LIVES WORKING PAPER 4

Profit and financial risk in the smallholder irrigated agriculture of Ethiopia

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June 2015

Editing, design and layout—ILRI Editorial and Publishing Services, Addis Ababa, Ethiopia.

Cover photo—ILRI/Dereje Legesse, Zerihun Sewenet, Apollo Habtamu

ISBN: 92–9146–427–9

Citation: Getnet, K., Haileslassie, A. and Dessalegn, Y. 2015. Profit and financial risk in the smallholder irrigated agriculture of Ethiopia. LIVES Working Paper 4. Nairobi, Kenya: International Livestock Research Institute (ILRI).

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Acknowledgement

We acknowledge the generous financial support of the department of Foreign Affairs, Trade and Development of Canada and the Water Land and Ecosystem (WLE) of the CGIAR.

1 Introduction

The agenda for Africa's agricultural growth emphasizes the need to promote irrigated agriculture both as a source of farm income for rural poverty reduction and as an adaptation strategy to ensure food security and livelihood resilience in the event of climate variability (NEPAD, 2003). Similarly, the Growth and Transformation Plan of Ethiopia gives due attention to irrigation development with the objective of enhancing agricultural productivity and food security in the country (MoFED, 2010; MOA, 2011).

The importance of smallholder irrigation in Ethiopia's agriculture is on the rise. Apart from the need to increase staple crop production in the country through irrigated agriculture, the growing demand for high value products from irrigated agriculture (driven by population growth, income growth and urbanization) may create income generating opportunities for smallholder irrigators to increasingly participate in supplying high value irrigated crops to markets. Similarly, the growing demand for livestock products such as meat and milk likely creates market opportunities for farmers as potential participants in the production of non-traditional commodities such as irrigated fodder and fodder seeds.

Profit can be considered as important economic incentive driving the investment decisions of smallholder semi-commercial irrigating farmers to continue their engagement in irrigated agriculture as an income generating activity. However, as a new business entity to most smallholder farmers in the country and as an intrinsically risky business, production of high value irrigated crops and irrigated fodder and fodder seeds can be risky for smallholder farmers. This makes it important to understand profitability and risk associated with irrigated agriculture, together with the sources of business risk to better inform investment decisions, risk management practices and value chain development interventions. This is important especially in the context of state withdrawal from subsidizing the irrigation sector (Kamara et al., 2001).

Level of and variations in crop yield, production cost and output price (as exogenous variables) can be important sources of loss as business risk to smallholder irrigating farmers. Low yield can be a limiting factor to profitability in irrigated agriculture (Van Halsema et al., 2011) because most farmers lack adequate experience in the agronomic and management practices of irrigated crops. Crop yield can be limiting also because of disease outbreak and natural vagaries facing production activities. Prices of vegetables can be seasonally low and highly variable because of an atomistic product market (characterized by many sellers), volatile business environment, perishable nature of products, and underdeveloped value chains. It is also possible that farmers incur high production costs because of various reasons, including lack of organized input supply system to efficiently procure planting and seed materials and because of small-scale production activities for farmers to benefit from economies of scale by distributing costs over a large product volume. Such uncertainty and risk makes it necessary to understand the business risk associated with investments in smallholder irrigated agriculture by assessing profit outcomes under different crop yield, production cost, and output price scenarios.

This report presents analysis results on the profitability of selected irrigated commodities and on farmers' risk perception in Ethiopia. The analysis, which is particularly focused on profit level, its determinants and variability, is based on data collected from selected sites in four regions of Ethiopia (Amhara, Oromia, SNNPR, and Tigray) for the 2013/14 production year. The purpose of the analysis is to get insights that inform investment decisions, risk management strategies and service provision in smallholder irrigated agriculture.

Notwithstanding location variability, the study finds that the level of profit generated from irrigated production of high value crops such as onion, tomato, and Rhodes grass seed is promising. Compared to high value crops, profit generated from irrigated production of cereals such as maize, wheat, and barley is quite low. However, it is important that such findings are interpreted cautiously and should not be taken as necessarily conclusive. Farmers perceive that there is a moderate to high level risk in the business, arising from all stages (input supply, production, and post-harvest stages) of the value chain.

The next section discusses the methodology used in the analysis. Section 3 presents the results obtained from deterministic and stochastic profit analysis and issues related to farmers' perception of risk and its sources. Section 4 concludes.

2 Methodology

2.1 Study area

The study was conducted in six sites located in four regions of Ethiopia (Amhara, Oromia, SNNPR and Tigray) where the Livestock and Irrigation Value Chain for Ethiopian Smallholders (LIVES) project is currently implemented. The specific sites are Koga (Amhara), Dugda (Oromia), Mirab Abaya (SNNPR) and Mesanu (Tigray). The sites were selected based on information in terms of the current importance of the sites for irrigated production of the respective crops studied in each region. Each site in the respective region is considered for specific commodities. Information on sites and respective commodities is summarized in Table 1.

2.2 Commodities

Commodities considered in the study are those believed to be of high importance in terms of area coverage and production as irrigated agricultural products. These include onion and tomato as the most important commodities produced across the four regions under irrigated agriculture. However, since Koga irrigation scheme in Amhara has a high diversity of irrigated commodities, perhaps each competing for land, water, labor, fertilizer and other key inputs, it was decided to include seed production from Rhodes grass (Chloris gayana), irrigated wheat, irrigated barley, rain fed wheat and rain fed barley as additional crops.

2.3 Sample selection

Respondent farmers in each site were selected randomly from three irrigating farmer categories: motor pump non-user male headed households, motor pump user male headed households and motor pump user female headed households. The purpose of selecting farmers from the three categories was to ensure representativeness in terms of irrigator farmer typologies since whether or not a farmer uses a motor pump has implications both in terms of crop yield, production cost and profit. It was also important to follow such a sampling procedure in order to ensure gender representation and to make a gender disaggregated profit analysis.

