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Economic analysis and trade-offs of irrigated fodder production in Ethiopia: Implications for smallholder dairy transformation

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Economic analysis and trade-offs of irrigated fodder production in Ethiopia: Implications for smallholder dairy transformation

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This report on the economic analysis of irrigated fodder production is a discussion paper sponsored by the USAID Feed the Future Innovation Lab for Small-Scale Irrigation (ILSSI) project. The report could serve as a reference document and input for a national strategy and policy brief in smallholder dairy transformation and development of the forage subsector. The report is the result of interviews conducted among smallholder dairy producers and key stakeholders along the dairy supply chains in the Bahir Dar milkshed, Ethiopia.

We are grateful to Aberra Adie and Fikadu Tessema, for their hard work and inputs. We are also thankful to the many smallholder dairy producers in the research site for expressing their views, opinions, and cooperation in the case study. Finally, we thank the key informants from farming communities, livestock experts and staff of the Andasa Livestock Research Center and district agriculture office who patiently responded to our questions and openly shared their views with us.

Executive summary

In Ethiopia, efficient milk production requires a regular supply of fodder of adequate quantity and quality. This is a challenge for smallholder dairy producers for several technical and institutional constraints. In response to feed and forage shortages, farmers practice improved fodder production using small-scale irrigation. This study analysed the economic viability of irrigated fodder production (IFP) and the trade-offs associated with it. The Bahir Dar milkshed was used for the empirical case. A mixed method approach, a combination of qualitative and quantitative research designs was employed.

A survey was conducted with a total of 30 dairy producers (adopters of irrigated fodder technologies). The survey was complimented by in-depth interviews of 30 key stakeholders along the dairy supply chain in the study region. Findings demonstrate that improved forage production and quality feed supply are among key packages for smallholder dairy transformation in the region. Economic analysis results identified three classes of variable costs in IFP – labour inputs cost, farm inputs cost, and animal inputs cost, with a larger share (61%) going to labour inputs cost. The findings also show that IFP is a viable agribusiness option for smallholder dairy producers in the study milkshed, with a considerable net economic return annually from irrigated fodder production. Moreover, the business case comparison results reveal that there is a significant (17%) trade-off and competition for land from khat production. Important recommendations are forwarded to enhance forage development and smallholder dairying in the study milkshed.

Key policy recommendations from this study include recognition of irrigated fodder production as a lucrative agribusiness that is critical to increase dairy farm productivity and milk quality, capacity building of smallholder dairy producers to use small-scale irrigation for increased production and supply of improved fodder, capacity development for smallholder farmers to conserve fodder as a way of reducing waste during the rainy season and enhancing the role played by dairy cooperatives to deliver better services and milk market linkages.

1. Introduction

Ethiopia has large potential for dairy development and its dairy value chain has undergone rapid changes in recent decades (Minten et al. 2020; Ruben et al. 2017). On the one hand, supply side development, characterized by increased adoption of livestock services and dairy technologies by upstream actors, has led to increased milk yields and dairy production. On the other hand, demand development has driven the growth of the sector. Demand side development is commonly driven by increasing urbanization, population growth, rising incomes, increased consumption of animal products, and increased demand for diet diversity and food safety. This modernization of the dairy supply chain has positive implications at the national and household level in the country. Specifically, it helps to reduce rural poverty and enhance food and nutrition security at the farm household level. There is growing evidence indicating that such value chain development provides farmers the necessary incentives to modernize and intensify their agricultural production practices.

Despite this progress, many smallholders face serious constraints in delivering their products to more demanding peri-urban retail outlets, where quality, safety, and taste criteria are crucial for receiving higher prices and better margins. In addition, milk yields and productivity are below the sectors' potential. Approximately, the national average for milk production is 1.5 litres/day/cow, which is ranked low in the African continent. This is due to technical and institutional factors (Getachew et al. 2019). Technical factors include shortage of quality feed, land scarcity for improved fodder, weak veterinary service, disease, and poor breeding strategy (low genetic potential of indigenous cows). Institutional constraints encompass poor infrastructure, fragmented value chains, lack of policy focus, and dairy packages implementation gaps. The livestock extension system is poorly organized and underdeveloped in the country, which exacerbates the systemic challenge of the dairy sector.

In order to respond to these multifaceted challenges and enhance smallholder dairy transformation concerted efforts are needed. Government, private actors, dairy cooperatives, and other key stakeholders in the dairy supply chain are required to invest in the system collectively through dairy hub and innovation platforms. Training and research institutes as well as donors also need to support initiatives to realize the potential of smallholder dairying and its implications for food and nutrition security. Several studies indicated that efficient dairy production requires a regular supply of fodder of adequate quantity and quality. This remains a challenge for smallholder dairy farmers for a number of reasons – low fodder production practices, scarcity of land for forage, poor forage yields associated with seasonality of rainfall, limited forage conservation, and dysfunctional or missing forage markets (Gebregziabher et al. 2009).

In Ethiopia, despite the huge potential, production of improved fodder using small-scale irrigation technologies is underdeveloped and not commonly practiced (Baranchuluun et al. 2015; Getnet et al. 2017). This is may be due to the lack of awareness among smallholders and the impression that irrigated fodder production is not economically attractive and viable (Bezabih et al. 2016). However, a recent study by Getnet et al. (2017) has shown that irrigated fodder (e.g. Rhodes grass) production has positive impacts on increased milk production and yield. The same study showed that farmers obtain better income from irrigated fodder production compared to irrigated vegetables production. In the same vein, feeding of concentrate feed could give high return, but it may not be economically viable as the ingredients (grains, oilcakes, and milling by-products) are very costly (Mengistu et al. 2021). In most livestock enterprises, it has been shown that feeding concentrate feed increases farm expenses, which in turn raises the variable cost of production (Abate et al. 2014; Beyi 2016). On the other hand, use of on-farm grown good-quality forages as a substitute to concentrate feeds can considerably reduce feeding costs and optimize income of smallholders (Mengistu et al. 2021; Hailesilassie 2016).

The Innovation Lab for Small Scale Irrigation (ILSSI) project has been conducting research-for-development work in Ethiopia on irrigated fodder production in an effort to address feed shortage (quantity and quality) problems through promotion and support of small-scale irrigation technologies (Schmitter et al. 2016; Blummel and Adie 2019). Farmers' awareness of the importance of small-scale irrigation for fodder production has increased gradually, with more farmers adopting the new practice in the project sites. Although farmers have witnessed increased animal productivity and income because of the new fodder production practices (Adie 2021), there have not been a formal analysis of the economic viability of irrigated fodder production and its impact on smallholder dairy transformation. This study aimed to understand and analyse the variable costs and economic viability of small-scale irrigated fodder production. Moreover, it assessed the potential trade-offs associated with the new practices at the farm household level.

The key research question that this study attempted to answer was: Does irrigated (improved) fodder production offer a viable agribusiness for smallholder dairy producers in Ethiopia? To this end, we used data collected from dairy producers located in the Bahir Dar milkshed, using a mixed method approach. The specific research questions of the study were:

i. What are major variable costs and expenses in improved fodder production using small-scale irrigation?

ii. Do smallholder dairy producers economically benefit from irrigated fodder production?

iii. Is there a trade-off in irrigated fodder cultivation and other land use practices (e.g. vegetables and khat production) in the research site?

iv. What are the main challenges in the production, adoption, and marketing of irrigated fodder in the study area?

The rest of the report is organized as follows. Section 2 presents a conceptual framework of the study including determinants of smallholder dairy transformation. Section 3 explains the methodology of the research. It provides description of methods of data collection (qualitative and quantitative) and the data analysis strategy. Section 4 presents and discusses findings of the study. Section 5 presents a cross-case comparison. Finally, section 6 concludes with recommendations.

