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Constraints to Integration of Vegetable Production in Smallholder Dairy Systems of Uganda

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Abstract: *Crop-livestock integration provides a more efficient pathway for increased intensification especially under resource poor smallholder farmers. This study was conducted to identify the challenges to integration of vegetable production in smallholder systems of Uganda in Masaka and Ngora districts. Sixty farming households were interviewed from each district. The results of the study showed that the farm household characteristics in the two districts were similar but differences in enterprise allocation to land occurred mainly due to land ownership systems and main source of income for the household. Farmers' choice of vegetables was informed by their economic importance with "Nakati"(Solanum aethiopicum) ranking first choice in Masaka and tomatoes (Lycopersicon esculentum) in Ngora Farmers' also considered other factors like tolerance to water stress and contribution to household food security. Lack of market (31 and 43%), high cost of inputs (24 and 44%), (24 and 45%), pests (44 and 30%) and lack of seed (19 and 30%) were major constraints at production level in Masaka and Ngora respectively. Low rainfall (45%) and limited knowledge in agronomic practices (21%) were peculiar constraints in Ngora. Lack of processing equipment was the single most important constraint to post harvest handling for over 60% of respondents in Masaka and Ngora. Since farmers' choice of vegetable is based on economic importance, addressing market and post harvest challenges may provide incentives to farmers for more efficient integration of vegetables in dairy production. Because land is a major limiting factor in smallholder farmers' vegetables with residues that are edible to cattle should be prioritize to minimize competition for land between vegetables and pastures. This should be accompanied by farmers' trainings in utilization of vegetable residues in dairy feeding systems.*

Keywords: *Crop-livestock integration, Smallholder dairy, Intensification,*

1. INTRODUCTION

Smallholder crop-livestock production system comprises the majority of ruminant livestock (80%) and provides most of the meat and milk in Sub-Saharan Africa [1]. Integration of crop–livestock production in developing countries is a common and efficient pathway for intensification of agriculture [1, 2]. The increasing demand for food of animal origin is continuously driving changes in livestock production and creating variations in integration levels both in time and space as well as the crops being integrated with livestock [3, 4]. Mixed crop-livestock production systems habitually play important roles to smallholder farmers that include provision of food-feed crops, human food, draft power, animals store wealth and among all provides for nutrient recycling between animal and crop components in terms of manure and crop residues [5, 6].

Considerable attention in mixed crop-livestock production systems is on availability of crops that could provide food for humans as well as producing crop residues for animal production [7, 8]. However, changes in market pressures, the need for high value crops, land scarcity and need for water efficient crops are forcing the system to evolve and increase intensification. Intensification of livestock sector provides new livelihood opportunities for women, children and the youth who otherwise often lack access and control over land based means of production [9]. As such, dairy-vegetable integration provides an excellent avenue for increased involvement of women, children and youth in production, marketing and improving household food and nutrition security. Most of the vegetables grown by smallholder farmers have high levels of proteins, vitamins and minerals compared to the majority food crops [10] and are thus important in improving nutrition. Crop-livestock integration also plays an important role as a climate change adaptation measure in smallholder production systems across Africa [11] as they are fast maturing, easy to irrigate and diversifies income. Vegetables are among the easiest crops to irrigate [12, 13] and provide for utilization of reclaimed water in their production hence increasing their value in climate change adaption. However lack of assessments on adaptations, what crops to grow, environmental resources and their allocations, capital often constrain the integration and adaptive capacities [14].

Vegetable production provides for high value crops that can be raised on small pieces of land throughout the year and as such, many smallholder farmers have increasingly gained interest in them [15]. Integration of vegetables in dairy production is a type of "new conservation agriculture", where production goals are matched with the resource base to achieve both profitability and environmental benefits [16]. Because of this, crop-livestock integration systems play important roles in improving agricultural productivity [17]. However the importance of vegetables in dairy integration systems must be realized together with retaining the benefits of multi-purpose use for both food and feed as is the case with other crops such as cereals and legumes. Under crop-livestock integrated production systems, farmers are faced with major challenges in deciding the crop to grow given the prevailing production resources of land, labor, capital requirements and profitability [10, 15]. The purpose of this paper is to assess the availability and allocation of production resources, choice and level of integration of vegetables in dairy production and the constraints encountered by smallholder farmers in integrating vegetables into dairy production.

