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# Knowledge assessment on the effects of climate change due to keeping livestock in urban and peri-urban areas of Dar es Salaam, Tanzania

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**This paper discusses assessment results of the respondents who kept livestock in urban and peri-urban areas in the three municipalities of Kinondoni, Ilala, and Temeke in Dar es Salaam city region, if they had knowledge that their activities had an effect on climate change. Data show that over two thirds of the respondents did not think that the presence of solid waste, liquid waste, and pollution resulting from keeping livestock would have an effect on climate risks in the future. However, the respondents thought that presence of chemical pollution and land degradation due to keeping livestock in urban and peri-urban agriculture (UPA) would have an effect on climate change. Furthermore, the article stipulates actions that urban livestock keepers would take in the future for mitigating climate risks. In addition, the respondents in UPA thought that people keeping livestock would in the future incur additional costs because of climate risks. The respondents indicated that most livestock types kept in UPA would be vulnerable and sensitive to climate risks and proposed adaptation options to take in the future. It is paramount that time has come for the three Dar es Salaam municipalities of Kinondoni, Ilala and Temeke through their relevant departments (agriculture and livestock, health, planning, community development), among other things, to educate livestock owners on climate risks due to livestock keeping and how to lessen them in the future. Other municipalities in Tanzania and elsewhere could use these results.**

**Key words:** Dar es Salaam, urban and peri-urban areas, livestock keepers, knowledge, opinions, climate change.

## INTRODUCTION

Based on the 2002 Tanzania Population and Housing Census, Dar es Salaam city region, which comprise of municipalities of Kinondoni, Ilala and Temeke had 2,487,288 inhabitants, of whom 1,254,853 were males and the rest females. Of the three municipalities, Kinondoni had the highest population with a total of 1,083,913 inhabitants, followed by Temeke with 768,451 and Ilala with 634,924 inhabitants. Dar es Salaam region

is estimated (2012) to have a population of about 5million that could reach up to 8 million by 2020 if present trends continue (URT, 2011). The city's population has been growing at the rapid rate of about 8% per annum (World Bank, 2002), a result of high in-migration from other areas and a birth rate of about 4.5% per annum. With population densities reaching 1,500 persons/hectare (on average, approximately 150 persons/hectare), it has a population of about seven times the size of the next most populated city, Mwanza, and continues to attract the most migrants (System for Analysis Research and Training (START, 2011).

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Dar es Salaam is one of the fastest growing cities in Sub Saharan Africa. The city's population grew from only about 3,500 in 1867 to 128,742 in 1957, to 272,821 in 1967 and to 843,000 in 1978. Seventy percent of Dar es Salaam's population lives in unplanned settlements, and over half of them live on an average income of \$1 a day. These settlements lack adequate infrastructure and services, and are highly prone to adverse impacts of frequent flooding. Poor solid waste disposal and sanitation practices, combined with rainfall, result in contamination of water and spread of disease. Climate change will exacerbate these issues in the absence of sound, forward-looking planning measures (START, 2011).

### **DAR ES SALAAM: GEOGRAPHICAL AND CLIMATIC BACKGROUND**

Dar es Salaam is a city where urban poverty and climate variability – floods as well as drought - jointly create a situation of high vulnerability for the poor that affects crucial aspects of their lives, for example, health, sanitation and access to clean water, and safety of housing and property (START, 2011). Tanzania's largest city, with over 4 million inhabitants, Dar es Salaam is characterized by urban sprawl and expanding informal settlements, resulting from increasing population pressure, poor infrastructure and town planning.

Dar es Salaam is located in the eastern part of the Tanzanian mainland at 6°51'S latitude and 39°18'E longitude. With an area of 1,350 km<sup>2</sup>, it occupies 0.19% of the Tanzanian mainland, stretching about 100 km between the Mpiji River to the North and beyond the Mzinga River in the South. The Indian Ocean borders it to the East and by the Coast Region on the other sides. The beach and shoreline comprise sand dunes and tidal swamps. Coastal plains composed of limestone extend 10 km to the west of the city, 2 to 8 km to the north, and 5 to 8 km to the south. Inland, alluvial plains comprise a series of steep-sided U-shaped valleys. The upland plateau comprises the dissected Pugu Hills, 100 to 200 m in altitude. Dominated by limestones, sandy clays, coarse sands and mixed alluvial deposits, the soils of the Dar es Salaam region are not particularly fertile (Dongus, 2000).

The City is divided into three ecological zones, namely the upland zone comprising hilly areas to the west and north of the City, the middle plateau, and the lowlands, which include Msimbazi Valley, Jangwani, Mtoni, Africana and Ununio areas. The City is divided into three ecological zones, namely the upland zone comprising hilly areas to the west and north of the City, the middle plateau, and the lowlands, which include Msimbazi Valley, Jangwani, Mtoni, Africana and Ununio areas. Natural vegetation mainly includes coastal palm groves, coastal shrubs, Miombo woodland, coastal swamps, and swampy mangrove trees and reeds. Prolonged human

interference has reduced the diversity of woodland and scrub.