2. Conceptual framework

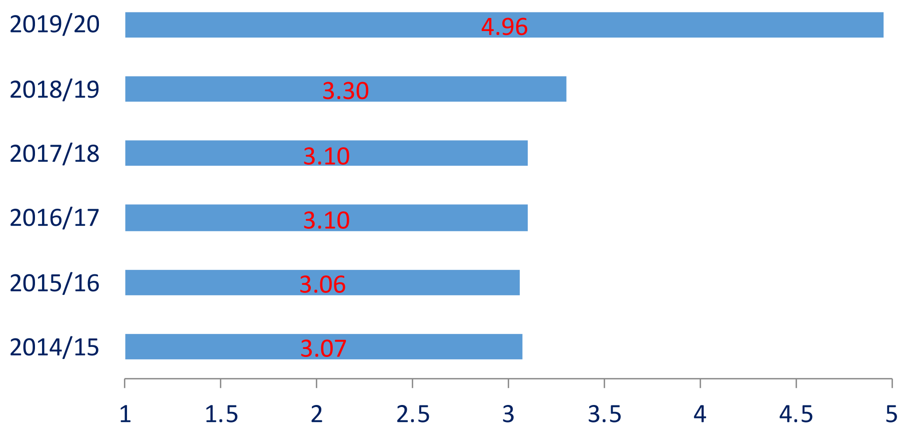
This section provides a synthesis of existing evidence on the importance of improved (irrigated) fodder production and forage commercialization for smallholder dairy transformation. The synthesis is based on the following leading question: How does improved/irrigated fodder production and forage commercialization influence smallholder dairy transformation in Ethiopia? A scoping literature review and desk research was used to collate existing evidence and answer the question. The synthesis is mainly based on local literature and secondary data analysis on the forage subsector and dairy value chain in Ethiopia. We also used a conceptual model to shape and structure the links between irrigated fodder production/commercialization and smallholder dairy transition.

The dairy sector in Ethiopia plays a crucial role in improving nutrition and generating income mostly for rural households. Cognizant to this, the government of Ethiopia considers the dairy value chain a valuable pathway to inclusive economic growth. Dairy has been identified as a priority commodity for the recently established large-scale investment Integrated Agro-industrial Parks (IAIP) (Bure in Amhara), (Bulbula in Oromia), and (Yirgalem in Sidama) (Woolfrey et al. 2021).

The dairy value chain was chosen for this big investment due to the country's comparative advantage on livestock (huge population of livestock), commercial potential, and increasing demand for animal-origin products (from the point of view of food and nutrition security, animal-sourced foods play a key role in healthy diets). The subsector also has good job opportunity potential for youth and women in milk processing and aggregation. In the mixed crop-livestock system, dairying in Ethiopia is mainly smallholder-based (15 million milk producers), dependent on local breeds, and on informal market channels. There is also emergence of large-scale dairy commercial farms in the urban and peri-urban areas, which often use formal market channels (Minten et al. 2020).

There is growing dynamics in the Ethiopian dairy value chain linked to the demand and supply factors. One dynamic is the trend in national milk production and dairy cow population. Milk production in the country has generally increased over the last decade (Figure 1).

Figure 1. National milk production (billion litres).



Moreover, the total number of dairy cows has also generally increased in the last 10 years (Table 1). For instance, the national milk production increased from about 3.07 billion litres in 2015 to about 4.96 billion litres in 2020. This 62% growth in the national milk production could mostly be associated with an increase in the number of cows and not due to increase in productivity.

Table 1. Trends in total number of dairy cows in Ethiopia (2015–2020)

Years	Cattle population (million)	Dairy cows (million)	Annual milk yield (billion litres)	Comments
2014/15	56.71	6.50	3.07	
2015/16	57.83	6.74	3.06	
2016/17	59.49	7.16	3.10	Milk production increases with increase in the number of dairy cows
2017/18	60.39	6.66	3.10	
2018/19	61.51	7.09	3.30	
2019/20	70.29	7.56	4.96	
Average	61.04	6.95	3.43	

Source: CSA, 2015-2020, https://www.statsethiopia.gov.et/our-survey-reports/

Driven by rising per capita incomes, rapid urbanization and population growth Ethiopia has seen a steady increase in demand for dairy products in recent years. Average milk consumption in the country is estimated at around 20 litres per capita per year. Ethiopia has a low level of milk consumption compared to other countries in the region (e.g. Kenya = 90 l/capita; Uganda = 50 l/capita) (Getachew et al. 2019; Minten et al. 2020). These studies also reported that consumption in Addis Ababa is higher, at 40 litres per capita per year, but this is still much lower than the 200 litres per capita recommended by the World Health Organization (WHO). Minten et al. (2020) showed that average expenditures by households on milk and milk products has also generally increased particularly in urban areas.

The supply of dairy products in the country has been unable to keep pace with demand primarily due to low productivity. Milk yields per cow are still relatively low (1.48 l/cow/day) compared with yields in Kenya (10 l/cow/day) and Sudan (6 l/cow/day) (Table 2). In order to balance the mismatch in demand and supply the government has increased its importation of powdered milk. This is puzzling given the livestock/dairy potential in Ethiopia.

Table 2. Total number of milking cows and average milk yield per cow – 2020

Variables	Units	Quantity	Comments
Total number of milking cows	Million heads	15.04	
Average daily milk production	Litres/cow	1.48	Milk yield is very low compared to Kenya and other African countries
Average lactation period	Days	210	
Total national milk production	Billion litres	4.96	

Source: CSA, 2019/20

One of the major factors behind Ethiopia's chronic low dairy productivity is a lack of quality feed options with high nutrient content. Producers in mixed, rainfed crop-livestock systems are particularly constrained by a shortage of feed resources during dry seasons; this condition is increasingly aggravated by pressures arising from climate change and variability. In Ethiopia, the dominant feed resources in the mixed crop-livestock system include crop residues, natural pasture, and conserved forage (e.g. hay) (Table 3). At the national level, the use of natural pasture is the highest (55%) followed by crop residues (31%). The utilization level of improved forage is less than one per cent (0.6%) at the national level. But at the regional level, the most utilized feed type is crop residues (43%) followed by natural pasture (35%) (Tegegne and Assefa 2015). Following the same pattern, the production and utilization rate of improved forage is very low (0.2%) in the Amhara region, where this study was carried out. Thus, there is room for improvement in this area both at national and regional levels.

Table 3. Feed resources and utilization at national level – 2020

Types of feed	Total # of households (million)	Feed utilization (%)		Comments
		National	Amhara region	
Natural pasture	15.53	54.54	35.08	Improved fodder utilization is very low (<1%) in both cases
Crop residues	13.78	31.13	43.90	
Improved forage	0.65	0.57	0.23	
Hay	5.76	7.35	14.19	This may be due to low production (land scarcity) and lack of awareness
By-products	2.08	2.03	1.44	
Others	4.34	4.37	5.15	Lack of policy focus could also contribute
Total	42.14	100	100	

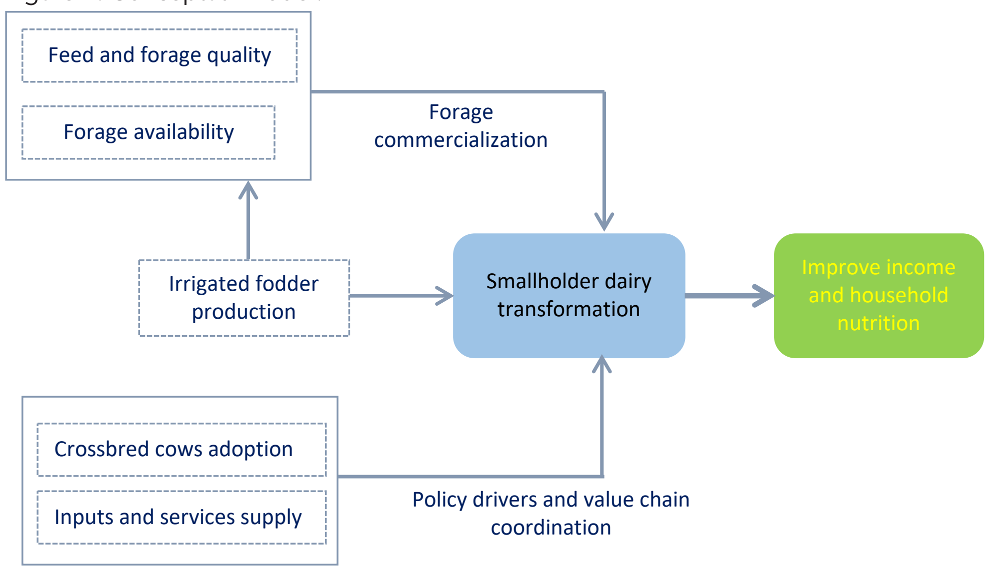
Source: CSA, 2020

Furthermore, there is growing evidence (Kebebe 2015; Birlle 2016; Salo et al. 2017) that shows improved fodder production is increasingly practiced to mitigate feed shortage problems during the dry seasons in Ethiopia. Supported by state and donors, there is an emergence of improved fodder production and utilization by smallholder dairy farmers in different regions of the country. Feeding improved forage and green fodder (grass, legume, and cereal fodder) has positive milk yield and economic impacts at the farm level (Salmon et al. 2018).