2. Materials and Methods

A survey was conducted in Masaka and Ngora districts of Uganda where the National Livestock Resources Research Institute had implemented a project on crop-livestock integration for sustainable natural resources management between 2008 and 2011. Masaka district is found in the Lake Victoria crescent zone while Ngora is found in the Eastern Semi-Arid Zone and thus represented the the humid and semi-arid agro-ecological zones, respectively. Sixty (60) dairy-vegetable farmers were selected from each district following systematic random sampling procedures from a list of available farmers in each district. Household interviews were conducted to gain an in-depth understanding of the dairy-vegetable integrated production system. Household demographic data, production resources, dairy-vegetable production and constraints faced in the production were collected. The data collected was coded and analyzed with XLSTAT 2011. Data on farmers ranking of the economic importance of different vegetable types was disaggregated by district and then subjected to nonparametric statistics (Kruskal-Wallis one-way analysis of variance) to determine if significant differences existed between the different vegetables. Thirteen vegetables were ranked by farmers in Masaka using a scale of 1 to 13, while in Ngora, 8 vegetables were ranked using a scale of 1 to 8, with one being the most important vegetable.

3. Results and Discussion

3.1. Household Demographic Characteristics

Majority of the respondents were females with only 28.33 and 8.33 % of the respondents being males in Masaka and Ngora districts respectively. The average age of respondents was 54.9 years in Masaka and 49.9 years in Ngora (Table 1). All household heads had attained formal education, with more in Masaka having attained post primary education (52%) compared to Ngora (29.2). Farming was the major occupation of household heads in Masaka (68%) and Ngora (75%). With the exception of Ngora where 8.33% of the household heads had no occupation, all household heads in Masaka had occupations. Masaka had a higher number of household heads formal employment (e.g teaching) (16.67%) and in business (16.67%) compared to Ngora with 8.33% of household heads employed in either occupations. Farming households in Masaka had more years in dairying (3 years) as opposed to Ngora households (2.26 years). The average number of members in a household was higher in Ngora (9) than Masaka (8) (Fig. 1). The majority of members in a household were under the age of ten years in the two districts with an average of seven. Masaka had the highest number of household members between 21 and 60 years (6) compared to five in Ngora households.

Table1. *Gender, age, education and occupation of respondents*

Household composition	District		
	Masaka	Ngora	Average
Gender of household head (%)			
Male	28.33	8.33	18.33
Female	71.67	91.67	81.67
Average age of respondent (years)	54.9	49.9	52.4
Education level of household head (%)			
Non-formal	-	-	
Primary	46.67	70.00	58.34
Secondary	36.67	21.67	29.17
Tertiary	16.67	8.33	12.50
Adult education	-	-	
Occupation of household head (%)			
None	-	8.33	4.17
Farming	66.67	75.01	70.84
Employed	16.67	8.33	12.50
Business	16.67	8.33	12.50
Average years in dairy farming (numbers)	3.0	2.26	2.63

