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Food security status, perceived benefits and constraints among urban dairy-keeping households in Woldia town, north-eastern Ethiopia

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Abstract

Urban agriculture is promoted as a way to improve food security in fast-growing African towns, but evidence on what urban dairy farming delivers for household food security is limited. We assessed dairy practices, perceived contributions, food-security status and constraints among dairy-keeping households in Woldia town, north-eastern Ethiopia, using a concurrent mixed-methods design. A survey of 231 households in three kebeles was complemented by three focus group discussions, four key-informant interviews and six life-history narratives. Food security was classified with a 24-item multidimensional household index. Herds were small (mean 3.5 cows; none above seven); 81.8% of households kept improved crossbred cows, all sold milk, all purchased feed, and 57.6% farmed on land owned by the town administration. Ninety-five percent of households perceived that dairy contributed to their food security. However, only 5.6% were classified as food secure, 26.4% as mildly and 68.0% as moderately food insecure; none were severely food insecure. Food-security scores did not differ between users of improved and local cows ($t(229) = 0.44$, $p = 0.66$). Feed shortage, insecure land, limited market outlets and uneven institutional support were the main constraints, and 39% of households received no government support. Dairy farming is valued and embedded in household livelihoods, but as currently practiced it is associated with limited food security. Secure land, feed systems, market outlets and tailored services are priority entry points for strengthening its contribution.

Keywords: Urban agriculture; Dairy farming; Household food security; Multidimensional food-security index; Mixed methods; Ethiopia

1 Introduction

Food insecurity is concentrated in sub-Saharan Africa [1, 2], and the region's towns and cities are growing quickly. Ethiopia's urban population was projected to triple between 2012 and 2034, from about 15 million to about 42 million people [3]. Feeding

this population with nutritious, affordable food is a sustainability problem in its own right (SDG 2 and SDG 11), because food produced far from towns depends on weak rural infrastructure and long supply chains. Urban and peri-urban agriculture is one response, and dairy production is among its most common forms, since it arises where population density is high and farmland is shrinking [4], and it supplies milk that rural producers often cannot deliver to towns [5].

Ethiopia holds a very large cattle population, but its dairy sector is dominated by traditional smallholder systems that account for most milk output [6]. The sector is largely informal, with only a small share of milk passing through formal chains [7], and it is constrained by feed shortage, animal disease, low-yielding genetics, and weak marketing and support services [7, 8]. Demand for milk is nevertheless rising in towns, and it fluctuates with religious fasting periods that depress consumption of animal-source foods [3]. In Mekelle, a cluster analysis of 304 urban dairy farms identified five farm types that differed widely in productivity, profitability and market integration, which implies that urban dairy systems need tailored rather than uniform support [5].

Studies from elsewhere in Ethiopia associate dairying with better household outcomes. They include analyses of dairy market participation and food security in Jimma zone [9], dairy production and food security in central Gondar [10], the nutritional effects of participation in the dairy value chain [11], the welfare effects of milk production in Addis Ababa [12], and the effects of milk-safety practices on food and nutrition security [13]. Two gaps remain. First, most of this work concerns rural or large-city producers, and less evidence exists for dairying in secondary towns of the Amhara region, where land is allocated by the municipality and feed is purchased rather than grazed. Second, food security is usually measured with a single indicator, although indicators classify the same households very differently [14, 15]. Combining several dimensions in one measure reduces the risk of misclassification, and it allows a direct test of whether the breed of cow (improved crossbred versus local) makes a measurable difference to food security, a question with direct policy relevance because improved cows are promoted by government packages.

This paper addresses these gaps for Woldia, a town in North Wollo Zone, north-eastern Ethiopia. Using a concurrent mixed-methods design, it (i) describes current urban dairy practices, (ii) assesses how dairy farming contributes to household food security, as perceived by households and as measured with a multidimensional index,

including a comparison between users of improved and local cows, and (iii) identifies the challenges and opportunities for urban dairy farming. To our knowledge, this is the first study of its kind in Woldia. The study does not include non-dairy households, so it describes food security among dairy-keeping households and cannot estimate what dairy farming adds relative to not farming dairy; we return to this in the Discussion.

2 Conceptual backgrounds

We link urban dairy farming to food security through three pathways (Fig. 1). The first is direct availability: households that keep cows have milk and milk products for their own consumption, which may improve dietary diversity and nutrient intake. The second is income: sales of milk and milk products raise household income, and own consumption reduces food expenditure. The third is access: income and savings can be used to buy other foods. These pathways operate through the four dimensions of food security (availability, access, utilization and stability) [15]. Some authors propose additional dimensions, such as agency and sustainability [16], which we do not measure. The pathways are shaped by an enabling environment (access to services, indigenous knowledge, and demand for milk) and a constraining environment (lack of feed, water, and market facilities, seasonal price variation, and limited awareness). The framework treats the contribution of dairy farming as a hypothesis to be tested, not an assumption. Urban food production can deliver high yields but requires careful management of inputs to be sustainable [17], so the constraining environment is an integral part of the analysis.

