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SIMULATED ECONOMIC AND NUTRITION IMPACTS OF IRRIGATED FODDER AND CROSSBRED COWS ON HOUSEHOLDS IN LEMO WOREDA OF ETHIOPIA

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Background

The livestock sector is one of the main pillars of Ethiopia's economy, contributing approximately 45% to the agricultural GDP (Negassa et al. 2013; FAO 2017). Ethiopia's annual milk and dairy products imports are valuated over 45 million Birr (1.2 million USD), and demand for animal source foods is projected to increase due to the high population, income growth and urbanization (Abera, 2012). Besides the critical economic and social roles that livestock play in the livelihoods of smallholder farmers, it helps people cope with shocks and accumulate wealth, particularly where formal financial institutions are lacking. Despite the importance of livestock in the Ethiopian economy, several constraints related to livestock production, such as low livestock productivity, remain a major barrier to the development of the livestock sector in Ethiopia (Negassa et al., 2013; Shapiro et al., 2015). According to Shapiro et al. (2015), better breeds (i.e., genetics), feed, and veterinary care are critically important for improving the productivity of dairy cows in Ethiopia. Thus, this study evaluates how improving animal feed resources and breeds impact both household income and nutrition through the production, consumption and sale of live animals and animal products.

A farm level economic and nutrition simulation model (FARMSIM) was used to carry out the study in Upper Gana kebele (village), Lemo woreda (district), which is located in Hadiya zone of the Southern Nations, Nationalities, and Peoples' Region (SNNP) region of Ethiopia. Crop and animal production are the major economic activities in this part of the country. FARMSIM is a Monte Carlo simulation model that simultaneously evaluates and forecasts for five years a current (baseline) crop and livestock farming systems and an alternative technology system for a farm (Bizimana & Richardson, 2019). In the study presented here, small-scale irrigation technologies, improved seeds and fertilizer are used to grow and improve yields of fodder (oats, vetch). It assumes that these are fed to native and dairy crossbred cows and that the aim is to improve household nutrition and income. Annual net farm cash income (profit) and the benefit cost ratio are the economic key output variables calculated by the model, while the nutrition variables comprise average available daily intake of calories, protein, fat, calcium, iron, and vitamin A for an adult equivalent (AE). Total nutrients consumed by the family from all sources are summed across plant and animal food stocks and compared with minimum daily recommended amounts for adults published by the Food and Agriculture Organization (FAO) (FAO, 2001a&b; FAO, 2010; IOM, 2006) to evaluate nutrition adequacy.

Input data for FARMSIM comprises information on farm assets, liabilities, production costs, yields, output prices, and use of crops and livestock products for human consumption and livestock feed. The input information on crops and livestock for the baseline scenario was acquired from a household survey conducted in Lemo woreda by the International Food Policy Research Institute (IFPRI) in 2017. Data input for the alternative scenarios were collected during field trials conducted from 2015-2017 with local farmers in Upper Gana and Jawe kebeles and led by the

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Africa Research in Sustainable Intensification for the Next Generation (Africa Rising), the International Water Management Institute and the International Livestock Research Institute (ILRI) (Schmitter et al., 2016). Information on crossbred cows was collected from field trials and farmers in Lemo (SNNP region). A crossbred cow can produce approximately 5 liters per day with supplemental forage nutrition, or 1500 liters annually assuming 305 lactating days in year, as opposed to 1.2 liters for local or native cows (Adie Aberra and Bezabih M. Derseh/ILRI, personal communication 2019). This information is roughly comparable to the numbers reported in the Ethiopian Livestock Master Plan for the period from 2014/2015-2019/2020 in which crossbred dairy cows are expected to produce 6 liters per day compared to 1.9 liters for local or native cows (Shapiro et al., 2015).

Scenario analysis

To explore the synergistic benefits arising from livestock and irrigation innovations, livestock production technologies (fodder, crossbred cows) were aligned with water lifting technologies (rope and washer, solar pumps). In the baseline scenario, fodder crops (oats, vetch) are grown on limited land with minimal irrigation and fertilizer applications. Due to limited production, all the fodder produced is sold at the market for revenue generation. However, in the alternative scenarios, more land (3-7 times the baseline scenario land) is allocated to fodder especially during the dry season due to irrigation in addition to raising crossbred cows. Higher fertilizer rates and improved seeds are also utilized in the alternative scenarios compared to the baseline. A portion of the total production of fodder is fed to cows, bulls, and sheep to increase the production of milk and meat while the remainder is sold to generate income. The four scenarios analyzed are as follows:

Baseline:	No or minimal irrigation; no supplemental fodder feeding; local or native cows
Alt.1--R&W-P_N:	Rope and washer pump used in optimally irrigated systems + Supplemental feeding of native cows
Alt.2--Solar-P_N:	Solar pump used in optimally irrigated systems + Supplemental fodder of native cows
Alt.3--Solar-P_CB:	Solar pump used in optimally irrigated systems + Supplemental fodder feeding of crossbred cows