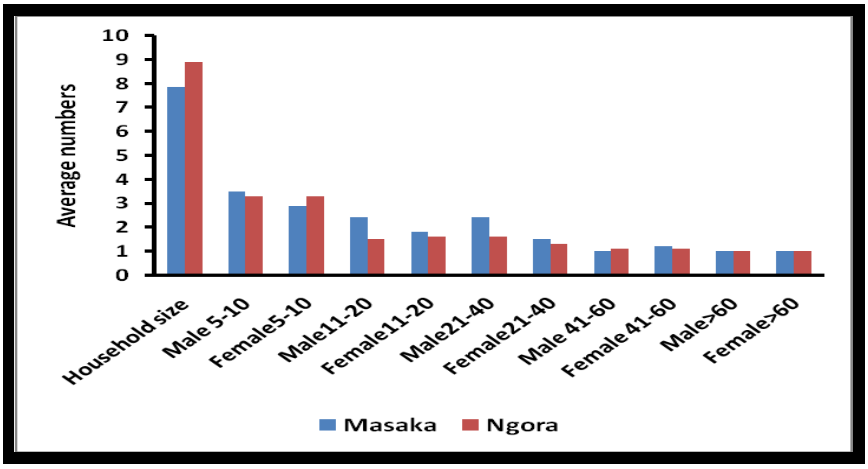

Fig1. *Household composition by age and sex*

Sex, age, education, non farm incomes of a household and labour availability have been reported by several authors to influence the levels of adoption of improved agricultural technologies [18, 19, 20]. In communities where females are discriminated in access to knowledge and production inputs, men adopt more [21]. However, where males and females have equal access to knowledge and production inputs, there are no differences in adoption levels [22]. The presence of more female households heads therefore meant good access to production resources and hence better adoption of technologies. Although it is believed that farmers adoption of agricultural technologies is more likely to increase with age due to preferential access to new information and technologies and accumulation of more capital to invest in new technologies by older farmers [23], some authors have indicated that old farmers tend to stick on their old ways of doing things [21] and also that young farmers are more flexible and likely to adopt new technologies more than old farmers [21, 24]. Household heads in Ngora may therefore be more adoptive than their counterparts in Masaka provided that all have equitable access to production resources. Education has been reported to positively influence adoption of agricultural technologies [18, 19, 21] with more educated farmers adopting more due to increased awareness of availability of improved farm inputs and technologies as well as their applicability. Households with access to non farm incomes were also noted to adopt more than their counterparts [18] due to their increased ability to acquire the necessary farm inputs and new technologies. The presence of many households heads in Masaka with off farm employments (employed and business) therefore suggests that households in Masaka may be having more income to invest in new technologies and inputs and hence adopt more than their counterparts in Ngora. Labor availability significantly influences adoption of agricultural technologies with households having more labor adopting more than their counterparts. The high number of household members under productive age in Masaka may be suggestive of a high labor force and more readiness to adopt than in Ngora.

3.2. Land Ownership and Utilization

Average land area and number of parcels owned by households were higher in Ngora than in Masaka (Table 2). With the exception of Masaka where some farmers had full rights over land under the Mailo land system (24%), most of the land was under customary ownership in Ngora (87.5%) and Masaka (28%). There were more households owning (83.33%) and having high numbers (3.9) of indigenous cattle breeds in Ngora than Masaka, while Masaka had a high number of households owning crossbred (80%) and exotic cattle (16.67%) as well as high number of cross and exotic cattle owned per household than in Ngora (Table 2).

In all Districts, the majority of land was allocated to food crop production, followed by cash crops while least land was allocated to vegetable production (Fig. 2). Apart from cultivated pastures and natural grass which were higher in Masaka, other land uses were higher in Ngora. Area under food crop was 2.66 acres in Ngora and 1.84 in Masaka, cash crop was 1.29 and 1.21, planted pasture 0.82 and 0.99, natural grass was 0.8 and 0.98, vegetable production was 0.52 and 0.49 in Ngora and Masaka respectively. On average, cultivated and natural pastures covered 45.1% and 32.3% of total land owned in Masaka and Ngora respectively.

Table2. *Land ownership systems*

Land ownership	District	
	Masaka	**Ngora**
Average land area (acres)	4.59	4.65
Average number of parcels	2.5	3.7
Land ownership (%)		
Customary	28	87.5
Leasehold	28	4.17
Institutional	-	-
Rented	4	-
Freehold	16	8.33
Mailo	24	-
Cattle ownership: percentage of households owning a particular breed and (number owned)		
Indigenous breeds	11.67 (0.28)	83.33 (3.9)
Crossbreeds	80.00 (1.84)	41.67 (0.71)
Exotic breeds	16.67 (0.24)	8.33 (0.1)

Although farm size is reported to positively influence adoption of agricultural technologies [18, 20], the distance of land from the households negatively affects adoption [18]. As such, households in Ngora with more scattered land parcels may have limited adoption than their counterparts in Masaka who had small but not scattered parcels of land as distant parcels constrains household labor. Access and ownership of land has been reported by many authors as a major factor determining adoption of agricultural technologies [22, 25, 26]. Farming households in Masaka with full land rights are therefore expected to have higher levels of adoption than in Ngora where most of the land is customary.