### **Rainfall**

Dar es Salaam is a coastal city. It receives over 1,000 mm of rainfall per year and has a bimodal rainfall distribution, the two main rain seasons being the long rains and the short rains, associated with southward and northwards movements respectively of the Inter-Tropical Convergence Zone (ITCZ). The long rains season (*Masika*) occurs from mid March to end May, and the short rains (*Vuli*) from mid October to late December. Although June to September is typically a dry season for most parts of the country, coastal areas tend to receive a small amount of rainfall over this period. Rainfall in Tanzania is influenced by the southeast monsoon winds (May–September), the northeast monsoons (October–March), El-Nino Southern Oscillation (ENSO), tropical cyclones, easterly waves and the Congo air mass (START, 2011).

### **Temperature**

Analysis of both maximum and minimum temperatures at Dar es Salaam International Airport indicates significant positive trends over the past 4 to 5 decades (START, 2011). Temperature variation is of a great concern for urban and peri-urban agriculture (UPA), which directly affects the livelihoods of the urban poor, most of which raise livestock and cultivate crops.

### **Rainfall**

Rainfall in UPA is vital. Currently, its variation in Dar es Salaam is affecting UPA, which exacerbates poverty among the urban poor. As cited in START (2011), mean annual rainfall has declined in Dar es Salaam over the past five decades (as recorded at the Dar es Salaam Airport station), and the number of rain days for various locations in Dar es Salaam have declined.

### ***Rainfall intensity***

The mean 24-h maximum rainfall ranges from over 50 mm in April-May to 10 mm for July-August for the years 1971 to 2009 (START, (2011)). The absolute 24-h maximum rainfall for the time period studied was recorded within the past decade. This negative trend in rainfall intensity has had effects on UPA having impacts on urban food supply systems and distribution. Also, serious effects are seen in the disruption of employment among youth and women who depend on UPA for their livelihood. For instance, effects on youth cultivating of



**Table 1.** Sampled respondents in three municipalities of Dar es Salaam (N=281).

Parameter	Sample of respondents in Dar es Salaam municipalities					
	Kinondoni		Ilala		Temeke	
	Urban	Peri-urban	Urban	Peri-urban	Urban	Peri-urban
Vegetables	25	22	23	20	25	23
Field crops	0	3	0	2	0	0
Dairy/chicken	17	18	17	14	16	20
Chicken only	5	3	5	3	5	1
Other livestock	3	3	2	3	2	1
<b>Total</b>	50	49	47	42	48	45

as harbouring disease causing mosquitoes, among other things. It was in this context that this assessment was carried out.

## METHODOLOGY

This assessment interviewed a total of 281 respondents in three urban municipalities of Kinondoni, Ilala, and Temeke in Dar es Salaam city. In each municipality, using a table of random numbers three urban wards, and three peri-urban wards were selected, hence a total of 18 wards. In each ward, 16 respondents were randomly selected; hence a total number of 288 respondents, but only 281 were interviewed with seven non-respondents (Table 1). In the sampled urban wards, respondents were drawn from low-, medium-, and high-density areas. In each ward, females and males undertaking UPA who kept livestock (that is, keeping dairy cattle, broilers, laying hens, pigs), and grew crops (that is, vegetables, field crops) were interviewed.

Primary data were collected using a structured questionnaire, which had mainly close-ended questions. Pre-testing of the instrument was done in two wards (urban, peri-urban). Data from the primary source was verified, coded, entered and analyzed using the Statistical Package for Social Sciences (SPSS) computer program. The program produced frequencies, percentages, and cross tabulations and Pearson moment values to detect any association among variables.

## RESULTS AND DISCUSSION

### Socio-demographic characteristics of urban and peri-urban agriculture (UPA) respondents

Of the 281 respondents, 185 (66%) were males, and 99 (35%) females. Of all the respondents, most, 225 (80%) indicated that they were married, while 28 (10%) were single, with few indicating that they were widowed, and divorced. Of the 281 respondents, over half, 167 (59%) indicated that they had finished primary education, while few, 91 (32%) reported to had completed secondary education. Of all the respondents, less than half, 124 (44%) indicated that were also teachers, while 73 (26%) said they only engaged in UPA, while 33 (12%) were also tailors, and 32 (11%) indicated that in addition they did businesses.