Assumptions

To show the full potential of adopting new technologies, the alternative crop farming technologies are assumed to be fully adopted (100%) while a lower and progressive adoption rate was considered for the livestock technologies in the course of the five-year forecasting period based on household survey information. We also assume in the model that there is at least one crossbred cow per household in Lemo, although its adoption is still low (3%) due to the high purchasing cost. Consequently, we incorporated a loan scheme for each household in Lemo to purchase one crossbred cow, payable in four years at 10% interest rate. Second, the markets were assumed to be accessible and competitive with no distortion. Last, based on preliminary simulation runs on profitability, we estimated that each household, in both baseline and alternative scenarios will allocate close to 37% of their net profit (if available) to purchase supplemental foodstuffs that comprise staples and animal source foods. In this analysis, farm families consume food grown on the farm and/or purchased at the market for their nutrition. A preliminary analysis of food items consumed by an average household in Lemo woreda indicates a predominance of a cereal-based diet with

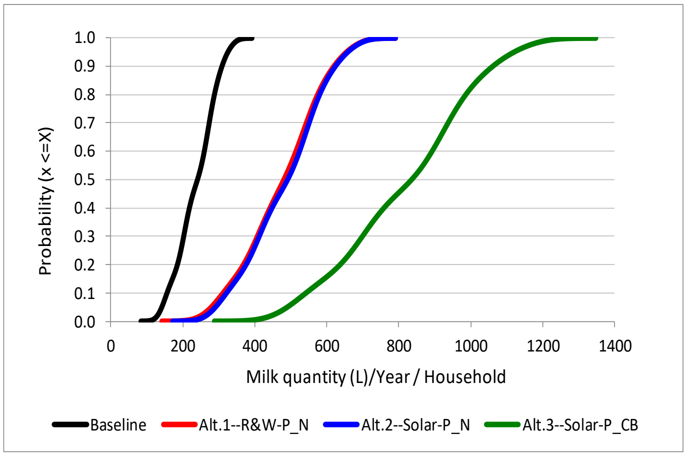

Figure 1. Cumulative distribution function of annual milk production per household in Lemo. The baseline and three alternative scenarios (Alt.1-3) are described in the table above.

substantial shortage of animal-source food consumption. About 64% of the profit is allocated to the purchase of eggs and butter under alternative scenarios for nutrition improvement. Although no new milk purchase was made under the alternative scenarios and the fraction of milk consumed (70%) remained unchanged for all scenarios, the quantity consumed increased at home due to the increase in milk production under alternative scenarios (Figure 1). The types of crops grown and consumed by families in Lemo woreda comprised mainly wheat, maize, teff, cabbage, carrots, banana and haricot beans and moderate purchases of teff and maize were added to these. Significant amounts of vegetables (carrot and cabbage) were purchased under the Alt.3 scenario associated with crossbred cows to compensate for the reallocation of land previously used for on-farm vegetable production to fodder production. On-farm production and consumption of animal products such as milk, butter, eggs, chicken, sheep, and beef were included also in the analysis.

Simulation results

1. Economic impacts

The annual net cash farm income (NCFI) in year five, which represents the economic profitability at the household level, shows that the average profit under alternative scenarios (Alt.1, Alt.2, and Alt.3) is two to three times higher than that of the baseline scenario. The increase in profit from the baseline to the alternative scenarios were 90%, 99% and 263%, respectively (Table 1). However, the NCFI distribution shows between 4% and 6% probability of having a profit equal to or less than zero (loss) for Alt.1 and Alt.2 but only 0.2% probability for Alt.3 (crossbred cow scenario). Although the profit under alternative farming technologies shows higher gains compared to the baseline, the distribution results highlight the risk associated with high production and water lifting tool (such as solar pump) costs involved in investing in small scale irrigation technologies investment. Alt.3 associated with crossbred cows, clearly shows higher profit compared to other scenarios, as its cumulative distribution function curve stands farther to the right of all other scenarios, mainly due to increase in fodder sale.

Table 1. Economic impacts of livestock technologies in Lemo woreda

	Baseline	Alt.1--R&W-P_N	Alt.2--Solar-P_N	Alt.3--Solar-P_CB
Economics:	Averages values in Birr/family in year 5			
Net present value (5yrs)	119,429	160,237	152,340	140,750
Tot avg. net profit	4,139	7,863	8,233	15,009
% change profit: Alt./Baseline		90%	99%	263%
Benefit Cost Ratio (BCR): Alt/Base		1.9	1.0	1.2
Internal rate of return (IRR)		0.5	0.1	0.2
Prob BCR> 1 (%)		97	50	88
Prob IRR> 0.1 (%)		97.5	50.8	88
Avg. Livestock net profit	3,134	2,833	2,833	3,089

Note: Exchange rate: 1USD = 37.5 Birr as of August 2020. The three alternative scenarios (Alt.1-3) are described in the table above.