Smallholder dairy transformation is driven by a number of technical (biological) factors, value chain, policy and other institutional factors. Within these general drivers, our interest of focus is on feed supply (quality and quantity) and commercialization, which plays a pivotal role in smallholder dairy transition. We have depicted the schematic and conceptual model of how the different feed and dairy technology related specific drivers shape and influence the transformation of the sector in Figure 2.

The first driver is availability and supply of quality feed. The quality and nutrition value of feed is the main ingredient for higher milk production per cow. Given the rising demand, increased quality milk production generates extra income for the farm household, which leads to better food security and nutrition. The second most important deriver that positively affects smallholder dairy transformation is forage commercialization. The direct sale of green fodder and crop residues in the nearby local markets could diversify and increase farm incomes; this in turn could lead to improved farmers livelihoods. The sources of commercial forage are either from irrigated fodder production and/or rainfed forage production. The other important drivers are dairy technology adoption, modern inputs supply, and policy drivers (Figure 2).

Figure 2. Conceptual model.

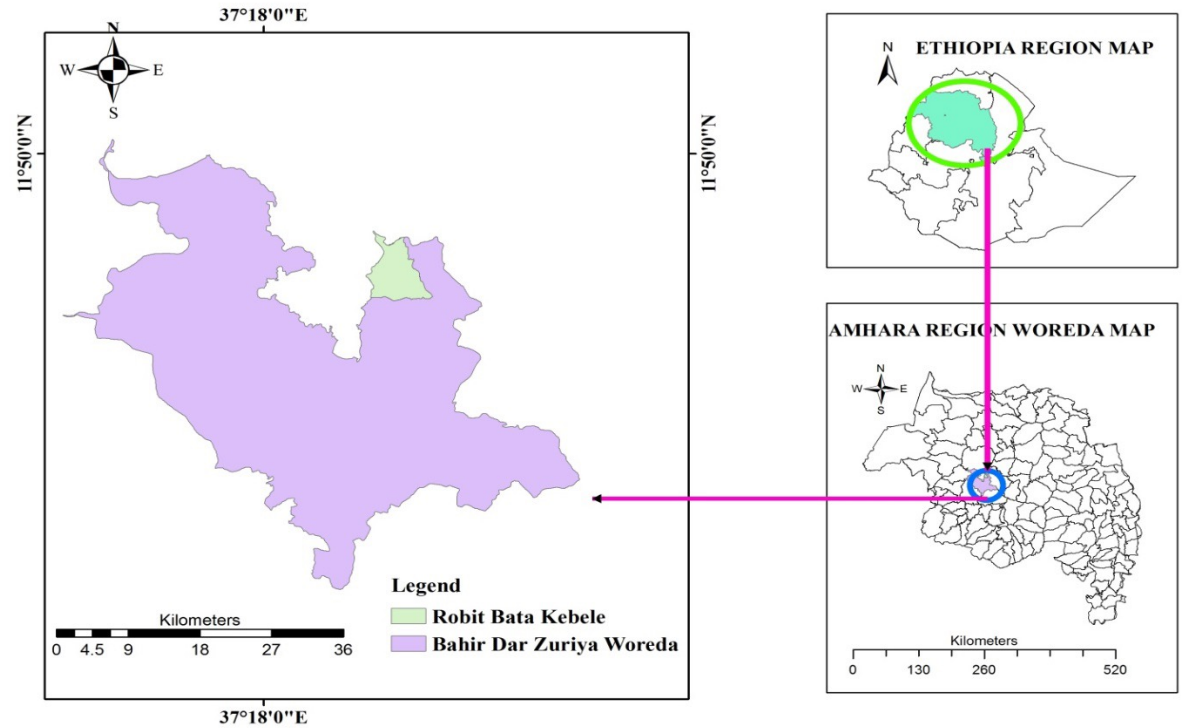


3. Data and methodology

3.1 Study context

The study was conducted in northeastern Amhara region, Ethiopia. The research site (Figure 3) is approximately 35 km away from the regional capital, Bahir Dar. Bahir Dar Zuria District is one of the intervention sites for the irrigated fodder technologies initiative of the ILRI-led ILSSI project. The district is in the West Gojjam Zone of the Amhara region, which is 560 km from Addis Ababa. It is located at an altitude of 1,700-2,300 metres above sea level and has a total area of 151,119 ha. The area receives an average annual rainfall of about 1,035 mm, and the minimum and maximum temperatures in the are 10°C and 30°C, respectively (Anteneh 2015).

Figure 3. Map of the research area.



Source: Getaneh (2021).

The majority of the population in the district subsist on agriculture, the main source of livelihood. The crop-livestock mixed farming system is the dominant production system in the district. Annual crops such as teff, maize, and wheat are produced under rainfed conditions for household consumption and markets. The district (*woreda*) has a total livestock population of about 844,010 (See Annex A). The cattle population is mainly cows of local breed followed by oxen. Livestock are raised for milk, food, manure production, draught power, sources of income, and as assets. Smallholder dairy farming is an integral component of the mixed farming system in the district. The local breeds of cows are the dominant dairy producing animals, which are kept by most farmers for milk that is mostly consumed at home or sold for income.

The study area has three main dairy production systems (see Annex B) – ***urban production system, peri-urban production system, and rural production system***. The urban production system is characterized by stall feeding (zero-grazing), dominated by crossbred cows with few exotic breeds, intensive management practices, semi-modern and market orientation. It is commonly found in Bahir Dar city. The peri-urban production system combines stall feeding and grazing. It is often practiced by smallholder farmers who reside in nearby towns. The system is less market oriented and dominated by local breed cows with few crossbreed dairy animals. The rural production system is entirely dependent on natural pasture and crop residues and commonly found in rural kebeles of the district. It is the traditional system and has poor market orientation for liquid milk. Local breed cows are the main dairy producing animals.

In the district, livestock holding per household is in a decreasing trend due to the decline in communal grazing pasture (caused by competition for crop farming and other land uses). As a result, smallholder farmers have gradually started practicing cut-and-carry feeding with minimum or zero-grazing (the peri-urban production system). Over recent years, the irrigated fodder has helped dairy farmers to feed their milking cows and increase milk yield and quality. Various types of institutions exist in the study area that provide support to smallholder farmers. For instance, the Genet Lerobite Dairy Cooperative is one of the key actors that facilitates smallholder dairy farmers' linkages to markets. The cooperative was established in 2009 by 47 members. Currently, the cooperative has 203 members (163 male and 40 female). The Andasa Livestock Research Center (ALRC) also provides support to farmers in the area with various livestock packages. The district livestock desk and farmer training centers (FTCs) also play an important role in supporting dairy farmers and disseminating dairy production technologies.

Nearly 21% of the land in the district is arable/cultivable and about 36% is covered by water. The main source of water for small-scale irrigation is well water but a single water well in a household is not able to serve throughout the dry period. As a result, many of the households have more than one water well (Wondatir et al. 2015). Most rivers are seasonal (rainy season) and their contribution to irrigation is limited. In the district, smallholder farmers produce different types of crops including green fodder, fresh fruits and vegetables (FFV), and khat using small-scale irrigation. Farmers there are increasingly adopting khat, which has become the dominant cash crop in the area and serves as an additional source of income for most of the farm households in the study district (Wondatir et al. 2015; Ruder 2018). Moreover, farmers produced FFV including avocados, mangoes, 'gesho' and other crops using small-scale irrigation.

Connected to smallholder dairying, feed is the most important factor that affects milk production, both in term of its quantity and quality. Asmare et al. (2017) show that the most important feed resources in the district are communal grazing (natural pasture), crop residues and hay. In addition, farmers in the study district are using and adopting improved forages such as Napier grass and Sesbania (Bezabih et al. 2020). For milking cows concentrate feeding is also given. Despite this, feed shortage is still a key problem for smallholder dairy production in the area. Feed shortage occurs both in the dry and in the wet season; it is severe during the dry season (Asaminew 2009). In order to mitigate these seasonal feed shortage challenges, the community practices feed conservation such as hay making and storage of crop residues (e.g. maize stover, teff straw). In recent years, farmers have started producing green and improved fodder using small-scale irrigation as a result of the awareness created through the ILSSI project, implemented by an ILRI collaboration with Andasa Livestock Research Center (ALRC) and the district agriculture livestock desk.

