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Importance of Irrigated Agriculture to the Ethiopian Economy: Capturing the direct net benefits of irrigation

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Abstract

Irrigation development is seen as one of the means to reduce poverty and promote economic growth. While a lot of effort is exerted towards irrigation development, little attempt is done to quantify the contribution of irrigation to national income in Ethiopia. This study is an attempt to quantify the actual and expected contribution of irrigation to the Ethiopian national economy for 2005/06 cropping season and 2009/10 using adjusted net gross margin analysis.

Our results show that irrigation in the study sites generates an average income of about USD 323/ ha. This compares to the calculated gross margin for rainfed which is USD 147/ha. This indicates that after accounting for annual investment replacement cost net gross margin from irrigation is more than twice higher than gross margin from rainfed agriculture. On the contribution of irrigation to national economy, in 2005/06 smallholder irrigated agriculture contributed about 262.3 million USD. This accounts for about 4.46 percent of the agricultural GDP in 2005/2006 and 1.97 percent of the total overall GDP. The total income earned from large scale schemes is estimated to be about 74.0 million USD. This accounts for about 1.26 percent of the agricultural and 0.5 percent of the total GDP respectively. Overall, the contribution of irrigation to agricultural and total national GDP was about 5.7 and 2.5 percent during the 2005/06 cropping season.

As a result of expansion, by the year 2009/2010 the expected contribution of

smallholder managed irrigation to national economy, assuming that exiting cropping pattern, and the average gross margin values for different crop categories are still valid, is expected to increase from USD 262.3 million in 2005/2006 to about USD 414.2 million in 2009/2010, which accounts to about 5.5 percent of the agricultural GDP and 2.3 of the overall GDP for the same year. On the other hand, the contribution coming from the large scale sugar growing estates in 2009/2010 is estimated to be USD 217.5 million which amounts to 2.9 and 1.2 percent of the agricultural and overall GDP respectively. Similarly the contribution coming from large scale commercial farms growing crops other than sugar cane is expected to increase to USD 35.8 million in 2009/2010 which accounts to 0.4 and 0.2 percent of the agricultural and overall GDP respectively. This implies that large scale commercial farms will contribute about 3.3 and 1.4 of the agricultural and overall GDP respectively. In summary, our results indicate that under conservative estimates the future contribution of irrigation to agricultural and overall GDP will be about 9 and 3.7 percent respectively.

When some of the assumptions related to cropping pattern, input and output prices,

and efficiency levels are relaxed, the contribution of smallholder managed irrigation to agricultural and overall GDP will vary between 4 to 6 and 1.8 to 1.9 percent respectively. Similarly, the contribution from large scale irrigation to agricultural and overall GDP will be in the range of 3 to 6 and 1.2 to 2.5 percent respectively. Overall, the future contribution of irrigation to agricultural GDP will be in the range of 7 to 12 percent while the contribution to overall GDP will be in the range of about 4 percent. To enhance the contribution of irrigation to national economy, besides increasing the presence of physical water infrastructure, however, there is a need to: i) improve provision of agricultural inputs, ii) promote high value crops through the extension system, iii) create good market conditions, and iv) increase the efficiency of small and large schemes.

1. Introduction

Unreliable rainfall, recurrent drought and limited use of the available water resources, coupled with heavy reliance on rain-fed subsistence agriculture, have contributed adversely to the economy of Ethiopia. In fact, the World Bank (2006) estimates that unmitigated hydrological variability currently costs the economy over one-third of its growth potential and leads to 25 percent increase in poverty rates. Hence, enhancing public and private investment in irrigation development has been identified as one of the core strategies aimed to de-link economic performance from rainfall and to enable sustainable growth and development (World Bank 2006; MoWRa, 2002; MoWR, 2002b; MOFED, 2006). In the government policy documents, irrigation development is identified as an important tool to stimulate sustainable economic growth and rural development and is considered as a corner stone of food security and poverty reduction (MoWRa, 2002; MoWR, 2002b; MOFED, 2006).

Ethiopia is said to have an estimated irrigation potential of 3.5 million hectares (Awulachew et al. 2007). However, the total estimated area of irrigated agriculture in the country in 2005/2006 was 625,819 ha, which in total constitutes about 18 percent of the potential (MOWR, 2007).

Irrigation is expected to contribute to the national economy in several ways. At the micro level, irrigation could lead to an increase in yield per hectare and subsequent increases in income, consumption and food security (Bhattarai and Pandy, 1997; Vaidynathanet al., 1994; Ahmed and Sampath, 1992; Lipton et al. 2003; Hussain and Hanjra, 2004). Furthermore, Hussain and Hanjra (2004), based on their studies in Asia, indicated that irrigation benefits the poor through higher production, higher yields, lower risks of crop failure, and higher and year round farm and non-farm employment. Irrigation enables smallholders to adopt more diversified cropping pattern, and to switch from low value subsistence production to high-value market-oriented production (Hagos et al., 2007).

Macro level impacts manifest themselves through agricultural impacts on economic growth. At the aggregate level irrigation investments act as production and supply shifters, and have a positive effect on economic growth. Studies in Asia show that agricultural growth serves as an “engine” of economic growth, and irrigation-led technological changes are the key drivers behind productivity growth in the agricultural sector (Hussain and Hanjra 2004; Alagh, 2001; Dhawan, 1988). Other effects of irrigation on changes in the environment and other social impacts have been reported in the literature such as on the economic value of wetlands (Barbier and Thompson, 1998); employment impact of irrigation (Berck and Hoffman, 2002) and non-farm sector benefits from irrigation investment (Bhattarai, et al. 2003).

The methodological approaches applied to capture these diverse impacts of irrigation varied from linear programming, to regression models, to partial equilibrium models, to economy–wide models such as input-output models, Social Accounting Matrices (SAM) and Computable General Equilibrium (CGE) Models. For instance, Bhattarai and Pandy (1997) used a linear programming technique to isolate the impact of irrigation from other factors (such as road and market) on crop production and productivity in Nepal. Vaidynathan et al. (1994) used regression analysis at the aggregate level to assess the difference in land productivity between irrigated and un irrigated lands in India. Ahmed and Sampath (1992) used a partial equilibrium model that incorporates demand and supply shifts to assess the impact of irrigation on efficiency and equity in Bangladesh. Makombe (2000) used a similar partial equilibrium model to estimate the impact of irrigation induced technological change in Zimbabwe. Bell and Hazel (1980) used SAM and a semi input-out model to measure the magnitude and incidence of regional downstream effects of the Muda irrigation project in Malaysia. While there are various studies that have tried to capture the diverse impacts of irrigation, there are, however, few studies that attempted to capture the direct contribution of irrigation to the national economy. One such study is by Doak et al., (2004) and Doak (2005) which develop a simple methodological framework to measure the economic value of irrigation to the New Zealand's National economy. Our study builds on the approach followed by Doak et al., (2004) and Doak (2005).

The objective of this study, hence, was to estimate the net contribution of irrigation to GDP at the farm gate. This study attempted only to capture the direct benefits of irrigation to national economy for a given year (2005/2006) using a farm gate value approach and made forecasts on its future contribution based on the projected annual growth-rate of irrigated areas in the National Irrigation Development Program (MoWR, 2002b; MOFED, 2006) and associated changes in cropping patterns. In so doing, we tried to determine how much irrigation is contributing and will contribute to national income relative to rain fed agriculture. This method of adjusted gross margin analysis accords with the System of Environmental and Economic Accounts (SEEA) recommendations (UN, 2003) and provides a "best estimate" of the change in GDP generated by irrigation at the farm gate (Doak, 2005). However, it should be noted that a large number of estimates and assumptions are required to estimate the impact on GDP, and the results should be interpreted with caution. In addition, the increased output from irrigated farms will have different multiplier effects in the wider economy, so the total impact of irrigation on GDP is likely to be higher than the farm gate impact.

For estimating the contribution of smallholder irrigation we relied on data collected during the 2005/6 season from eight smallholder irrigation schemes in four regional states in Ethiopia, namely Amhara, Oromia, Southern Nations Nationalities and Peoples Regional Government (SNNPR) and Tigray. The data collected included command area, actual cultivated area cropping pattern, output types and value, input use and input expenditure and information on the level of operation, (e.g. fully operational, medium, low or not operational). Moreover, we used secondary data gathered from selected large scale commercial farms in the Awash and Nile Valleys and price data and production data from the Central Statistical Authority (CSA).

The research report is presented as follows. Section two outlines the methodology used to value the contribution of irrigation to the national economy followed by presentation of data sources in section three. In section four we present an overview of the contribution of agriculture to national economy while section five outlines the hitherto irrigation development in Ethiopia

followed by, in section six and seven, by presentation of agricultural production and cropping pattern, both rainfed and irrigated respectively. In section eight, we present the envisaged future expansion of irrigated agriculture based on the National Irrigation Development Program (IDP). Sections nine and ten present the results of the valuation, current and future, to national economy. In section eleven, we conduct sensitivity analysis to take account of possible changes in cropping patterns and crop cover, in input and output prices and improvements in efficiency levels. The final part concludes and draws some policy recommendations.