To assess whether the benefits are worth the investment cost, a cost benefit analysis was conducted using two net present value-related metrics illustrated by the benefit cost ratio (BCR) and the internal rate of return (IRR). The two metrics inform on the profitability and return on investments in small-scale irrigation technologies, fertilizers and crossbred cows. The results indicate on average BCR values for all alternative scenarios equal or greater than 1.0, and IRR values equal or greater than the discount rate of 0.1 (threshold values), which is an indication of profitability (or break-even) of the investment in alternative technology (Table 1). Noticeably for Alt.2 scenario under the solar pump system and native cows, the results show on average a break-even point with a BCR ratio of 1 and an IRR of 0.1.

2. Nutritional impacts

We evaluated nutrition variables and compared them to daily minimum requirements per AE, to determine adequacy of calories, proteins, fat, calcium, iron, and vitamin A intake available to the household.

Simulation results show that the amount of milk consumed by families in Lemo increased by 77% in Alt.1 and Alt.2 scenarios associated with native cows compared to the baseline scenario, while the amount of eggs consumed increased four times. Under the Alt.3 scenario associated with crossbred cows, milk production by families increased 3-fold (304%) while the consumption of eggs increased 28-fold due to purchases. The amount of butter consumed by families increased by 62% from the baseline to Alt.1 & 2 scenarios, while it increased 20 times for Alt.3. due to purchases. The expansion of irrigated fodder cropping area under Alt.3. led to an increase in fodder production as well as fodder sales, which led to 5-fold increases in receipts and profit compared to the baseline. The increase in live weight for cattle and sheep led to an increase in consumption of beef by 31% and mutton by 54%. Overall, the nutrition simulation results show that the food products consumed by families in the baseline and alternative scenarios met the minimum daily requirements for calories, proteins, iron, and vitamin A but were insufficient for meeting calcium and fat requirements (Table 2). Calcium deficiency may be due to low consumption of animal products rich in calcium in developing countries (vs. developed countries) as well as possible high threshold value (1 gram) in comparison to the actual daily requirements (Agueh, V. et. al, 2015; FAO, 2001). The consumption of milk, however, alleviated some of the deficits in calcium, increasing its intake by 73% under Alt.1 & 2 and 84% under Alt.3. Deficits in fat were completely addressed by the increase in consumption of purchased butter under Alt.3 scenario.

Table 2. Nutritional impacts of livestock technologies in Lemo woreda

		Baseline	Alt.1-- R&W-P_N	Alt.2-- Solar-P_N	Alt.3-- Solar-P_CB	Change in Nutrient: Base/Alt (in %)	
Nutrition:	Min req.	Average daily nutrients in year 5				Base/Alt2	Base/Alt3
Energy (calories/AE)	2353	2,437	2,608	2,576	2,752	***6***	***13***
Proteins (grs/AE)	41.2	69	78	77	80	***12***	***16***
Fat (grs/AE)	51	23	31	28	51	***24***	***22***
Calcium (grs/AE)	1	0.38	0.67	0.66	0.71	***73***	***84***
Iron (grs/AE)	0.009	0.016	0.017	0.017	0.016	***5***	***0***
Vitamin A (μg RAE/AE)	600	1,000	1,000	1,000	1,000	***17***	***31***

Note**:** AE = Adult equivalent; grs = grams; Min req. = Minimum requirements; Base/Alt = increase from the baseline to the alternative scenario (Alt.2 and Alt.3); Unit for vitamin A = μg RAE/ AE (RAE: Retinol Activity Equivalent); Numbers in red indicate available nutrient deficiency for an adult equivalent

Conclusions and recommendations

Improving feed resources and cow genetics (using crossbreds that produce more milk) can address the potential shortage in milk supply that the livestock sector in Ethiopia is expected to face in future due to the increases in population, urbanization and income. In this study, we simulate the production and use of irrigated fodder through improved small-scale irrigation technologies to produce feeds for livestock and sell the surplus for income generation. This is coupled with introduction of crossbred dairy cows with a potential for milk production that is three times higher than that of local or native cows. The simulation results show the economic feasibility of these enterprises and also predict potential profits under the alternative scenarios (irrigation technologies and crossbred cows) compared to the baseline if crossbred cows and improved production of feeds are adopted. Deficits in fat intake at the household level are addressed while those in calcium are partially alleviated through the increase in milk consumption. Therefore, adopting improved livestock technologies (feed and improved breeds) has potential to improve economic and nutritional wellbeing in Ethiopia and presents an opportunity to help the country meet its goals of economic development, better nutrition, and improved food security.

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