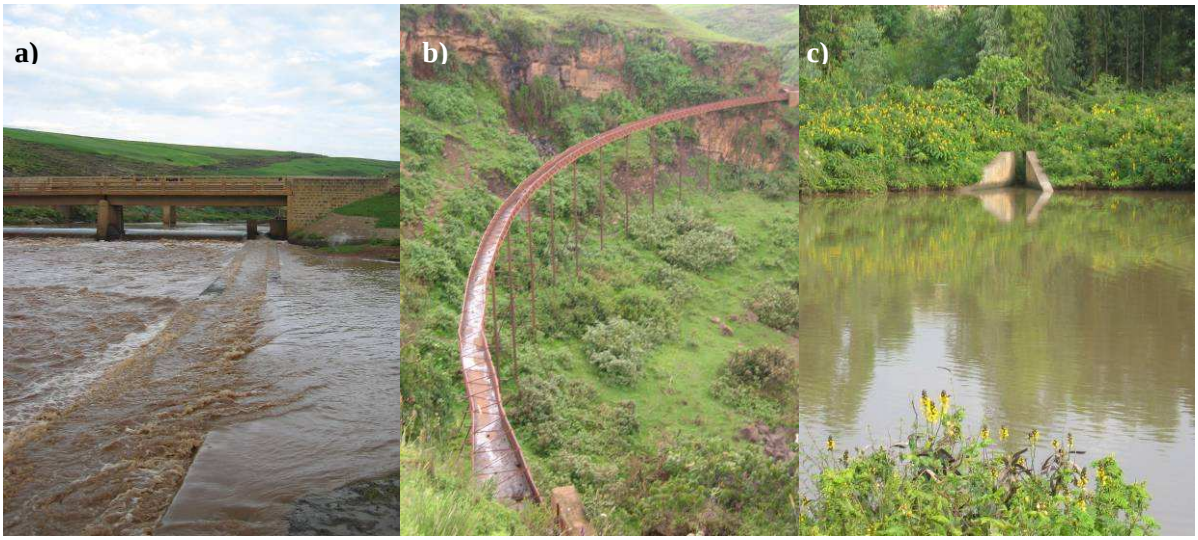


Figure 6. (a) and (b) Diversion channels 'Katar Irrigation Development Project' constructed by OIDA and JICA, Tiyo *woreda*. (c) Irrigation pond of 'Arata Irrigation Development Project financed' by IFAD, Tiyo Woreda.

In lowland areas pumps are used to extract water from Lake Ziway, hand dug wells along its shore and from Meki, Katar and the Bulbula river. Other lakes are not used for irrigation because of the high salinity (Lake Abyata and Shala) and steep shores (Lake Langano).

In highland areas farmers hardly have to irrigate during the rainy season. A second season starts after the rainy season, when the river discharge is still high. Some farmers downstream face problems of water shortages at the end of this season. Sometimes a third season is possible, depending on the river and the size of the irrigation pond.

Two irrigation systems exist, namely traditional and modern irrigation systems. This distinction is mainly based on the construction of irrigation schemes. Modern schemes consist of concrete and steel in addition to hand made structures (i.e. canals, ditches, water regulators etc.) as the traditional schemes. Furthermore the schemes differ depending on the support they receive or have received during scheme construction, on farmer's education and on the presence of a cooperation. After completion of a scheme, the 'Irrigation department' of the A&D-office in combination with a WUA or Union is responsible for maintenance support. All modern schemes have been constructed with support of governmental institutions or NGO's, while traditional schemes are built by the farmers, mostly without external support. In general, traditional schemes are smaller in area and number of farmers. The area per farmer is for both types of irrigation schemes about 0.5 ha. In addition to the irrigation schemes, individual farmers have their own irrigated plots and sometimes share their pump with other farmers on small scale.

5.1.1 Cropping season in irrigated area

In general, irrigated agriculture has two to three cropping seasons per year, while a crop rotation is practiced. Only green pepper is sometimes grown in succession at the same plot. Any consistent pattern in cropping seasons is lacking. According to officers at the A&D-offices most farmers grow one crop during

the rainy season and one during the dry season. The first cropping season starts with the beginning of the rainy season early June. After the two driest months, November and October, the second cropping season begins in January when rainfall increases each month until the rainy season. The cropping pattern is based on meteorological influences and although it is possible to irrigate the land, farmers choose for more guaranteed crop yields in case pumps collapse and they start production at the beginning of the rainy season. If financial capacity is sufficient, farmers grow a second irrigated crop in the more risky dry season when precipitation is lower but market prices are higher.

Some farmers choose to plan their harvest period just before important national holidays and during fasting periods, because crop prices increase as a result of higher demand. The most important fasting period is during March and April and ends after 55 days with Fasika, Orthodox Eastern. Also shorter fasting periods are considered while planning cropping seasons.

However, on the basis of field study by JICA and OIDA (2004) and the cropping seasons as described by the RVCWDA (2006) it is hard to identify any pattern in cropping seasons. Also during my visits to the study area no clear crop patterns could be recognized. Two case-studies executed by IDE (2004) in Dugda Bora and Adami Tulu Jido Kombolcha *woreda* suggest that the cropping seasons for all vegetables is more or less similar. Their conclusion, however, does not match with other studies and the information collected at the A&D-offices.

5.1.2 Water use for irrigation

Except for some pilot projects all smallholder farmers use furrow irrigation. In this system water is collected in an elevated distribution canal or pond and from here it is distributed over the land by small ditches. Since exact data on water use by smallholder farmers is not monitored, estimations have to be made. Two methods have been applied to estimate water use.
The first method is based on the pump capacity and the hours of pumping per cropping season. By applying this method it became clear that the pump capacity as assumed on the pump does generally not correspond with the actual capacity. This is caused by the elevation head and the condition of the pump. Furthermore poor maintenance does not only affect the capacity but also the effectiveness of the irrigation system. Leaking through pipelines as well as transportation channels result in loss of water (Figure 7). The effect of the reduced capacity and the extra capacity needed because of loss of water are hard to determine. In combination with the widely different number of pumping hours, varying from several hours per day to 24 hours per day, it is difficult to estimate water use accurately. Due to the absence of proper measurement equipment and often fixed pipelines, measuring actual capacity is not possible.