2. Methodology in valuing the contribution of irrigation for the national income

The methodology calculates the contribution of existing irrigation to gross domestic product (GDP) by taking into account the alternative rainfed production from the same area of land. The method adopted follows a "with minus without" irrigation approach, adjusted for changes in farm type and scale.

Following Doak (2005) the formula is:
Farm gate GDP due to irrigation = GDP with irrigation – GDP without irrigation.
*= (irrigated land use mix * (irrigated Gross Margin – fixed costs)) – (rainfed land use mix * (rainfed Gross Margin – fixed costs)).*

(1)

A gross margin is the total revenue associated with a particular production (income) less the costs that clearly vary in direct proportion to the level of production - the direct or variable costs associated with the enterprise. Gross margin analysis is an accepted tool commonly used in the evaluation of farming enterprises. It has been used for the evaluation of the costs and benefits of irrigation in cost benefit analysis. Assessing the change to the gross margin per unit area as a result of irrigation and then scaling this appropriately by the total affected area provides an initial estimate of the GDP change (at the farm gate) likely to occur as a result of irrigation.

In the Ethiopian context, farmers use full irrigation to grow crops during the dry season when crop production from rain is not possible. This implies that households get additional income from irrigation to that what farmers get during the main cropping season. Under small scale irrigation system, irrigation does not replace rain fed agriculture but supplements it. Large scale schemes, however, are under full irrigation throughout the year. We made adjustments in the methodology to take account of this difference between small and large scale irrigation. Hence, for a given farmer i under smallholder agriculture,

$$NetIncome_i = Netm\arg in_{irrig} + Netm\arg in_{rf} \quad (2),$$

where the total income constitutes of income from rainfed and income from irrigation.

The gross margins (GMs) were determined for farm types in each of the schemes and aggregated to a scheme scale throughout Ethiopia based on the data obtained from the household surveys and secondary sources. The gross margins are those for the 2005/06 season and are defined as the revenue generated from the activity less the direct costs of producing the revenue. The Gross Margins were adjusted to account for the differences in overheads (fixed costs) of land uses with and without irrigation, and also for differences in shadow prices of labor and oxen in irrigated and rain fed systems (for the small scale schemes). Shadow prices of labor and oxen were estimated from the production data by first estimating labor elasticity, which was used to estimated the marginal value of labor, in a production function framework (for details see Jacoby, 1993).

The "without irrigation" land use is that which would now exist if irrigation had not been developed, rather than if irrigation was

no longer available for that particular land. This was estimated based on GM of rain fed agriculture around the scheme or average GM value for all rainfed, if data for adjacent rainfed plots were not available. The value of irrigated production and the value of production from the rainfed use that would be most likely if there was no irrigation were derived from the survey data for each scheme. For the large scale schemes, we explored the dominant rainfed production type and estimated average gross margins per ha from the household survey.

The assumption here is that all of the now irrigated lands would have been under some sort of rain-fed farming had it not been converted to irrigation plots. There are also some other possible scenarios. It is possible that some of the current irrigated lands are hitherto uncultivated lands or new openings[5]. If this is true, the methodology we adopted may underestimate the true contribution of irrigation development without considering the environmental costs of such changes. It may be that the current irrigated land may have been used for grazing livestock[6]. The direction of bias on our estimation depends on whether the gross margin per unit area from livestock rearing is greater or less than the gross margin per unit area for cropping under rainfed. While a meaningful analysis should take account of these diverse scenarios, the lack of data on livestock productivity under pastoral production in Ethiopia and environmental costs of land use change made it impossible. Hence, the approach described above (in equations 1 and 2) was used to assess the current and future contribution of irrigation to the national economy.

For the fixed cost, we calculated an annual replacement cost all on per ha basis. Annual replacement cost was computed as initial investment divided by project lifetime (25 years) and O & M was assumed to be 10 percent of annual replacement for small scale schemes and 50 yrs and 5 percent for large scale schemes (Inocencio et al., 2007).

In estimating the future contribution of irrigation to national economy, we used information about the expected growth of the irrigation sector during 2005/2006 to 2009/2010 based on the country's Irrigation Development Program (IDP) (MoWR, 2006; World Bank, 2006; MOFED, 2006). These policy documents outline how irrigation is expected to develop over the planning period. The details are provided in section eight of this paper.

A complex issue related to the calculation of the future contribution of irrigation to the national economy is how to address the impact of increased output on price. Gross margin calculations generally assume that a change in output has no effect on prices. While for small-scale changes at the individual farm level this may well approximate the truth[7], the large-scale land use changes generated by irrigation on the national scale are believed to be sufficient to have some measurable effect on output prices. Lipton et al. (2003) state that if irrigation leads to increases in staples or non-staple food output then this may result in lower prices for staples and food in imperfectly open economies or if there are significant transport costs from food-surplus area to towns or food deficit areas. For crops that are largely dependent on the local market and for which there is little opportunity to develop large-scale export markets increases in production tend to have a dramatic effect on price (Doek, et al., 2004). A complicating factor in assessing the impact of future irrigation-driven increases in output on price is also that growers of annual crops are very flexible in the combinations of crops that they choose to grow (Doak et al., 2004). If, for example,

[5] The development of Finchaaa Sugar estate is a case in point.

[6] The development irrigation in the middle and lower Awash is a case in point.

[7] Even at the small scale, we observe increases in crop output of tomato and onion leading to crashes in prices.

potatoes are in over supply, growers would switch to another crop which proves more profitable. The farmer is, therefore, able to choose the most profitable product to produce, and to increase the value of the product e.g., by producing at a time of the year when price is highest, or by increasing the quality of the product (for example, through improved fruit size). There is also the possibility that as irrigation expands, it tends to get more government support e.g. extension and hence intensification can increase. This upside potential has by and large been included in the analysis. We suggested possible scenarios in changes in cropping patterns. However, it is difficult to exactly forecast the possible future changes in cropping patterns. The crop combinations and gross margins used in the analysis are, therefore, only indicative of a range of possible crops with similar outcomes.

To quantify the price effect of irrigation development we assumed different price scenarios based on certain assumptions about demand growth and output growth. In the light of all these considerations, we assumed different price changes in price of the major produce when assessing the impact of future irrigation driven increases in output. This is described in detail in section ten of this report.

Finally, there are a host of multiplier effects expected to manifest themselves with irrigation development, including expansion of the off-farm sector, provision of inputs to industry and better nutrition for rural households. These effects are not captured in this study. Our calculated GDP represents, at best, the return to producers' labor and capital (including capital tied up in land). It is also worth noting that the high income sector of irrigation (emerging flower farming and capital intensive commercial farms are not included in our assessment. Our method therefore underestimates the true contribution of irrigation to GDP.

3. Data sources

This study made use of both primary data on smallholder production collected from household surveys and data from various secondary sources. The household survey was part of a comprehensive nationwide study on the impacts of irrigation on poverty and environment run between 2004 and 2007 in Ethiopia. It was a component of the Impact of Irrigation on Poverty and Environment (IIPE) research project run by the International Water Management Institute (IWMI) with support from the Austrian government. The survey, which investigated the impact of irrigation on poverty and irrigation's contribution to national economy, addressed a total sample size of 1024 households from eight irrigation sites in 4 regional states involving traditional and modern and rainfed systems. The total sample comprised 397 households practicing purely rainfed agriculture and 627 households (382 modern and 245 traditional) practice irrigated agriculture. These households operate a total of 4,953 plots (a household operating five plots on average). The data collected include demographics, asset holdings, access to services, plot level production and sale and input use data (distinguished between irrigated and rain fed), constraints to agricultural production and household perceptions about the impact of irrigation on poverty, environment and health and other household and site specific data. The data were collected for the 2005/2006 cropping season. We used part of this comprehensive dataset for the analysis here.

We also used secondary data from various sources. From the large scale schemes we gathered data on investment cost/initial capital outlays, cost of production, output and revenue among others. From official documents such as the policy documents of the government (MoWR, 2006; World Bank, 2006; MoFED, 2006) we gathered developed and projected irrigation development plans and we used land utilization and crop cover data from the Central Statistics Agency (CSA, 2006). Furthermore, for specific data on future

expansion and new development plans on sugar estates we used the revised master plan of the Ethiopian Sugar Development Agency (ESDA, 2007). The plans for the development of small scale irrigation are prepared by the regional governments and are compiled by the Ministry of Agriculture and Rural Development that oversees the development of the sub-sector.