2.4 Sample size

The study is based on observed data for 15 farmers for each commodity; 5 motor pump non-user male headed households, 5 motor pump user male headed households and 5 motor pump user women headed households. We decided to use a small sample size for each crop type to avoid time and cost related constraints from a large number of commodities (especially in the Koga site) spread across four regions. To address the potential analytic problems from small sample size used for each crop type, we used descriptive and simulation techniques. Accordingly, a total of 195 farmers were considered in the study (105 in Koga irrigation scheme (Amhara) across 7 commodities, 30 in Dugda (Oromia) across 2 commodities, 30 in Mirab Abaya (SNNPR) across 2 commodities and 30 in Mesanu (Tigray) across 2 commodities. Table 1 provides information about the commodity specific sites and the number of sample farmers considered.

Table 1. Research design

Study area	Commodity	Sample size	Respondent category
Koga irrigation scheme (West Gojjam, Amhara)	Onion, Tomato, Fodder seed (Rhodes grass), Irrigated wheat, Irrigated barley, Rain fed Wheat, Rain fed Barley	105 (15 farmers per crop type)	5 MPNUa (male headed) + 5 MPUb (male headed) + 5 MPU (women headed)
Dugda (East Shoa, Oromia)	Onion and Tomato	30 (15 farmers per crop type)	Same
Mirab Abaya (Gamogofa, SNNPR)	Onion and Tomato	30 (15 farmers per crop type)	Same
Mesanu (Wukro, Tigray)	Onion and Tomato	30 (15 farmers per crop type)	Same

2.5 Data type and data collection

Data used in the study are primary data collected from selected sample farmers in each study site. The data collected include crop yield, production cost and output price as observed and reported by the sample farm households for the 2013/14 production year. Data were collected in November 2014 using face-to-face interview and structured questionnaire.

2.6 Profit analysis

Profit analysis was made using descriptive and stochastic simulation techniques. We first calculated average yield, cost and price figures using the data collected from the sample farmers for each commodity in each site. The average yield, cost and price figures are then used to calculate net profit per hectare of land obtained from each commodity during the 2013/14 production year. We used descriptive analysis to assess profit based on observed data while a stochastic simulation technique is used to assess profit under the assumption of varying (stochastic) levels of the explanatory variables so that temporal and spatial data variations and other limitations from the descriptive analysis become addressed. Profit generated from each respective commodity is calculated using the standard formula for farm profit calculation (equation 1)

$$\pi_i = [P_i * Q_i * L_i + V_i] - [(\sum_{j=1}^{n} r_{ji} * R_{ji}) + F_i] \quad (1)$$

where π is profit, P is average price of commodity i per kg, Q is average yield of commodity i per unit land area, L is total land area cultivated under commodity i, V is estimated average money value of byproducts or residues as livestock feed, R is average quantity of production input, r is average input price and F average fixed cost. Profit calculation takes into consideration all relevant income and cost items (variable and fixed cost components) that farmers generate from and incur in the production of the particular commodities analyzed. Production cost includes cost incurred on family and hired labor, seed, fertilizer, herbicides, fuel, depreciation, interest and tax. Therefore, profit analyzed and discussed in the paper refers to net economic profit.

Profit from descriptive analysis provides information only about a snapshot (deterministic) profit level based on a single observation on each variable (yield, price and cost) considered for profit calculation. Information from projections made on the basis of point estimate values of uncertain variables may not tell the full story of outcome variable distribution to enable appropriate decision making in uncertain business environment (Thorne and Hennessy, nd). As such, it becomes difficult to have useful insights about the actual profit level and its distribution that can be observed as a result of changes in the values of all or some of the cost and income variables considered in its calculation.

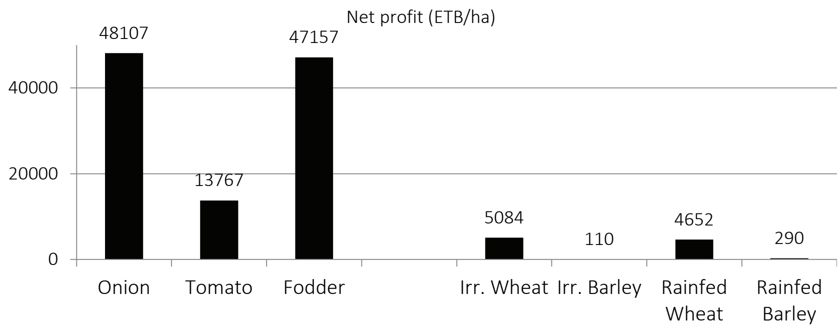
Given the variability of cost, price and yield variables, the small sample size and the cross-sectional and time specific nature of the data set used in our study, a stochastic profit analysis is considered to be supplementary to better understand profit levels observed for each commodity. The stochastic analysis results can be used also to assess the level of uncertainty and risk associated with profit from each commodity and the potential impact of alternative scenarios (yield growth, cost reduction and/or price increase) on the profit level obtainable from each commodity.

3 Results

3.1 Deterministic farm profit

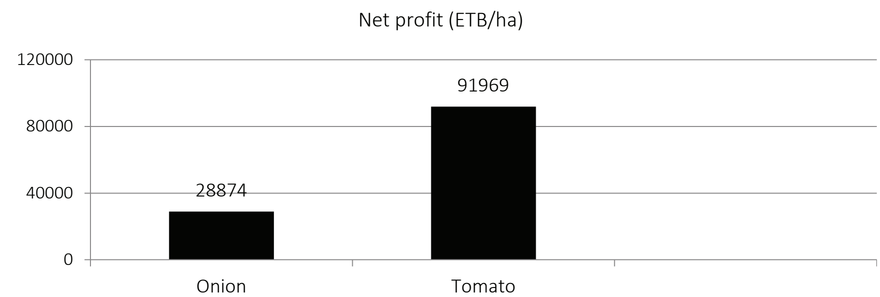
Onion and fodder seed show a high profit level in the Koga irrigation scheme, followed by tomato, irrigated wheat and rain fed wheat. Profit per hectare is ETB 48,107 from onion, ETB 47,157 from fodder (Rhodes grass seed)[1] and ETB 13,769 from tomato (Figure 1). Profit level observed for onion in Koga irrigation scheme is the highest observed for the commodity across all the sites. While profit from irrigated wheat and rain fed wheat is considerable, profit from irrigated and rain fed barley is on the margin.

Figure 1. Profit by commodity type (Koga irrigation scheme).



