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Urban Livestock Waste Management Practices in Tigray, Northern Ethiopia

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Abstract: This study aimed to explore the status of livestock waste management and utilization practices in three towns of Tigray, Ethiopia. The three study towns (Shire, Aksum and Adwa) were selected purposively due to the presence of relatively better number of market oriented small-holder urban livestock producers and large human population size. A total of 150 urban livestock owning households (50 from each town) were selected using a systematic random sampling technique and primary data were collected using semi-structured questionnaire and focus group discussions. Farm monitoring was undertaken to determine the amount of manure produced at farm level for three months. Analysis of variance, Chi-squire, index ranking and qualitative analysis were applied using Statistical Procedures for Social Sciences. The result showed that chicken out number among the livestock species across the study towns. The average daily fresh manure produced per farm was 98 kilogram. The dominantly used feeding system was stall-feeding mainly on roughage feeds with concentrate supplementation. Nearly 68% of respondents collected manure from animal houses once a day using and stored as heap within 10 meters distance from the farm. About 6% of the households stored manure for more than three months across the study towns. Manure was primarily converted into dry dung for fuel followed by fertilizer. The critical manure management constraints were lack of technical knowhow, shortage of land, distant plots, lack of transport, less market demand and labor intensiveness in their order of importance. This study highlighted that current manure management practices were unsafe for urban inhabitants and the environment. Viable technologies that can promote sustainable environmental friendly urban livestock production and integration with other agricultural activities should deserve attention. It also demands developing and implementing strict regulations and guidelines for waste management.

Keywords: Environment, Ethiopia, Livestock, Manure, Urban, Waste.

Introduction:

Urban population growth is driving the expansion of urban livestock production in developing countries like Ethiopia (Solomon et al., 2021). This type of livestock production system is practiced in and around major cities due to market and relatively

better input access than the rural dairy small holders (Alemu, 2019). The system is contributing immensely towards filling the gap between demand and supply for milk and milk products, egg and meat in urban centers, where consumption of these products is remarkably high (Zelalem et al., 2011). Urban dwellers are also the beneficiaries of this rapid growth of livestock in towns to respond in to problems of high unemployment and opportunities of high market demand (Mohamed et al., 2004). Overall, urban livestock production plays a substantial role in reducing poverty and contributing towards food security in the city (Lombebo and Wosoro, 2019).

Despite the valuable contribution of urban livestock production in improving household nutrition, incomes and food security among the growing population, the system generate large quantities of waste products resulting serious health and environment related problems that could otherwise be diverted into economic opportunities. Ogbuewu et al. (2012) also suggested that the conversion of livestock waste to useful products that are environmental friendly turn out to be the only alternative to the emerging environmental issues associated with indiscriminate livestock waste disposal. Livestock manure is a known source of zoonotic pathogens and it is thus a major risk factor for the spread of disease among both animals and humans if left untreated (De et al., 2003). In addition to the ability of many animal pathogens to pose health risks to exposed humans and animals, there are also mounting fears about the presence of antibiotic-resistant bacteria in livestock manures (Yost et al., 2011). Furthermore, environmental pollution and conflicts with neighbors result from improper urban livestock waste management and disposal (Iheke, 2016; Tadesse and Mengistie, 2016). A recent study (Lumbago and Wosoro, 2019) showed that inappropriate waste management as the leading constraint for urban dairy farmers in Hosanna Town, Southern Ethiopia. This suggests that proper livestock waste management is pivotal to ensuring environmental and health quality, avoiding societal conflicts, and boosting production.

Like any other urban areas in different areas of Ethiopia, there is an expanding trend of urban livestock enterprises in different parts of Tigray. Yet, this rapid expansion of urban livestock farming has been causing detrimental effects both on the environment and health of urban inhabitants. The is largely due to the fact that the issue of proper urban livestock waste management and utilization has not received much focus both by livestock producers and policy makers to make it environmentally sound. Therefore, it is fundamental to explore the current urban livestock waste management and utilization practices for designing and implementing effective interventions to make urban livestock enterprise environmental friendly. In this view, there are no empirical research works about urban livestock waste handling and utilization practices in urban areas of Tigray region, Ethiopia. This study was, therefore, initiated with the objective to assess livestock waste management, utilization practices and challenges

among urban livestock producers in three major towns (Shire, Aksum and Adwa) of Tigray, Northern Ethiopia.