4. Contribution of agriculture to national economy

Agriculture is the main stay of the Ethiopian economy. It is major contributor to the national economy both in terms of income, employment and generation of export revenue. Its contribution to GDP, although showing slight decline over the years, has remained very high, about 44 percent. From among the sub-sectors of agriculture, crop production is major contributor to GDP accounting for about 28 percent in 2005/06. The most important crops grown and their area coverage are described in section six and seven.

Table 1: Contribution of Agriculture to GDP (in 000 Birr) (1995/96-2005/06)

Year	GDP at Current Market Prices	Agricultural GDP	Crop GDP	Agri contribution to GDP	Crop contribution to GDP
1995/96	53,597,593	28,613,235	17,286,203	0.53	0.32
1996/97	55,520,011	28,767,766	16,764,422	0.52	0.30
1997/98	53,391,285	25,214,701	14,505,336	0.47	0.27
1998/99	57,368,203	25,397,662	15,500,013	0.44	0.27
1999/00	64,397,933	28,444,382	17,713,717	0.44	0.28
2000/01	65,687,343	27,750,560	16,333,285	0.42	0.25
2001/02	63,461,569	24,460,704	13,135,220	0.39	0.21
2002/03	68,898,037	26,207,930	14,963,341	0.38	0.22
2003/04	81,754,514	32,229,991	19,746,954	0.39	0.24
2004/05	98,397,946	42,196,370	27,349,050	0.43	0.28
2005/06	115,589,480	50,893,906	32,246,432	0.44	0.28

Source: FDRE (2006).

5. Overview of irrigation development in Ethiopia

Ethiopia is said to have an estimated irrigation potential of 3.5 million hectares of irrigation land (Awulachew et al. 2007)[8]. The total estimated area of irrigated agriculture in the country is about in 2005/2006 was 625,819 ha, out of which 483, 472 is from the traditional irrigation, 56032 ha is from modern small scale,

[8] Other estimates put it in the order of 3.7 million hectares (MoWR, 2002; World Bank, 2006).

86,612 ha is from modern medium and large scale schemes. Out of the total irrigated area, 197,250 ha is covered by the so-called modern schemes while the remaining area traditional schemes (MoWR, 2002). The total and modern irrigated area account for about 17 and 5 percent of the potential respectively. The total cultivated land area, rainfed included, in 2005/06 was about 12.28 million hectares (MOFED, 2006). The total current irrigated land area, hence, accounts for about 5 percent of the total cultivated land. When the traditional schemes are not considered, the irrigated land area covers a minimum of about 1.6 percent of the total cultivated area.

There is high spatial variability in water resources endowment and development in the country. Hence, ninety percent of the country's water resources development occurs in four river basins (World Bank, 2006). Much of the formal irrigation developments are located in the Awash Basin, where about 50 medium- and large scale irrigated farms are located (Fig. 1).

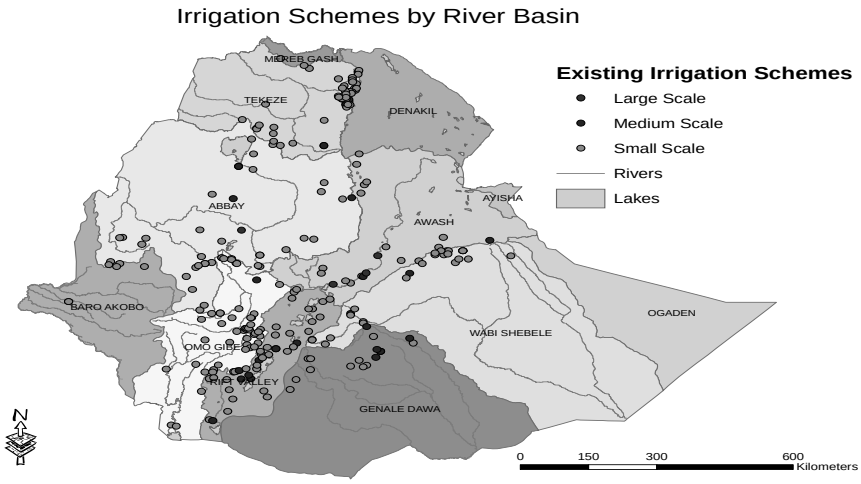

Fig.1: Existing Irrigation Schemes in various river basins in Ethiopia (Source: Awulachew, et al. 2007)

In terms of regional distribution, Afar and Oromia have the bulk of the share in irrigated agriculture accounting for 45 and 31 percent of the total irrigated area. Amhara, SNNPR and Tigray account for 8, 7 and 5 percent of the total irrigated area respectively (Awulachew, et al. 2007).

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6. Agriculture production and cropping pattern

Based on Central Statistics Agency's 2005/06 agricultural sample survey (CSA, 2006), the major crops during the main rainy season (a.k.a ***meher season***) are cereals, pulses, oilseeds, vegetables, root crops, fruit crops, stimulant crops[9] and sugar cane. Cereals are the dominant food crops covering 58 % of the land area[10] and 87 % of the volume of grain production[11] (See Fig 2). The major cereal crops include: teff (*Eragrostis tef*), barley (*Hordeum vulgare)*, wheat (*Triticum durum*), maize (*Zea mays)*, sorghum (*Sorghum bicolour*) and finger

[9] Stimulant crops consist of Chat, coffee and hops.

[10] Total cultivated land area during 2005/06 cropping season was estimated at 12.28 million hectares.

[11] Total volume of agricultural produce during 2005/06 cropping season was 133. 1 million quintals. A quintal is equivalent to 100 kgs.

millet (*Eleusine coracana*). Teff, maize, sorghum and wheat took up 22, 15, 14 and 14 percent of the grain crop area, respectively. Maize, wheat, Teff and sorghum made up 25, 17, 16 and 16 percent of the grain production in the same order.

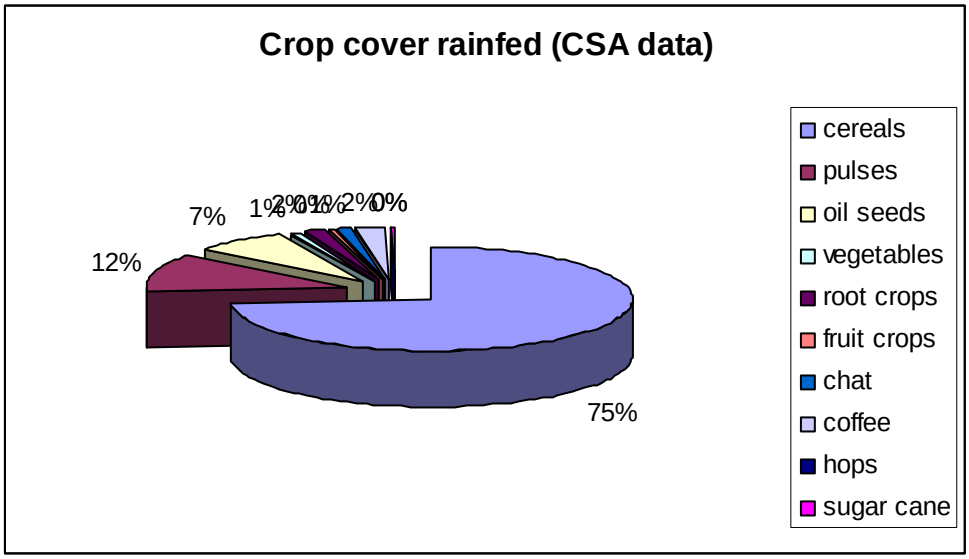


Fig 2: Crop cover during the ***Meher*** season of 2005/2006 (Source: CSA (2006))

Pulses grown in 2005/06 covered 12.7 % of the grain crop area and 9.5 % of the grain production. Faba beans (*Vicia faba*), field peas (*Pisum sativum)* and chick-peas (*Cicer arietinum*) were planted on 4.5, 2.29 and 1.98 percent of the grain crop area. The production obtained from the same crops was 3.8, 1.4 and 1.6 percent of the grain production.

Oilseeds comprised 7.8% of the grain crop area and 3.6% of the production to the national grain total. Neug (*Guizotia abyssinca*), linseed (*Linum sativum*) and sesame (*Sesamum indicum*) covered 3.0, 2.1 and 2.0 of the grain crop area and 1.1, 0.9 and 1.1 of the grain production.

Vegetables took up 1.1% of the area under all crops at national level. Of all the area under vegetables 69 and 19 percent was under red peppers and Ethiopian Cabbage (*Brassica carinata*), respectively. As to production of vegetables, 39.8 and 40.2 percent was that of the same crops.

Root crops covered more than 1.6% of the area under all crops in the country. Potatoes, sweet potatoes and taro covered 36.5, 29.7 and 15.1 percent of the area to the root crop total. The same crops and onion contributed 33.7, 30.6, 12.9 and 13.2 percent to the root crop production in the same order.