In Dugda, farmers make a relatively more profit from tomato production (ETB 91,962/ha), followed by onion (ETB 28,874/ha) (Figure 2). Observed profit level generated from tomato in Dugda is the highest among all commodities observed across all the sites in the four regions considered.

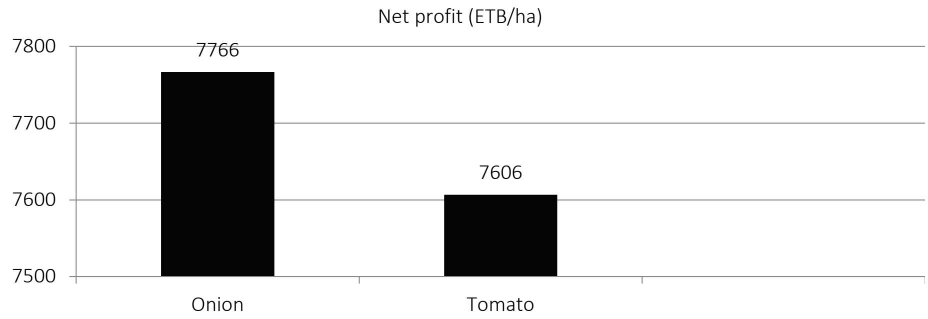
Figure 2. Profit by commodity type (Dugda).



1 High profit generated from Rhodes grass seed is possibly because of the high price paid to farmers by institutional buyers such as the Bureau of Agriculture. As such, it is necessary to track hoe profit from the commodity responds to price decline from increased product supply in the future.

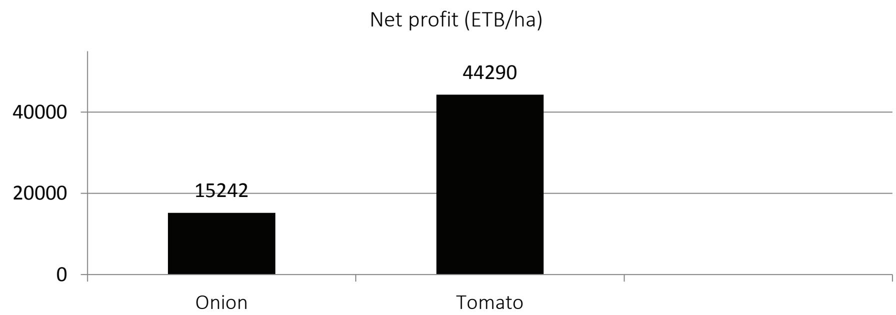
Both onion and tomato are profitable commodities in Mirab Abaya (Figure 3), like in Dugada. However, the profit level observed for onion and tomato is quite low (ETB 7,768 and ETB 7,607/ha, respectively). As shown in Figure 7, this might be attributed mainly to the problem of low yield obtained per hectare, or to distance from major consumer markets such as Hawassa and Addis Ababa.

Figure 3. Profit by commodity type (Mirab Abaya).



In Tigray, tomato provides one of the highest profit levels (Figure 4) observed for the commodity across the four sites (ETB 44,291/ha), next to that observed at Dugda. However, farmers make comparatively low profit from onion production, perhaps explained by high production cost as shown in Figure 9.

Figure 4. Profit by commodity type (Mesanu).



Average profit of the two commodities (onion and tomato) across the four regions shows that both commodities are profitable (Figure 6). Therefore, it can be concluded that smallholder irrigated agriculture is generally profitable for the two commodities of interest though there are inter-commodity and inter-regional variations (Figure 5).

Figure 5. Profit by commodity type (comparison among sites in the four regions).

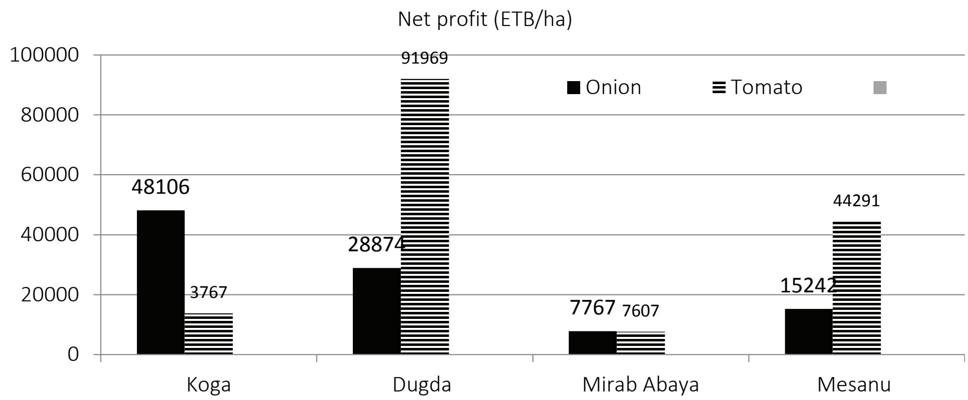
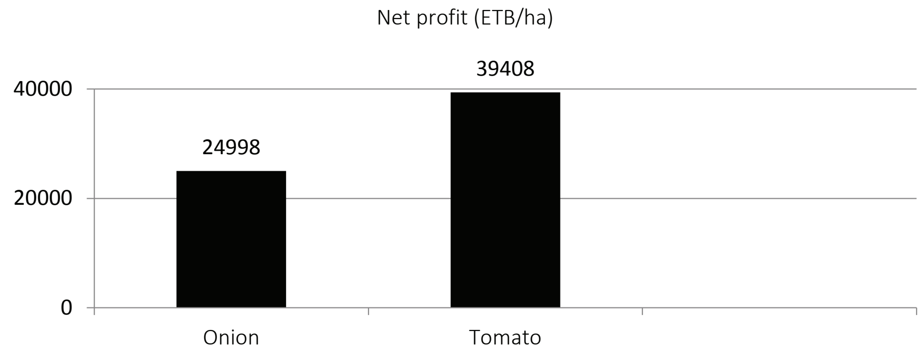


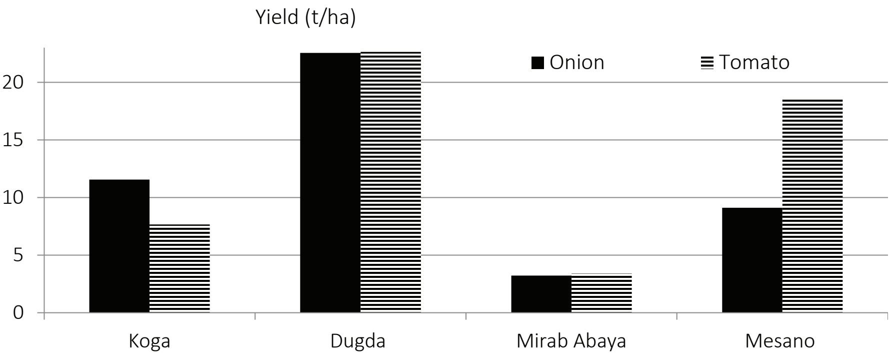
Figure 6. Profit by commodity type (average of sites in the four regions).