Figure 7. Water loss due to poor maintenance of pipes and channels.

The second method applied is the calculation of water use through information on the inundation depth and the frequency of irrigation. With this method the water use per irrigation session can be estimated. The size of the ditches, inundation depth and size of the beds between the ditches has been determined in the field (Figure 8). The proportion covered by ditches is about 50% of the field surface.

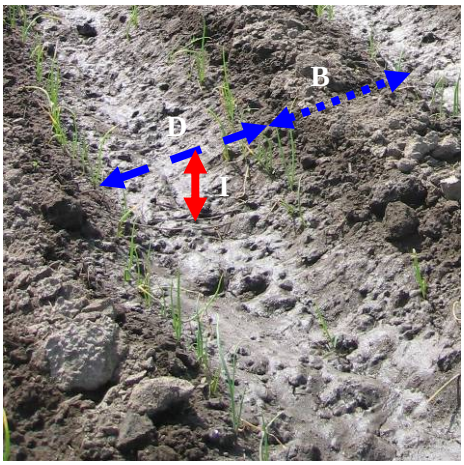


Figure 8. Determination of inundation depth (I) and ditch (D) and bed (B) size.

Farmers were asked about the average irrigation frequency per crop. The inundation depth differs not only between crops, but also within crop types. For each crop an average inundation can be determined. In Table 6 the calculation is further explained for tomato production. This method has been applied for other crops as well and the estimated water use per cropping season is determined at 10000 m^3/ha.

Table 6. Calculation of the amount of irrigation water used in tomato. During the first 30 days of production, every 4 days the land is irrigated, resulting in 7,5 irrigation sessions. The ditches are inundated with 15 cm of water, resulting in an average inundation for the total plot of 7,5 cm. On the basis of this inundation and the number of irrigation sessions the water use per cropping season can be estimated.

Production (days)	Frequency (1/…..days)	Irrigation sessions	Inundation (m)	Average inundation (m)	Water use (m^3/ha/session)	Water use (m^3/ha/season)
30	4	7,5	0,15	0,075	750	5625
60	7	8,6	0,15	0,075	750	6429
90 (season)						**12054**

This method for estimating irrigation water use has also been applied to the other open-field fruit and vegetable production systems, namely the Ziway State Farm (section 5.3) and the private farms (section 5.4).

The total irrigated land by smallholders in the CRV is 7305 ha. Of all *woredas* Dugda Bora has most irrigated land, i.e. 3449 ha (Table 7). According to officers at the A&D-office in Meki, approximately 70% (2414 ha) of the irrigated land is located in the CRV, the other 30% in the Lake Koka catchment. Dugda Bora has good opportunities for irrigated agriculture because of the presence of Lake Ziway and Meki river, the good transportation possibilities and the favourable location compared to important markets like Addis Ababa and Nazareth.

Table 7. Irrigated area for smallholder farming per *woreda.*

Woreda	Irrigated area (ha)
Dugda Bora	2414
Adami Tulu	658
Ziway Dugda	748
Tiyo	701
Degeluna Tijo	1200
Meskana	307
Mareko	40
Munessa	799
Arsi Negele	188
Sodo	250
Total	**7305**

5.2 Closed vegetable and flower production systems on private farms.

The horticultural and floricultural sector has been rapidly expanding in Ethiopia in the last years. In the Central Rift Valley one complex of greenhouses is in production, the Sher complex.

5.2.1 Sher complex

At the time of visit 13 greenhouses with each an area of 9 ha were in production or almost ready for production (Table 8). In the near future, according to the current scheme, 40 of those greenhouses will be constructed to cover 360 ha. Another 300 ha is purchased from the neighbouring state farm to construct another complex of greenhouses in the future. Finally, a planned area of 1000 ha of greenhouses will be developed.

Table 8. Farmers and their greenhouses in the Sher-complex.

Company name	Total area (ha)	Crops	In production
Ziway Roses	27	Roses	Yes
AQ Roses	18	Roses	Yes
Van der Burg	18	Unknown	No
Alex	18	Unknown	No
Jan Prins	9	Vegetables	No
Joint venture of 11 Ethiopians	27	Unknown	No

During a visit to Ziway Roses and Ammerlaan Quality Roses information was collected on production activities. Both companies grow several varieties of roses and produce 200 (Look variety) up to 350 (Pistache) roses/m^2/year. Cost prices of the roses range from € 0,10 to € 0,11 per rose, of which approximately one third are transport costs. Given a profit of € 0,02 per rose, total profit per ha will be €50000 per ha, assuming a production of 250 roses/m^2/year (2,5 million roses/ha/year).

Pesticides and fertilizers used for the production of roses are the same as in The Netherlands, because farmers are familiar with the use of these products. A study on the management and input use in the Ethiopian floriculture sector has been carried out, including the Sher complex (Danse et al., 2007). For chemical spraying workers wear protection clothing and spraying mostly takes place at night, when other workers are not in the greenhouses. Spraying workers get a periodic health check. Chemical residues drain into the ground. The surface drainage channels that lead from the Sher-complex to the Bulbula river, drain rainwater collected from the greenhouse roofs.

Sher has the right to extract water from Bulbula river without having to pay any fees to the Ethiopian government. At the time of visit 81 ha was under irrigation. Per hectare about 26900 m^3 of irrigation water is used, which is representative for flower producers in Ethiopia. In total 2.2 million m^3 water is extracted from Bulbula river per year.

5.3 Open-field vegetable and fruit production systems on state farms

There are two arable state farms in the CRV. One located on the east side of Lake Langano in the *woreda* Munessa. This farm produces only rainfed crops (Section 6.2) The other state farm is located along the upstream part of the Bulbula river, south of the Sher complex.
North of Lake Ziway, another large farm is located, whether this farm is state or private owned is unknown. The main rainfed crop grown on this farm is green bean. Only small part of the total farm is in production. The largest part is currently used as pasture land.

5.3.1 Ziway State Farm

After sale of 300 ha to the Sher complex, that started production in June 2005, 700 ha is available for irrigated agriculture, of which 482 ha was cultivated in the 2005/2006 season. For the 2006/2007 season, 681 ha is planned to be cultivated. Another 350 ha is sold to the Sher complex, but is still in use by the state farm. Major crops grown are beans and maize for seeds production, in addition to other vegetables and fruits (Annex III).