More than 45 thousand hectares of land is under fruit crops in Ethiopia. Bananas contributed about 62.4% of the fruit crop area followed by mangoes that contributed 12% of the area. Nearly 4.3 million quintals of fruits was produced in the country in 2005/2006. Bananas, Papayas, mangoes and oranges took up 49.4, 16.6, 12.8 and 11.8 percent of the fruit production, respectively.

The area and production of chat and coffee are larger than that of fruits since they earn a considerable amount of cash for the holders. Chat (*Catus adulis*) and coffee shared 1.24 and 2.39 percent of the area under all crops in the country and 1.2 and 1.7 million quintals of produce was obtained from these

crops in the same agricultural year respectively.

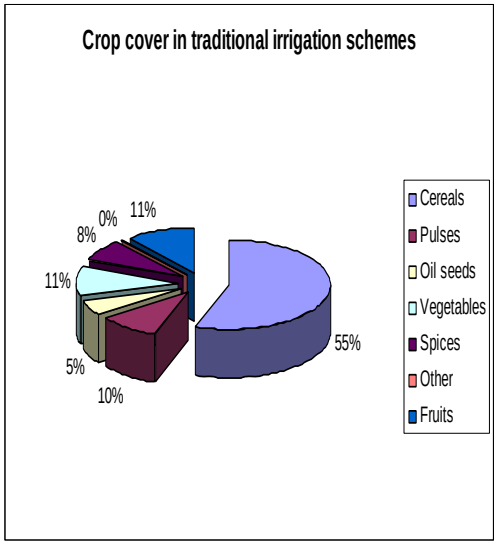
Sugar Cane is grown on about 19 thousand hectares of land in the country, yielding 16.1 million quintals of produce by the peasant holders.

7. Irrigation typologies and cropping patterns

In the Ethiopian context, the irrigation sub-sector is classified as small (less than 200 ha), medium (200 to 3000 ha) and large-scale (over 3000 ha) schemes (MoWR 2002a; Awulachew et al., 2005). Small scale irrigation schemes are considered as traditional if the diversion weirs are made from local material which needs annual reconstruction. The canals are usually earthen and the schemes are managed by the community. Many are constructed by local community effort and have been functional for relatively longer periods of time. On the other hand, small scale schemes are considered as modern schemes if they have more permanent diversion weirs made from concrete, and the primary and sometimes secondary canals are made of concrete. They are generally community managed and have recently been constructed by government or NGO. Werfring (2004) and Makombe et al. (2007) describe the typology of small scale irrigation in Ethiopia, the former in more detail. Small and medium scale schemes grow cereals as main crops. During the main rainy season most of small and medium scale irrigation schemes grow cereals like teff, maize and barley, with little or no supplementary irrigation, under rain fed conditions. During the dry season farmers grow cereals and a variety of vegetables including onions, tomatoes, and leafy green vegetables like lettuce under full irrigation. Farmers also grow perennial crops like mango, banana, sugar cane which are sometimes intercropped with seasonal crops.

From our survey data, we present below the composition of crops under irrigated and rain fed conditions. We made the distinction between traditional and modern irrigation schemes while looking into cropping composition. We clustered crops into different categories; namely, cereals, pulses, oil seeds, spices, vegetables, fruits and others and calculated area cover (as percentage of the total area) for these different crop categories in the different systems. The dominant crop categories under traditional irrigation system, in terms of the percentage area covered are: cereals (55%), vegetables (11%), fruits (11%), pulses (10%), spices (8%), oil seeds (5%), and others (0.2%) (Figure 3a). In the modern irrigation systems, in the order of importance, the dominant crops are: cereals (67%), vegetables (17%), fruits (4%), pulses (3%), spices (0.2%), oil seeds (0.4%), and others (5 %) (Figure 3b).

Under the rainfed agricultural system the dominant crops are: cereals (77%), pulses (16 %), vegetables (1.3 %), fruits (1%), oil seeds (1%), spices (0.4%), and others (3.3 %) (Figure 3c).



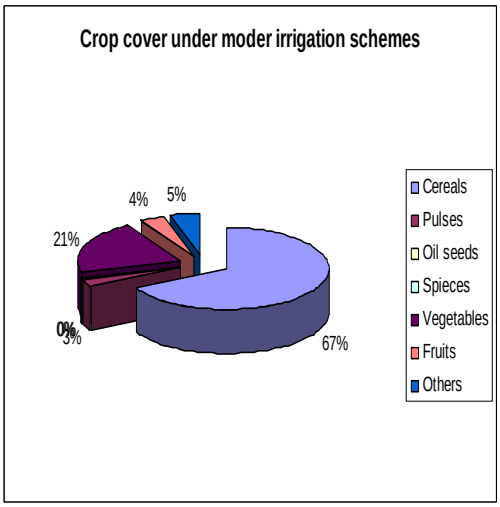


Fig. 3a: Dominant crops under traditional irrigation system (n= 1240) Fig. 3b: Dominant crops under modern irrigation system (n= 2092)

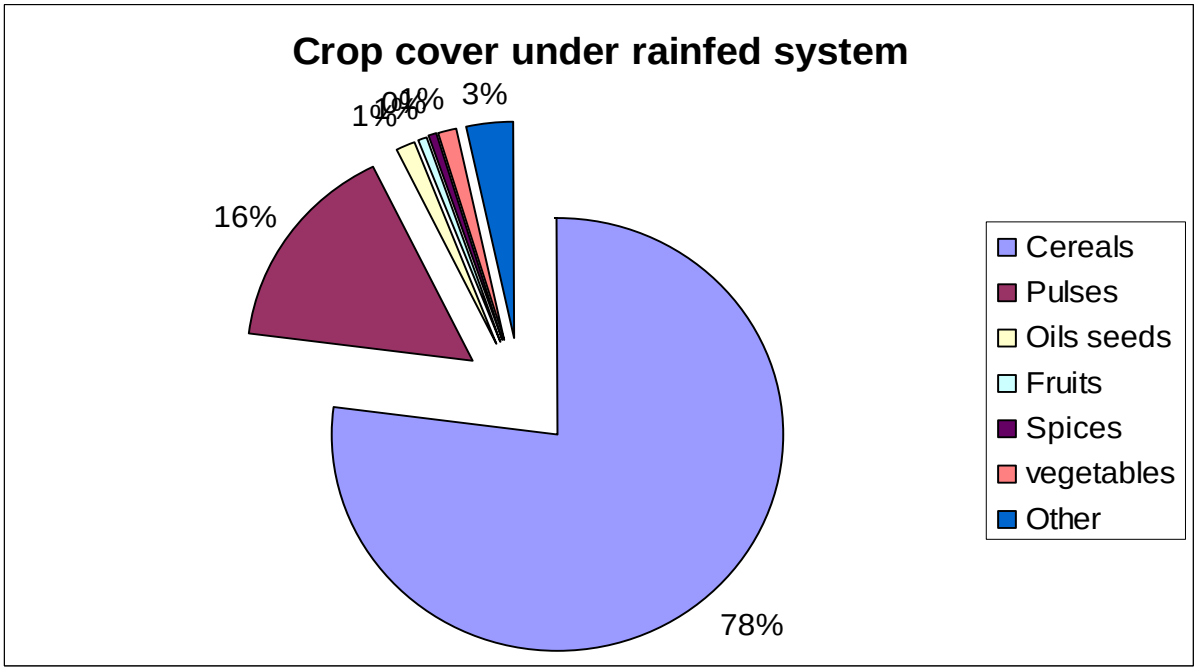


Fig. 3c: Dominant crops under modern rain fed system (n= 1533)

The figures above show that there is difference in the relative importance of the crop categories under different systems. Cereals and pulses are dominant under rainfed system while vegetables and fruits cover about 2 percent of the land area. While cereals still remain dominant under the irrigation systems, covering about 61 percent of the land area, vegetables and fruits become important under both traditional and modern systems. There is also noticeable difference in the share of land taken by vegetables and fruits between the modern and traditional irrigation systems. Vegetables take more land area under the modern systems compared to that of traditional systems while more land area is covered with fruit tress under the traditional system indicating perhaps the

difference in age between the two type of systems.