Materials and methods:

Study area description

The study was conducted in three towns (Shire, Aksum and Adwa) of Tigray, Northern Ethiopia (Figure 1). The study towns are located 1078, 1024 and 1006 kilometers far from Addis Ababa, capital city of Ethiopia (Misganaw et al., 2017; Kebede et al.,2018, respectively. Shire town is located in Northwest zone of Tigray and lies at an altitude of 1900 meters above sea level as well as located with a geographical extent between 38° 15′ 0″ to 38° 21′ 0″ E and 14° 4′ 30″ to 14° 7′ 30″ N (Asfaw,2018; Gidey et al.,2023). The second study town, Aksum, is located in the Central Zone of Tigray at an altitude of 2100 meters above sea level, and lies on the geographical coordinates of 14° 7' 46" N, 38° 42' 56" E. The third study town, Adwa, is also found in Central Zone of Tigray at a longitude and latitude of 14°10′N 38°54′E, and an elevation of 1907 meters. The three study towns were chosen purposively due to the presence of relatively better number of market oriented small-holder urban livestock producers and large human population (Misganaw et al., 2017; Gidey et al., 2023).

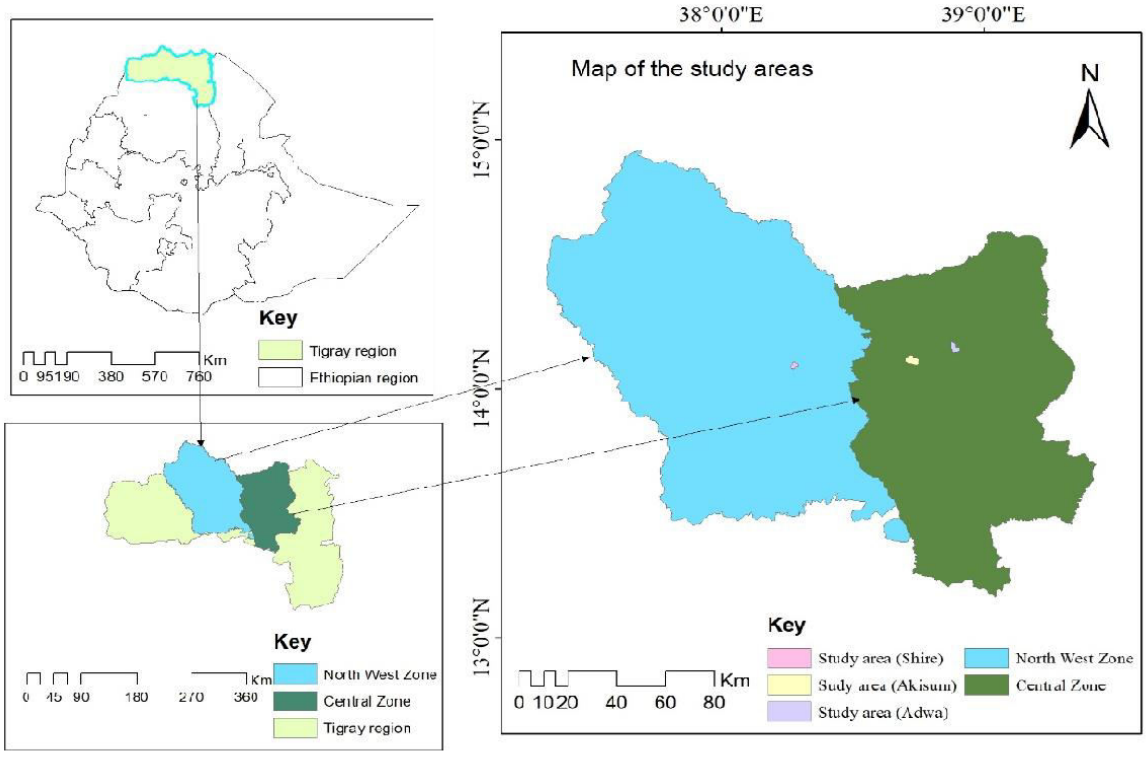

Fig.1 Map of study areas

Sampling design

A two stage sampling procedure was employed to select households who participated in the cross-sectional survey. In the first stage, households who engaged in any urban livestock farming activities (dairy, fattening, sheep and goat, poultry) were identified and listed from each study towns(Shire, Aksum and Adwa). In the second stage, based on the information obtained, a total of 150 households (50 from each town) were selected using systematic random sampling technique.