Key variables affecting the level of profit generated from a commodity include yield, price and cost. Other variables held constant, high yield, low cost and high price increase profit. Understanding the importance of each of these variables in a comparative context helps to inform intervention decisions aimed at improving the profit level from the commodities. Whether variation in each of such variables provides a plausible explanation to inter-regional differences in the profit level of the commodities is discussed below.

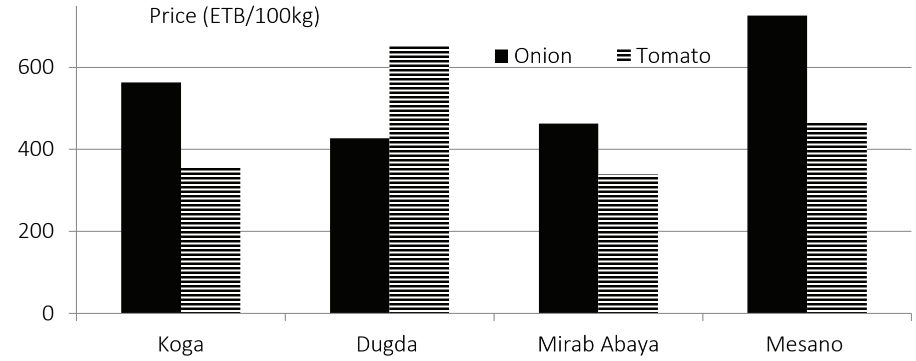
The pattern of yield variation matches with the pattern of profit variation observed among commodities, especially in the case of onion and tomato in Koga irrigation scheme and tomato in the case of Dugda and Mesanu. It seems that a relatively high yield of onion (coupled with high unit price and low production cost) in Koga irrigation scheme contributed to high profit from onion, followed by tomato (Figure 7), with similar patters observed for onion and tomato in Dugda and Mirab Abaya. Yet, yield levels of both crops fall below the expected national average. According to Gebreselassie (2003), average yield of onion in Ethiopia is about 17 t/ha and that of tomato varies between 10 and 18 t/ha (both figures not achieved by farmers in any of the four sites considered in the study). According to Getachew and Mohammed (2012), the yield level is about 28 and 30 t/ha, respectively, in the Central Rift Valley area, suggesting the need to enhance yield in the specific study sites considered.

Figure 7. Yield variation by commodity among sites in the four regions.



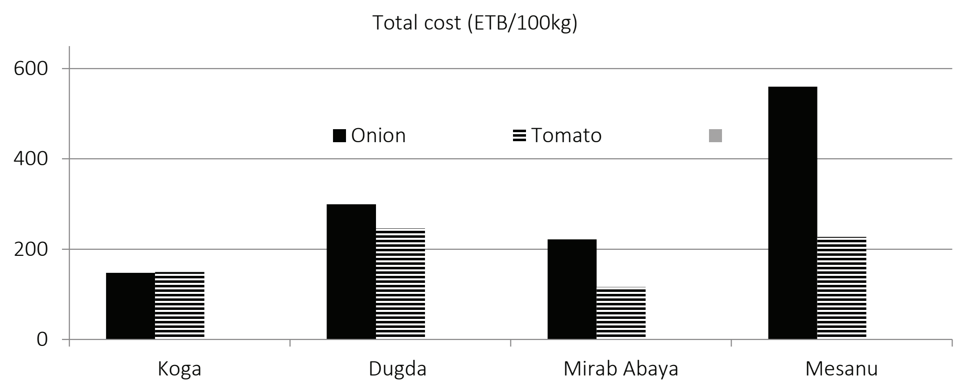
Price, an important economic variable, exhibits important variation among regions for a similar commodity and within a region for different commodities. The relatively high price for onion in Koga irrigation scheme (ETB 563/ 00kg) and for tomato in Dugda (ETB 427/ 100kg) seem contributing to high profitability of the respective commodities in the respective sites (Figure 8). However, the high price for onion in Mesanu (ETB 726/100kg – Figure 8) vis-a-vis the low profit generated from onion is at odds with high profit expectations, unless the mismatch is explained by the high production cost for the commodity (ETB 797/ 100kg – Figure 9) and/or by the low yield level observed (about 9 t/ha– Figure 7).

Figure 8. Price variation by commodity among sites in the four regions.



Variations in cost structure may explain variations in commodity profit level among sites and, as such, can provide useful information to guide interventions. Figure 9 shows that farmers at Mesanu (Tigray) incur much cost (compared to farmers in other sites) for onion production, perhaps explaining the relatively low profit level generated from the commodity. On the contrary, farmers at Mesanu incur relatively low cost for tomato production as a possible explanation to the high profit they make from the commodity. Yet, not only cost but also low productivity as a result of limited adoption of recommended practices is expected to explain low profit level from a commodity.