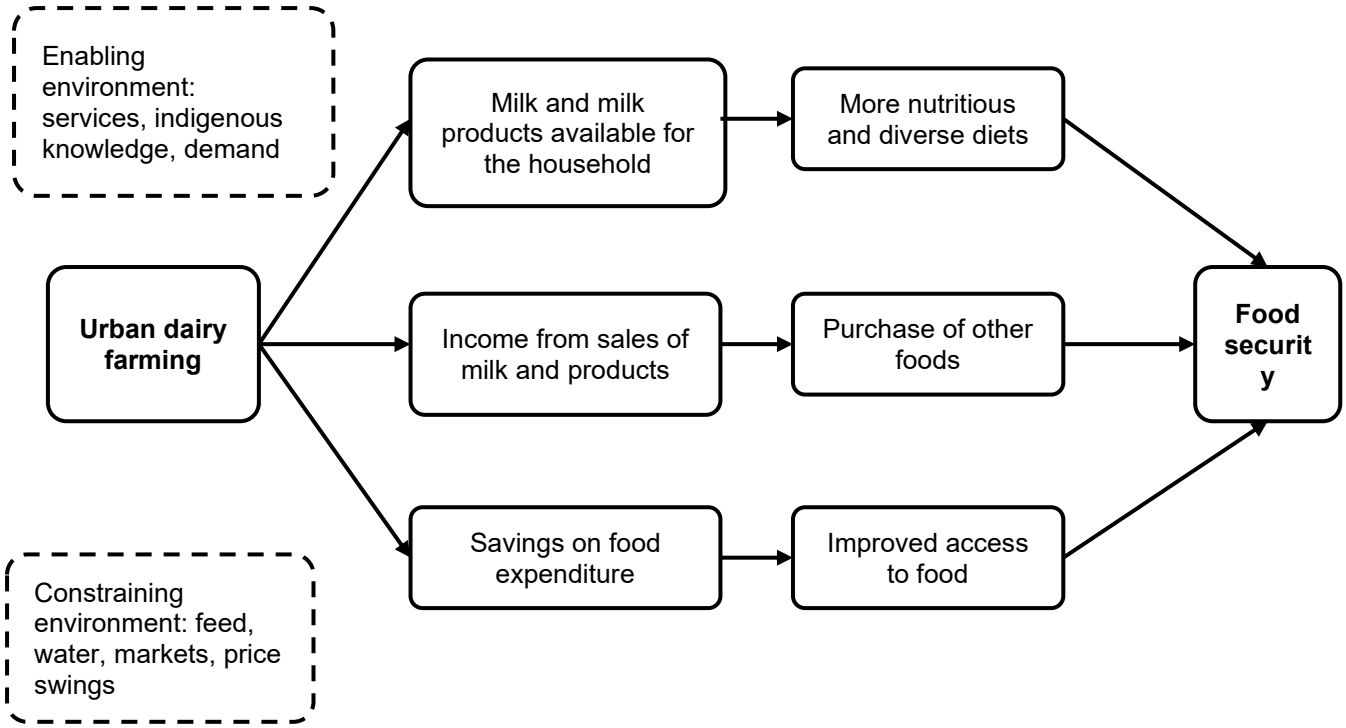


Fig. 1 Conceptual framework linking urban dairy farming to household food security. Solid boxes show the pathways assessed; dashed boxes show the enabling and constraining environment that shapes them

3 Materials and methods

3.1 Study area

Woldia is located in North Wollo Zone, Amhara National Regional State, north-eastern Ethiopia, located between 11°47′–11°50′N latitude and 39°33′–39°36′E longitude, approximately 520 km north of Addis Ababa (Fig. 2). Elevation ranges from 1,500 to 2,400 m, mean annual rainfall is about 850 mm, and the typical daily temperature is about 22 °C [18]. The town had an estimated population of 93,349, about 70% of whom were under 30 years of age, and it grew by about 3.2% per year between 2007 and 2017 (Amhara Region Bureau of Finance and Economic Development). A 2019 urban agriculture survey by the Woldia Town Agriculture Office recorded about 2,500 ha under urban agriculture and about 12,000 urban and peri-urban farmers keeping poultry, goats, sheep, and dairy cattle (Woldia Town Agriculture Office, unpublished). The local economy rests mainly on agriculture and livestock, with non-farm income from firewood and charcoal sales, trade, and migration. Urban farms lie within town limits with no access to pasture, so animals are stall-fed on purchased or conserved feed.

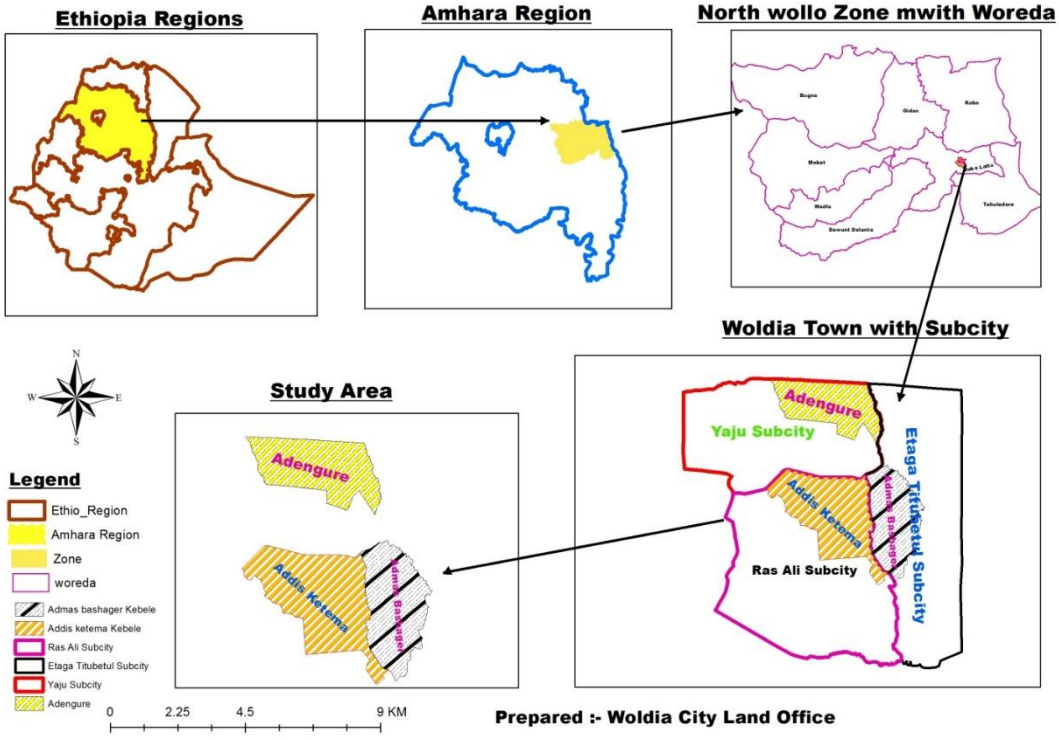


Fig. 2 Location of the study area: Ethiopia, Amhara region, North Wollo Zone, Woldia town and the three study kebeles.