Data collection

A cross-sectional survey was undertaken in order to collect data on livestock number, feeding, manure production, management practices, utilization and its challenges using pre-tested semi-structured questionnaire. In addition, three focus group discussions comprising of six participants (one group per study town) were conducted to validate the information gathered in the course of the questionnaire survey. Farm monitoring was undertaken to monitor manure production (fresh weight kg day-1) at farm level for a period of three months. Farm level monitoring were conducted in the three towns and five farmers were selected from each study town based on their readiness to undergo farm monitoring.

Statistical analysis

Depending on the type of information collected, different analysis methods were applied using Statistical Procedures for Social Sciences (SPSS, 2011).

One-way ANOVA was applied to analyze livestock holdings and quantity of manure produced per day. The model is expressed as:

$$Yij = \mu + Ti + eij$$

Where, Yij is Response variables, μ is overall mean, Ti is effects of towns where i = 1 Shire, i = 2 is Aksum, and i = 3 is Adwa, and eij is random errors with normal distribution. The comparison between the means was performed by using Tukey HSD (honestly significant difference).

Ranking index

This method of ranking was employed for ranking urban livestock manure utilization practices and constraints employed by Musa et al. (2006).

Results and Discussion:

Livestock holding

Regardless of towns, the major livestock species kept include chickens, cattle, small ruminants and equines (Table 1). There was no significant difference among urban livestock holding households of the three towns in the average size of the different species of domestic animals. Chickens were the dominant species in terms of number. According to Azage (2004), urban livestock farmers usually keep more than one type of animal, and cattle and poultry are the major species that contribute significantly to the urban economy and to people's diets.

Table 1: Average livestock holding by species in three study towns of Tigray (values are mean (SD))

Livestock Species	Study town			Overall	ANOVA Test	
	Adwa	Aksum	Shire		F-value	p-value
Small ruminants	5±1.20	4±1.00	5±1.3	4.5±1.00	1.63	0.14
Dairy	6±1.80	6±0.44	7±0.20	6.3±0.33	1.93	0.31
Beef	1±0.10	1±0.00	1±1.01	1±1.00	1.30	0.11
Chicken	14±3.30	15±1.4	15±0.08	14.3±1.10	1.97	0.55
Equines	0.5±0.01	0.5±0.20	0.6±0.10	0.53±0.11	1.33	0.11

SD=standard deviation

Feeding system

Information pertaining to urban livestock feeding systems in the study towns is given in Table 2. The dominantly used feeding system across the three towns was stall-feeding on roughage feeds with concentrate supplementation. Nearly 13 percent of the interviewed households relay on stall-feeding mainly on roughage feeds only, which might be due to the high cost of supplementary feeds. About five percent of households use outdoor system. A study in urban areas of Tanzania reveled that less than half of cattle kept in-door and fed by a "cut and carry" method (Lupindu et al., 2012). It has been reported that indoor livestock rearing system provided maximum opportunity for manure collection and handling (Snijders et al., 2009). According to Leitner et al. (2021), feeding practices help to reduce livestock manure yield and potential emissions from manure management. Le Dinh et al. (2022) noted that feed and feeding manipulation are effective measures for reducing manure outputs and pollutant emissions.

Table 2: Livestock feeding systems in three study towns of Tigray

Feeding systems	Study towns				Test	
	Adwa	Aksum	Shire	Overall	X^{2}-value	p-value
	N (%)	N (%)	N (%)	N (%)		
Stall-feeding on roughage feeds only	8(16)	5(10)	6(12)	19(12.7)	0.10	0.89
Stall-feeding on roughage and concentrate supplements	40(80)	41(82)	43(86)	124(82.7)		
Out door	2(4)	4(8)	1(2)	7(4.7)		

N=Number of responses

Manure production

Manure produced (fresh weight kg day^{-1}) per farm across the towns was similar. The three months farm monitory data indicated about 98 kg day^{-1} of overall average fresh manure production (Table 3). According to Rukiko et al. (2018), the total quantity of manure that needs to be removed depends mainly on stocking rate, digestibility of the diet, moisture content, frequency of cleaning and techniques. An increase in manure production in urban areas might lead to scarce area for disposal, produce odor and favored breeding of pathogens and flies (Kadigi, 2013). This highlights the need for designing and implementing pertinent strategy that could link urban livestock with peri-urban system whereby manure produced in urban can be made available for crop producers.