The respondents' stay in Dar es Salaam varied. For instance, 57 (20%) indicated to had stayed below five years, 72 (26%) six to ten years, and 91 (32%) indicated to had stayed in urban and peri-urban areas for 11 to 20 years. Of the 281 respondents, one third, 84 107 (38%) mentioned that their main monthly incomes were earned from formal employment, while 73 (26%) said from selling milk, 67 (24%) mentioned from selling vegetables 67 (24%) and 34 (12%) said from eggs. This reinforces the notion that UPA activities in Dar es Salaam are important supplementary earnings to other forms.

Of the 281 respondents, 145 (52%) indicated that they owned land on which they practiced UPA, few, 88 (31%) reported that they did not know the owner of land on which they farmed. Yet, 42 (15%) reported that they did not rent land, but used it with permission from the land owners, while few, seven (2%) indicated that they rented land from the state (for example, from the military). Most of the respondents, 230 (82%) mentioned that they owned the houses in which they lived in. But 51 (18%) said they that did not own the houses but had agreements with owners to guard them.

However, this paper discusses assessment results of the 138 (49%) of the respondents who kept livestock in urban and peri-urban areas in the three municipalities of Kinondoni, Ilala, and Temeke in Dar es Salaaam city region if they had knowledge that their activities had an effect on climate change.

### Effects of keeping livestock in urban and peri-urban agriculture (UPA) on climate change

Data show that out of the 281 respondents, 138 (49%) kept livestock, as follows, 102 (36%) kept dairy cattle and chicken, 22 (8%) kept chicken only and 14 (5%) kept other livestock species. Using a questionnaire these 138 livestock keepers were asked to state whether they had any knowledge of the nine livestock related environmental problems and the actions they would take in the future to reduce/lessen the effects of environmental problems on climate change. The nine environmental problems included solid wastes, liquid wastes, pollution,

**Table 2.** Respondents' opinions on effects of keeping livestock in UPA on climate change (n=138).

Variable	No. of statement <sup>1</sup>	D/A <sup>2</sup>	Mean (%)	Sd	t	Df	p (2-tailed)
Respondents' opinions on the presence of solid wastes emanating from keeping livestock in UPA that contributes to climate change	11	D A	43.3 37.6	14.6 14.2	1.14	32	0.26
Respondents' opinions on the presence of liquid waste emanating from keeping livestock in UPA that contributes to climate change	17	D A	43.3 35.9	14.3 12.8	1.59	32	0.12
Respondents' opinions on the presence of pollution emanating from keeping livestock in UPA that contributes to climate change	10	D A	49.3 35.5	18.6 19.8	1.61	18	0.12
Respondents' opinions on the presence of chemical pollution emanating from keeping livestock in UPA that contributes to climate change	12	D A	43.6 30.6	11.4 9.8	3.07	22	0.00
Respondents' opinions on the presence of soil erosion emanating from keeping livestock in UPA that contributes to climate change	13	D A	38.1 38.2	9.4 13.8	-0.03	24	0.97
Respondents' opinions on the presence of land degradation emanating from keeping livestock in UPA that contributes to climate change	12	D A	45.6 43.0	13.2 14.2	2.16	22	0.04
Respondents' opinions on whether competing land use due to keeping livestock in UPA would have an effect on climate change	12	D A	64.8 18.8	20.9 15.7	6.10	22	0.00
Respondents' opinions on whether competing water use due to keeping livestock in UPA would have an effect on climate change	12	D A	32.9 50.7	17.6 18.6	-2.4	22	0.02
Respondents' opinions on whether forage shortages due to keeping livestock in UPA would have an effect on climate change	12	D A	47.5 32.3	15.1 13.9	2.55	22	0.01

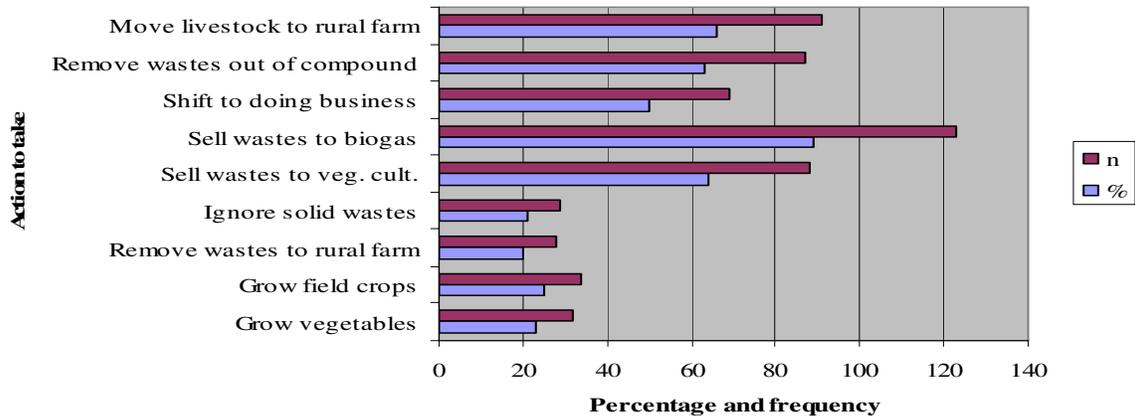
<sup>1</sup>Statements; <sup>2</sup>D = Disagree, A = Agree.