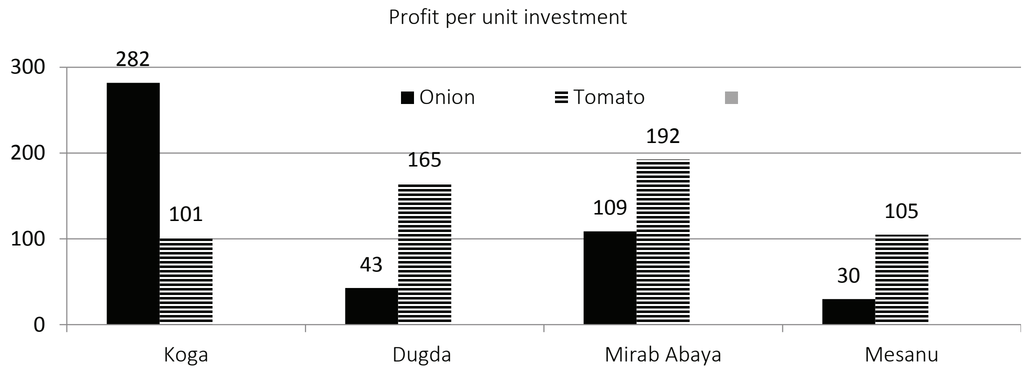
Figure 9. Cost variation by commodity among sites in the four regions.



3.2 Profit per unit investment

How can a farmer be assured that profit generated by each commodity (based on the descriptive profit analysis results) is sufficient enough to justify investments? Such questions can be answered by comparing the profitability (i.e., profit to investment ratio) of commodities with the opportunity cost of the investments made. Investments on those commodities that secure better profit per unit investment can be considered more financially feasible. The highest profitability rate is observed for onion at Koga (282%), followed by tomato in Mirab Abaya (192%) (Figure 10).

Figure 10. Profitability of commodities per unit investment by site in the four regions.



3.3 Intervention scenarios and stochastic profit

The stochastic profit for each commodity is assessed by subjecting respective cost and income variables used in deterministic profit analysis to stochastic distribution. That is, each of such variables are assumed to follow a stochastic distribution so that they mimic the uncertain business environment in farmer operate. The analysis provides information about profit level of each commodity by site, depending on varying levels of yield, price and cost values. The analysis helps to answer the following key questions:

a) What is the probabilistic distribution of profit from each commodity under varying levels of explanatory variables, within the context of the business as usual situation?

b) What is the profit impact of alternative intervention scenarios, such as yield improvement (which can be resulted from improved irrigation agronomy, better extension service and capacity building) and of cost reduction (which can be resulted from value chain development mainly to influence input costs)? The assessment considered the case of three intervention scenarios, each for commodities at Koga, Dugda, Mirab Abaya and Mesanu (Table 2).

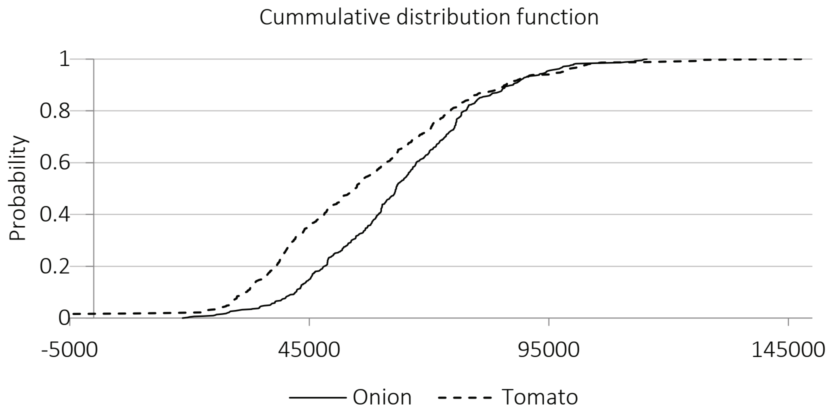
Table 2. Alternative intervention scenarios to enhance profit

Site	Intervention scenario	Commodity
Koga	2. 15% growth in crop yield	Tomato
	3. 15% reduction in total cost	Irrigated wheat
	4. 2 and 3 above	Irrigated barley
Dugda	2. 15% growth in crop yield	Onion
	3. 15% reduction in total cost	
	4. 2 and 3 above	
Mirab Abaya	2. 15% growth in crop yield	Onion
	3. 15% reduction in total coat	Tomato
	4. 2 and 3 above	
Mesanu	2. 15% growth in crop yield	Onion
	3. 15% reduction in total coat	Tomato
	4. 2 and 3 above	

Note: Scenario 1 (not mentioned here) is the baseline situation characterized by the current situation.

The probabilistic distribution of profit for each commodity under stochastic exogenous variables (crop yield, production cost and output price) within the context of the baseline situation shows that profit patterns observed from the deterministic analysis remain unchanged both for the aggregate of all sites from the four regions (Figure 11) and for the case of each site in each region (Figure 12, 13, 14 and 15). As such, the finding reflects the validity of the results obtained from the deterministic analysis. For the aggregate of all sites from the four regions, onion generates more profit in most of the cases, followed by tomato. Though, the upper end of the cumulative distribution curve (Figure 11) shows nearly similar profit generated from onion and tomato, suggesting lack of first level stochastic dominance by any of the two commodities at such extreme levels of profit.

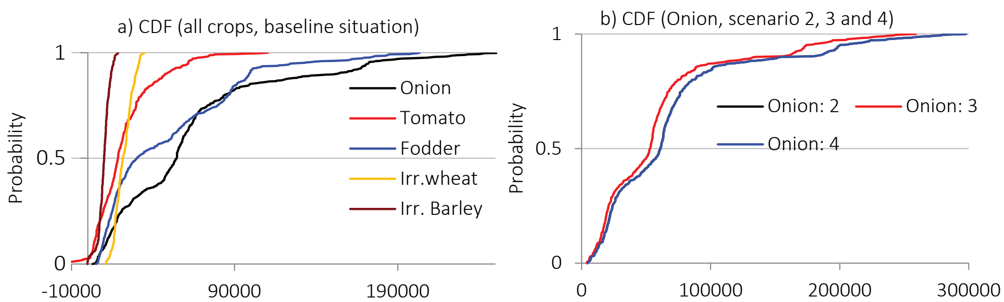
Figure 11. Simulated profit (average of sites in the four regions).