3.2 Case description

Three agribusiness cases are studied in the research area. These cases were purposively selected based on smallholder dairy producers' engagement. Within each case, we reviewed business farm operations, production practices, and economic viability. We also studied the different types of farm inputs, variable costs, and production subsystems employed under each case.

Case A: Irrigated fodder agribusiness

This agribusiness case focuses on the production and marketing of improved fodder using small-scale irrigation technologies. Smallholder dairy farmers in the study district use various feed resources to feed their dairy animals. This includes green fodder, crops residues (e.g. stover, teff straw), hay, and concentrate feeds. They often source these feed resources from their own production and markets depending on the types of feed. For instance, dairy farmers often purchase concentrate feed from markets and cooperative unions and many of them grow green fodder using small-scale irrigation. Most farmers use well water through pulley irrigation. The cut-and-carry system is used to feed dairy cows with the green fodder to increase milk yield and quality.

Case B: Fresh fruit and vegetables (FFV)

This case is about smallholders' engagement in the production of horticultural cash crops using small-scale irrigation. In the study area smallholders produce various types of horticultural crops such as mangoes, avocados, gesho (ingredient for local drink preparation) and cabbage. They use these cash crops as sources of income (from sales in markets) and home consumption. Most farmers grow these crops in their backyard and use well water for irrigation (pulley system). Farmers use various farm inputs including fertilizer, improved seeds, labour and pesticides to produce cash crops in the study area.

Case C: Khat production agribusiness

This is an emerging business in the study district, in which smallholders engage in the production and marketing of khat, a stimulant drug, for income. Farmers use small-scale irrigation to produce khat in small plots of land near their residences. Various farm inputs including labour, pesticides and fertilizers have been used to produce and sell khat in the nearby town (Bahir Dar) market. Khat is a perennial crop whose leaves are cut and sold many times per year.

3.3 Data collection

In this study, a mixed method research design was employed to collect relevant data and address the four research questions outlined in the introduction. A combination of qualitative and quantitative research approaches was used to gather the required primary data. Combining a qualitative and quantitative approach has the merit of minimizing the weaknesses of each method and gathering more rich data.

A. Qualitative data collection

Qualitative research helps to develop an in-depth understanding of the phenomena and to obtain rich data on the cases under consideration. Three major data collection methods employed in this study were key informant interviews, focus group discussions, and structured field observation (Table 4). These methods were used to collect primary qualitative data. Qualitative data on access to small-scale irrigation, utilization of irrigation water, access to farm inputs and cost, and production practices was gathered. Information was also gathered on trade-offs and competition for land.

Table 4. Types of qualitative data collection method and data sources

Qualitative methods	Primary data sources			Secondary data sources
	No of interviews (n = 30)	Type of interviewee	Agribusiness cases	
Key informant interview (KII)	14	One-on-one interview	Irrigated fodder [Case A]	ALRC unpublished reports, district livestock desk reports, consultant reports, ILSSI project reports (unpublished), and published articles.
Focus group discussion (FGD)	16	Group discussion (2 FGDs]	FFV production [Case B]	
Structured field observation (SFO)	-	8-10 plots visited	Khat production [Case C]	

Source: Own completion (2021).

a. Key informant interviews

Key informant interview was used to gather information to better understand the cases under study. First, a semi-structured checklist was developed. Second, important qualitative data was gathered from relevant key informants through face-to-face interviews using the checklist. The key informants were resource persons and subject matter specialists in the study district. A total of 14 key informants were contacted and interviewed (Table 4). The key informants consisted of district agriculture office experts, kebele development agents (DAs), livestock researchers, cooperative leaders, and elder farmers in the research area. Open-ended questions were used to initiate discussion and capture the responses well. Questions related to access to small-scale irrigation, irrigated fodder cultivation practices, constraints and opportunities of irrigated fodder technologies were discussed, and data collected. In addition, cash crops and khat production practices were also discussed and important data was gathered.

b. Focus group discussions

Focus group discussions were used to better understand the production and marketing issues in the three business cases. They also helped to gather rich information and primary data on the expenses and economic returns of these activities. Farm households collectively (group) discussed crucial themes using a semi-structured guideline. Two FGDs were held with 8-12 participants in each FGD (Table 4). Participants of the focus group included farmers with different status (poor, rich, sex, age, and education). The key themes discussed included improved forage varieties, irrigation-related issues and sources of irrigation water, irrigation mechanism, cash crop production, khat production, economic benefits, and cost structures. The profitability of milk yield (associated with irrigated fodder production) compared to khat and horticultural crop production was also assessed in the FGDs. A semi-structured guideline with open-ended questions was employed to guide the group discussion. All the FGD participants were smallholder farmers engaged in the production of irrigated fodder, FFV, and khat in the study area.

c. Structured field observation

In order to complement the qualitative data collected using the FGDs and KIIs, field visits and observation of several plots (FFV, irrigated forage and khat) were carried out. This direct field observation method helped to assess the status and conditions of farm plots and types of forage varieties grown in the research site. Structured observation was made and notes were taken on how dairy farmers feed green fodder to livestock and how they access and use irrigation water for the three cases.

B. Quantitative data collection

A household survey was used to gather quantitative data and address the aforementioned research questions. A structured questionnaire was developed and administered by well-trained enumerators. For the survey, a targeted or deliberate sampling procedure was followed and a total of 30 sample farm households were selected from Robit Bata Kebele. A number of parameters were considered to select sample farm households including access to well water, green fodder plot, engaged in FFV production, having khat plot, owning milking cows, membership in a dairy cooperative, and adoption of small-scale irrigation. Quantitative data was collected on the three agribusiness cases described above. Data collected in the survey covered among others production practices, types of products produced, types of farm inputs, farm expenses, related prices, and economic and other benefits.

Descriptive statistics (Annex C) of the demographic characteristics of the sample households indicated that most (90%) sample farmers were male headed. Among the sample respondents only 10% were female-headed households. It should be noted that the number of female-headed households in the study kebele is in general low. The average age of sampled household heads was 52 years with a minimum of 27 and maximum of 83 years . Most sample household members were illiterate with minimum years of schooling 0 and maximum of 8. The other important demographic variable was family size; the average family size between the ages of 15-65 years was 3.36 with a minimum of 0 and maximum of 8 people. The mean of irrigation experience for the sampled respondents was about 14 years.

3.4 Data analysis

Cost-benefit analysis (CBA) was employed to analyse cost structures and economic benefits of smallholder producers from the three agribusiness cases. CBA helps to understand the viability and profitability of irrigated fodder production relative to the other two cases. According to Baranchuluun et al. (2015), CBA is often used to assess adaptation approaches. Therefore, in this study, we assessed various costs and economic benefits associated with adaptation approaches employed by smallholder farmers in the production of irrigated fodder, khat and FFV. CBA is applicable in assessing the adoption of technologies by identifying the most effective and economical options based on general information provided by farmers and their responses to the research questions.

Model specification

Net economic return = Total gross revenue - Total variable cost -------------------------------------- (1)

Total gross revenue is the overall monetary value from all the three agribusiness cases practiced by farmers in the study area. The total variable costs were the costs of production (excluding land and irrigation equipment) and were calculated as follows. Land and irrigation instruments were taken as fixed costs.

CP = C_human labour + C_animal labour + C_material input -- (2)

Where, CP = cost of production, C_human labour = cost of human labour considered for (land preparation, planting, fertilizer, and manure application, weeding, spraying, harvesting, threshing, gathering, and water drinking), C_animal labour = cost of animal labour considered for (plowing, trampling and threshing) and C_material input = costs of inputs such as seed, fertilizer, pesticides, and herbicides.

The economic viability of the agribusinesses could also be calculated using the gross margin approach, which is the difference between gross revenue and the total variable cost incurred in the production of specific farm produce. Algebraically,

Net economic return = Gross revenue - Total variable cost ---(3)

Moreover, to determine trade-offs or investment choice (alternative land use practices) marginal analysis and marginal rate of return calculation was employed.