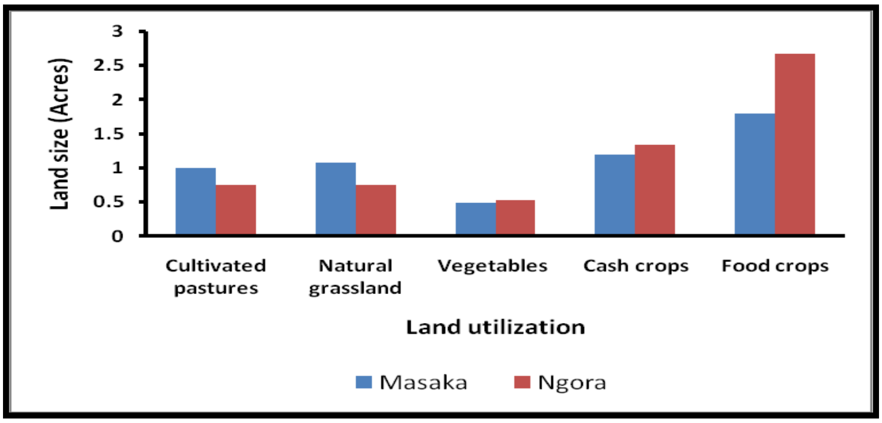

Fig2. *Allocation of land to different enterprises*

Differences in cattle ownership and breed types in Masaka and Ngora districts may be explained by the high access to and increased awareness of availability of improved breeds in Masaka than Ngora. Ngora district is among the areas that were affected by rebel activities of Lord's Resistance Army (LRA). Masaka district has many development organizations that work in dairy improvement and thus the increased farmers' awareness of improved breeds and their adoption. Similar trends of awareness increasing adoption were reported by other authors [18]. The ownership of more improved breeds, under zero grazing systems in Masaka explains the allocation of more land to cultivated pastures in Masaka than Ngora where indigenous cattle are kept under grazing systems.

The allocation of more land to food crop production demonstrates the subsistence nature of households but was also explained by the need to plant different crop types as an adaptation strategy to climate change especially in Ngora district which is in a semi-arid zone. Failure of one crop due to climate variability always leaves households with another option for food. Also, households needed more than one food crop is grown in order to balance household diets and minimize the expense of buying food for the household. As more food crops are introduced, the land allocated food production increase compared to other land uses.

3.3. Production Characteristics of Masaka and Ngora Systems

Thirteen quantitative variables were used to run a similarity percentage between the respondents farming households of Masaka and Ngora Districts. The Masaka and Ngora farming systems were 83% similar and this was contributed by six parameters namely; age of respondent, members in household, average land size, number of parcels, area under food crop, and number of local cattle owned. Divergences in two systems stemmed from manure management, number of crossbred cattle, area under cash crop production, area under planted pasture, area under natural grass, area under vegetable production, and number of Exotic cattle owned (Table 3).

Smallholder farmers in the two districts had similar demographic characteristics and access to production resources but varied utilization of land resources in terms of enterprise allocation. This was basically attributed the household's major source of income as a major driver of land utilization. In Masaka district where households' had more improved cattle and livelihoods based of dairy farming, land allocation to pasture (cultivated and natural) was more than in Ngora where a crop based livelihood dominated.

Table3. *Similarity percentage between Masaka and Ngora*

Parameter	Contribution	Cumulative %	Means	
			Masaka	Ngora
Age of respondent	7.20	42.09	54.90	49.90
Members in household	2.58	57.20	8.13	8.88
Average land size	1.57	66.39	4.59	4.65
Number of parcels	1.47	74.99	2.50	3.70
Area under food crop	0.95	80.56	1.84	2.66
Number of local cattle	0.94	86.04	0.28	3.9
Manure/day	0.80	90.71	2.76	1.89
Number of cross cattle	0.41	93.10	1.84	0.71
Area under cash crop	0.40	95.43	1.21	1.29
Area under planted pasture	0.27	97.01	0.99	0.82
Area under natural grass	0.26	98.54	0.98	0.80
Area under vegetable	0.17	99.53	0.49	0.52
Number of Exotic cattle	0.08	100	0.24	0.1

3.4. Vegetable Production by Smallholder Dairy Farmers

Famers' ranking of the economic importance of different vegetables differed significantly ($p<0.05$) amongst farmers in Masaka and Ngora districts. Scarlet Eggplant locally known as 'Nakati" (*Solanum aethiopicum*) was ranked to have the highest economic benefits among all the vegetables cultivated in Masaka while green pepper was ranked as the vegetable with the least economic value to farmers (Table 4). In Ngora District, tomatoes were ranked to have the highest economic importance while green pepper was ranked least (Table 4).