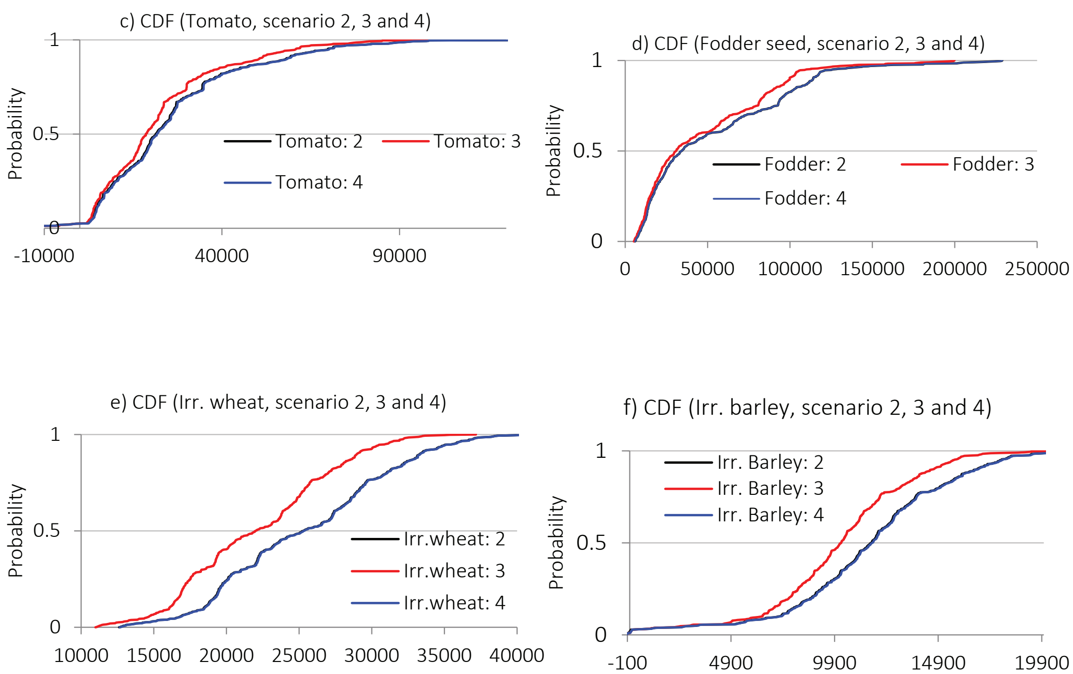


Profit pattern observed for different commodities from the deterministic analysis for Koga irrigation scheme is repeated in the case of simulated profit. Figure 12.a shows that simulated profit for onion is higher than that of fodder seed and tomato as the second and third important crops in terms of simulated profit level. For the same level of probability, more profit is generated from onion, followed by fodder seed and tomato.

Alternative intervention scenarios such as yield increase by 15%, cost reduction by 15% and a mix of the two (Table 2) aimed at increasing profit level raises obtainable profit level from each commodity in the Koga irrigation scheme (Figures12.b, c, d, e, and f). Yield growth has the most noticeable impact in terms of profit growth. Compared to that of the baseline situation (i.e., without any intervention), simulated profit increases by 15.3%,16.5%, 13.5%, and 14.5% for onion, tomato, fodder seed, and irrigated wheat under the scenario of 15% yield growth while it is limited to 0.3%, 1.5%, 0.06%, and 0.23%, respectively, for the scenario of 15% cost reduction. The finding shows that profit is more responsive to yield enhancing interventions, compared to cost reduction interventions. The impact of scenario 4 (i.e., 15% yield growth and 15% cost reduction combined) on simulated profit is obvious in that it increases profit by more than what each independent scenario 2 or 3 impacts, as a result of the combined effect of the two scenarios.

Figure 12. Simulated stochastic profit (Koga irrigation scheme).

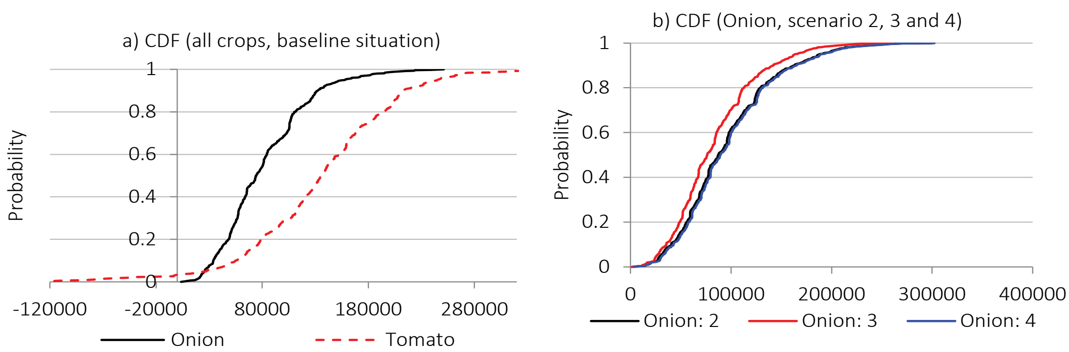




Note: CDF curves for scenario 2 and scenario 4 aren't distinctly different because of substantial overlap.

The dominance of tomato in the case of Dugda in terms of generating more profit is clearly visible from the simulation results (Figure 13). For Dugda, simulated profit under the baseline situation (Figure 13.a) gives similar results to those observed under the deterministic analysis in that high profit is generated from tomato, followed by onion. The impact of yield growth and cost reduction scenarios (all by 15%) is tested for onion (as commodity with a relatively low profit for the case of Oromia region). Mean simulated profit from onion becomes ET|B 95,575 (scenario 2), ETB 83,391 (scenario3) and ETB 97,742 (scenario 4) (Figure 13.b). The results show that profit in Dugda is more responsive to yield related interventions compared to cost reduction interventions.