Large-scale irrigation schemes, on the other hand, grow mainly sugar cane, cotton and fruits and vegetables. Wonji/Shoa, Metehara and Finchaa schemes grow sugar cane, while the Amibara and Upper Awash schemes grow cotton and Fruits and vegetables respectively (see Table 2)

Table 2: Large scale schemes under irrigation and type of cropping

Region	Scheme name	Major crop	Area 2005/06 (in ha)
Afar	Amibara (Middle Awash)	Cotton	6448
Oromia	Finchaa sugar plantation	Sugar cane	7185
Oromia	Metehara sugar plantation	Sugar cane	10145.9
Oromia	Upper Awash	Vegetables & fruits	6017.34
Oromia	Wonji/Shoa sugar plantation	Sugar cane	4094

Source: ESDA (2007); MOFED (2006);

8. Future expansion of irrigation development in the country

The Irrigation Development Program (IDP) as set out in the government's Plan for Accelerated and Sustained Development to End Poverty (PASDEP) document (2005/06-2009/10) envisages the expansion of irrigation in the country by an additional 430,061 ha by the year 2010 (MoWR, 2006; MOFED, 2006). This will consist of mainly medium and large scale schemes. Accordingly, 39 significant irrigation projects are planned to be implemented during the PASDEP period. These include World Bank project around Tana (100,000 ha); Anger Negesso Project in Oromia (49,563 ha); Humera project in Tigray (42,965 ha); Kessem Tendaho in Afar (90,000 ha); Upper Beles in Benishangul Gumz (53,000 ha) and Ilo-Uen Buldoho (32,000 ha) in Somali (MOFED, 2006; MoWR, 2006). Most of these irrigation schemes will be community managed schemes to be used by small scale farmers. Exceptions are the schemes to be developed in the Awash basin which will mainly involve expansion of the already existing large scale schemes or development of new ones (see Table 3). About 90,000 ha of irrigation land will be developed in Kesem and Tendaho to grow sugar cane while there are planned expansions in the already existing sugar plantations. Overall, by the year 2010 there will an additional 122,000 ha of irrigated land developed to grow sugar cane (ESDA, 2007).

There are also parallel plans to develop 98,625 ha under small scale irrigation by the regional governments (Atnafu, 2007). The total extension to irrigated area by the year 2009/10 compared to 2005/2006 will be in the range of 528,686 ha. This implies that further development will extend the irrigated area to about cover 33 percent of the irrigated potential and about 9 percent of the total cultivated land area. These plans are used as indicative targets for future irrigation development for valuing the future contribution of irrigation to the national economy.

Table 3: Future development plans of large scale schemes

Region	Scheme name	Main crop	Future expansion/development until 2010 (in ha)
Oromia	Finchaaa	Sugar cane	12000
Afar	Kesem	Sugar cane	40000
Oromia	Metehara	Sugar cane	10000
Afar	Tendaho	Sugar cane	50000
Oromia	Wonji/Shoa	Sugar cane	10000

Source: ESDA (2007)

9. Value of irrigation to national economy

The contribution of agriculture to national economy is estimated on the basis of the estimated production during the ***Meher*** (main rainy season) and the ***Belg*** seasons (small rainy season) (BOFED, 2006). We assume that the contribution from irrigation is included in the production during the ***Belg season,*** although not explicitly stated in the document**.** Farmers use full irrigation to grow crops during the dry season when crop production using rain is not possible. This implies that household's get additional income from irrigation in comparison to farmers who can only grow during the main rainy season. Under small scale irrigation system, irrigation does not replace rainfed agriculture but supplements it. Large scale schemes, however, are under full irrigation through out the year.

Based on the net gross margin calculations (see table 4), irrigation in the study sites generates an average income of about Birr 2800 /ha, which is equivalent to USD 323/ ha[12]. This compares to the calculated gross margin for rainfed which is USD 147/ha. This indicates that after accounting for annual investment replacement cost, net gross margin from irrigation is more than two times higher than gross margin from rainfed agriculture.

When we disaggregate net income by irrigation typology, we also see a strong difference between the categories. Average income from small scale but modern schemes is about USD 355/ha while from small scale traditional is about USD 477/ha. This may sound counter intuitive in the sense that schemes with permanent structures and well lined canals should have led to better returns. The reason for higher margins for traditional schemes may have to do with high average investment cost of modern schemes compared to the traditional ones. The relatively longer irrigation experience and, hence, acquired improved irrigated crop management practices of farmers working and the composition of crops grown under traditional system may also contribute to this difference. The development of modern irrigation schemes is a recent phenomenon in Ethiopia.

There are also huge inter-scheme differences in income within the same typology which could be attributed to relative difference in irrigation experience and access to market. When it comes to medium scale irrigation schemes, the average income from modern irrigation schemes was USD 400/ha. We do not know the corresponding figure for a traditional medium scale scheme as we did not have such a scheme in our sample. We assumed in this study that the average net income from a traditional medium scale scheme is USD 400.

[12] 1 USD was equivalent to 8.67 ETB in 2005/06 prices.

Table 4: Gross margin calculation from small and medium scale irrigation schemes

Scheme name	Scheme scale	Typology	Area (in ha)	AFC	GM/ha rain fed	GM/ha irrigated	GI minus FC	Total income
Indris	Medium	Modern/ traditional	382	74	429	1850	1776	678571
Gologota	Medium	Modern	850	303	1068	7596	7293	6199193
WBS	Medium	Modern/ traditional	685	200	1485	2603	2402	1645656
Tikurit	Small	Traditional	102	91	1353	4140	4050	413081
Zengeny	Small	Modern	270	222	1971	3375	3152	851160
Haiba	Small	Modern	250	437	1585	2795	2358	589537
Golgol Raya	Micro irrigation	Modern	104	1372	1710	2240	868	90280
Hare	Medium	Modern/ traditional	1345	159	646	950	791	1064206

Source: Own calculation

Taking the average income from smallholder managed small and medium scale irrigation schemes in the country and the total hectarage for both categories, we calculated the total income driven from irrigation to be Birr 2.27 billion (about 262.3 million USD). This accounts for about 4.46 percent of the agricultural GDP in 2005/2006 and 1.97 percent of the total GDP.

Table 5: Gross margin calculation from large scale irrigation schemes

Scheme name	Main crop	Area (in ha)	Average investment cost/ ha	Annual recovery cost/ ha	Total GM (in million)	GM per ha	Net income	Total income
Amibara*	cotton	5358	11418	228	13.8	1212	984	5270343
Finchaa	sugar cane	7185	62672	1253	184.4	2943	1689	12137261
Metehara	sugar cane	10146	9303	186	303.7	32649	32463	32936660
Upper Awash	fruits & vegetables	6017	3793	76	62.9	16594	16518	99396889
Wonji/Shoa**	Sugar cane	4094	35987	720	439.3	12210	11490	47040510

* Based on 2004/2005 estimate

** Average investment cost for Wonji is taken as the average for Metehara and Finchaa

When it comes to valuation of the contribution from large scale schemes, we followed strictly the approach outlined in section two. Hence, in calculating net income from large scale schemes we deducted the contribution of rainfed from the net income obtained under irrigation to account for the income foregone for not using the land under rainfed production. The rationale behind this is that irrigation in the large scale schemes is full season devoid of any possibilities to practice rain fed agriculture. Before netting out the contribution coming from rainfed, the average income from large scale schemes was USD1456/ha. There are strong differences in GM between the schemes, however. As we did not have data from rainfed in and around the large scale schemes, we used rainfed data from the medium and small scale sites. The calculated average gross margin per ha from

rainfed agriculture, as indicated earlier, was USD 147. Taking this value into account, the netted income from a hectare of irrigation under large scale schemes is USD 1308. When we differentiate the large scale schemes into sugar plantation and other crop growing plantations (i.e. predominantly vegetables and fruits and cotton growing schemes) the average net income is USD 1782.5 and USD 998.9 respectively. Taking the all large scale schemes in the country, differentiated by their cropping pattern, and the average income from the selected learning sites, the total income earned from large scale schemes amounts to Birr 641 million (ca 74.0 million USD). This accounts for about 1.26 percent of the agricultural GDP and 0.5 percent of the total GDP respectively. When only the improved system is considered, it contributed to about 1.26 and 0.5 percent of the agricultural GDP and GDP respectively. Overall, the contribution of irrigation to agricultural GDP and total national GDP was about 5.7 and 2.5 percent during the 2005/06 cropping season. This shows that the contribution of irrigation to national income is still very small compared to the 28 percent contribution of crop production. Regional comparisons could shed some light on this. In the Sudan, for instance, irrigation contributes about 50 percent of the crop production while almost all agriculture in Egypt is irrigated (FAO, 1997).

10. Projecting future contribution of irrigation

In this section we present the projected expansion of irrigated agriculture vis-à-vis rain fed agriculture and the contribution of the former to agricultural GDP. To set the future scenario we used cropping patterns as observed in our empirical results and projected cropping patterns of the PASDEP (2005/06-2009/10) document (see Table 7). The projected irrigation development, both small-and medium scale and large scale schemes is taken into account in setting the future scenario.