4. Empirical results and analysis

We present the findings of the study in three parts. First, empirical results on fodder production and marketing are presented. Second, we present the empirical evidence on the economics of costs including farm input expenses, labour inputs, agrochemical costs for the three agribusiness cases in the study region. Third, we provide results on the economic returns in the three agribusiness cases, as well as a comparison among the three cases based on production costs and farm performance in terms of yield, gross income, price, and net returns.

4.1 Green forage marketing

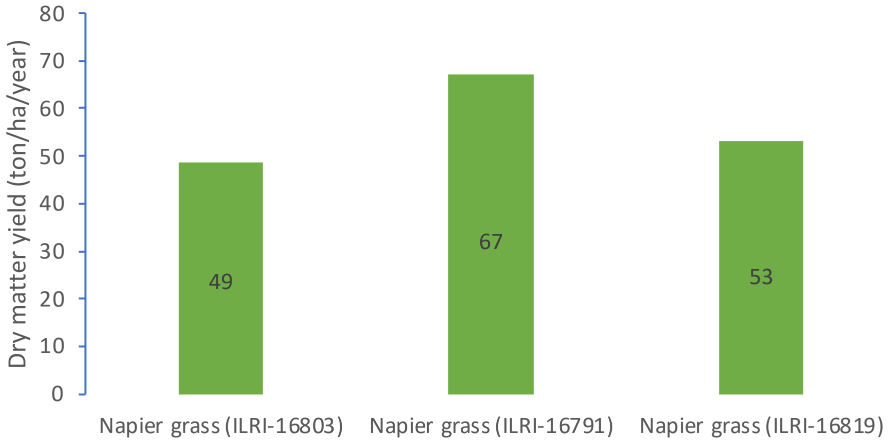
This subsection presents the empirical results on forage production practices, forage marketing and pricing in the study area. Farmers in the study use small-scale shallow well water (pulley irrigation) to produce improved fodder to feed their lactating cows. The most common types of fodder produced using small-scale irrigation include Rhodes grass, elephant/Napier grass, ***Desmodium*** and Sesbania (source: FGDs in Robit Bata Kebele). Farmers grow improved fodder using mixed planting of grasses with legumes (source: direct field observation).

Our field analyses result also show that farmers in the study area produce irrigated fodder in small plots around their residences (due to ease of watering and protection). A prior study in the same area by Bezabih et al. (2020) indicated that the mean plot size allocated for improved forage production is about 0.25 ha. FGD results reveal that irrigated fodder is particularly crucial during the dry season to feed lactating cows and ensure milk yield and quality. In the research area, farmers practice green fodder feeding for only milking cows and small calves.

Feed and forage marketing is an emerging phenomenon in the Bahir Dar milkshed. Dairy farmers often purchase concentrate feed (to feed lactating cows) from cooperatives and traders in the local markets. Our field observation and KII results also indicate that green forage marketing is not commonly practiced or well developed in the area. This could be due to a lack of awareness of the business potential and profitability of green fodder marketing. It could also be associated with cultural barriers and seasonal availability of green fodder.

As green forage marketing is at its inception in the area, we have used simulation of green forage pricing to better understand viability of forage commercialization from a smallholder perspective. Connected to this, the yield performance of irrigated Napier grass can be considered as a basis to estimate the potential income that can be generated from direct sale of green fodder in the local markets. The yield performance of three Napier grass (***Cenchrus purpureus***) accessions have been evaluated under framers' management conditions and demonstration plots in the ILSSI project sites including the study area. The annual biomass yield of the three accessions during the second year of the fodder establishment are presented in Figure 4. Based on this figure, the feed biomass produced from Napier grass using supplemental irrigation during the dry period can range from 49 – 67 tons dry matter/ha/year.

Figure 4. Yield performance of irrigated Napier grass (*Cenchrus purpureus*) grown in Bahir Dar Zuria District.

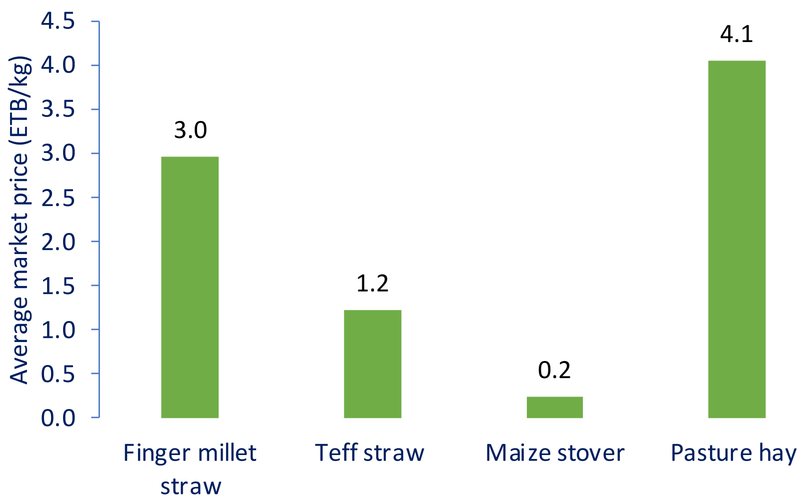


Source: ILSSI project, unpublished data.

Our field analyses also reveal that crop residues and hay are commonly marketed in the local markets in the Bahir Dar milkshed. Figure 5 presents the average price for hay and crop residues of various types in the local markets at the time of the data collection. As can be seen from the figure, the average price for crop residues and hay were ETB 0.20/kg (maize stover), ETB1.2/kg (teff straw), ETB3/kg (finger millet straw), and ETB4/kg for pasture hay. Taking a conservative assumption, irrigated fodder could be sold at a similar price as hay. But the nutritional quality of irrigated fodder is much higher than natural pasture hay and crop residues. Based on this market information and annual biomass yield of irrigated Napier grass (Figure 4), the gross income is estimated to range from ETB196,000–268,000 per hectare per year. Assuming that 50-60% of the income goes to labour, transport and input costs, the net income from the sale of green fodder still remains an attractive business for farmers (ETB98,000 – 134,000/ha/year).

Thus, from a smallholder's perspective, green fodder marketing could be an emerging opportunity to increase and diversify their farm income in Ethiopia. For instance, in the southern part of the country (Hossana area), green fodder marketing is relatively well developed and there are green fodder market places for daily fodder transactions (Bezabih et al. 2020). The same study indicated that smallholders obtain additional income from the sale of green fodder. This is crucial to solve their immediate cash need particularly for women. From a youth and gender perspective, this green fodder trading seems to be an unexploited opportunity for small and medium enterprises to generate a significant amount of income and contribute to feed resource availability for dairy and meat production.

Figure 5. Average market price of crop residues and pasture hay in the local market in Bahir Dar Zuria District.



Source: Local market observation, November, 2021.

Despite such potential, currently there is limited attention to and investment in this agribusiness activity. Different constraints on fodder production and marketing have been reported in the study district, including poor feed storage, unattractiveness of dairy markets, bulkiness of hay and straw, land shortage, insufficient extension services and seasonality of fodder supply (Table 5). On the other hand, in the study site the prices of hay and crop residues were reported to be high, in part due to a stiff competition between their use as feed and local housing construction material.

Table 5. Constraints in forage production and marketing in the study site

Constraints	Rank (1–6)	Comments
Poor feed storage and management	1	These are dairy farmers rate of the constraints as they experienced and perceived
Unattractiveness of milk markets	2	
Bulkiness (difficulty in feeding) of hay and straw	3	
Shortage of land for forage cultivation	4	
Weak extension services	5	
Seasonal availability of fodder	6	

Source: Bezabih et al. (2020).

4.2 Production cost economics

In farm economics, smallholder farmers use various types of inputs or factors of production. These include farm machinery, agrochemical s (herbicides and pesticides), fertilizers (urea, NPS), seeds of improved forages, crossbred cows, feeds, artificial insemination (AI), veterinary services and drugs, labour, land, entrepreneurship, and others depending on the size and type of agribusiness enterprises. Technically, these farm resources could be classified as fixed and variable based on the time horizon (planning period) of production. In the short-term analysis, agrochemical s (herbicides and pesticides), fertilizers (urea, NPS), improved forage seeds, feeds, AI, vets and drugs, and labour are variable inputs. In the long-term analysis, all inputs are variable and influence the level of farm production directly. For instance, in the long run (>3 years), farmers can make major investment decisions on their plot of land (e.g. totally shift to other forms of business).