According to the assistant manager, theft of crops is becoming a serious problem due to recent settling of migrants in the region. This has contributed to a net farm loss of 1.3 million Birr for the 2005/2005 production season. Before, net profit was approximately 700000 Birr/year.

5.3.2 Water use for irrigation

The water use for irrigation is comparable to that of smallholder farming. The farm uses a furrow system that is fed by a diversion channel from Bulbula river. The water is extracted by five pumps, of which one is not operational because of the reduced size of the farm, while another pump is standby and the other three are operational depending on the prevailing precipitation.
Although water management is similar to smallholder irrigation, three differences can be noticed. First, ditches at the Ziway State Farm are prepared by tractors and ploughs. As observed, this results in deeper ditches, especially for maize, than the ones made by oxen and plough. Second, the state farm grows different crops, for example maize for seed production and fruits. This maize is irrigated throughout its 150 days growing season. Furthermore fruit production on the state farm requires continuous irrigation throughout the year, nevertheless with a lower frequency than annual crops. Third, the pump capacity of the state farm is much larger than that of smallholders; in fact the state farm has a surplus capacity since the pump house was designed to irrigate over 1000 ha.
Because the effect of the deeper ditch depth on irrigation water use is hard to determine, only the effect of the cropping pattern for the 2005-2006 production season has been taken into account. The total water use during this season is estimated at 8.7 million m^3/year for the total 681 ha (12783 m^3/ha/year) (Annex IV).

5.4 Open-field vegetable and fruit production systems on private farms

The fourth production system found in the CRV is the open-field vegetable and fruit production on private farms. What distinguishes this production system from the smallholder system is the size of the farms. The Ethio-Flora farm on the bank of Bulbula river is such a farm. It is a mixed farm with both cattle and irrigated agriculture. Unlike the rest of the CRV, cattle is held in barns and in fenced fields. In contrast with many smallholder farmers that burn the residues of crops like maize, here residues are used to feed cattle.
The farm covers 70 ha and cultivates both fruits and vegetables. Most important crops are hybrid corn (23 ha), onion, green bean (7 ha) and papaya. Hybrid corn is the most profitable crop and is sold at a fixed price of 2,50 Birr/kg. Green beans are grown for the European market and are sold to a Dutch trader. Other crops are sold to a trader from Addis Ababa.
The farm employs 350 up to 400 workers of which most are seasonal workers. Furthermore the land is cultivated by tractors. The farm manager sometime faces the problem of workers that do not show up when they are self sufficient by the grain they produce on their own plots of land.

Figure 9. Fruit production (papaya) (a) and cattle (b) on the Ethio-Flora farm.

Besides the Ethio-Flora farm not many large private farms are located in the CRV. Only in Ziway Gugda *woreda* five farms are found (not visited), varying in size from 8 up to 54 ha. Major crops grown are vegetables like onion, tomato, potato, sugar cane and on one particular farm, soybean.

5.4.1 Water use for irrigation

Because all large-scale private farms use furrow irrigation, water use per ha will be comparable to that of smallholder farmers. Although some other crops are grown, like maize and soy beans, irrigation has been determined at approximately 12000 m^3/ha/season. Total water extraction by private farms in the CRV has been estimated to be 5.2 million m^3/year (Annex IV)

5.5 Comparison of water use

Four major water users can be distinguished regarding irrigated agriculture, i.e. open-field vegetable and fruit production systems on smallholder, state (Ziway State Farm) and private farms and closed vegetable and flower production systems (the greenhouses of the Sher complex). Total water extraction of each production system depends on several aspects: total area covered by the production system, type of crops grown, number and duration of the growing seasons and efficiency of the irrigation method. In Table 9 the total water extraction for each production system in the CRV is estimated. The water extraction per hectare per season for each production system as shown in Table 9 is calculated in previous sections. The number of growing seasons differs per production system. For the Sher complex one season is assumed to cover one year (365 days). For the Ziway State farm all separate growing seasons are summed (Annex V) and converted into one season. Most smallholders that grow vegetables attempt to have two seasons. Because all vegetables require approximately the same amount of irrigation water per season, a further differentiation within smallholder farming has not been made.

Table 9. Total water use for irrigation of four production systems.

Production system[1)]	Irrigation (m^3/ha/season)	No. of seasons	Area (ha)	Total water Extraction (Million m^3/year)	Percentage of total extraction
Open smallholder	10000	2	7305	146	90.1
Closed private	26900	1	81	2.2	1.3
Open state	-	1	-	8.7	5.4
Open private	10000	2	260	5.2	3.2
Total			7646	162.1	100

[1)] Open smallholder: Open-field vegetable and fruit production systems on smallholder farms
Closed private: Closed vegetable and flower production systems on private farms
Open state: Open-field vegetable and fruit production systems on state farms
Open private: Open-field vegetable and fruit production systems on private farms

Obviously, the area of each production system affects considerably the total water use by each system.

5.6 Effect of water use on the water balance

As can be seen in Table 9 total water use for irrigation in the CRV is approximately 162 Mm^3/year. Total evaporation from the lakes is estimated at 2506 Mm^3/year (Ayenew, 2004). This means that total water extraction for irrigation equals approximately 6,5% of annual evaporation. The size of Lake Abyata has decreased rapidly during the last years and has a volume of 800 Mm^3 (Legesse & Ayenew, 2006). Major human activities using water in the CRV are:

- Water use for irrigation
- Domestic water use by human population
- Water consumption by cattle population
- Water evaporation for soda-ash production

Major natural variation affecting water availability in the CRV:

- Variation in precipitation
- Variation in evapotranspiration
- Variation in water availability

Water consumption by the human and cattle population can be neglected, because this water remains within the catchment and is relatively small compared to other factors. The evaporation for soda-ash production is estimated at 1.5 Mm^3/year (Hengsdijk, 2007). With respect to natural changes some trends can be detected. Annual temperature tends to increase, possibly resulting in higher evapotranspiration (Hengsdijk, 2007). The annual precipitation, measured at several stations in the CRV, tends to be consistent over the period from 1966 till 1999 (Wako, 2004). From 1996 till 2005 however, annual precipitation tended to be decreasing with 10-15% (Hengsdijk, 2007). Such drops have occurred before and this decreasing precipitation trend is too short to call it a structural change in climate. As mentioned before, water use for irrigation is only a minor part of water outflow from the hydrological system compared to evapotranspiration.