Table 3: Average quantity of livestock manure production in three study towns of Tigray (Mean ±SD)

Quantity (fresh weight kg day^{-1})	Study towns			Overall	**ANOVA Test**	
	Adwa	Aksum	Shire		**F-value**	**p-value**
	96±10.00	98±11.00	99±14.00	97.7±10.12	1.77	0.15

SD=standard deviation

Manure management practices

Sixty eight percent of respondents collected manure from animal houses once a day (Table 4), which is consistent with the report of Lupindu et al. (2012) in urban and peri-urban areas of Tanzania. It has been shown that frequent removal of manure can reduce both methane and ammonia emissions (Gronow-Schubert and Gallmann, 2014). Iheke (2016) suggested that quick and frequent disposal of waste is crucial to avoid environmental sanitation problems and conflict between households. According

to Chadwick (2005), compacting and covering manure heaps does have the potential to reduce emissions of both NH_3 and N_2O The greater majority (66%) of the households store manure as heap very close(less than 10m) to the farm followed by disposing to damping area and throwing to any area in that order

Table 4: Livestock manure management practices in three towns of Tigray

Parameters	Study towns				Test	
	Adwa	Aksum	Shire	Total		
	N (%)	N (%)	N (%)	N (%)	X2-value	p-value
Frequency of collection						
• Once per day	35(70)	34(68)	33(66)	102(68)	1.00	0.23
• Twice per day	10(20)	11(7.3)	14(28)	35(23)		
• Once per week	3(6)	4(16)	2(4)	9(6)		
• Twice per week	2(4)	1(2)	1(2)	4(2.7)		
Collection means						
• Spade	30(60)	34(68)	31(62)	95(63.3)	1.66	0.15
• Hand picking	17(34)	12(24)	14(28)	43(28.7)		
• Water splash	3(6)	4(16)	5(10)	12(8)		
Transportation tools						
• Buckets	29(58)	28(56)	31(62)	88(58.7)	1.44	0.43
• Plastic bags	16(32)	18(36)	14(28)	48(32)		
• Wheel barrow	5(10)	4(8)	5(10)	14(9.3)		
Storage types						
• Heaping	34(68)	32(64)	33(66)	99(66)	1.82	0.14
• Disposed to dumping area	10(20)	13(26)	10(20)	33(22)		
• Disposed to any area found	5(10)	2(4)	4(16)	11(7.3)		
• Tipped in a pit at home	1(2)	3(6)	3(6)	7(4.6)		
Manure disposal distances						
• Within 10m	40(80)	37(74)	40(80)	117(78)	1.58	0.32
• Outside 10m	10(20)	13(26)	10(20)	33(22)		
Manure storage period						
• <7 days	2(4)	3(6)	2(4)	7(4.6)	1.11	0.22
• 1-2 weeks	1(2)	4(8)	4(8)	9(6)		
• 3-4weeks	9(18)	7(14)	8(16)	24(16)		
• 1-3month	8(16)	6(12)	7(14)	21(14)		
• >3month	32(44)	30(60)	29(58)	91(60.6)		

Similarly, livestock wastes were commonly heaped without any cover in the courtyard close to the barn or around the house in urban areas of Burkina Faso, Mali and Nigeria

(Amadou et al. 2012). Ndambi et al. (2019) also depicted that in confined system of animal farming manure is collected and stored in heaps, mostly without cover. Recent study indicated that organic waste (including livestock waste) is dumped in open spaces and along the main road in some towns of Oromia, Ethiopia (Gasu et al., 2017). Recently, Berhe et al. (2020) indicated that methane from manure management was higher in urban production than mixed and pastoral production systems. The authors revealed that improved manure handling and management system reduced methane and nitric oxide emission from manure 37.87 and 17.02% in livestock urban production systems, respectively.

The observed livestock waste disposal in the three study tows of our study suggests the urgent need in developing a collection, handling, storage and transport systems that are environmental friendly. The commonly used tool for collecting manure was spade followed by hand picking and splashing with water. The current results were similar with reports of Lupindu et al. (2012). The most common way to remove manure or clean animal houses was with bare hands in Uganda (Karin, 2007). Different tools such as buckets, plastic bags and wheel barrow were used to transport manure from the livestock shed to the storage site, in that order which were inconsistent with reports of Lupindu et al. (2012) who stated that manure was removed by hand picking. The different storage types used in the study towns were making pile, disposing to dumping site, disposing to anywhere, tipping in to a pit at home, in that rank. According to Wilson (2018), inappropriate disposal or storage of livestock waste such as uncovered manure heaps and dumping in streets may be responsible for zoonotic diseases. Wastes were commonly disposed within 10m from the farm and stored for more than 3 months across the three visited towns. According to Rukiko et al. (2018), cattle manure is piled outside the pen for an average of six months until the pile is big enough to be shifted to the farm or into a pit. Holman et al. (2016) also suggested that the manure must be eliminated in a manner which is consistent with public health and environmental related guidelines.