Table 6: Cropping pattern under different systems (% area covered by) by small and medium scale irrigation

Crop category	Area under Rain fed system (%)	Area under Traditional irrigation (%)	Area under Modern irrigation (%)	Average area Cover under irrigation (%)
Cereals	77	55	67	61
Vegetables	1	11	21	16
Perennials/fruits	1	11	4	7
Pulses	16	10	3	6
Oil seeds	1	5	0.4	3
Spices	0.5	8	0.3	4
Others	3	0.2	5	2.5

Source: Own calculation

In projecting future scenarios we assumed that the cropping pattern of the large scale sugar plantations to be the same. We ruled out reductions of irrigated land due to salinity or other environmental damages in those sugar plantation for lack of data that clearly shows the magnitude of the problem or how effective are the ameliorative measures undertaken by these schemes. On the other hand, we assumed that the cropping pattern in the smallholder managed large, medium and small scale irrigation schemes to be the same as depicted in Table 6. The land cover statistics of the irrigation, all typologies considered, and rainfed systems are also given in Table 7. We relaxed this assumption later in the sensitivity analysis as it is realistic that farmers will shift to high paying crops as they gain experience and the market situation likely to improve.

Table 7: Land use assumptions for future irrigated areas (2005/06-2009/2010)

Land use	**Area with irrigation (in 000 ha)**	**Area without irrigation (in million ha)**
Cereals	809.2	9.2
Pulses		1.6
Oil seed crops	119.4	1.2
Vegetables	212.2	
Fruits	99.5	0.419
Cotton		0.043
Sugar cane	122.0	0.060
Coffee		0.734
Floriculture	n.a.	0.002
Tea		0.0038
Other	86.2	0.039
Total	**1326.5**	**12.65**

Source: MOFED (2006) and own calculation; n.a.= no data available

The PASDEP document also outlines the projected development of the economy for the whole planning period. Accordingly, the Ethiopian economy is expected to grow at an average of 7.3 percent through out the PASDEP period. Agriculture, the major sector of the economy is also expected to grow at an average rate of 6.2 percent (MOFED, 2006, p. 55). Agriculture's share to the economy will show slight reduction from 46.2 percent in 2004/2005 to 43.9 percent at the end of the planning period. Taking the baseline situation (2005/06), Ethiopia's GDP will grow to Birr 153.2 billion while agricultural GDP will grow to Birr 64.7 billion both at 1999/00 constant basic prices.

For the assumptions about the IDP differentiated into small-medium scale & large scale we used MOFED (2006) and MoWR (2006), as indicated in section eight. As the national IDP indicates the country's irrigation coverage will increase from the current 625,819 ha to 1.15 Million hectares. Accordingly, there will be 638,129 ha of small scale irrigation, both traditional and improved, 328,485.9 ha of smallholder managed medium and large scale irrigation schemes and 122000 ha of large scale schemes dedicated for sugar plantations and 35511 ha of large scale commercial farms dedicated to growing of vegetables, fruits and cotton.

Taking all the envisaged areal expansion, crop cover assumptions as indicated in Tables 7 and 8 and the average gross margin by crop category (table 9), we calculated that the contribution of smallholder managed irrigation to national economy to increase from USD 262.3 million in 2005/2006 to about USD 414.2 million in 2009/2010, which accounts to about 5.5 percent of the agricultural GDP and 2.3 of the overall GDP for the same year. On the other hand, the contribution coming from the large scale sugar growing estates is in 2009/2010 is estimated to be USD 217.5 million which amounts to 2.9 and 1.2 percent of the agricultural and overall GDP respectively. Similarly the contribution

coming from large scale commercial farms growing other crops other than sugar cane is expected to increase to USD 35.8 million in 2009/2010 which accounts to 0.4 and 0.2 percent of the agricultural GDP and overall GDP respectively. This implies that large scale commercial farms will contribute about 3.3 and 1.4 of the agricultural GDP and overall GDP respectively. This shows that the bulk of the contribution is expected to come from smallholder managed irrigation systems. In summary, this indicates that under conservative estimates the future contribution of irrigation to agricultural GDP and overall GDP will be in the range of 9 and 3.7 percent respectively. This estimation is based on the projected areal expansion, current cropping patterns and prices. These results are likely to change when some of the assumptions were allowed to change as shown below.

11. Sensitivity analysis

In projecting the future contribution of irrigation to national economy or agricultural GDP our assumptions were rigid: only a change in area expansion was assumed. However, it is realistic to assume that there will be various changes associated with irrigation expansion. For instance, given the significant difference in the gross margin between different crop categories, farmers will benefit economically from growing more vegetables and fruits than growing cereals. Hence it is realistic to assume that farmers will gradually shift to high value crops. Prices of inputs and outputs cannot be taken to remain constant. It is realistic to assume that there could be either upward or down ward movements in prices of agricultural inputs and outputs. Furthermore, the efficiency of farmers is also expected to improve with time as they gain irrigation experience and experiment with various technologies and combinations. Hence it is important to relax these assumptions and see the effect of these changes on irrigation's contribution to national income. This section presents the results of the sensitivity analysis.

11.1 Simulating changes in cropping patterns under smallholder managed irrigation schemes

To simulate the effect of such change in cropping pattern on the agricultural GDP we set the following scenarios: Scenario 1 involves 10 percent increase in area coverage of vegetables and fruits (10 percent decrease in area for cereals) while areas for pulses and oil seeds and other crops remain the same; Scenario 2 assumes 10 percent increase in area of vegetables and 5 percent in fruits (15 percent reduction in area for cereals *cetaris paribus*) and Scenario 3 assumes 10 percent increase in area for both vegetables and fruits (20 percent reduction in area for cereals) and finally scenario 4 assumes a 25 percent increase in area of vegetables and fruits (i.e. 25 percent reduction in area for cereals ceteris paribus). The outcomes of these scenarios were compared against the baseline scenario where we assumed that there will be only aerial expansion (Table 11).

Table 8: Estimated average gross margin for different crop categories

Average Gross margins by crop category	Birr/ ha - rain fed	Birr/ ha - irrigated
Cereals	1282.32	1720.84
Vegetables		3421.2
Fruits		2754.9
Pulses & oil seeds	1481.45	1558.19
Sugar cane		4528.7
Cotton		709.6
others (hops, chat, etc)	1254.8	2891.8

Source: Own calculation

As can be seen from Table 8 (See also Table 10a and 10b in Annex) there is significant difference in the gross margin between different crop categories. On average farmers get Birr 1720 per ha from growing cereals, Birr 3421 from vegetables, Birr 2755 from fruits, Birr 1558 from pulses and oil seeds, and Birr 1719 from growing other crops such as spices and stimulants.

Table 9: The effect of change in cropping pattern on the projected contribution of small holder managed irrigated agriculture to Agricultural GDP (Net gross margin in BIRR)

Crop type	Total NGM (in Million USD)	Contribution to AgGDP in 2009/2010 (%)	Contribution to GDP in 2009/2010 (%)	Relative change (%)
Baseline	315.2	4.22	1.78	
Scenario 1	327.9	4.39	1.85	17
Scenario 2	335.8	4.5	1.9	28
Scenario 3	340.6	4.56	1.92	34
Scenario 4	3.84.5	4.67	1.97	45

As can be seen from the simulation results, the contribution from smallholder managed irrigation schemes to Agricultural GDP increases to about 4.5 percent or even more when these various changes in cropping patterns are assumed. 15 and 10 percent increase in the area of vegetables and fruits (25 percent reduction in the area of cereals) lead to about 45 percent increase in the contribution of smallholder irrigation to agricultural GDP as compared to the baseline scenario. This is an important result indicating that the contribution of irrigation could be maximized if smallholder farmers shift their cropping pattern to high value crops. Hence, the extension system could play an important role in providing and promoting high value crops.

11.2 Simulating changes in crop prices

The factors that influence price change could be related to overall demographic change and improved economic performance (through increased demand) and increase in supply of output. It is reasonable to assume that the population of Ethiopia will continue to grow in the foreseeable future while there could be differences in opinion about the prospects of economic growth in the country. The prospects point towards improved economic performance, however. For this exercise, hence, we assumed that demand factors will play a more significant role in influencing the price of outputs.. To simulate the effect of these changes in prices of output on the contribution of irrigation to national economy, we set various scenarios: baseline scenario GM net of annual investment recovery cost; 10 percent increase in price of vegetables and fruits *ceteris paribus* (scenario 1); 15 percent increase in price of vegetables and fruits *ceteris paribus* (scenario 2); 10 and 15 percent increase in price of cereals *ceteris paribus* (scenarios 3 and 4); 10 and 15 percent increase in the price of pulses and oil seeds *ceteris paribus* (scenarios 5-6); and 10 and 15 percent increase in price of other crops *ceteris paribus* (scenario 7 and 8). The simulation results are reported in table 10 below.