Table4. *Farmers' ranking of important vegetables in Masaka District*

Vegetable Local (common) name	Botanical name	Sum of ranks	Mean of ranks	Farmers Rank
Nakati (Scarlet eggplant)	*Solanum aethiopicum*	502.5	22.8[a]	1
Ddodo (Amaranth)	*Amaranthus dubius*	193.5	32.3[ab]	2
Butungulu (Onions)	*Allium cepa*	66.5	33.3[ab]	3
Sukuma wiki (Kale)	*Brassica oleracea cv Acephala*	105.0	35.0[ab]	4
Jjobyo (spider plant)	*Gynandropis gynandra*	155.5	38.9[ab]	5
Mboga (Cabbage)	*Brassica okeracea*	426.0	42.6[ab]	6
Bbugga (Amaranth)	*Amaranthus gracecizans*	174.5	43.6[ab]	7
Gobe (cowpea leaves)	*Vigna unguiculata*	89.0	44.5[ab]	8
Biringanya (Eggplant)	*Solanum melongena*	365.0	45.6[ab]	9
Ntula (Eggplant)	*Solanum melongena*	277.5	46.3[ab]	10
(Carrot)	*Daucus carota*	225.0	56.3[ab]	11
Enyanya (Tomato)	*Lycopersicon esculentum*	136.0	68.0[ab]	12
(Green pepper)	*Capsicum annum*	287.0	71.8[b]	13

Table5. *Farmers' ranking of important vegetables in Ngora District*

Vegetable Local (common) name	Botanical name	Sum of ranks	Mean of ranks	Farmers rank
Enyanya (Tomato)	*Lycopersicon esculentum*	371.0	16.1[ab]	1
Biringanya (Eggplant)	*Solanum melongena*	966.5	40.3[ab]	2
Butungulu (Onions)	*Allium cepa*	771.5	64.3[bc]	3
Gobe (cowpea leaves)	*Vigna unguiculata*	783.5	71.2[bc]	4
Ddodo (Amaranth)	*Amaranthus dubius*	549.5	78.5[bc]	5
Mboga (Cabbage)	*Brassica okeracea*	868.5	78.9[c]	6
Sukuma wiki (Kale)	*Brassica oleracea cv Acephala*	1589.5	79.5[c]	7
(Green pepper)	*Capsicum annum*	205.0	102.5[c]	8

In an attempt to focus on crop-livestock production enterprises that contribute significant incomes to farmers, the ranking of different vegetables were based on the amount of economic benefits derived from cultivation of the various vegetables. This implied that Nakati and tomato production contributed the highest economic benefits to farmers in Masaka and Ngora respectively while green pepper contributed least in terms of economic benefits. These results are suggestive that efforts to enhance crop-livestock farmers' incomes need to focus on enhancing productivity of Nakati and tomatoes in Masaka and Ngora respectively. Although Sukuma wiki (kale) was ranked among the vegetables with the least economic benefits, it was noted that the vegetable is widely cultivated by farmers for food security reasons in Ngora due to its tolerance to water stress while cabbages are largely cultivated for the same reason in Masaka.

3.5. Constraints to Integration Vegetable Production into Dairy Systems

The constraints in integration of vegetables in dairy production were categorized into production and post harvest constraints. Among the production constraints, lack of market (31 and 43%), high cost of inputs (24 and 44%), (24 and 45%), pests (44 and 30%) and lack of seed (19 and 30%) were major constraints in Masaka and Ngora respectively. Low rainfall (45%) and limited knowledge in agronomic practices (21%) were peculiar constraints in Ngora (Fig.3).