In this report, we only focus on the short-term analysis. ***The fundamental question*** in the production cost economics is ***which costs are variable and directly affect farm performance in the short-term***? In a smallholder context, expenses for agrochemicals (herbicides and pesticides), fertilizers (urea, NPS), seeds of improved forage varieties, feeds, AI, vets and drugs and labour are considered as variable costs. In case of labour cost analysis, ***the opportunity cost,*** which is the real value (cost) for family labour, is important and needs to be considered. Thus, when members of the family do the farm work, it is necessary to estimate the cost of family labour – that is, the value which is given up to do the same work as a hired labourer. Overall, three important types of variable costs were identified in this study, namely labour input costs, animal input costs, and agrochemical input costs. The results of each cost type are presented as follows.

a) Labour input costs

Labour is one of the key inputs in farm management and economics. It helps to undertake important farm and agribusiness activities such as planting, irrigating, weeding, harvesting, storing and marketing. In this analysis, we have tried to estimate the main labour input expenses spent in the agronomic and production activities for the three agribusiness cases. Table 6 presents summary results of labour input costs in the three cases. As can be seen in the table, among the three cases, farmers utilized more labour inputs in the production of khat (case C). On average, 28.50 man-days per year are utilized to undertake the main agronomic and production activities in the khat agribusiness. From the production activities, harvesting takes the largest share (33%) of labour inputs. This is mainly due to the fact that most of the harvesting work is done manually by hand and requires more casual labour to maintain better quality that fulfills the market demand.

Fresh fruit and vegetable production (Case B) is the second most labour intensive farm business. In Case B, labour inputs are required to undertake production activities of mangoes, avocados, banana, gesho, and sometimes cereals (mainly teff) produced using small-scale irrigation. On average, 19.55 man-days per year are used in the production of FFV (Table 6). Irrigated fodder production is less labour intensive compared to khat and FFV production. On average, 9.50 labour input (man-days) are used in the production activities of irrigated fodder. Thus, relative to Case B and Case C, irrigated fodder production used a small number of labour inputs. In Case A, labour is more required for irrigation (watering), harvesting, and feeding the milking cows. From total labour inputs, 32% and 21% are utilized for irrigation and planting purposes, respectively (Table 6). Overall, farmers spend total labour cost (ETB per ha) of 1,141; 2,166 and 3,420 in Case A, Case B and Case C, respectively.

Table 6: Summary of labour inputs cost for the three agribusiness cases in the district

	Case A			Case B			Case C		
Agronomic activities	Average labour (man-day)	Cost/ ha(ETB)	Share (%)	Average labour (man-day)	Cost/ ha(ETB)	Share (%)	Average labour (man-day)	Cost/ha (ETB)	Share (%)
Land preparation	1.25	150	13.15	3.75	450	19.81	3.0	360	10.52
Planting/sowing	2.00	240	21.05	2.00	240	10.23	4.5	540	15.78
Fertilization	0.25	30	2.63	0.50	60	2.55	0.5	60	1.75
Weeding	0.50	60	5.26	2.50	300	12.78	3.5	420	12.28
Spraying	0	0	0	0	0	0	3.5	420	12.28
Harvesting	1.00	120	10.52	3.50	420	17.90	9.5	1140	33.33
Threshing	0	0	0	1.50	180	7.67	0	0	0
Gathering	1.50	180	15.78	1.50	180	7.67	0	0	0
Irrigation(watering)	3.00	360	31.57	4.30	516	21.99	4.0	480	14.03
TC (ETB/ha)		1,140			2,166			3,420	

Note: Case A = irrigated fodder production, Case B = FFV production; Case C = Khat production. Source: Survey data (2021).

b) Animal input costs

The second important variable cost category is animal input costs/animal labour costs. Animal draft power is required mainly for plowing, trampling and threshing. The results of this cost structures are summarized and presented in Table 7. As shown in the table, irrigated forage and khat production do not use traction power for trampling and threshing activities. Animal traction is used for plowing in all the three cases. The results reveal that Case B utilizes more traction power and incurs more cost per hectare (ETB 542) followed by Case C (ETB 396). Case A utilizes the least (ETB 263/ha). This indicates that FFV production is more animal labour-intensive than the other two cases.

Table 7: Summary of animal inputs cost for the three agribusiness cases in the district

Traction inputs	Case A			Case B			Case C		
	Average labour/ ha	Cost/ha	Share (%)	Average labour/ ha	Cost/ha	Share (%)	Average labour/ ha	Cost/ha	Share (%)
Plowing	1.04	262.33	100	1.16	252	53.70	1.57	396.66	100
Trampling	0	0	0	0.5	145	23.14	0	0	0
Threshing	0	0	0	0.5	145	23.14	0	0	0
TC(ETB/ha)		263.33			542.00			396.00	

Note: Case A = irrigated fodder production, Case B = FFV production; Case C = Khat production; labour is measured in man-days. Source: Survey data (2021).

c) Agrochemicals costs

The agrochemicals costs consists of three categories namely fertilizers, pesticides and herbicides. Access to these inputs is mostly from nearby local markets (pesticides and herbicides) and cooperatives (fertilizers). Forage seed/ seedlings are often supplied by the Andasa Livestock Research Center (ALRC). Table 8 presents summary results for agrochemicals input quantities and costs. It also summarizes the quantity of seed and costs in the three production cases. Improved seeds are utilized in all three business cases, with the highest cost per hectare in Case A (ETB 407) followed by Case B (ETB 393). The high cost may be due to the high price of forage seeds in the area. Fertilizer is used in all the agribusiness cases except for production of khat. The highest fertilizers cost per hectare is incurred in Case B (ETB1,000) followed by Case A (ETB56). The two main types of fertilizer used are NPS and urea. Pesticides are not used in the production of fodder and vegetables but are used in khat production. Herbicides are used only in the production of vegetables (FFV).

In Case C, from the total farm inputs, 76% is pesticides and the remaining 24% is for seedlings (Table 8). On average, khat production incurs the highest cost (ETB4,148/ha) compared to irrigated forage (ETB467/ha) and FFV production (ETB1,574/ha). This is because khat must be sprayed with pesticides two times per month to protect the leaves from pests and insects. In Case A, from the total material input 87% is seed input (Table 8). In the same vein, in Case B, fertilizer takes the major share of agrochemicals used. On average, 64% is used for fertilizer inputs from the total material input for vegetable production (Table 8).

Table 8: Agrochemicals costs in irrigated fodder, FFV, and khat production in the study area

Cost items	Case A			Case B			Case C		
	Input quantity	Cost/ha	Share (%)	Input quantity	Cost /ha	Share (%)	Input quantity	Cost/ha	Share (%)
Seed (kg)	10.0	407.18	87.16	15	393.46	24.99	1,000	24.1	24.2
Fertilizers* (kg)	7.5	56.25	12.04	75	1,000.86	63.59	0	0	0
Pesticide (l)	0	0	0	0	0	0	2.5	3,148.1	75.8
Herbicide (l)	0	0	0	0.5	180.00	11.43	0	0	0
TC (ETB/ha)		467.15			1,573.86			4,148.10	

Note: Case A = irrigated fodder production, Case B = FFV production; Case C = Khat production; * Urea and NPS. Source: Own survey (2021).

4.3 Economic viability

An economic analysis was employed to determine the economic viability of the three agribusiness activities in the study area. The economic return of any agribusiness activity mainly depends on the type of inputs used and production methods applied. Smallholder farmers in the study area obtain gross revenue from the three agribusiness activities summarized and presented in Table 9. The economic return of each case is calculated by multiplying the grain yield and straw yield by the average field price. As can be seen in Table 9, the average gross return from production of irrigated fodder (proxy milk yield[1]) is about ETB21,869. The average gross revenue that smallholder farmers obtained from the production of FFV is ETB16,565. The economic analysis of khat production indicates that on average farmers obtained gross income of ETB31,383 (Table 9). Comparing the three cases, khat production provides the highest gross income. Gross income from khat is 89% and 44% higher than FFV production and irrigated fodder production, respectively.

1 The gross income from irrigated fodder is estimated using milk yield as a proxy.The mean milk yield difference between adopters of irrigated fodder and non-adopters is considered for this calculation.The assumption is that adopters produce more milk because of the irrigated fodder (Getaneh 2021).