Although human influences seem relatively limited, the direct impact of human interference in the hydrological system of Lake Abyata, i.e. Lake Abyata and Bulbula river, can not be neglected. Lake Abyata is fed by precipitation and inflow from Bulbula and Horakelo river. Some major irrigated production systems, like the Sher-complex, Ziway State Farm, two private farms and some smallholder plots, are located along Bulbula river. In total approximately 25 Mm^3/year is extracted from Bulbula river, equal to 10 to 15% of the annual discharge. Furthermore the soda-ash factory extracts water directly from Lake Abyata.

5.7 Future reduction of water use

Because irrigated agriculture in the CRV is still increasing, measures have to be taken to maintain economically viable and ecologically sound irrigated agriculture. Drip irrigation can be beneficial both for the environment as well as for the farmer. Through more effecient water use of water, the amount of water extracted can be reduced, which reduces fuel costs. In addition, often yields increase under drip irrigation due to more uniform and guaranteed supply of water. Especially, farmers in areas with insecure water supply may benefit from drip irrigation. Water harvesting in combination with drip irrigation enables them to practice irrigated agriculture for a longer period. Farmers can collect rain water or water from temporal rivers for use later in the growing season.

Yet, large-scale drip irrigation for smallholder farming is not common in Ethiopia yet. In the CRV some NGO's (e.g. OIDA and IDE) have started pilot projects. All projects make use of gravity in order to distribute the water through pipes and drip lines over the plot. The pipelines are connected to a barrel that is put on a platform. The barrel is filled by a motor or peddle pump from another water source (i.e. pond, dug well, river etc.)

6 Rainfed agriculture

With an area of over 320000 ha (≈ 25% of total area CRV) rainfed agriculture is still the most important livelihood in the CRV. Crop yields are generally low due to natural effects, like diseases and irregular precipitation, and the use of traditional instead of improved seeds. Most labour is carried out by hand. Machinery is only used for large plots, which are not very common for smallholders. Workers are sometimes hired for sowing, weeding, spraying agrochemicals and harvesting. Some farmers employ a labourer all year round. In most cases he lives and eats with the family and generally he does not receives a salary. Only in few cases he receives part of farmers' profit.

6.1 Smallholder grain and vegetable production

The crops grown in the rainfed area depend on micro-climatical conditions. The highland areas have lower temperatures and higher precipitations. This influences both the crop choice and the cropping pattern. The most important rainfed crops are wheat and maize, while in highland areas also barley is grown at a fairly large scale (Table 10).

Table 10. Crop area in rainfed area.

	Area (ha)	Percentage of total
Wheat	102841	32
Maize	74005	23
Barley	43245	13
Tef	37671	12
Haricot beans	17163	5
Potato	11593	4
Horse beans	7923	2
Sorghum	6317	2
Pea	6155	2
Onion	5600	2
Red pepper (berbere)	5372	2
Flex	2647	1
Rape	1015	0,3
Oat	250	0,1
Total	**321797**	**100**

The cropping pattern in rainfed areas is highly dependent on the rainy season, which lasts from early June till the end of September. Sowing takes place before or during the rainy season, dependent on the growing period of the crops, and most crops are harvested after the rainy season. A differentiation can be made between low- and highland areas with respect to the crop, growing period and the time of sowing and harvesting (Table 11).

In most *woreda'*s farmers are offered three input packages by cooperatives (Chapter 7), that may include improved seeds and fertilizers. In combination with the micro-climate, the used packages result in different crop yields. Because of variation in supply and demand, output prices fluctuate per year and within each year (Annex VI, both rainfed and irrigated crops). Higher crop yields can be obtained by the use of drought and disease resistant seeds, fertilizers and chemicals. Storage should be expanded and improved, both by farmers and cooperatives/unions, in order to supply all year long and sell products when prices are most profitable.

Table 11. Cropping pattern in the rainfed lowland and highland area.

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Rainfed Lowland						Maize						
							Wheat					
							Teff					
			Sorghum									
						Haricot bean						
Rainfed Highland				Maize								
						Wheat						
							Teff					
						Barley						
						Sorghum						
							Horse bean					
							Pea					

6.2 Grain and vegetable production on Munessa State Farm

The Munessa State Farm is a 2425 ha rainfed farm, located on the east side of Lake Langano (Figure 10). It is situated on one of the plateaus of the escarpment at an altitude of 2450 meters a.s.l. The state farm is under supervision by The Ministery of Public Enterprises. Government is the most important buyer in periods of drought for food programs. Otherwise most wheat is used for pasta production by private factories.

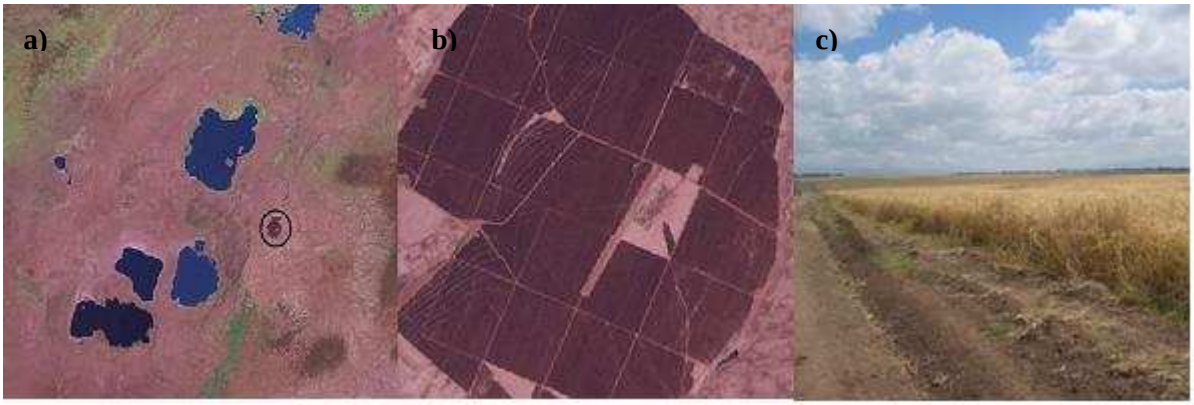


Figure 10. Munessa State Farm, (a) in circle, (b) detailed and (c) wheat production on farm.