chemical pollution, soil erosion, land degradation, competing land uses with other sectors, competing water uses with other sectors, and forage availability. For this assessment, knowledge is taken to mean "a familiarity with someone or something, which can include facts, information, description, or skills acquired through experience or education. It can refer to the theoretical or practical understanding of a subject" (Cavell, 2002). In this case, it was the livestock keepers in UPA practical understanding of the livestock related environmental problems to climate risks.

The answers to the statements on a structured questionnaire were given based on the Likert scale, that is, 1= strongly disagree, 2= disagree, 3=neutral, 4=agree, and 5=strongly agree to the statements. During the analysis, the mean values for neutral were dropped. Hence, the means for 'strongly disagree' and 'disagree' were summed up to form one group of those who 'disagree'. And another group of means for 'agree' and 'strongly agree' were also summed up to form one group of those who 'agree'. The 'disagree' and 'agree' means

were used to discuss the opinions the respondents gave to the nine environmental problems related to livestock keeping in UPA and the future actions they would take to mitigate the effects of these problems on climate change. Later, the two groups of means were compared using the t-test statistic and the results are reported in the subsequent tables.

The data show that over two thirds of the respondents did not think that the following aspects resulting from keeping livestock had an effect on climate change. These included the presence of solid waste (43.3%), presence of liquid waste (43.3%), and pollution (49.3%). And the difference between proportions of those who disagreed and those who agreed with the statements in the three variables were not significantly different at  $p < 0.26$ , 0.12, and 0.12, respectively (Table 2). These two groups of statements 'presence of chemical pollution' and 'presence of land degradation' due to keeping livestock in UPA were thought to have an effect on climate change. The proportions of those who agreed with the statements for chemical pollution and land degradation were



**Figure 1.** Actions to take in the future to mitigate climate change effect due to solid wastes from keeping livestock in UPA.

statistically significant different from those who disagreed at  $p < 0.00$  and  $< 0.04$ , respectively (Table 2). But the respondents agreed with statements for competing water uses with other sectors at  $p < 0.02$ .

### Solid wastes

The first part of the question asked the respondents to say if they had known that 'solid wastes' resulting from keeping livestock in UPA had an effect on climate change. The second part of the question asked the respondents to indicate the actions they would take in the future to lessen, 'solid wastes' in order to mitigate climate change in UPA. Specifically, there were 11 statements that were solicited from respondents on whether solid wastes (that is, cow dung, forage leftovers, mixture of feed, grass bedding) emanating from keeping livestock in UPA has an effect on climate change. The second part required the respondents to indicate the type of actions livestock keepers would take in future to mitigate climate change. The respondents disagreed that solid wastes had an effect on climate change.

### *Actions livestock keepers would take in the future*

A total of 138 respondents who kept livestock gave their opinions on actions they would take in the future to reduce /lessen the effects of solid wastes due to keeping livestock on climate change. Most respondents, 123 (89%) agreed that they would in the future still continue to keep livestock and sell solid wastes to urban farmers having biogas digesters. Of the 138 respondents keeping livestock in UPA, over half, 88 (64%) agreed that they would in the future still continue to keep livestock and sell solid wastes to urban farmers cultivating vegetables. Yet two thirds of the respondents, 91 (66%) agreed that in

future they would shift their livestock to farms in the rural areas, remove solid waste from compounds mentioned by 87 (63%), and stop keeping livestock and do other business instead said by 69 (50%) (Figure 1).

Furthermore, less than a quarter of the 138 respondents who kept livestock in UPA, 34 (25%) agreed that they would in the future stop keeping livestock in UPA and 23 (23%) agreed that in the future they would cultivate field crops and cultivate vegetables. Yet, few respondents, 21 (29%) agreed that in the future they would not stop keeping livestock but remove solid wastes to their farms in rural areas and 28 (20%) agreed that they would ignore nuisance of solid wastes.

### Liquid wastes

Specifically, there were 17 statements which required the respondents to give their opinions on whether liquid wastes (urine, slurry) emanating from keeping dairy cattle in UPA would have an effect on climate change and what strategies they would adapt in the future to mitigate the problem. However, the differences between the proportions of those who agreed and those who disagreed were not statistically significant at  $p < 0.12$  meaning that liquid wastes due to keeping livestock in UPA were perceived as not having an effect on climate change (Table 2).