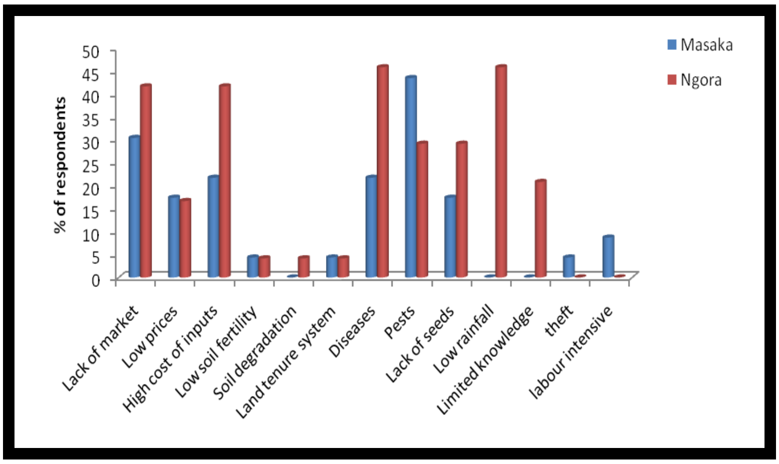

Fig3. *Constraints in vegetable production*

This calls for dedicated efforts to enhance marketability of vegetables in both districts in addition to ensuring availability of adequate water for production through embracing water harvesting and conservation technologies.

The effect of inadequate rainfall in vegetable production in Ngora District was underlined by the proportion of farmers (45%) undertaking irrigation technologies as compared to only 12% of the farmers executing irrigation technologies in Masaka District. All the farmers irrigating vegetables in both districts were noted to use watering cans while watering their crops suggesting the need for improved time and labour saving irrigation techniques to foster wide adoption of irrigation technologies. No farmer was involved in vegetable processing in Ngora while 12% of the famers in Masaka were involved in vegetable processing.

3.6. Constraints in Post Harvest Handling of Vegetables

Solar drying and open sun drying were noted as the only processing techniques undertaken by farmers. Solar driers were reported as the only processing equipments utilized by farmers in processing, no wonder, over 60% of the farmers in both districts regarded "lack of processing equipments" as the main constraint to processing of vegetables (Fig. 4). Limited knowledge on processing technologies was also noted as a major constraint to vegetable processing in Ngora. The results of this study were consistent with other studies by [18] who noted that Lack of awareness of availability of improved farm inputs and information on their applicability limit adoption levels.

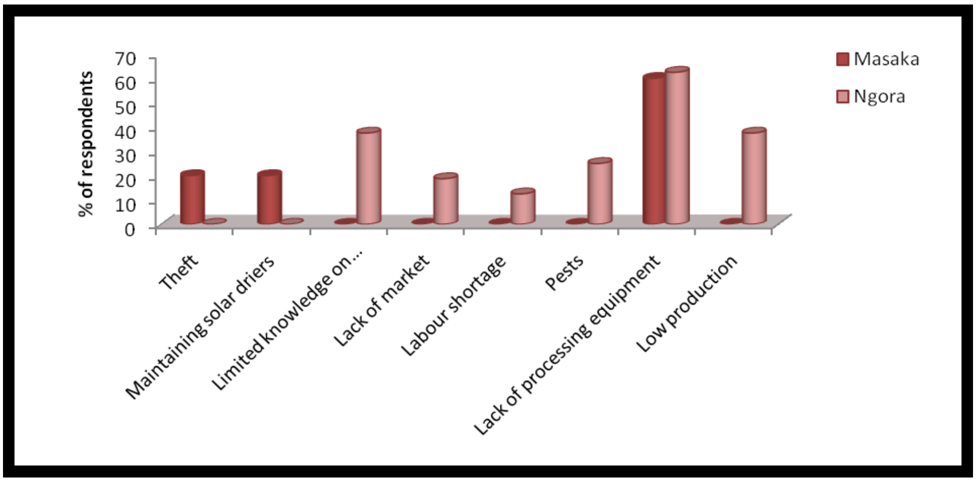

Fig4. *Constraints to post harvest handling of vegetables*

4. Conclusion

Vegetable production provides a more efficient enterprise in utilizing animal manure than other crop enterprise due to its proximity to homesteads and hence less labor requirements to transport manure and also due to rapid returns to investment. The study identified market challenges, high cost of inputs, pests and diseases, lack of seed, low rainfall and lack of agronomic and post harvesting knowledge as major constraints to integration of vegetables in smallholder dairy production systems. Since farmers' choice of vegetable is based on economic importance, addressing market and post harvest challenges may provide incentives to farmers for more efficient integration of vegetables in dairy production. Because land is a major limiting factor in smallholder farmers' vegetables with residues that are edible to cattle should be prioritize to minimize competition for land between vegetables and pastures. This should be accompanied by farmers' trainings in utilization of vegetable residues in dairy feeding systems.

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