These simulation results show that a 10-15 percent increase in the price of fruits and vegetables leads to 15-23 percent increase in the relative contribution of smallholder irrigation to agricultural GDP. An equivalent increase in the price of cereals leads to 22-32 percent increase in the relative contribution of the sub sector. One the other hand, the same level of increase in prices of pulses, oil seeds and other crops did not yield significant change in their contribution. The relative higher contribution from cereals comes from the bigger share cereals have on land cover claiming about 61 percent of the cultivated area under irrigation, Hence, vegetables and fruits are economically more attractive. This implies that an increase or decrease of prices of vegetables and fruits will have a stronger relative impact on the contribution of irrigation to national economy compared to the price change of cereals.

Table 10: the effect of change in output prices on the projected contribution of small holder managed irrigated agriculture to Agricultural GDP

Scenarios	Description	Contribution to AgGDP in 2009/2010 (%)	Contribution to GDP in 2009/2010 (%)	Relative change (%)
Baseline	GM net of investment recovery cost	4.22	1.8	
Scenario 1	10 % increase in price of vegetables & fruits	4.37	1.85	15
Scenario 2	15 % increase in price of vegetables & fruits	4.45	1.88	23
Scenario 3	10 % increase in price of cereals	4.44	1.87	22
Scenario 4	15 % increase in price of cereals	4.55	1.92	32
Scenario 5	10 % increase in price of pulses and oil seeds	4.25	1.79	3
Scenario 6	15 % increase in price of pulses and oil seeds	4.26	1.80	4
Scenario 7	10 % increase in price of other crops	4.25	1.79	3
Scenario 8	15 % increase in price of other crops	4.26	1.80	4

11.3 Simulating changes in input prices

Fertilizer is the most important input for smallholder farmers working under irrigation. The average cost of fertilizer varies by type of crop category. Cereals and vegetables are major consumers of fertilizer with average expenditure per hectare of Birr 287 and Birr 403 respectively. Pulses and oil seeds, other crops and fruits reported expenditure per hectare of Birr 238, 161 and 47 respectively. In projecting the impact of irrigation on national economy, one needs to consider the effect of changes in input prices on the gross margin. To simulate such an effect, we determined the impact of the following scenarios: 10, 15, 25 and 35 percent increase in the price of fertilizer. Given the current trends in fertilizer prices, it seems realistic to assume that fertilizer prices will increase.

Table 11: Effect of changes in fertilizer prices on contribution of smallholder contribution to agricultural GDP

Crop category	Contribution to AgGDP	Contribution to GDP	Relative change
Baseline	4.22	1.78	
Scenario 1	4.17	1.76	-5
Scenario 2	4.14	1.75	-8
Scenario 3	4.08	1.72	-14
Scenario 4	4.03	1.70	-19

As can be seen from the simulation results, the contribution from smallholder managed irrigation schemes to agricultural GDP does fall significantly compared to the baseline scenario if there is a 10 percent or more increase in price of fertilizer. A 35 percent increase in price of fertilizer, while assuming other things remain constant, for

instance, leads to a 19 percent reduction in its contribution to agricultural GDP compared to the baseline scenario.

11.4 Improvement in efficiency of smallholder managed schemes

Besides exogenous changes in prices and changes in cropping patterns, farmers are also expected to gain irrigation experience and improve their efficiency in using land and water. This is also expected to lead to increase in gross margin. We, hence, explored what happens to irrigation's contribution if gross margin of smallholder agriculture increases to that of irrigators in the traditional schemes. The simulation results show that the contribution from smallholder managed irrigation will increase to about USD 475.5 million that accounts to 6.4 and 2.7 percent of the agricultural GDP and overall GDP in 2009/2010. This has also an important policy implication; government and extension support through education and training contributes to improved efficiency and increased contribution of irrigation to national economy.

11.5 Projecting the future contribution of large scale plantations

In projecting the future contribution from large scale commercial plantations, we tested various scenarios. First we need to differentiate between large scale smallholder managed and large scale commercial plantations. The former category was covered in the proceeding sections while in this section we focus on the large scale commercial production. The major expansion in the state owned commercial plantations involves predominantly growing of sugar cane for sugar production. There is no information on future expansion plans of fruits and vegetables and other crop growing large scale commercial farms. Our focus in this section, hence, will be on sugar plantations. Worth noting is that in the existing sugar plantations there is huge difference in annual investment recovery costs and net gross margin (see Table 5). These differences could be attributed to differences in structure of investment and management and, hence, efficiency of the schemes. The lack of relevant information on initial investment expenditure has also made the analysis difficult. In schemes where we couldn't get data on initial investment costs we used data related to initial capital outlays. The huge differences in annual investment recovery costs and net gross margin could partly be attributed to lack of reliable data.

In simulating the future contribution of large scale schemes, we set certain assumptions based on the differences in net gross margin between the three major sugar growing schemes. Since there will be emerging schemes, e.g. Kesem and Tendaho on 90000 ha of land, in sugar cane production, we need to set certain assumptions about these schemes performance. We first assumed that the net gross margin for Finachaa, Metehara and Wonjo/Shoa respectively applies to the new schemes (Scenario 1-3); Kesem & Tendaho perform on the average of the three exiting schemes (scenario 4); all schemes, existing and emerging, perform like Finachaa (scenario 5); all schemes perform like Metehara (scenario 6), all perform like Wonji/Shoa or all perform on the average of the three (scenarios 7 & 8) . Finally we assumed a 10 and 15 percent increase in the price of sugar while the average gross margin works in all schemes (scenarios 9 and 10). For details see Table 12 below. Following these scenarios, the contribution from large scale plantations to agricultural GDP, ranges from less than 1 percent for scenario 5 (worst scenario) to about 6 percent in scenario 2 (best scenario). The intermediate outcomes lie somewhere in between contributing about 3 percent to the agricultural GDP. These results show that the structure of investment and the way these schemes are managed may have a significant bearing on their contribution to national economy.

Table 12: Projected contribution of large scale sugar estates to Agricultural GDP

Scenarios	Description	Contribution to AgGDP	Contribution to GDP	% Change
Baseline	average NGM for LSS assumed	2.9	1.2	
Scenario 1	Kesem & Tendaho performs like Finchaa	1.5	0.65	- 140
Scenario 2	Kesem & Tendaho performs like Metehara	5.8	2.46	290
Scenario 3	Kesem & Tendaho performs like Wonji/Shoa	2.9	1.22	0
Scenario 4	Kesem & Tendaho achieves average performance	3.4	1.4	50
Scenario 5	All perform like Finchaa	0.32	0.13	-258
Scenario 6	All perform like metehara	6.1	2.5	320
Scenario 7	All perform like Wonji/Shoa	2.16	0.9	-74
Scenario 8	All perform like average	2.87	1.2	-3
Scenario 9	10 percent increase in baseline NGM	2.87	1.2	-3
Scenario 10	15 percent increase in baseline NGM	2.87	1.2	-3

Taking these scenarios into account the contribution of smallholder managed irrigation to agricultural and overall GDP will vary between 4 to 6 and 1.8 to 1.9 percent respectively. Similarly, the contribution from large scale irrigation to agricultural and overall GDP will be in the range of 3 to 6 and 1.2 to 2.5 percent

respectively. Overall, the future contribution of irrigation to agricultural GDP will be in the range of 7 to 12 percent while the contribution to overall GDP will be in the range of about 4 percent.

12. Conclusions and recommendations

Irrigation development is quite a recent phenomenon in Ethiopia. While the country has huge potential for irrigation only about 5 percent of this potential is currently used. Irrigation development is identified as an important tool to stimulate sustainable economic growth and rural development and is considered as a corner stone for food security and poverty reduction in the country. To this effect a comprehensive national Irrigation Development Strategy (2005/06-2009-2010) has been developed and is being implemented with the aim of establishing small, medium and large scale irrigation schemes, either for use either under smallholder managed schemes or large scale commercial plantations. In spite of this, there is little attempt to measure the actual and expected contribution of irrigation to the national economy. Hence, the objective of this study was to estimate the net contribution of irrigation to GDP at the farm gate following an adjusted gross margin analysis approach. Studies of this kind could be instrumental in comparing the actual and expected direct benefits of irrigation with the actual and expected costs of irrigation expansion to guide policy makers in irrigation development. However, there is need for caution. This study does not capture the all the multiplier effects of irrigation. Doing that requires more data than is presently available. However, this first attempt can be extended to more precise analysis of economy wide effects of irrigated agriculture development.