### *Actions livestock keepers would take in the future*

Half of the 138 respondents who kept livestock gave their opinions on actions they would take in the future to reduce /lessen the effects of liquid wastes on climate change due to keeping livestock in UPA. Most of the respondents, 109 (79%) agreed that they would in the future continue keeping livestock but sell liquid wastes to

neighbours who would use the liquid waste as manure for vegetable cultivation. Over half of the respondents, 70 (51%) agreed that they would in the future continue keeping livestock in UPA but build modern livestock sheds, while others said they would zero-graze their cattle to contain liquid wastes effects on climate change.

Further, less than half, agreed that they would mitigate the effects of liquid wastes due to keeping livestock, 63 (46%) said that in the future they would reduce the number of animals, and 61 (44%) said they would remove the wastes from their compounds. Yet, few, 43 (31%) agreed that in the future they would move their livestock to farms in rural areas to avoid their effects on climate change.

### **Pollution (odour, stench)**

There were ten statements that required the respondents to give their opinions on issues concerning pollution resulting from keeping livestock in UPA. The difference between the percentages of those who agreed and those who disagreed were not statistically significant at  $p < 0.12$  meaning that the respondents did not think that pollution due to keeping livestock had an effect on climate change (Table 1).

### ***Actions livestock keepers would take in the future***

The results show that more than half of the respondents disagreed to seven statements out of the ten. However, over two thirds of the respondents, 92 (67%) agreed that in the future they would remove livestock wastes to farms in rural areas, and 88 (64%) said that they would reduce the number of livestock to keep half to lessen pollution. About half, 69 (50%) agreed that they would in the future stop keeping all other types of livestock, but resort to keeping indigenous chicken, while few, 50 (30%) said they would stop keeping all other types of livestock, but keep laying and broiler chicken.

### **Chemical pollution**

There were 12 statements that required the respondents to give their opinions on whether chemical pollution (acaricide, insecticide, fungicide, antibiotics) emanating from keeping dairy cattle in UPA would have an effect on climate change and what strategies they would adapt to mitigate the effects. The proportions of those who agreed and those who disagreed with the 12 statements were significantly different at  $p < 0.001$  meaning that the respondents disagreed (mean average of 44%) that chemical pollution due to keeping livestock in UPA would in the future have an effect on climate change (Table 2).

More than half of the respondents disagreed to only two statements.

### ***Actions livestock keepers would take in the future***

Less than a half, 68 (49%) of the total 138 respondents agreed that in the future they would dig pits and bury chemical waste to lessen the effects of chemical pollution (resulting from keeping livestock in UPA) on climate change. Yet, few, 68 (49%) agreed that they would in the future reduce animals by half, and 47 (34%) said that they would stop keeping other livestock types and keep indigenous chicken that do not require chemicals. Although chemical pollution was thought to have an effect on climate change, none of the 12 statements was accepted by above 50% of the respondents. Perhaps this is an indication that most respondents minimally associated chemical use in livestock and its effect on environment and climate change.

### **Soil erosion**

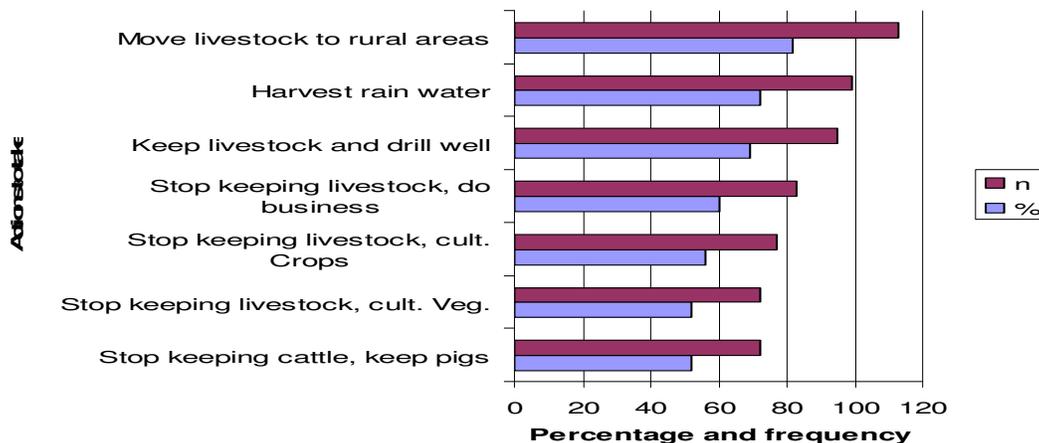
There were 13 statements which required the respondents to give their opinions on whether soil erosion due to keeping dairy cattle in UPA would have an effect on climate change and what strategies they would adapt to mitigate the effects. The difference between the proportions of those who agreed and disagreed with the 13 statements in this group were not statistically significant at  $p < 0.97$ , meaning that the respondents did not think that soil erosion due to keeping dairy cattle had an effect on climate change (Table 2).