3.2 Research design

We used a concurrent mixed-methods design [19]. Quantitative (household survey) and qualitative (focus groups, key-informant interviews, life-history narratives and direct observation) data were collected in the same period, analyzed separately, and then integrated by comparing findings on each of the three objectives. The study area was selected purposively because its agro-ecological conditions support dairy farming and because armed conflict in other parts of North Wollo Zone made fieldwork elsewhere impractical.

3.3 Sampling

Three kebeles (the lowest administrative unit) were purposively selected from three sub-cities on the basis of their dairy activity: Admas Bashager (Etaga Taytu sub-city), Adiss Ketema (Ras Ali) and Adengur (Yeju). These contained 547 dairy-keeping households [source: Woldia Woreda Small Scale Enterprises Office]. We calculated the sample size using Yamane's formula [20]:

$$n = \frac{N}{1+N(e)^2} \qquad (Eq.1)$$

where N represents t8he total population under study, and e denotes the precision or sampling error, which is typically set at values such as 0.10, 0.05, or 0.01. For this study, a maximum allowable error of 5% (0.05) was computed, resulting in a total sample size of: $n = \frac{547}{1+547(0,05)^2} = 231$.

The sample was allocated in proportion to kebele size, and respondents within each kebele were selected by systematic random sampling (Table 1). The sample was not stratified by cow type at selection; 189 households (81.8%) kept improved cows and 42 (18.2%) kept local cows, and these two groups were compared after data collection.

Table 1 Sample kebeles, dairy households and sample size

Sub-city	Kebele	Dairy households (N)	Sample (n)	Share of sample (%)
Etaga Taytu	Admas Bashager	169	71	30.7
Ras Ali	Adiss Ketema	134	57	24.7
Yeju	Adengur	244	103	44.6
Total		**547**	**231**	**100.0**

Source: authors' survey and kebele administration records, 2024.

Qualitative participants were selected purposively with the help of animal-resource development agents and the Woldia Town agricultural office head. They were three focus group discussions (FGDs) of eight dairy household heads each (one per kebele; 24 participants), four key informants (three kebele-level and one zonal-level animal and fish resource development agents), and six household heads (two per kebele) who provided life-history narratives and were chosen for their engagement in dairy farming, living standards, and record of creating jobs for others. In total, 265 people participated.

3.4 Data collection

A structured questionnaire, translated from English into Amharic, was administered face-to-face in 2024 by three enumerators (agricultural experts, one per kebele) under the supervision of the coordinator of the Woldia Town fish and animal development office, after the enumerators were briefed by the lead researcher. It covered demographic characteristics, herd composition, land and housing, feed, marketing, extension and support services, perceived benefits of dairy products, production and income from milk and milk products, and the 24 food-security items described in Table 2. FGDs and key-informant interviews followed guideline checklists, were held at

times and places chosen by participants, and were recorded by notes (and, for FGDs, video). Life-history narratives were collected during milking hours over four consecutive days. The first author/researcher also made direct observations of marketing, housing, feeding, milking, transport, sanitation and animal-health practices.

3.5 Measuring food security

Food security was measured with a multidimensional household index built from 24 frequency-of-occurrence items over a 30-day recall period. The items cover severe access problems (for example, going a whole day without eating and sending household members to beg), staple consumption and coping (for example, eating pulses and grain, consuming seed stock), dietary quality, worry and a self-assessed rating of food security, and consumption of five food groups (dairy, eggs, meat or fish, fruit, vegetables). All items except the self-assessed rating were answered on a four-point scale (never, rarely, sometimes, often), and the self-assessed item was answered on a four-point scale from food secure to severely food insecure. The approach follows the logic of comparing and combining several widely used indicators [14, 21]. Households were classified into four categories, from food secure to severely food insecure, by an algorithm in which any single adverse response can move a household to a less secure category (Table 2). This makes the classification deliberately conservative: a household is classed as food secure only if it reports favorable responses on essentially all items.

Table 2 Structure of the 24-item multidimensional food-security index and the main classification rules

Items (variable names)	Domain	Required for "food secure"	Sufficient for "severely food insecure"
1–6 (No Eat, sleep hungry, no food, Skip eat, Send beg, Send eat)	Severe access problems in the past 30 days	Best response ("never") on every item	Worst or second-worst response on any item
7–13 (Pulse, Grain, eat seed, Wild, food credit, Borrow, not want)	Staple consumption and coping	Best response on every item	Worst response on any item
14–19 (limited dietary variety; ate less preferred foods*; ate fewer meals; limited portion sizes; worried about not having enough food; self-assessed food security)	Diet quality, meal reduction, worry and self-assessed food security	Best or second-best response on every item	Not used for this category

Items (variable names)	Domain	Required for "food secure"	Sufficient for "severely food insecure"
20–24 (Dairy, Eggs, Meat, Fruit, Vegetables)	Consumption of five food groups	Any response except the worst on every item	Not used for this category

Responses: never, rarely, sometimes. Mildly and moderately food-insecure households are defined by intermediate responses: any response short of the “food secure” requirements places a household in the mildly or moderately insecure categories according to its most adverse answers.

The instrument also yields a summed score (24–96) that was used in a group comparison. Because the meaning of a high or low response differs across items (for example, eating grain often is favorable, whereas skipping meals often is not), the raw sum does not have a consistent direction. We therefore report the summed score for comparison only between groups and treat the categorical classification as the primary outcome.