Our results show that irrigation in the study sites generates an average income of about USD 323/ ha. This compares to the calculated gross margin for rainfed which is USD 147/ha. This indicates that after accounting for replacement cost, net gross margin from irrigation is more than twice higher than the gross margin from rainfed agriculture. When disaggregated by irrigation typology, average income from small scale modern systems is about USD 355/ ha while from small scale traditional systems it is about USD 477/ha. This difference in net income between the traditional and modern systems could be attributed to differences in the investment cost and relative irrigation experience. We also found huge inter-scheme differences in average income within the same typology which could be attributed to differences in relative irrigation experience and access to market. When it comes to medium scale irrigation schemes, the average income from modern irrigation schemes was USD 400/ha. Taking the average income from smallholder managed small and medium scale irrigation schemes in the country and the total hectarage for both categories, we calculated the total income driven from irrigation to be Birr 2.27 billion (about 262.3 million USD). This accounts for about 4.46 percent of the agricultural GDP in 2005/2006 and 1.97 percent of the total overall GDP.

On the other hand, the average income net of annual recovery cost from a hectare of irrigation under large scale schemes is USD 1,308. Taking the all large scale schemes in the country, differentiated by their cropping pattern, and the average income from the selected learning sites, the total income earned from large scale schemes is estimated to be Birr 641 million (ca 74.0 million USD). This accounts for about 1.26 percent of the agricultural and 0.5 percent of the total GDP respectively. Overall, the contribution of irrigation to agricultural and total national GDP was about 5.7 and 2.5 percent during the 2005/06 cropping season. When only the improved system is considered, it contributed to about 1.26 and 0.5 percent of the agricultural GDP and GDP respectively. Our result show that the bulk of the contribution to national economy comes from the smallholder managed irrigation schemes, most importantly from

the traditional schemes. The same results also show that the contribution of irrigation to national income is still very small compared to the 28 percent contribution of crop production and role of irrigation to national economy in some countries such as the Sudan and Egypt where in the former irrigation contributes to about 50 percent of the crop production while in the latter almost all agriculture is irrigated.

Taking all the envisaged areal expansion, exiting cropping pattern, and the average gross margin values for different crop categories, the expected contribution of smallholder managed irrigation to national economy is expected to increase from USD 262.3 million in 2005/2006 to about USD 414.2 million in 2009/2010, which accounts to about 5.5 percent of the agricultural GDP and 2.3 of the overall GDP for the same year. On the other hand, the contribution coming from the large scale sugar growing estates in 2009/2010 is estimated to be USD 217.5 million which amounts to 2.9 and 1.2 percent of the agricultural and overall GDP respectively. Similarly the contribution coming from large scale commercial farms growing crops other than sugar cane is expected to increase to USD 35.8 million in 2009/2010 which accounts to 0.4 and 0.2 percent of the agricultural and overall GDP respectively. This implies that large scale commercial farms will contribute about 3.3 and 1.4 of the agricultural and overall GDP respectively. In summary, our results indicate that under conservative estimates the future contribution of irrigation to agricultural and overall GDP will be in the range of 9 and 3.7 percent respectively.

Furthermore, we also relaxed some of the assumptions to check the sensitivity of our results to model assumptions. We assumed various changes in cropping patterns, changes in input and output prices and improvement in levels of efficiency.

Our results from the simulation exercise in relation to shift in cropping patterns show that a 15 and 10 percent increase in the area of vegetables and fruits respectively (i.e. 25 percent reduction in the area of cereals) leads to about 45 percent increase in the contribution of smallholder irrigation to agricultural GDP as compared to the baseline scenario. This is an important result indicating that the contribution of irrigation could be maximized if smallholder farmers shift their cropping pattern to more high value crops. Hence, the extension system could play an important role in providing and promoting high value crops.

Likewise, simulation results on the effect of price change show that a 10-15 percent increase in the price of fruits and vegetables leads to 15-23 percent increase in the relative contribution of smallholder irrigation to agricultural GDP. An equivalent increase in the price of cereals leads to 22-32 percent increase in the relative contribution of the sub sector. One the other hand, the same level of increase in prices of pulses, oil seeds and other crops did not yield significant change in their contribution. The relatively higher contribution coming from cereals is attributed to the bigger share cereals have on land claiming about 61 percent of the cultivated area under irrigation. This implies that an increase or decrease of prices of vegetables and fruits will have a stronger relative impact on the contribution of irrigation to national economy compared to that of cereals. Hence, vegetables and fruits are economically more attractive and could yield more value to the economy if more a more land is shifted from cereal production to production of vegetables and fruits.

On the other hand, increase in price of fertilizer leads to reduction in the contribution of irrigation to national economy. Accordingly, a 35 percent increase in price of fertilizer, while assuming other things remain constant, for instance, leads to a 19 percent reduction in small holder irrigation's contribution to agricultural GDP compared to the baseline scenario.

Besides changes in prices and cropping patterns, improved efficiency is found to impact significant increased in the

contribution of irrigation to national economy. Our simulation results show that the contribution from smallholder managed irrigation will increase to about USD 475.5 million, which is 6.4 and 2.7 percent of the agricultural and overall GDP in 2009/2010, when all smallholder irrigation farmers perform to the level of traditional irrigators. This has also an important policy implication: government and extension support through education and training contributes to improved efficiency and increased contribution of irrigation to national economy.

Furthermore, when we simulated the effect of changes in efficiency levels of existing and emerging large scale sugar plantations and changes in the price of sugar we found that the contribution from large scale plantations to agricultural GDP, ranges from less than 1 percent for worst scenario to about 6 percent in the best scenario. The intermediate outcomes lie somewhere in between contributing about 3 percent to the agricultural GDP. These results show that the structure of investment and the way these schemes are managed may have a significant bearing on their contribution to national economy.

In summary, taking these scenarios into account the contribution of smallholder managed irrigation to agricultural and overall GDP will vary between 4 to 6 and 1.8 to 1.9 percent respectively. Similarly, the contribution from large scale irrigation to agricultural and overall GDP will be in the range of 3 to 6 and 1.2 to 2.5 percent respectively. Overall, the future contribution of irrigation to agricultural GDP will be in the range of 7 to 12 percent while the contribution to overall GDP will be in the range of about 4 percent. To enhance the contribution of irrigation to national economy, besides increasing the presence of physical water infrastructure, there is a need to: i) improve provision of agricultural inputs, ii) promote high value crops through the extension system, iii) create good market conditions, and iv) increase the efficiency of small and large schemes.

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Annex I

Table 10a: Gross margin of rain fed crops

Crop type	Mean area (in timad)	Gross value of output/ mean area	GM rain fed	GM per ha rain fed
Wheat	1.3	857	366.7	1089.6
Teff	1.8	806	437.8	956.9
Barley	1.2	507.7	429.2	1493
Maize	1.7	609.2	341	816.7
Finger millet	1.3	717	652.6	2055.4
Sorghum	2.4	754.7	644.6	1053.8
Chick pea	1.3	498.4	337.9	1031.7
Lathyrus	1.2	654.8	592.2	1970.8
Bean	1.2	725	334.3	1078.5
Lentil	0.6	309.4	250.4	1584.8
Nug	2.2	1132.3	939.6	1709.9
Grass pea	1.6	568.2	237.9	599.2
Eucalyptus	0.9	271.3	259.7	1185.6
Hops	0.6	214.1	136.5	956
Other	1.1	495.4	407.8	1553.6

Table 10b: Gross margin of irrigated crops

Crop type	Mean area (in timad)	GVOUT	GM irrigated	GM per ha
Wheat	1.4	1291.2	745.3	2077.7
Teff	1.5	904.7	514.2	1418.4
Barley	1	687.2	513.1	2052.3
Maize	1.6	864.7	610.4	1575.1
Sorghum	1.7	720.4	610.8	1480.7
Cotton	2	394.9	354.8	709.6
Chick pea	1.4	966.3	452.3	1256.5
Lathyrus	1.3	390	252	800.1
Bean	1.1	641.1	265.8	1012.6
Lentil	1	1505	1309.4	5237.6
Nug	1.4	717	538.5	1516.8
Grass pea	2.2	916.4	420.2	771.8
Pea	1.5	1467	617.7	1625.5
Linseed	2.1	445.2	252.7	493
Pepper	1	952.2	833.7	3437.9
Potato	0.9	574.6	420	1812.5
Sweet potato	2	498	397	814.3
Cabbage	0.8	821	662.3	3230.8
Onion	1.5	3112	2699.4	7415.8
Tomato	1.5	1506.1	1017.7	2765.4
Shallot	0.9	1873.5	1016.2	4471.7
Papaya	1	679.5	625.4	2399.9
Banana	1.9	534.1	475.8	995.9
Mango	1.2	711	652.2	2211
Guava	0.7	1038	933.7	5412.8
Coffee	0.7	8407.4	8341.4	45210.6
Sugar cane	0.8	1001.3	869.52	4528.77
Eucalyptus	0.8	5191.9	5113.7	26808.3
Hops	0.9	441.4	340	1456.1
Chat	0.6	1221.9	1098.5	7323.7
Enset	1	400.5	258.3	1051.2
Other	1	505.6	441.4	1736.2