### ***Actions livestock keepers would take in the future***

The effects of soil erosion due to keeping livestock in UPA are real, especially in areas dominated by dairy cattle. The effects are serious when cattle keepers cut forage from various sources to feed zero-grazed animals. The assessment results show that about half of the respondents, 77 (56%) agreed that in the future they would reduce the number of livestock in UPA by half, and 69 (50%) would zero-graze their cattle. Further, few, 63 (46%) agreed that in the future they would stop keeping livestock and instead keep indigenous chicken to lessen the effects of soil erosion.

### **Land degradation**

There were 12 statements that required the respondents to comment on issues concerning land degradation due to keeping livestock in UPA in Dar es Salaam. The difference between the proportions of those who agreed and disagreed with the statements in this group were statistically significant at  $p < 0.04$ , meaning that the respondents perceived land degradation due to keeping livestock in UPA as having an effect on climate change (Table 2).



**Figure 2.** Actions take in the future to mitigate climate change effect due to competing water use with other sectors from keeping livestock in UPA.

### **Actions livestock keepers would take in the future**

More than two thirds, 94 (68%) of the total 138 respondents agreed that in the future they would zero-graze dairy cattle in UPA to lessen the land degradation and hence mitigate climate change. Yet, less than half, 63 (46%) of the respondents agreed that in the future they would reduce by half the number of animals to keep. Other respondents, 47 (34%) said that they would shift their livestock to farms in rural areas, while few, 37 (27%) agreed that in the future they would stop keeping dairy cattle and instead keep chicken (laying, broilers).

### **Competing urban land uses**

There were 12 statements that required the respondents to give their opinions concerning competing land use with other sectors due to keeping livestock in UPA and how the effects of climate change would increase in the future. The difference between the proportions of those who agreed and those who disagreed with the statements in this group were statistically significant at  $p < 0.00$ , meaning that the respondents disagreed (an average mean of 64.8% versus 18.8% agree) that the effects of competing land use with other sectors due to keeping livestock in UPA would increase the effects of climate change in the future (Table 2).

### **Actions livestock keepers would take in the future**

Over a half of the 138 respondents, 73 (53%) who kept livestock agreed that in the future they would shift their livestock to farms in the rural areas as a way to avoid competing urban land uses with other sectors in UPA. Further, few, 52 (38%) agreed that they would in the

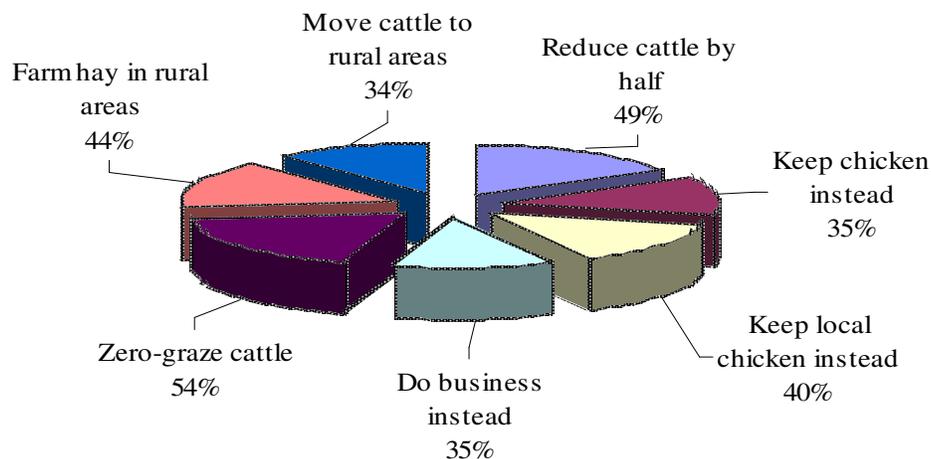
future zero-graze their dairy cattle to reduce competing land use with other sectors in UPA.

### **Competing water use for livestock with other sectors**

Water in UPA is a critical resource for both watering livestock and crops. Here too, there were 12 statements that required the respondents to respond to questions concerning competing water use between livestock and other sectors in UPA. Also, they were required to state as to how competing water use for livestock would in the future increase climate change and mitigation strategies they would adapt. The differences between those who agreed and those who disagreed with the statements in this group were statistically significant at  $p < 0.02$  (Table 2). This means that the respondents perceived that the competition for water uses with other sectors due to keeping livestock in UPA will increase the effects of climate change in the future (agree average mean of 50.7% versus 32.9% disagree). Of the 12 group statements examined, the respondents disagreed with three statements that competing water uses with other sectors was a problem.