The main crops grown are wheat (1701 ha), rape seed (385 ha) and horse bean (80 ha). In Figure 10 (b) an airstrip can be identified, which is used for spraying by airplane. Transport is done by road. According to the farm manager, annual profit is calculated at approximately three to four million Birr (Annex VII).

The farm has do deal with two major problems. First, is the irregularity of rainfall. In the period from 1991 to 2005 annual yearly rainfall varied between 533 and 889 mm with the highest precipitation from June till August. The second problem is the occurrence of diseases and the lack of resistant seeds. Agrochemical spraying is done by airplane, but nevertheless outbreaks and spread of diseases are hard to control.

7 Agricultural cooperatives for smallholder farming

The extent in which farmers cooperate strongly differs within the CRV. In some *woreda's* farmers are fairly well organized, while in other districts cooperation is not very common. Cooperation mainly consists of purchasing inputs like seeds, fertilizers and pesticides, but some cooperatives also collaborate in storing, transporting and selling their products

7.1 Water User Associations and cooperatives

In general, both traditional and modern irrigation schemes have some kind of cooperation and farmers have set up Water Users Associations (WUA). The extent of cooperation depends in particular on the support by (local) government and NGO's. Farmers within a WUA collaborate in pump use and they share fuel costs. When a WUA has a certain level of organization it reaches the status of cooperative (e.g. Horticulture Growers Cooperatives, service cooperatives). The structure of the cooperatives differs per *woreda*. In general, cooperation at this level involves two major activities, i.e. providing service and marketing products. Service consists of purchasing inputs like (improved) seeds, fertilizers, chemicals, sprayers etc. At the output side cooperatives try to increase bargaining power of members at markets. Products are sold by the cooperative directly to the local market or to a union. Cooperatives also store non-perishable crops to sell them when market prices have increased. A third activity of cooperatives sometimes involves the management of savings, for example for maintenance and for insurance in years with poor crop yields. Although farmers tend to organize, due to limited financial capabilities input supply to members is below desirable level and bargaining power is still very weak due to limited transportation possibilities.
Also water allocation is arranged within these organizations. Within the WUA or cooperative this is often not an issue. Between organizations in highland areas where farmers extract water from rivers however, allocation of the available water between upstream and downstream areas is often a problem. Cooperation between cooperatives in these areas in unions (Section 7.2) is often poor.

Also farmers that do not have irrigated plots have united themselves into peasant cooperatives. In almost every *woreda*, each *kebele* consists of one or more peasant cooperative. The model of these cooperatives is similar to those in irrigated areas and farmers face similar problems.

7.2 Unions

To increase the bargaining power of the peasant cooperatives, unions have been set up. Some unions are *woreda* based, others operate across *woreda*. By collective marketing unions try to improve output prices. Fixed prices for products can compensate farmers who have low quality products. As a result farmers leave the cooperatives because they get marginally better prices than by their own bargaining efforts. Other cooperatives and unions do not have fixed prices and farmers' profits depend on the quality of their products. Furthermore some unions provide their members with agronomic and technical advice with respect to irrigation system maintenance.

7.3 Input use and problems

Many farmers purchase inputs from cooperatives but sometimes also at the local market if prices are favourable. Farmer input use mainly depends on his/her financial situation. Farmers sometimes start production without improved seeds or agrochemicals, because they lack the finances to buy them timely. Another problem farmers and cooperatives face is the shortage of improved seeds, mainly maize and wheat seeds, because the supply by Ethiopian Seed Enterprise is insufficient. For this reason farmers are forced to use local seeds or buy (imported) improved seeds on the local market. The Ethiopian Seed Enterprise only sells nationally multiplied seeds, which have been improved by one of the Ethiopian Agricultural Universities or seed institutes.
Agrochemicals are also purchased from cooperatives and the local market. Agrochemicals used most are the fertilizers DAP and UREA. In highland areas on the eastern escarpment farmers have stopped using fertilizers because of favourable climatological and soil condition. Due to the use of fertilizers crops grow too rapid, resulting in weak stems and lodging of the crop. The most common used insecticides are

Malatine, Karate and DDT, the herbicides U46 and 2,4 D and the fungicides Ridomil, Mancozeb and Kocide. The amount of used chemicals is variable. Both fieldworkers and department officers confirm that farmers intend to use the amount that is recommended on the packing. However, agrochemicals are expensive and therefore sometimes farmers use less then the recommended amount. This results in low yields or even crop failure, and thus low income limiting investment possibilities for the next year.

8 Conclusions

Main livelihood of the rural population in the CRV is rainfed agriculture and cattle breeding. Although expanding, irrigated agriculture is still minor compared to rainfed agriculture. Productivity in both rainfed and irrigated agriculture is low. Inputs such as improved seeds are expensive and not always available or accessible for smallholders. The organisation of smallholders differs per *woreda* and *kebele*. The level of cooperation between farmers determines the capability of individual farmers to purchase inputs and to market their products. Better organisation of farmers will improve their position on the market and may help to have a rather constant income over the year.

The condition of many smallholder irrigation schemes is poor which contributes to inefficient use of water and high irrigation costs. Pumps are broken or not working at desired capacity and pipes and diversion canals are leaking. Many irrigation schemes are constructed with governmental or non-governmental support, but operational and maintenance support is often lacking or only partly received. Water Users Associations lack the know-how for proper maintenance of irrigation equipment and infrastructure and lack the financial skills to manage irrigation systems adequately over longer periods. Many WUA's do not have sufficient savings in case of (un)expected expenditure. Before new irrigation schemes are constructed, existing schemes should be rehabilitated and farmers should receive support on maintenance of systems, agricultural management and the management of Water User Associations should be reinforced to improve the cooperation among farmers in an effective way.

Water use for irrigation has increased rapidly during the last years. Compared to natural variability on the hydrology in the CRV, like precipitation and evapotranspiration, human interference is relatively small since water extraction for agriculture is only 6,5% of annual evapotranspiration. However, since 10% to 15% of Bulbula's discharge is directly extracted for agriculture and the Soda Ash factory is extracting from Lake Abyata, these extractions can have contributed to the decreased size of Lake Abyata.