3.6 Data analysis

Quantitative data were cleaned, coded, and analyzed in SPSS version 20. We report frequencies, percentages, means, and standard deviations. Improved and local cow users were compared on the summed food-security score with an independent-samples t-test (with Levene's test for equality of variances) and eta squared as the effect size. Internal consistency of the questionnaire was assessed with Cronbach's alpha. Multiple-response items are reported as the percentage of respondents (cases) selecting each option, so percentages can exceed 100%. Qualitative data were transcribed, coded, and analyzed thematically into main themes and sub-themes, and integrated with the survey results by comparing convergence and divergence on each objective.

3.7 Quality assurance

Experts reviewed the questionnaire for clarity and relevance and removed vague or repetitive items. Cronbach's alpha was 0.75, which is acceptable by the usual threshold of 0.70. Fieldwork was supervised in each kebele, and the qualitative material was reviewed by experts for trustworthiness and dependability.

3.8 Ethical considerations

This study was approved by the Research Ethics Committee of the Postgraduate Program, Department of Geography and Environmental Studies, College of Social Sciences and Humanities, Woldia University, Ethiopia, in accordance with the

university's Research Operation Policy and Procedures and its Research and Ethics Guidelines. A letter of approval from the Department of Geography and Environmental Studies was presented to the Woldia Town Agricultural Office, and permission to conduct the research was obtained from local authorities. Before each interview, participants were informed of the study's objectives and procedures, that participation was voluntary, and that they could withdraw at any time without consequence. Verbal informed consent was obtained from all participants prior to data collection. Responses are reported in aggregate, and no identifying details are disclosed, except where participants voluntarily agreed to be identified, such as in photographs of focus group discussion (FGD) participants and of field survey activities.

4 Results

4.1 Respondent characteristics

Of the 231 respondents, 88.7% were male, and 91.3% were married (Table 3). Most were aged 36 to 51 years (73.1%), and 53.2% had been born in the locality where they lived. Educational attainment was mixed: 9.1% could not read or write, 36.4% had completed secondary school (grades 9–12), and 19.1% held a certificate, diploma, or degree. Nearly all (89.6%) described their main occupation as private and formal, which in this setting includes dairy farming, crop farming, livestock fattening, and petty trade. Two-thirds (68.0%) owned their dwelling. Mean family size was 4.58 (SD 1.45).

Table 3 Characteristics of respondents (n = 231)

Characteristic	Category	n	%
Sex	Male	205	88.7
	Female	26	11.3
Age (years)	25–35	35	15.1
	36–40	67	29.0
	41–46	70	30.3
	47–51	32	13.8
	52–60	26	11.2
	>60	1	0.4
Marital status	Single	11	4.8
	Currently married	211	91.3
	Divorced	9	3.9
Place of birth	This locality	123	53.2
	Elsewhere in the town	73	31.6
	Outside Woldia	35	15.2

Characteristic	Category	n	%
Education	Unable to read and write	21	9.1
	Non-formal education	33	14.3
	Primary (grades 1–8)	49	21.2
	Secondary (grades 9–12)	84	36.4
	Certificate	9	3.9
	Diploma	17	7.4
	First degree	18	7.8
Main occupation	Private (formal)	207	89.6
	Government employee	10	4.3
	Private (informal)	9	3.9
	Private hired (informal)	5	2.2
Housing	Privately owned	157	68.0
	Private rented	51	22.1
	Kebele rented	19	8.2
	Private, no rent	4	1.7
Family size	Mean (SD)	4.58 (1.45)	

Source: authors' survey, 2024. Percentages are of 231 respondents.

4.2 Current practice of urban dairy farming

4.2.1 Experience and herd composition

Dairy farming was an established activity for most households. Reported years of experience in dairy farming were more than 15 years for 44.6% of respondents (n = 103), 11 to 15 years for 12.1%, 6 to 10 years for 17.3%, and up to 5 years for 26.0%. In their own enterprise, 68.8% had kept dairy cows for more than five years and 14.7% for less than one year. FGD participants said that they had learned dairying from their parents and by observing other households, which agrees with the survey result.

Herds were small. Households kept between one and seven cows, with a mean of 3.5 (Table 4). Improved cows (crossbred) were used by 81.8% of households (189), of which 73.2% (169) kept a "family package" herd of two to five cows and 8.7% (20) kept a "small-scale specialized" herd of six or seven. Local cows were kept by 18.2% (42), nearly all with one or two animals. Under the Ethiopian dairy management guidelines, which set a family package at three to five cows and small-scale specialized herds at 6–30 cows [22], 136 households (58.9% of the sample) kept three to five improved cows; a further 33 improved-cow households kept only two cows, and no household reached the medium-scale specialized category of 31–100 cows (Fig. 3).

Table 4 Herd size by cow type and package (n = 231)

Cow type and package	Cows per household	Households (n)	Share of sample (%)
Improved, family package	2	33	14.3
	3	43	18.6
	4	49	21.2
	5	44	19.0
Subtotal		**169**	**73.2**
Improved, small-scale specialized	6	18	7.8
	7	2	0.9
Subtotal		**20**	**8.7**
Local	1	9	3.9
	2	28	12.1
	3	5	2.2
Subtotal		**42**	**18.2**
All households		**231**	**100.0**

Mean herd size: improved cows 3.88, local cows 1.90, all households 3.52 (calculated from the distribution). Family package = 3–5 cows and small-scale specialized = 6–30 cows under national guidelines [22]. Source: authors' survey, 2024.