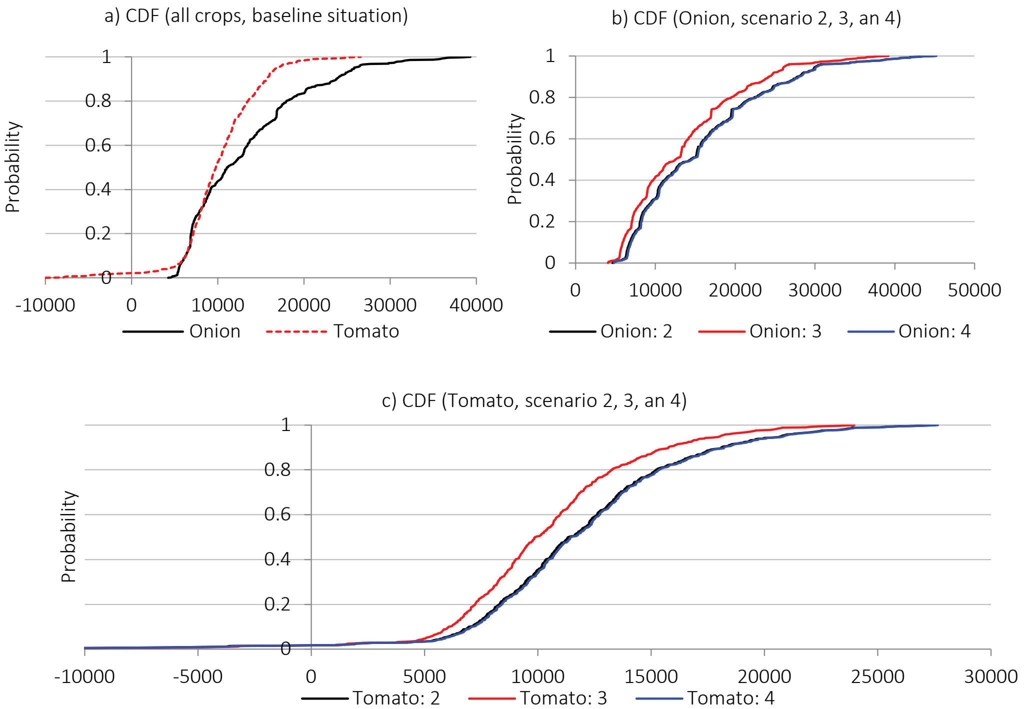
Figure 13. Simulated stochastic profit (Dugda).



Note: CDF curves for scenario 2 and scenario 4 aren't distinctly different because of substantial overlap.

The pattern of simulated profit level observed under scenario 2, 3 and 4 (Table 2) for Koga irrigation scheme and for Dugada holds true also for the case of Mirab Abaya. For both crops, scenario 2 generates more profit compared to scenario 3 (Figure 14), reaffirming the importance of targeting interventions on yield enhancing activities.

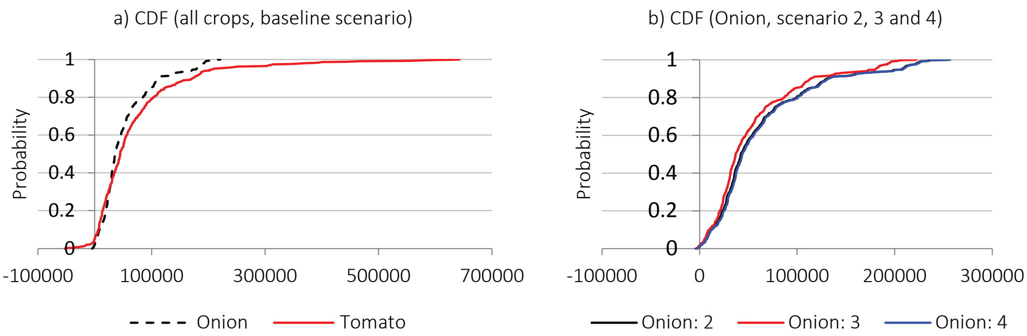
Figure 14. Simulated stochastic profit (Mirab Abaya).



Note: CDF curves for scenario 2 and scenario 4 aren't distinctly different because of substantial overlap.

Simulated profit for Mesanu shows that tomato provides the highest profit, followed by onion (reflecting the patterns observed from the descriptive profit analysis results). For the descriptive results, showed low yield and high production cost as possible explanations to low profit from onion, the profit impact of yield growth (15%) and cost reduction scenarios (15%) is simulated (Figure 15). The simulation results show that mean simulated profit increases when compared to that of the baseline situation (from ETB 52,920 to ETB 63,628 for onion and from ETB 70,862 to ETB 83,256 for tomato). The curve of simulated profit for each crop under the baseline situation (Figure 15.a) moves to the right as a result of scenario 2, 3 and 4 for each crop (Figure 15.b, c, d). The mean simulated profit for each crop is more responsive to yield growth scenario (17.6% for onion and 16% for tomato) than to cost reduction scenario (only 2.6% for onion and 1.2% for tomato). This is evident also from the position of simulated profit curves (Figure 15.b, c, d) corresponding to each scenario in which curves from scenario 2 lie at the right of curves from scenario 3. It is, therefore, important to focus more on productivity related interventions in order to improve profit from irrigated crops in Mesanu.

Figure 15. Simulated stochastic profit (Mesanu).

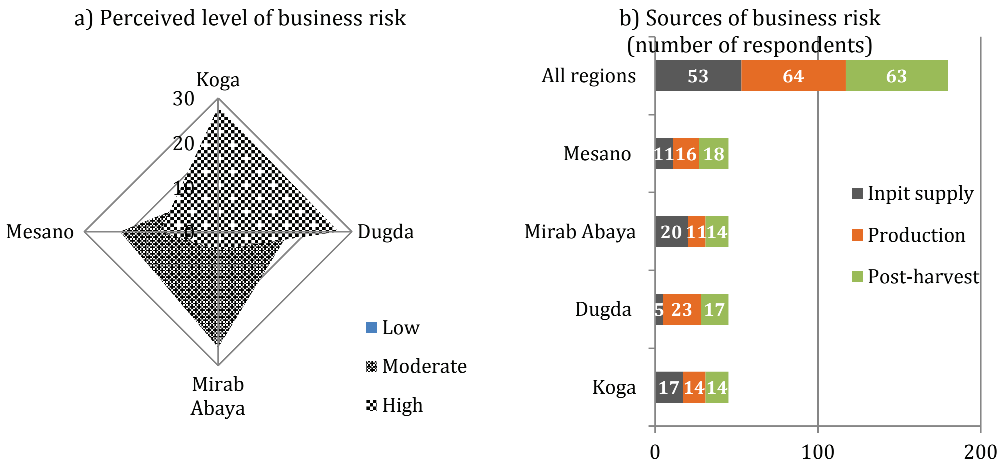


Note: CDF curves for scenario 2 and scenario 4 aren't distinctly different because of substantial overlap.