Manure and effluent treatment techniques

Livestock manure and effluent handling techniques in the study towns is given in Table 5. The most dominantly used manure handling technique was heaping as afresh followed by heaping after pan caking, direct spread on land and composting. This result indicates the less attention given for diverting livestock wastes into compost. Innocent et al. (2014) reported that composting as the dominant manure handling technique employed by farmers. The present finding might suggest the need for awareness creation and market linkage in order to recover livestock wastes through composting. According to Maru and Juliet (2016), urban waste composting has to be the integral part of waste management of towns to reduce cost of disposal and to build

pristine environment. If the manure is heaped for a longer period of time and exposed to rain, there might be a high risk that the rain carries off some of the nutrients and pollutes the environment. Hence, promoting a system of integrating urban livestock with peri-urban farmers or creating linkage between livestock farming with other agricultural activities (backyard vegetable and fruit farming) could be one viable option to sustain livestock production and food security in urban areas.

Table 5: Livestock manure and effluent treatment techniques in three study towns of Tigray

Manure and effluent handling techniques	Study towns			Overall	Test	
	Adwa	Aksum	Shire			
	N (%)	N (%)	N (%)	N (%)	X^{2-} value	p-value
Manure treatment						
• Heaping as fresh	30(60)	29(58)	31(62)	90(60)	0.33	0.78
• Heaping after pan caking	10(20)	11(22)	9(18)	30(20)		
• Direct spread on land	6(12)	4(8)	7(14)	17(11.3)		
• Compost preparation	4(8)	6(12)	3(6)	13(8.7)		
Effluent handling						
• Pit	47(94)	48(96)	47(94)	142(94.7)	0.66	0.98
• Direct spread on land	3(6)	2(4)	3(6)	8(5.3)		

Personal hygiene protective measures

Most of the urban livestock holders did wear ordinary clothes and shoes in the course of manure collection, transportation and disposal. Nearly seven and five percent of the interviewed households were found to use rubber boots and work bare-footed during animal waste handling, respectively (Table 6). Similarly, a number of urban and peri-urban Tanzania cattle farmers did not use protective measures and equipment to handle manure because of the associated costs (Lupindu et al., 2012).Greater proportion of farmers reported that after completing the routine activities with manure waste handling practices, they did wash their hands while only 13.3 percent took shower. The current reported manure handling was found to be unsafe and below standard, and it can pose public health risk. This might also bring failure to produce livestock product, like milk and its products, which are safe and quality. Studies have identified that human handling and dumping of livestock manure as a risk factor for pathogen contamination and potential contaminator of food products (Pham-Duc et al., 2014). According to Lupindu et al. (2012), lack of hygienic protective measures among livestock holding households underlines the need for disseminating information on proper handling of animal wastes to guide farmers on safe collection, conveyance, storage and disposal of manure.

Table 6: Household's response on personal hygienic protective measures in three study towns of Tigray

Hygienic practices	Study towns			Overall	Test	
	Adwa	Aksum	Shire		X^2-value	p-value
	N (%)	N (%)	N (%)	N (%)		
Types of clothes					1.32	0.79
• Ordinary	45(90)	46(92)	46(92)	137(91.3)		
• Overall	5(10)	4(8)	4(8)	13(8.7)		
Shoe wears						
• Ordinary	44(88)	44(88)	45(9)	133(88.7)	1.11	0.51
• Rubber boot	3(6)	4(8)	3(6)	10(6.7)		
• Bare-foot	3(6)	2(4)	2(4)	7(4.7)		
Hand wears						
• Not used	49(98)	48(96)	49(48)	146(97.3)	1.66	0.91
• Used	1(2)	2(4)	1(2)	4(2.7)		
Washing after manure collection and dispos-al						
• Taking shower	8(16)	7(14)	5(10)	20(13.3)	1.47	0.44
• Hand washing	42(84)	42(84)	45(90)	129(86)		