Table 9: Summary of gross revenue for the three agribusiness cases in the study district

	Milk yield*			FFV yield			Khat yield		
Outcome variables	Yield (litres/ day)	Price / litre	Total value (ETB)	Yield (quintal)	Price / quintal	Total value (ETB)	Yield (kg/year)	Price /kg	Total value (ETB)
Grain yield	3.75	22.40	21,869.30	5.31	3,875.80	12,815.13	154.03	235.16	31,383.3
Straw yield	0	0	0	25	150	3,750	0	0	0
Gross income (ETB)			21,869.3			16,565.1			31,383.3

Note: Average lactation length (day) = 260; * As direct sale of green fodder is not yet developed in the study area, we use average milk yield as a proxy (we understand this is a conservative assumption). Source: Own survey (2021).

Gross income is crude and does not consider the expenses that farmers incurred in the production and marketing of farm produce in each case. Thus, to estimate economic viability and profitability in each agribusiness case considering variable costs in the analysis is crucial. To this end, we have deducted variable costs from the gross income to get net income or an economic profit indicator. The summary of the results is presented in Table 10. As can be seen in the table, average total variable cost for Case A, Case B, and Case C is ETB1,870, 4,282, and 7,965, respectively. Thus, farmers incurred more cost in khat production.

Table 10: Summary of revenue, variable cost and net economic returns for the three cases

Indicators		Case A	Case B	Case C
Revenue (ETB)	Yield revenue	21,869.3	12,815.13	31,383.30
	Straw revenue	0	3,750.00	0
	Total revenue	21,869.3	16,565.13	31,383.30
Variable cost of production (ETB)	Human labour cost	1,140	2,166.00	3,420.00
	Animal labour cost	263.33	542.00	396.66
	Farm inputs cost	467.15	1,573.86	4,148.10
	Total variable cost (ETB/ha)	1,870.48	4,281.86	7,964.76
Net return (ETB)		19,998.82	12,283.27	23,418.54

Note: Case A = irrigated fodder production, Case B = FFV production; Case C = Khat production. Source: Survey data (2021).

The actual performance and economic viability of each business case is measured in terms of net income or economic profit. Based on Table 10, the average net income per farm household for Case A, Case B, and Case C is ETB20,000; 12,283, and 23,419, respectively. This implies that all the three agribusiness activities are economically viable and farmers obtain positive profit from their investment. Khat production is the most lucrative and profitable agribusiness in the study area. Farmers obtain 91% more net income from khat production than vegetable production (Case B). Moreover, khat production is 17% more lucrative than irrigated fodder production in economic return. Despite the high economic return, khat production utilizes a large amount of pesticides and has negative sociocultural impacts on the community particularly on the youth. Furthermore, from a soil health and fertility point of view, (improved) irrigated fodder production is more advantageous as the legumes help to fix nitrogen in the soil and improve its fertility.

5. Cross-case comparison

This section attempts to assess factors influencing smallholder's investment choices in the study area. We compare the three cases (land use practices) and explore which investment is more lucrative for farmers and why. Marginal analysis using a partial budget is used to produce the relevant indicators for the comparison. Our qualitative analysis shows that farmers' choice of a given agribusiness depends on several farm and farmer-related factors. Farm-related inputs include competition for irrigation water, available labour, and other inputs. On the other hand, farmers' demographic and socio-economic characteristics affect the decision to choose a given agribusiness.

Farming is a risky business and farmers often prefer a risk neutral business (source: KIIs in Bahir Dar). Our key informant interview results also show that diversification is crucial to reduce the risks associated with the farming business. In this regard, smallholders in the study area often engaged in a combination of agribusiness activities. This brings trade-offs and competition for available farm resources. To better understand this and assess farmers' choice of agribusiness activities, a marginal analysis was carried out. The summary of the results is presented in Table 11. Based on the results, all three agribusiness cases are lucrative and viable in terms of economic gains (net income).

Case A. The empirical evidence shows that irrigated fodder production is the second most lucrative agribusiness activities in the study area in terms of economic gains. On average, a farm household obtains ETB 20,000 per production season (Table 8). Farmers' engagement in Case A (compared to the other two cases) has a number of merits and positive aspects that have not been accounted for in the present analysis. First, it ensures improved access to quality feed (improved fodder) at the farm household level. This continuous availability of green forage throughout the year (including the dry season) has a positive impact on milk yield and quality. This in turn leads to an increase in the productivity and reproductive efficiency of dairy animals (age at puberty, calving interval, and conception rates), and reduces the risk of feed shortage and diseases. Second, consequent to high-quality and increased milk yield, there is a possibility that farm family nutrition (health) and income improves.

From the marginal analysis results, marginal rate of return (MRR) in shifting the investment from Case A to Case C is 56%, which implies Case C is a worthwhile and acceptable choice to replace Case A at least in economic terms. However, the MRR from Case A to Case B is (-ve) 309%, which shows that this is not a worthwhile and acceptable choice.

Case B. FFV production is an emerging agribusiness activity in the study area. Farmers often produce fresh vegetables (e.g. onion, tomato, and green paper) fresh fruits (e.g. mangoes, avocados, banana, coffee, gesho, and apples) using small-scale irrigation. Comparing the three cases, FFV production is the least lucrative and viable agribusiness activity, with the mean net income of ETB12,283 per year per farm household. From the marginal analysis results this is also the least preferred agribusiness activity. However, this agribusiness activity utilizes more farm inputs and increases competition for resources. There are trade-offs in alternative use of resources, although Case A is a better investment that farmers choose.

Case C. Both the economic and marginal analysis results reveal that khat production is the most lucrative agribusiness of all. On average, a farm household obtains a net income of ETB23,419 per year from khat farming. Marginal analysis results show that the MRR in going from Case A to Case C is 56%, which implies Case C is a worthwhile and acceptable choice. In the case of the shift from Case B to Case C, the MRR is positive at 301% (Table 11). This implies that Case C is worthwhile and the preferred one. Existing evidence shows that khat production in Ethiopia has boomed over the last two decades, making the country the world's leading exporter of the crop. It is now one of the country's largest crops by area of cultivation and an essential source of income for smallholder farmers in the study area.

Table 11. Marginal analysis using partial budget

Business Cases	TVC (ETB)	Marginal cost	Net return (ETB)	Marginal net return	Marginal rate of return		Decision
					from…to	%	
A	1,870	-	19,999	-	A to C	56	(Weakly) worthwhile
B	4,282	2,416	12,283	(-) 7716	A to B	319	Not worthwhile and acceptable
C	7,965	3,683	23,419	11,135	B to C	302	Worthwhile and acceptable

Note: Minimum acceptable marginal rate of return (MRR) is 50% and MRR should be always positive.

Despite this finding, khat production is not socially and religiously accepted and encouraged in the study area. In addition, khat production in the current system utilizes more pesticides and labour inputs compared to irrigated fodder production. This implies that there is competition for productive resources and land allotted between Case A and Case C. In terms of territorial balance and transforming smallholder dairy sustainably, Case A could perform better as the production practice involves nature-positive practices and contributes to conserving the environment.

6. Conclusions and implications

In Ethiopia, the dairy subsector plays a crucial role in poverty reduction and food (nutrition) security. Driven by rising per capita incomes, rapid urbanization, population growth and preference for food of animal origin, the sector is witnessing a rapid change and transformation particularly in peri-urban and urban areas. The demand for dairy products has increased in recent years. The volume of milk produced has quadrupled in the last two decades – from 1 billion litres annual production in 2000 to more than 4.96 billion litres in 2020 (CSA 2020). Smallholders are an integral part of the dairy value chain and they contribute 98% of the national milk production.

However, the Ethiopian dairy sector faces a number of sustainability challenges. The average per capita milk consumption in the country is estimated at about 20 litres per year, which is still low compared with other African countries and is significantly lower than the 200 litres recommended by the WHO. Milk yields per cow (1.5 litres/cow/day) are still low compared with yields in neighboring countries like Kenya and Sudan. These challenges stem from various sources including technological, capacity, organizational and policy ones. The issue of feed availability and feed quality is crucial and needs immediate attention to transform the sector meaningfully. This study broadly contributes to this argument through examining improved forage development using small-scale irrigation in the country.