3.4 Business risk: Perception, causes and management

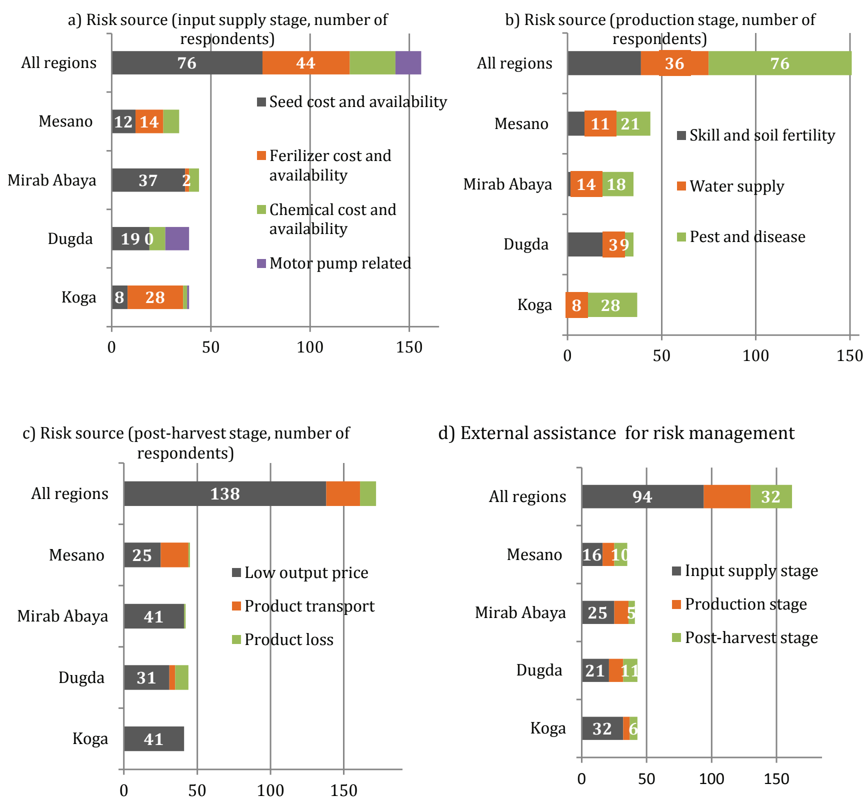
The level of perceived business risk by most irrigator farmers interviewed ranges from moderate (mainly at Mirab Abaya, Mesanu) to high (at Koga and Dugda) (Figure 16.a).Though farmers perceive the production stage of the value chain as the most important source of risk, Figure 18.b shows that business risk equally emanates from all stages of the value chain (input supply, production and post-harvest), suggesting the need to target interventions across all stages of the value chain.

Figure 16. Risk perception and its sources.



Business risk at each level of the value chain is attributed to different factors. The summarized figure for all the sites in the four regions show that risk is mainly caused by seed related factors (high seed cost and lack of quality seed with sufficient supply) at the input supply stage (Figure 17.a), pest and disease problems at the production stage (Figure 17.b) and low output price at the post-harvest stage (Figure 17.c).

Figure 17. Perceived risk sources at different value chain stages.



4. Conclusions and recommendations

Though it is important to be cautious in interpreting the results of the analysis, the major evidence is that smallholder irrigated agriculture of high value crops (onion and tomato) is in general profitable. Compared to irrigated cereal crops such as wheat and barley (the latter two commodities considered only in the case of Koga irrigation scheme), irrigated agriculture of high value crops generates more profit per unit irrigated area. Irrigated fodder seed production from Rhodes grass, a rather newly introduced commodity in the Koga irrigation scheme, also generates more profit compared to traditional irrigated commodities such as tomato. Improving fodder seed production agronomy and technology is expected to further enhance the profitability of the commodity provided that current high prices paid to farmers as a result of institutional buyers remain robust.

Though it is difficult to conclude whether the observed profit levels for each commodity are best indicators and true reflections of the potential profitability of the respective commodities (because the results are based on a snapshot observation on each exogenous variable), most commodities reveal high level of profitability. This may assure the feasibility of investments on the respective commodities vis-a-vis other investment alternatives, such as saving money in local banks to earn the commonly quoted commercial saving rates.

Difference in profit levels observed for commodities in a site and also between the profit levels of a commodity in different sites suggests differences either in one or all of the exogenous variables (yield, cost and price) that affect profit. While price is mainly exogenous and uncontrollable to farmers, yield and cost variables could possibly be intervened to improve the profitability of commodities. Scenario test results show that profit is responsive to yield growth and cost reduction interventions, with yield growth securing a higher response. Provided that output prices are stable, yield enhancing interventions secure more profit to farmers since profit is more responsive to yield growth than to cost rise. Accordingly, value chain development interventions can be targeted at yield enhancing activities. Moreover, cost reduction efforts need to be maneuvered in the cases where evidence for relatively higher cost of onion production is apparent.

Level of perceived business risk by farmers ranges from moderate to high. Though the difference is insignificant, the most important source of business risk is found to be at the production stage of the value chain, followed by the post-harvest and the input supply stages. While factors related to high seed cost and seed availability appear as the most important sources of risk in the input supply stage of the value chain, pest and disease and low output price are the important sources of business risk commonly experienced at the production and post-harvest stages of the value chain, respectively. The findings suggest the need to improve the entire value chain of irrigated agriculture by targeting interventions at all stages. Finally, we recommend repeating the analysis sing a spatially and temporally different dataset to see the consistency of the key results and findings.

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ISBN 92–9146–427–9

Livestock and irrigation value chains for Ethiopian smallholders project aims to improve the competitiveness, sustainability and equity of value chains for selected high-value livestock and irrigated crop commodities in target areas of four regions of Ethiopia. It identifies, targets and promotes improved technologies and innovations to develop high value livestock and irrigated crop value chains; it improves the capacities of value chain actors; it improves the use of knowledge at different levels; it generates knowledge through action-oriented research; and it promotes and disseminates good practices. Project carried out with the financial support of the Government of Canada provided through Foreign Affairs, Trade and Development Canada (DFATD). lives-ethiopia.org

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