### **Actions livestock keepers would take in the future**

Of the 138 respondents who kept livestock, most, 113 (82%) agreed that in the future they would shift their livestock to farms in the rural areas to avoid competing water use with other sectors in UPA. Yet, over two thirds of the respondents, 99 (72%) agreed that they would harvest rain water for livestock activities, 95 (69%) agreed that they would continue to keep the same number of animals in UPA, and 95 (65%) agreed that they would drill own water wells (Figure 2).



**Figure 3.** Actions to take in the future to mitigate climate change effect due to forage availability from keeping livestock in UPA.

Still, other respondents, 83 (60%), 77 (56%), and 72 (52%) agreed that they would in the future stop keeping livestock and instead do businesses, cultivate field crops, keep pigs, and cultivate vegetables, respectively. Given these assessment results, it is clear that most respondents who kept livestock in UPA perceived competing water use for livestock with other sectors as a problem and it is being increased by climate change. This is exemplified by an average mean of 50.7% for those agreeing with the statements versus 32.9% of those who disagreed (Table 2).

### **Forage availability**

Dairy cattle kept in Dar es Salaam UPA depend mainly on forage. Most of which is brought from outside the cattle keeper's compound, which is cut in valleys, verges, road sides, river ravines, and crop fields. It is gathered and transported to cattle sheds by head-carrying or using various vehicles (bicycles, ox-carts, trucks, lorries). Here too, there were 12 statements which required the respondents to respond to questions concerning availability of forage. Forage is brought from outside livestock keepers' homes and fed to zero-grazed dairy cattle kept in UPA.

The respondents were asked to give their opinions about how the problem of forage availability would in the future increase due to climate change, and what strategies the respondents would adapt to mitigate the problem. The differences between the percentages of those who agreed and those who disagreed with the statements in this group were statistically significant at  $p < 0.01$  (Table 2). This means that the respondents did not perceive (disagree average mean of 47.5% versus 32.5% agree) the problem of forage availability in UPA as being increased by the effects of climate change. Of the

12 group statements examined, the respondents disagreed with six statements that availability of forage in UPA was an environmental problem.

### **Actions livestock keepers would take in the future**

Half of the respondents (75, 54% of the total 138 respondents who kept livestock) agreed that in the future they would zero-graze their cattle to cope with the scarcity of forage in UPA. Yet, less than half, 67 (49%), 61 (44%), and 55 (40%) agreed that they would in the future reduce the number of dairy cattle by half, stop keeping dairy cattle and instead keep indigenous chicken, and cut hay in rural areas, respectively (Figure 3).

Still, a third of the respondents, 48 (37%) agreed that in the future they would stop keeping dairy cattle and do businesses instead, and 47 (34%) agreed that they would keep chicken (laying, broilers), and shift dairy cattle to farms in rural areas.

### **Linkages between urban and peri-urban agriculture (UPA) and urban food systems**

An assessment on linkages between UPA activities and urban food systems was done. A linkage is a relationship between two processes or phenomena where a change in process (for example, acidification) affects the other processes (for example, climate warming) and/or vice versa (Leatherman, 1989). Assessment results show that of the 138 respondents, most, 108 (78%) disagreed that in the future there would be linkages between UPA and urban food systems for livestock-related food products due to the effects of climate change. Livestock-related food products include milk, beef, eggs, broiler meat, and

**Table 3.** Respondents' opinions on additional costs in accessing livestock-related products from UPA due to climate change (N=138).

Variable	No items	D/A <sup>1</sup>	Mean (%)	SD	t	df	p (2-tailed)
Respondents' opinions on climate change effects on additional costs in accessing livestock-related products from UPA in the future	11	D	1.1	0.3	-42.8	20	0.000
		A	45.4	3.4			
Respondents' opinions on vulnerability to climate change effects of livestock-related products from UPA in the future	11	D	1.2	0.40	-623.9	20	0.000
		A	96.1	0.30			

<sup>1</sup>D = Disagree; A = Agree.

pork. Other food products include indigenous chicken meat, mutton, goat meat, duck meat, honey, and fish. One probable reason for lack of linkages for the livestock-related food products could be firstly that such products are mainly produced outside UPA. Secondly, for one to start a viable livestock enterprise in UPA, she/he required land and capital, which are difficult to get.

Other aspects that the assessment required the respondents in UPA to give their opinions were on the additional challenges that would emerge in the future because of climate change and affect the way people access livestock-related products from UPA. The assessment results show that in the future there would emerge additional challenges in the way people access livestock-related food products from UPA because of the effects of climate change.