Human population has increased rapidly in the CRV during the last decades. Both natural population growth and migration have caused an enormous pressure on the environment and available resources. The livestock population in the CRV is eminent, which has resulted in overgrazing at large-scale. The main livestock population consists of cattle, goats in lowland areas and sheep in highland areas. Livestock is kept mainly for draft, meat and social status and as savings for drought periods. Remarkable is the large human and livestock population in Shala-Abyata National Park.
Deforestation is another activity that contributes to the environmental degradation of the CRV. Illegal charcoal trading is an important complementary livelihood for many people and the only affordable source of fuel for most people in the CRV. The effect of deforestation on the microclimate, sediment run-off and soil degradation is unclear.

Besides subsistence agriculture some other livelihoods are available for rural population. The most important employers are the Sher-complex, the Ziway and Munessa State farm, some private farms and the soda-ash factory. In the future new livelihoods will have to be identified contributing to a sustainable development of the CRV. New livelihoods, however, may increase migration to the CRV as has happened in recent years which could increase the pressure on the natural resource base.

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Annex I Questionnaire Agricultural and Development Offices

Woreda:

1. General

total area **(ha)**		
	male	female
rural population		
urban population		
population growth		
total arable agricultural area in rain fed area **(ha)**		
prevailing soil types		
total agricultural area included pastoral land **unit……**		
total rain fed area		
total pasture area		
number of arable smallholder farmers in rain fed area (householders)		

average number of family members of arable farmers	
number of nomadic pastoralists	

number of large scale private enterprises		number of large state farms	
size of large scale private enterprises		size of large state farms	
major crops grown:		major crops grown:	

2. Crop information per cropping season in <u>rain fed area</u>

Yields

Crop					
total area					**specify**
crop yields rain fed area (kg/ha)* package 1					
crop yields rain fed area (kg/ha)* package 2					
crop yields rain fed area (kg/ha)* package 3					
growing season					
crop prices					
Crop					
total area					**specify**
crop yields rain fed area (kg/ha)* package 1					
crop yields rain fed area (kg/ha)* package 2					
crop yields rain fed area (kg/ha)* package 3					
growing season					
crop prices					
Crop					
crop yields rain fed area **unit……(kg/ha)***					**specify**
package 1					
package 2					
package 3					
growing season					

crop prices				

2. Crop information per cropping season in <u>rain fed area</u>

What are the major changes in grown crops in the last ten/twenty years?

What are the major problems in rain fed agriculture?

Or there relevant rural/agricultural development plans?

What is the opinion of the extension officer on the development of large-scale private farms?

What is the opinion of smallholders with respect to large-scale private farms?

Are the questions below the same for both irrigated and rain fed area's?

What is the reason for growing these crops?

Are the products sold on the market or to a middleman?

How is transport of products organised?

What is the availability of storage of perishable crops?

What are the post-harvest losses on average?

What happens with crop residues, if sold, what is the price?

What are the major changes in grown crops in the last ten/twenty years?

2. Irrigation Office

3

Crop information per cropping season in <u>irrigation area</u>

Yields

Crop					**specify**
crop yields irrigated land **unit…….(kg/ha)*** low					
crop yields irrigated land **unit…….(kg/ha)*** average					
crop yields irrigated land **unit…….(kg/ha)*** high					
growing season					
crop prices					
Crop					**specify**
crop yields irrigated land **unit…….(kg/ha)*** low					
crop yields irrigated land **unit…….(kg/ha)*** average					
crop yields irrigated land **unit…….(kg/ha)*** high					
growing season					
crop prices					
Crop					**specify**
crop yields irrigated land **unit…….(kg/ha)*** low					
crop yields irrigated land **unit…….(kg/ha)*** average					
crop yields irrigated land **unit…….(kg/ha)*** high					
growing season					
crop prices					

*specify in regions within the *woreda* when possible, and ask for reasons of the differences (altitude, soil, farmer, relief, fertilezers, pesticides)

2. Irrigation Office

4

Irrigation

total traditional irrigated land **(ha)**	
total modern irrigated land **(ha)**	
potential irrigated land	
number of farmers that use traditional irrigations methods	
number of farmers that use modern irrigations methods	
average plot size traditional irrigation **(ha)**	
population in irrigated area	
average family size	
main water sources	

2. Irrigation Office

5

Irrigation

Modern (joined in scheme)

number of modern schemes **(name/community)**					
number of members joined in each scheme					
area of the scheme **(ha)**					
supported by					
average plot size **(ha)**					
source of irrigation water					
average capacity of pumps **(l/s)**					

number of large scale private enterprises					
size of large scale private enterprises **(ha)**					
major crops grown					

number of large state farms					
size of large state farms					
major crops grown					

How are irrigation schemes organized (association, union)?

Are there regional irrigation development plans and if so, for what area?

Do farmers only use furrow irrigation or also drip irrigation?

What are the major problems of irrigated agriculture?

What is the opinion of the extension officer on the development of large-scale private farms?

What is the opinion of smallholders with respect to large-scale private farms?

4. Fertilizers (specify to traditional/modern irrigated agriculture, if possible/necessary) 6

percentage of farmers that use fertilizers	

Crop				
name of fertilizer				
type of fertilizer (organic, chemical, ……)				
amount **unit……..(kg/ha)**				
period of use during cropping season				
costs of the fertilizer **unit…….(Birr/l)**				
name of fertilizer				
type of fertilizer (organic, chemical, ……)				
amount **unit……..(l/ha)**				
period of use during cropping season				
costs of the fertilizer **unit…….(Birr/l)**				

yield loss due to absence of fertilizers **unit……..(kg/ha)**				

total amount of fertilizers used	type	amount (kg or l)

How is the access to fertilizers organised (association, union)?

5. Pesticides (specify to traditional/modern irrigated agriculture, if possible/necessary) 7

percentage of farmers that use pesticides				
Crop				
pesticide name				
amount **unit……(l/ha)**				
against what diseases/pests				
period of use during cropping season				
costs of the pesticides **unit……(Birr/l)**				
pesticide name				
amount **unit……(l/ha)**				
against what diseases/pests				
period of use during cropping season				
costs of the pesticides **unit……(Birr/l)**				
pesticide name				
amount **unit……(l/ha)**				
against what diseases/pests				
period of use during cropping season				
costs of the pesticides **unit……(Birr/l)**				
yield loss due to absence of pesticides **unit……..(kg/ha)**				

How is the access to pesticides organised?