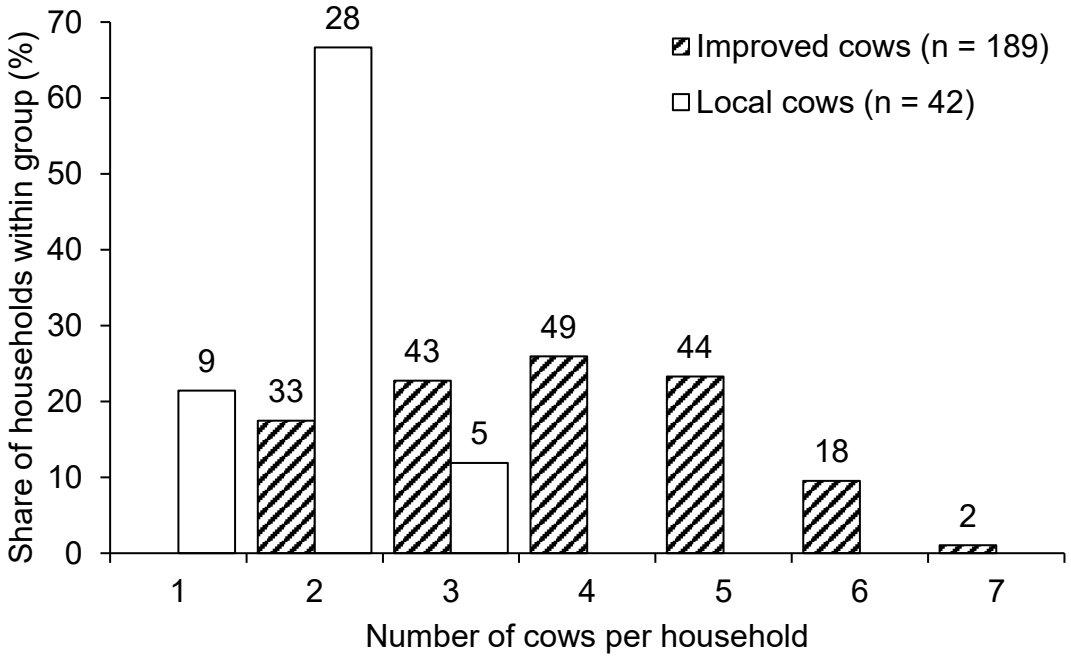


Fig. 3 Number of cows kept per household, by cow type (improved, n = 189; local, n = 42). Numbers above bars are the number of households

4.2.2 Land, housing and labor

Less than half of the respondents (40.7%, n = 94) owned the land used for dairy farming. The town administration owned the land of 57.6% (n = 133), and 1.7% (n =

4) rented it. Key informants and FGD participants explained that the town administration allocates land for small-scale dairy production to unemployed people, particularly youth, on a revolving basis, and that most youth engaged in dairy in Woldia do not own their land. They also said that allocation without secure tenure discourages investment and expansion from family-package to small-scale specialized herds. The floor area used for dairy housing ranged from 33 to 1,500 m² per household. Compared against the recommended 3.5 m² per cow, the minimum area reported exceeded the requirement of even the largest herd (7 cows × 3.5 m² = 24.5 m²), so space for housing was not the binding constraint in the survey data; land for fodder, which the survey did not measure directly, was (see section 4.4).

The household head managed dairy activities (86.1% overall). Management differed strongly by sex of the respondent: the household head managed the activity for 91.7% of male respondents but for 42.3% of female respondents, among whom hired labor (34.6%) and family labor (23.1%) were more common ($\chi^2(2) = 54.7$, $p < 0.001$; some expected cell counts are below 5, so the p-value is indicative).

4.2.3 Feed, marketing and extension

Every household purchased feed, and 10.8% also grew some fodder on their home plots. Nearly all households harvested and conserved fodder before the dry season. All respondents sold milk; most sold at more than one location (home, 82.3%; public market, 77.5%; other temporary or available places, 81.0%). Only 14.7% (n = 34) also sold milk products other than milk, chiefly butter and cheese, with yoghurt and whey as minor products. Participants in the life-history narratives said that Woldia has no designated dairy market area and only one public dairy outlet, a dairy cooperative that cannot absorb the output of the town's producers, so many sell from rented locations far from their homes, which affects milk quality and income. Extension services had reached 83.0% of households (n = 192).

4.3 Contribution of urban dairy farming to household food security

4.3.1 Production, income and perceived benefits

Dairy production differed sharply between cow types (Table 5). Households with improved cows reported a mean of 43.4 liters of milk per day (range 8–90 L) against 2.6 L per day (range 1.2–5.0 L) for households with local cows. These figures are per household. Given mean herd sizes of 3.9 and 1.9 cows, they correspond to roughly

11 L and 1.3 L per cow per day, before allowing for cows that were not in milk. Gross income from milk sales averaged ETB 75,659 per month (SD 50,157; range 2,520–189,000; n = 231), while income from cheese, butter and yoghurt was small and reported by few households. The income figures are gross receipts and do not account for feed and other costs. FGD participants (Fig. 4) said that households concentrated on selling milk rather than processing it because they lacked modern processing equipment, and that feed, particularly brewery by-products, limited further expansion.

Table 5 Dairy production and income from sales

Variable	n	Mean	SD	Min	Max
A. Daily production per household, improved cows					
Milk (L)	189	43.44	19.82	8	90
Cheese (kg)	115	1.33	0.62	0	2
Butter (kg)	107	0.98	0.24	0	2
Yoghurt (L)	18	1.06	0.54	0	2
B. Daily production per household, local cows					
Milk (L)	42	2.56	0.89	1.20	5.00
Cheese (kg)	7	0.37	0.13	0.25	0.50
Butter (kg)	4	0.58	0.30	0.30	1.00
C. Monthly income from sales, all households (ETB)					
Milk	231	75,659	50,157	2,520	189,000
Cheese	11	568	174	350	1,000
Butter	5	500	0	500	500
Yoghurt	18	151	64	125	350

Production figures are per household per day and are not standardized by herd size or number of cows in milk; product-specific counts differ across survey items. Income is gross revenue and excludes feed and other costs. Source: authors' survey, 2024.