Livestock manure utilization practices and challenges

Households' ranking of livestock manure utilization practices and limitations are presented in Table 7. Interviewed households used livestock manure primarily as household fuel in the form of dry dung followed by fertilizer, plastering material, energy source as biogas and sold as source of income in their order of importance. A study by Sintayehu et al. (2008) revealed that nearly 34 percent of urban producers used the cow dung primarily as household fuel in southern Ethiopia. Hamadoun (2012) also reported that manure is utilized primarily as fertilizer and burned including other household wastes. Integrating urban livestock production with crop farming allows livestock-keeping households to recycle animal wastes, usually as crop fertilizer (Roessler et al., 2016). Similar to the present finding, only a few households in western African towns did sell manure as income source (Amadou et al., 2012). Previous study in Niamey, Niger (Graefe et al., 2008) indicated high use of urban livestock manure for vegetable gardening and to a lesser extent for the production of staple food. It has been suggested (Sintayehu et al.,2008) that manure from urban livestock farms can be made available to the surrounding rural and peri-urban communities for use as organic fertilizer and thereby reduce expenses of farmers to purchase of inorganic fertilizers. Biogas from livestock manure is one of the best alternatives to reduce public health and environment related risks (Putria et al., 2012); however, households

experience in diverting manure into biogas rated fourth in this study. According to Siegmeier et al., (2015), biogas technology is an environmentally friendly method of manure management and energy generation to reduce greenhouse gas and odor emission.

Table 7: Households' ranking of livestock manure uses and limitations in three study towns of Tigray

	Study towns					
	Adwa		Aksum		Shire	
	Index	Rank	Index	Rank	Index	Rank
Manure uses						
• Sell as income source	0.09	5	0.02	5	0.1	5
• Energy source as dry dung	0.38	1	0.44	1	0.45	1
• Energy source as biogas	0.16	4	0.09	4	0.16	4
• Fertilizer	0.20	2	0.24	2	0.21	2
• Plastering material	0.17	3	0.21	3	0.18	3
Challenges						
• Transport	0.12	4	0.09	4	0.11	4
• Less market demand	0.10	5	0.05	5	0.10	5
• Labor intensive	0.03	6	0.02	6	0.05	6
• Lack of technical know how	0.30	1	0.52	1	0.35	1
• Shortage of land	0.20	2	0.24	2	0.18	2
• Distant plots	0.12	3	0.11	3	0.16	3

Lack of technical knowhow was the most pressing challenge of manure utilization in the study towns followed by shortage of land for disposing and storage, distant plots, and lack of transport, less market demand and labor intensiveness in that order (Table 7). This finding agrees with the report of Ndambi et al. (2019) in Malawi, where most of the farmers did not have sufficient knowledge on manure management practices and their potential benefits in Malawi. Similarly, limited knowledge and skills is one of the major bottlenecks of cattle manure handling and utilization in Tanzania (Rukiko et al., 2018). The present result might suggest that promoting sustainable and environmentally friendly urban livestock production requires education and awareness creation among producers. The reported ranking of manure utilization challenges disagreed with findings of Haque et al., (2017). Iheke (2016) indicated that the shorter the distance of livestock farm to residential households, the better manure disposal and utilization

Conclusion:

The results of from the present study highlighted chickens as the dominant species in terms of number followed by dairy cattle. Stall feeding was the commonly practiced feeding system. The average daily quality of fresh manure per farm was 98 kilograms. Most of the farmers removed manure from shed once per day using spade, stored as pile within 10m distance for a period of more than three months. Heaping as fresh and direct spreading on land were the treatment techniques for manure and effluent respectively. The study further showed that many of the urban livestock keepers did not use hygienic protective measures during manure handling activities. Livestock manure has been primarily utilized for fuel as dry dung followed by fertilizer, plastering material, energy source as biogas and sold as source of income. The identified challenges of livestock waste collection and disposal were of lack of technical knowhow, shortage of land, distant plots, and lack of transport, less market demand and labor intensiveness. Viable technologies that can maximize the economic benefits of urban technologies, such as biogas, composting, and processing, packaging, and marketing, should be introduced. Livestock keeping should also be linked with other urban agricultural (like backyard vegetable production) activities. The current poor urban livestock waste management demands implementing strict standards and guidelines. Further research works are also suggested to explore opportunities and viable techniques for a sustainable environmental friendly urban livestock farming.

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