Do farmers use pesticides that are prohibited? If so, which?

6. Cooperative office

8

Marketing/Prices rain fed area

Crop				
total area of grown crop **unit…….(ha)**				
prices of market crops **unit…….(Birr/ha) or (Birr/kg)**				
Crop				
total area of grown crop **unit…….(ha)**				
prices of market crops **unit…….(Birr/ha) or (Birr/kg)**				

Marketing/Prices irrigated area

Crop				
total area of grown crop **unit…….(ha)**				
prices of market crops **unit…….(Birr/ha) or (Birr/kg)**				
Crop				
total area of grown crop **unit…….(ha)**				
prices of market crops **unit…….(Birr/ha) or (Birr/kg)**				

What determines the price (diseases, supply and demand, holidays)?

6. Cooperative office

9

who is cutting the wood			
which wood is felt			
for what purpose			
for market of self-sufficiency			
if marketed, what are the prices			
is the wood replanted			

What are other important means of living in the *woreda?*

How many people work in that industry?

What are the wages in this industry?

How much water do they use?

7. Livestock

10

specify	Livestock (ox, cattle, sheep, goats, horses, mules asses, poultry)				
arable smallholder farms in irrigated area	cattle (incl. oxen)	goat	sheep	donkey	horse
total number					
use of livestock					

	Livestock (ox, cattle, sheep, goats, horses, mules asses, poultry)				
arable smallholder farms in rain fed area	mule	poultry			
total number					
use of livestock					

Does the office carry out a certain policy?

Annex II List of contacted persons

Contacted person	Organization	Function	Contact details		
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Annex III Ziway State Farm

Table 12. Cost - benefit analysis Ziway State Farm.

Crop	Area (ha)	Kg/ha	Total (kg)	Unit Price (Birr)	Total Revenue (Birr)	Total costs (Birr)	Total profit/loss per crop	Revenue/ha	Cost/ha	Revenue/kg	Cost/kg	Profit/kg
Fruit												
Papaya fruit bearing	10	42000	420000	0,78	328398	279175	49223	32840	27918	0,78	0,66	0,12
Papaya new	5	0	0	0,00	0		0	0	0	0,00	0,00	0,00
Avocado fruit bearing	4	20900	83600	1,26	105436	120848	-15412	26359	30212	1,26	1,45	-0,18
Grape vine fruit bearing	30	7000	210000	3,65	766500	1020171	-253671	25550	34006	3,65	4,86	-1,21
Grape vine new	10	0	0	0,00	0	0	0	0	0	0,00	0,00	0,00
Sub total	**59**		**713600**		**1200334**	**1420194**	**-219860**	**20345**	**24071**	**1,68**	**1,99**	**-0,31**
Vegetables												
Beans	200	7000	1400000	18,71	26194000	27584163	-1390163	130970	137921	18,71	19,70	-0,99
Onion	50	16500	825000	1,26	1041728	980276	61452	20835	19606	1,26	1,19	0,07
Tomato	38	37800	1436400	0,72	1036937	660790	376147	27288	17389	0,72	0,46	0,26
Green chilies	6	8400	504	1,76	88759	86711	2048	14793	14452	176,11	172,05	4,06
Sub total	**294**		**3711800**		**28361424**	**29311940**	**-950516**	**96467**	**99700**	**7,64**	**7,90**	**-0,26**
Seed production												
Maize seed (P.H.C.)	150	6000	900000	2,55	2295000	1234371	1060629	15300	8229	2,55	1,37	1,18
Maize seed (E.S.E.)	150	5500	825000	2,55	2103750	1231837	871913	14025	8212	2,55	1,49	1,06
Onion seed	3	400	1200	173,88	208656	116654	92002	69552	38885	173,88	97,21	76,67
Sub total	**303**		**1726200**		**4607406**	**2582862**	**2024544**	**15206**	**8524**	**2,67**	**1,50**	**1,17**
Cereals												
Maize	25	7500	187500	1,00	187500	196540	-9040	7500	7862	1,00	1,05	-0,05
Sub total	**25**		**187500**		**187500**	**196540**	**-9040**	**7500**	**7862**	**1,00**	**1,05**	-0,05
Total	**681**		**6339100**		**34.356.664**	**33511536**	**845128**	**50450**	**49209**	**5,42**	**5,29**	**0,13**

Table 13. Production pattern Ziway State Farm.

Crop	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Fruit													
Papaya fruit bearing	10	0	0	0	0	0	0	0	0	0	0	0	10
Papaya new	5	0	0	0	0	0	0	0	0	0	0	0	5
Avocado fruit bearing	4	0	0	0	0	0	0	0	0	0	0	0	4
Grape vine fruit bearing	30	0	0	0	0	0	0	0	0	0	0	0	30
Grape vine new	10	0	0	0	0	0	0	0	0	0	0	0	10
Sub total	**59**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**59**
Vegetables													
Beans	0	0	0	25	50	50	50	25	0	0	0	0	200
Onion	24	6	6	5	5	4	0	0	0	0	0	0	50
Tomato	17	4	4	4	3	3	3	0	0	0	0	0	38
Green chilies	0	0	0	3	3	0	0	0	0	0	0	0	6
Sub total	**41**	**10**	**10**	**37**	**61**	**57**	**53**	**25**	**0**	**0**	**0**	**0**	**294**
Seed production													
Maize seed (P.H.C.)	150	0	0	0	0	0	0	0	0	0	0	0	150
Maize seed (E.S.E.)	150	0	0	0	0	0	0	0	0	0	0	0	150
Onion seed	0	3	0	0	0	0	0	0	0	0	0	0	3
Sub total	**300**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**303**
Cereals													
Maize	25	0	0	0	0	0	0	0	0	0	0	0	25
Sub total	**25**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**25**
Total	**425**	**13**	**10**	**37**	**61**	**57**	**53**	**25**	**0**	**0**	**0**	**0**	**681**

Annex IV Water use by private farms

Table 14. Water use by private farms.