Fig. 4 Photo of FGDs with the presence of the lead researcher



Respondents valued dairy products for taste, nutrition, and cost savings. Virtually all considered milk nutritious (100%), and 96.1% said it saved money. Income creation was named as a main benefit of dairy production by all respondents, contribution to food security by 94.4%, reduced household expenses by 85.7%, fresh food by 79.2%, and healthy food by 69.3% (Table 6). Most respondents (94.8%) said they saved money through dairy, and 95.7% said they used dairy income to buy other food. Overall, 95% perceived that dairy production contributed to their household's food security, and 5% did not. Participants in the FGDs, KIIS and life-history narratives (Fig. 5) added that dairy income paid for school fees, house construction, health care, and other food, and that dairy enabled households to build livelihood resilience.



Fig. 5 Direct observations in the study area

Table 6 Main benefits of dairy production reported by households (multiple responses, n = 231)

Main benefit of dairy production	Households (n)	Households (%)
Income creation	231	100.0
Contribution to food security	218	94.4
Reduced household expenses	198	85.7
Fresh food	183	79.2
Healthy food	160	69.3
Easily available	70	30.3
Low-cost food	22	9.5

Percentages are of households (cases) and exceed 100% in total because respondents could give several answers. Source: authors' survey, 2024.

4.3.2 Measured food security status

Despite these perceived benefits, few households were classified as food secure (Fig. 6). Only 13 households (5.6%; 95% CI 3.3–9.4%) were food secure, 61 (26.4%) were mildly food insecure, and 157 (68.0%) were moderately food insecure. No household was classified as severely food insecure. In other words, 94.4% of dairy households met at least one of the criteria for some degree of food insecurity under the conservative classification used.

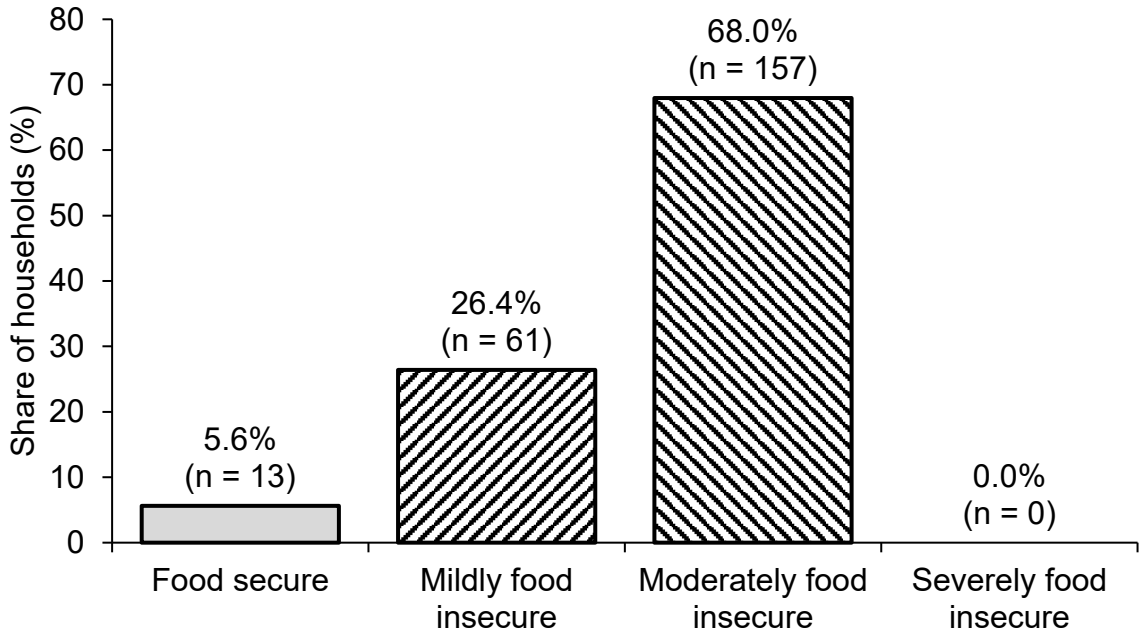


Fig. 6 Household food-security status (n = 231) from the 24-item multidimensional index. No household was classified as severely food insecure

Food security did not differ significantly between users of improved and local cows (Table 7). The mean summed score was 48.68 (SD 5.51) for improved-cow households and 49.10 (SD 5.81) for local-cow households, a difference (local minus improved) of 0.42 points (95% CI −1.45 to 2.29; t(229) = 0.44, p = 0.66; Welch t(58.6) = 0.43, p = 0.67). The effect size was negligible (η^2 = 0.0008; Cohen's d = 0.08). With 42 local-cow households, the study could detect a difference of roughly 2.7 points (d ≈ 0.5) with 80% power, so moderate differences cannot be excluded, but the confidence interval excludes differences larger than about 0.4 standard deviations.

Table 7 Multidimensional food-security score (summed, range 24–96) by cow type

Cow type	n	Mean score	SD	SE of mean
Local	42	49.10	5.81	0.90
Improved	189	48.68	5.51	0.40

Levene's test: F = 0.283, p = 0.595. Student's t(229) = 0.440, p = 0.660; mean difference (local − improved) 0.418, SE 0.950, 95% CI −1.45 to 2.29. Welch's t(58.6) = 0.426, p = 0.672. η^2 = 0.0008. The summed score has no consistent direction across items (see Methods); the classification in Fig. 6 is the primary outcome.

4.4 Challenges and opportunities

4.4.1 Challenges

FGD participants, life-history narrators and key informants gave a consistent account of the constraints on urban dairy farming. Shortage and high cost of feed was named first, particularly the scarcity of brewery by-products nearby, which forces households to buy from distant sources and raises transport costs. Land scarcity was the second constraint, including insecure tenure on municipal land. Other technical problems were seasonal price variation of milk and milk products, especially during fasting periods, and poor hygiene and sanitation management. Participants also described institutional barriers: limited extension (including technical assistance, training and education), limited market access and promotion, inadequate credit and insufficient market facilities. The high price of improved heifers and cows was mentioned as a barrier to moving from local to improved breeds. Lack of skills, limited collaboration and networking among farmers, and inadequate government support were also reported.