The study set out to explore the economic viability of improved fodder production using small-scale irrigation. In particular, it assessed (i) commercialization of green forage, (ii) production cost economics under a small farm context (iii) economic viability of irrigated fodder production as compared to FFV and khat production, and (iv) challenges and opportunities of irrigated fodder production in the context of small-scale dairy farming. The study was informed by an integrated conceptual framework and case study. A mixed method approach was used to generate qualitative and quantitative data.

The findings of the study demonstrate that quality feed supply and forage commercialization is among the key issues for smallholder dairy transformation in the study area. Smallholders' use of small-scale irrigation for improved forage production is crucial for increased dairy productivity and milk quality. This in turn increases farm income and food (and nutrition) security. The findings also show that smallholder farmers used small-scale irrigation for various types of agribusiness activities – production of improved forage, fresh fruits and vegetables, and khat. All these three agribusiness activities are emerging opportunities for smallholder farmers in the study region.

Our analysis reveals that dairy farmers in the study area engage in the marketing of crop residues and natural pasture hay. The average market price for these feed categories ranged from ETB0.20/kg (crop residue) to ETB4/kg (hay) in the local markets during the time of data collection. Urban and peri-urban dairy producers are the main buyers of these feed resources for their dairy animals. The study findings also indicate that marketing of green fodder is not yet well developed in the study milkshed. This is because of (i) shortage of supply (scarcity of land) for fodder development, and (ii) weak extension on green forage marketing in the district.

Our economic analysis shows that different types of variable costs impact the smallholders in the study area – labour input costs, agrochemical input costs and animal input costs. Cost analysis results indicate that these variable costs are varied among the three agribusiness activities. For instance, khat agribusiness requires more pesticides and labour input costs. In term of economic return, all three agribusinesses are economically viable and offer good income-generating opportunities for smallholder farmers. On average, farmers obtained a net profit of ETB 20,000, 12,283, and 23,419 per year from the production of irrigated fodder, FFV, and khat, respectively. Khat production is the most lucrative agribusiness followed by irrigated fodder and FFV production. But khat production uses more agrochemicals (pesticides) and has negative health implications particularly for the young and productive working population. On the other hand, irrigated fodder production has positive spillover effects on (i) farm family nutrition (women and youth) and health, (ii) environmental sustainability, and (iii) soil fertility, health and quality.

Policy implications

The study findings have several implications. The following targeted actions are needed to realize the untapped potential of smallholder dairy and fodder agribusiness in the Bahir Dar region:

1. Recognition of irrigated fodder production as a lucrative agribusiness that is critical to increase dairy farm productivity and milk quality. There is an opportunity to install institutional support structures and services for fodder agribusiness in the region.
2. Capacity building of smallholder dairy producers to use small-scale irrigation for increased production and supply of improved fodder. Provide material support and context-specific training for key actors on the use/application of small-scale irrigation in fodder agribusiness development.
3. Capacity development for smallholder farmers to conserve fodder as a way of reducing waste during the rainy season. Provide tailored training on fodder conservation and feeding systems for dairy producers and other key actors (DAs, livestock local experts, etc.)
4. Capacity building of dairy cooperatives for better services and milk market linkages. Provision of relevant training to cooperative leaders on business management, marketing management and group leadership. Dairy cooperatives to serve as a source of market information, demand, inputs supply, and a voice for dairy producers in the region.

Areas for further research

1. Conducting regular feed marketing survey and cost benefit analyses under different dairy production systems – traditional (grazing based) system with mainly local cows, peri-urban system with a mix of crossbred and local cows, and urban (zero-grazing) system with crosses and pure exotic breeds. As feed is the highest cost in milk production, these kinds of studies can help in prioritizing the most important feed types in different dairy production systems.
2. Case studies on the sustainability of the cooperative business model – nationally, the cooperative model has low market performance, managing only 5% of the dairy market share. In-depth analysis of why this organizational innovation is underperforming in marketing of dairy products is a good niche to explore. In addition to capacity issues in raw milk processing, the perceived market orientation of the cooperative business model is mostly weak. Reorientation of the role of dairy cooperatives to serve as a market for outputs and inputs (including forage seeds) is an area which needs to be explored further. In this regard, analysis of organizational elements and external factors that are crucial for market performance and resilience of the cooperative would be important.

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Appendices

Annex A: Types and number of animals in the Bahir Dar milkshed – 2020

Types of animals		Description	Total number of animals
Cattle	Local breed cows	Local breed cows in number of heads	150,171
	Cross breed cows	Cross breed cows in number of heads	1,310
	Local heifers	Local breed heifers in number of heads	57,058
	Cross heifers	Cross breed heifers in number of heads	506
	Ox and bulls	Ox and bulls in number of heads	156,491
	Calves	Numbers of calves (heads)	32,288
Small ruminant	Sheep	Number of sheep (heads)	60,672
	Goat	Number of goat (heads)	52,556
Equine	Horse	Number of horse (heads)	69
	Mule	Number of mule (heads)	1,703
	Donkey	Number of donkey (heads)	30,661
Poultry	Chicken	Number of chicken (heads)	300,545
		Total	844,010

Source: Bahir Dar Zuria woreda livestock desk records (unpublished)

Annex B: Characteristics of smallholder dairy production systems in the Bahir Dar milkshed

Production systems	Key managementpractices	Main types of feeds used & (sources)	Main types of dairy animals & herd size
Urban production system	Mainly stall feeding (zero grazing), Good attention to health care of dairy animals, Water availed to the cows, Intensive/semi modern system Cows produce > 10 litres of milk per day Market oriented	Crop residues and hay (market), Concentrate feeds (cooperative union & traders) Atela (brewer by-product) Green fodder (own production)	Few exotic breed (Holstein Friesian) Majorly exotic crosses with local breed types Average # of milking cows > 6 heads
Peri-urban system	Stall feeding and grazing: dairy animals graze in roadside Good attention to the general well-being of dairy animals Cows managed with other animals (oxen, heifers,) Mainly smallholders owned Cows produce 5-7 litres of milk per day Weak market integration	Irrigated fodder – grasses & legumes (own production) Crop residues & hay (own & markets) Little concentrate feeds (market)	Medium # of crossbred Large # of local breed cows Average # of milking cows > 3-6 heads
Rural production system	Grazing on natural pastures (roadsides, common grazing) Poor disease control: Animals treated as diseases occur Water available from rivers and ponds Extensive/traditional system Mostly smallholders owned Cows produce 2–3 litres of milk per day Poor market orientation	Natural pastures (communal grazing) Crop residues; cows allowed to graze on harvested lands Little or no concentrate feeds (market)	Very few # crossbred Large # local and indigenous breed Average # of milking cows ≤2 heads

Source: Literature review and exert interview (2021).

Annex C: Demographic characteristics of sample households (n =30)

Variables		Freq	%	Mean	Std. Dev	Min	Max
Sex of the household head	Male	27	90				
	Female	3	10				
Age of household head (year)				52.16	15.77	27.0	83.00
Education (year schooling)				2.60	2.95	.00	11.00
Family size b/n 15-65 (years)				3.36	2.28	.00	8.00
Irrigation experience (year)				14.03	10.69	1.00	45.00

Source: Survey data (2021).

Annex D: SWOT analysis of irrigated fodder production in Bahir Dar Milkshed

Strengths	Weaknesses
Strong and committed farming community	Inadequate support for dairy cooperative
Large number of smallholder dairy producers	Weak irrigation water management
Favorable weather and soil conditions for forage production	Poor dairy extension services (focus on crop)
Attention of regional government and NGOs intervention	Lack of access to forage seed and seedling
Irrigation experienced producer farmers, strong social communication skills at producer levels	Low adoption of credit service
Diversification feeding system	Lack of dairy strategies for the sector's development
Beneficial for environmental and soil conservation	No a strong centralized institution leading the dairy sector (e.g. Dairy Board)
	Limited large scale farming practices
	Lack of access to milk market information
Opportunities	**Threats**
Diverse agroecology and climate condition	Climate change challenges and extreme weather events
Increased farmers interest to engage in dairy farm business	Completion from other cash crops (FFV) and Khat because of scarcity land for irrigated fodder
Growing demand for milk and dairy products	Limited irrigation (water source) potential and traditional irrigation
Availability of dairy cooperatives	Informal and fragmented milk market value chain structure
Availability of NGOs and projects in forage and dairy production	Milk price volatility during the fasting season
Potential dairy products market in Bahir Dar	
Unexploited land and water resources	

Source: FGDs and key informant interview, 2021.

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