	Area (ha)	Water use (m3/ha/season)	No. of seasons	Total water use (m3/year)
Ziway Gugda	190	10000	2	3800000
Ethio-Flora	70	10000	2	1400000
Total	260			5200000

Annex V Water use by Ziway State Farm

Table 15. Water use Ziway State Farm.

	Irrigation (m^3/ha/session)	No. of sessions	Irrigation (m3/ha/season)	Area (ha)	Total irrigation (m3/season)
Maize	750	20	15000	300	4500000
Green beans	750	14	10500	200	2100000
Onion	750	15	11250	50	562500
Tomato	750	15	11250	38	427500
Green pepper	750	15	11250	6	67500
Avocado	750	28	21000	4	84000
Grape	750	16	12000	30	360000
Papaya	750	16	12000	10	120000
Other	750	15	11250	43	483750
Total				681	8705250

Annex VIa Prices, productivity and area of crops in irrigated agriculture

Table 16. Prices irrigated crops (Birr/kg).

		Tomato	Onion	Cabbage	Green pepper	Papaya	Potato	Sugar Cane	Carrot	Beetroot
Prices	Low	1,00	0,50	-	-	-	0,40	-	-	-
(Birr/kg)	Average	1,60	2,00	0,90	1,00	0,60	0,55	1,20 [1)]	?	?
	High	2,20	3,50	-	-	-	0,70	-	-	-

1) price per cane

Table 17. Crop area in irrigated area 2005/2006 (ha).

	Tomato	Onion	Cabbage	Green pepper	Papaya	Potato	Sugar Cane	Carrot	Beetroot
Dugda Bora	1838	2194	347	437	280	-	-	-	-
Adami Tulu Jido Kombolcha.	?	?	?	?	-	-	-	-	-
Ziway Gugda	?	?	?	?	-	-	-	-	-
Tiyo	20	-	-	-	-	118	32	-	-
Degeluna Tijo					-	896	-	67	60
Meskana	48	177	16	-	-	95	-	-	-
Mareko									
Munessa	48	177	16	-	-	95	-	-	-
Arsi Negel	10	39	4	-	-	35	-	11	8
Sodo	7	115	-	-	-	34	-	-	-

Table 18. Average crop yields in irrigated area 2005/2006 (kg/ha).

	Tomato	Onion	Cabbage	Green pepper	Papaya	Potato	Sugar Cane	Carrot	Beetroot
Lowland	26000	16000	12000	6000	45000	15000	-	-	-
Highland	11000	10000	-	-	-	9000	?	?	?
State farm	37800	16500	-	8400	42000	-	-	-	-

Annex VIb Prices, productivity and area of crops in rain fed agriculture

Table 19. Prices rainfed crops (Birr/kg).

		Tef	Wheat	Maize	Barley	Haricot bean	Horse bean	Sorghum	Pea	Rape	Flex
Prices	Low	2,60	1,80	1,10	1,30	1,60	1,80	1,80	2,70	2,80	2,40
(Birr/kg)	Average	3,60	2,70	1,60	2,30	2,30	3,20	2,30	3,15	3,15	3,05
	High	4,60	3,60	2,10	3,30	3,00	4,60	2,80	3,60	3,50	3,70

Table 20. Rainfed crop area (ha).

Woreda	Teff	Wheat	Maize	Barley	Haricot bean	Horse bean	Sorghum	Pea	Rape	Flex	Red pepper	Onion	Potato	Ohters
Dugda Bora	12354	16231	20409	-	12721	-	-	-	-	-	-	-	-	4590
Adami Tulu Jido Kombolcha.	?	?	?	?	?	?	?	?	?	?	-	-	-	?
Ziway Gugda	4987	8981	11027	-	-	-	-	-	-	-	-	-	-	6727
Tiyo	1250	11273	845	7209	-	1727	642	1160	305	-	-	-	-	630
Degeluna Tijo	-	17195	1100	16340	-	2150	-	1222	1015	2342	-	-	-	609
Meskana	4372	2345	5336	567	405	650	657	970	-	-	2379	550	-	3909
Mareko	-	4584	4752	-	1750	-	1150	-	-	-	2860	1050	-	582
Munessa	911	15571	5083	15968	342	1311	2145	70	-	-	-	-	-	6516
Arsi Negele	2909	18907	21330	1454	1940	-	-	-	-	-	-	4000	11550	-11013*
Sodo	-	7754	4125	1707	-	2085	1720	2733	-	-	133	-	43	2500

* Arsi Negele has a spring and a summer season, so total crop coverage exceeds total arable land

- Not considered as major crop or crops not grown in woreda ? Information not available at moment of visit or not available at all

Table 21. Average crop yields in rainfed area (kg/ha).

		Tef	Wheat	Maize	Barley	Haricot bean	Horse bean	Sorghum	Pea	Rape	Flex	Red pepper	Onion	Potato
Low land	Local seeds	1400	3000	1000-4000	-	800-1400	-	-	-	-	-	-	-	-
	Local seeds + fert.	1600	3600	4800	-	1400	-	-	-	-	-	-	-	-
	Impr. Seeds + fert.	1800	3800	5600	-	1600	-	-	-	-	-	-	-	-
Highland	Local seeds		-	2000	1500	-	1400	-	1100	1500	1200-1500	600	-	-
	Local seeds + fert.		2800	3000	2300	-	1600-2200	1800	1400-2200	-	-	1600	6000	4000
	Impr. Seeds + fert.		3200	-	3000	-	2200-2700	2600	2700	-	1600-2000	-	-	5000

Annex VII Munessa State Farm

Table 22. Cost - benefit analysis of Munessa State Farm.

Crop	Area (ha)	Typical yield performance (kg/ha)	Costs (Birr/kg)	Benefits[1] (Birr/kg)	Total average profit (Birr)	Total average profit (Birr/ha)
Wheat	1701	3200 – 3400	1,20	2,00 – 2,60	4240000	2500
Rape seed	385	1600 – 200	1,70	2,50 – 3,20	500000	1300
Horse bean	80	1500 - 1700	1,40	2,50 – 3,00	120000	1500
Other	3					
Not in use	266					
Total	2435				4860000[2]	2000

Includes 15% tax

Does not match with the profit as indicated by the farm manager. This will be the cause of fluctuations in yield, costs and returns.