4.4.2 Opportunities

Participants identified opportunities that include indigenous knowledge (traditional animal-health practices, marketing and management techniques, fodder development, long-term conservation of feed for the dry season, and self-management of hygiene and sanitation), access to fodder from institutions such as schools, universities, farmers' training centers and protected areas, rising demand for milk and milk products, and supervision and advisory support from experts. In the survey, 54.5% of households had received land from the government, 39.0% training, 21.2% market linkage, 3.9% technology transfer and 2.2% promotion, while 39.0% had received no support at all (Fig. 7).

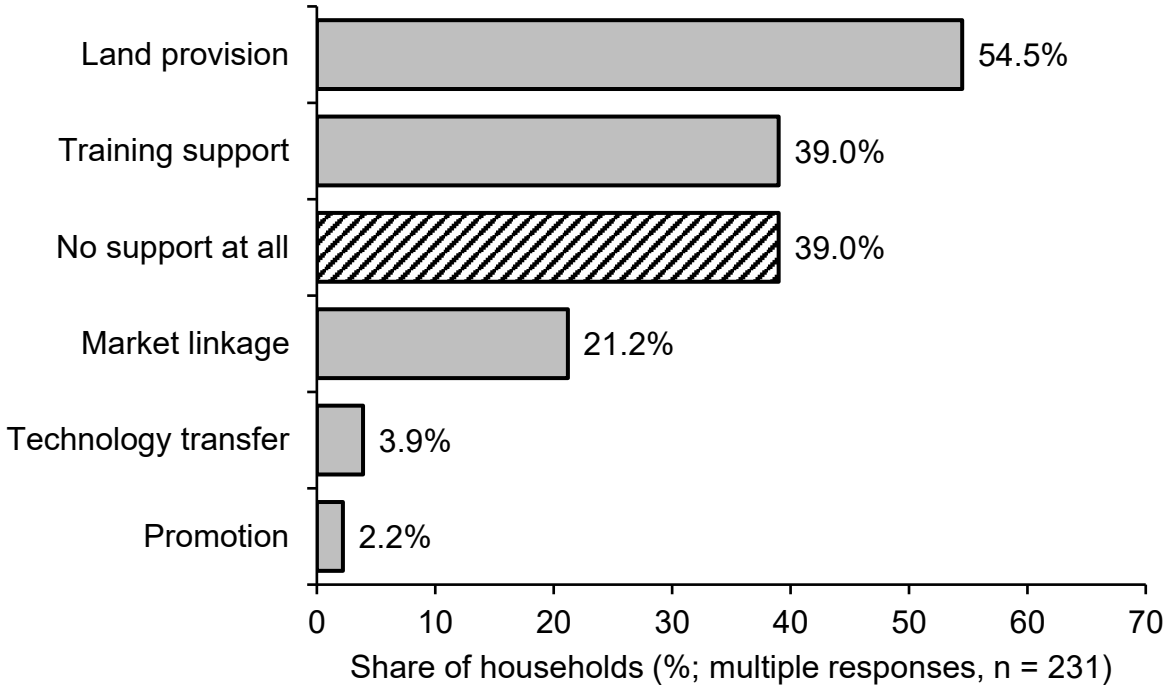


Fig. 7 Government support reported by dairy households (n = 231). Shares exceed 100% in total because respondents could report several types of support

5 Discussion

5.1 Perceived benefits are high, but measured food security is low

The main finding is a gap between perception and measurement. Nearly all households said that dairy contributed to their food security and that it gave them income, savings and the means to buy other food, yet by the multidimensional index only one household in eighteen was food secure and two-thirds were moderately food insecure. Three points help interpret this. First, the classification is conservative: a single adverse response on any of 24 items moves a household out of the food-secure category. Indicators differ widely in the prevalence they estimate for the same households [14], so the 94.4% should not be compared directly with prevalence figures from other instruments, and a less demanding classification would probably yield a lower prevalence. Second, the study covers only dairy-keeping households, so it cannot show whether food security is better or worse than it would be without dairy. Perceived contribution and measured status are answering different questions. Third, dairy households' reports of benefits are consistent with earlier studies that associate milk production or dairy market participation with welfare and food security [9, 10, 12], but our design, which has no comparison group, cannot test that association.

The data do show that dairy is deeply embedded in household strategies. All households sold milk, the great majority used the proceeds to buy other food, and life-history narratives linked dairy income to school fees, housing and health care. A plausible reading is that dairy is a valuable component of urban livelihoods that, at the scale currently achieved, is not sufficient by itself to make households food secure on all four dimensions. Testing this requires data on dairy and non-dairy households, on other income sources and on net returns.

5.2 Improved breeds and food security

Improved cows raised household milk output by an order of magnitude (43.4 versus 2.6 L per day), yet food-security scores did not differ between cow types. The result challenges the common expectation that improved breeds translate directly into better food security, but it should be read with the limits described above: the local-cow group was small, the summed score has no consistent direction across items, and the comparison is unadjusted for household characteristics. Several explanations are plausible and testable. Nearly all households buy feed, so gross receipts overstate net income. Those households also depend on milk as their main income source and therefore are more exposed to price, disease, and feed shocks, whereas local-cow households may combine milk with sales of other livestock and crops. The latter idea emerged from the authors' interpretation and was not measured in our survey. Finally, even large herds in this sample are small relative to the guideline categories for specialized dairying: no household kept more than seven cows, and 91.3% kept five or fewer. The practical implication is that promoting improved breeds alone is unlikely to be sufficient. It should be accompanied by feed, land, market and service support, and its effects should be tested with adjusted analyses or quasi-experimental designs.

5.3 Scale, land and feed constraints

Urban dairy in Woldia is a small-scale, feed-purchasing system. Its scale is limited by land tenure (most farmers use municipal land allocated on a revolving basis), by the high cost of improved heifers, and by the lack of credit. Our data suggest that housing area is adequate, so the land constraint reported by participants most probably refers to land for fodder and secure long-term use, which is consistent with reports from other Ethiopian towns that unskilled practices, weak collaboration and limited water constrain urban agriculture [23] and that institutional and resource constraints limit

urban dairy farms [24]. The finding that every household buys feed, and that brewery by-products in particular are scarce, is a sustainability concern as well as an economic one. Urban dairying that depends on feed transported from elsewhere is sensitive to price and supply shocks and may add to transport costs and emissions; waste management, water use and emissions were not measured here. Similar constraints were reported for Bona Zuria district in Sidama [25] and in a review of milk production in Ethiopia [26], which supports the transferability of these findings to other Ethiopian towns.

5.4 Markets, gender and institutional support

Market access emerged as a further bottleneck. With one public dairy outlet and no dedicated market area, most milk is sold from homes or temporary locations, and households sell little other than fresh milk. Seasonal price variation during fasting periods, which participants described, is consistent with evidence that religious fasting creates strong demand seasonality in Ethiopian milk markets [3], and with the focus on market integration and resilience to seasonality in the Mekelle typology [5]. Processing into butter, cheese or yoghurt, which would add value and help smooth demand, was rare because of the lack of equipment.

Institutional support was uneven. Extension reached 83% of households, but 39% had received no government support of any kind, and only small minorities had received technology transfer or promotion. Female respondents (11.3% of the sample) were much less likely to manage the dairy activity themselves than male respondents and more often relied on hired labor, which suggests different labor constraints and possibly different support needs. The numbers are small, and the survey did not collect the information needed to explain the difference.

5.5 Implications for policy and practice

The following implications follow from the evidence and should be viewed as hypotheses to pilot and evaluate, not as proven interventions. (i) Secure tenure, for example, multi-year leases on municipal land with designated space for fodder, would address the main reason participants gave for not scaling up. (ii) Feed systems need attention: cooperative bulk purchase or supply agreements for brewery by-products, institutional fodder arrangements of the kind participants described, and training in fodder production and conservation could reduce cost and supply risk. (iii) Permanent

market facilities and support for collective collection and processing would address the lack of market outlets and seasonal price swings. (iv) Extension should move beyond general services to herd management, hygiene and feeding, and product diversification. (v) Credit products for heifer purchase and feed could help households move between herd-size categories. (vi) Programmes should monitor food security with multidimensional measures rather than perceptions, and should check that women are reached.

5.6 Limitations

The study is cross-sectional and covers only dairy-keeping households, so dairy's contribution to food security was assessed through perceptions and within-sample comparison. The three kebeles were purposively selected, partly because conflict limited access to other sites, which restricts generalizability. The sample is dominated by male-headed (88.7%) and improved-cow (81.8%) households, and the small local-cow group (n = 42) limits statistical power; group comparisons are unadjusted. Production, income, land, and food security data are self-reported and subject to recall error, and income figures are gross. Some product-level counts (e.g., butter and cheese producers) differ across survey items and are not interpreted. The food security index uses a conservative classification and a summed score with inconsistent item direction, and its cut-offs are not validated against other indicators locally. Environmental outcomes (manure and waste handling, water use, greenhouse gas emissions) were not measured. The qualitative component (three FGDs, four key informants, six life histories) is small, mainly explains and corroborates the survey, and is reported thematically without verbatim quotations.

6 Conclusions

Urban dairy farming in Woldia is a widespread, experienced, and income-generating activity that households value, but it operates at a small scale, depends on purchased feed and municipal land, and is poorly served by markets and support services. Nearly all households perceived that dairy contributed to their food security, yet 94.4% were classified as mildly or moderately food insecure by a multidimensional index, and households with improved and local cows did not differ significantly in food-security score. The evidence therefore supports a cautious conclusion: dairy is an important livelihood component, but under current conditions it is associated with only limited

food security, and improved breeds alone do not close the gap. Secure land and fodder access, reliable feed supply, market infrastructure, tailored extension and credit, and monitoring of food security with multidimensional measures are priority entry points for making urban dairy farming a more sustainable contribution to food security in Ethiopian towns. Future research should include non-dairy comparison households, measure net returns and dietary diversity directly, adjust for household characteristics, follow households over seasons, and assess the environmental footprint of urban dairy systems.

Declarations

Funding.

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Competing interests.

The authors declare that they have no competing financial or non-financial interests to disclose.

Ethics approval:

This study was approved by the Research Ethics Committee of the Postgraduate Program, Department of Geography and Environmental Studies, College of Social Sciences and Humanities, Woldia University, Ethiopia.

Consent to participate:

The study followed widely recognized ethical standards for research with human participants. The Department of Geography and Environmental Studies, Woldia University, issued a letter of approval; the Woldia Town agricultural office was informed, and permission was obtained from local authorities. Before each type of data collection, participants were told the study's objectives and procedures, that participation was voluntary, and that they could withdraw at any time. We obtained informed consent, which served as the basis for data collection.

Ethical accordance/guidelines:

The study was conducted in accordance with the Revised Research, Publication Ethics, and Systems Guideline, Woldia University.

Consent to publish:

Informed consent to publish was obtained from all participants involved in the study.

Clinical trial number: Not applicable

Data availability.

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions.

Elsabet Ayenew: conceptualization, methodology, investigation, data curation, formal analysis, software, visualization, writing (original draft), and writing (review and editing). ***Fentaw Baye***: conceptualization, data curation, validation, supervision, and writing (review and editing). **Getnet Zeleke:** validation, supervision, and review.

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