An average of 119 (68% of the total 138 respondents) agreed that, livestock keepers in UPA would in the future face additional challenges in the way they produce livestock-related food products because of the effects of climate change. Specifically, the respondents gave the following ratings of agreement for the 11 common livestock-related products as: milk 124 (90%), broiler meat 123 (89%), eggs 121 (88%), indigenous chicken meat 119 (86%) and fish 117 (85%). Yet others were pork 115 (83%), duck meat 113 (82%), and mutton 112 (81%).

#### **Urban and peri-urban agriculture (UPA) additional costs caused by the effects of climate change**

There were 11 livestock-related food products for which the respondents were required to give their opinions on whether or not there would be additional costs in the future when accessing livestock-related food products from UPA because of the effects of climate change. The differences between the percentages of those who agreed and those who disagreed with the statements in this group were statistically significant at  $p < 0.001$ . This means that 45% of the 138 the respondents who keep livestock in the UPA agreed with the statements versus 1.1% of those who disagreed (Table 3). Further examination of assessment results show that

respondents agreed by an average of 117 (85%) that there would be additional costs in the future when accessing livestock-related food products from UPA because of the effects of climate change. The individual livestock-related food products agreements to statements were: milk 124 (90%), broiler meat 123 (89%), eggs 121 (88%), and beef 120 (87%) Yet, other livestock-related food products were indigenous chicken and goat meat 119 (86%), fish 117 (85%), pork 115 (83%), duck meat 114 (82%), and honey 109 (79%).

#### **Urban and peri-urban agriculture (UPA) vulnerability and sensitivity**

According to UN/ISDR (2004 as cited by Birkmann, 2006), vulnerability is the condition determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. Vulnerability is a multi-dimensional and differential, scale dependent, and dynamic (Vogel and O'Brien, 2004, cited in Birkmann, 2006). According to UN (2012), hazard is understood as a potentially damaging physical event, phenomenon and/or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. The assessment results indicate that livestock species raised in UPA would be vulnerable to climate risks in the future because of the effects of climate change as shown by a highly statistical significance at  $p < 0.001$  (Table 3).

Another aspect that was assessed was the livestock species in UPA that would in the future be sensitive to the effects of climate change. Climate sensitivity is the amount of warming expected at different atmospheric concentration of carbon dioxide (National Research Council of Academies (NRCA), 2010). Hence, of the 138 respondents keeping livestock in UPA, an average of 91 (66%) agreed that the eight livestock species would be highly sensitive to the effects of climate change in the future, this was highly statistically significant at  $p < 0.001$ . The individual livestock species responses were: improved dairy cattle 119 (86%), indigenous cattle 115 (83%), sheep 108 (78%), and indigenous chicken 83

**Table 4.** Livestock species and options to adapt to more climate resilience (n=138).

Livestock type	Pour water onto animals		Take animals out to cool	
	n	%	n	%
Improved dairy cattle	68	49	70	51
Laying chicken	45	33	94	68
Broiler chicken	39	28	99	72
Pigs	48	35	90	65
Indigenous cattle	41	30	97	70
Indigenous chicken	32	24	105	76
Rabbits	51	37	87	63
Average	37	27	91	66

(60%), pigs 81 (59%), broiler chicken and rabbits each 79 (57%), and ducks 77 (56%).

### **Livestock options to adapt to climate resilience**

The respondents gave their opinions to eight possible options for adapting to the effects of climate change for different livestock species. These were pouring water onto animals, taking animals to cool outside, thatching livestock sheds with indigenous thatch called *makuti*, and raising livestock shed roofs. Yet others mentioned putting roosters in chicken houses, putting wire mesh on windows, putting concrete floors in sheds, abandoning livestock keeping and taking up other businesses. Only two options received significant responses out of the eight options that the respondents would adapt in UPA in the future as possible mechanisms for adapting to more climate resilience. These were pouring water onto animals, and taking out animals to cool (Table 4).

Of the 138 respondents keeping livestock in UPA, an average of less than one third, 37 (27%) indicated that they would in the future pour water onto animals as a response to more climate resilience. Specifically, they mentioned to pouring water onto animals as follows: improved dairy cattle 68 (49%), rabbits 51 (37%), pigs 48 (35%) and laying chicken 45 (33%). Yet others were indigenous cattle 41 (30%), broiler chicken 39 (28%), and indigenous chicken 32 (24%) (Table 4). Looking at low percentages of responses (average of 27%) we can conclude that most respondents would in the future not pour water onto animals as an option to adapt to more climate resilience for livestock.

On the other hand, an average of two thirds of the 138 respondents, 91 (66%) indicated that they would in the future take out their animals to cool places, as a possible response to more climate resilience. The responses were as follows: indigenous chicken 105 (76%), broiler chicken 99 (72%), and indigenous cattle 97 (70%). Yet others were laying chicken 94 (68%), pigs 90 (65%), rabbits 87 (63%), and improved dairy cattle 70 (51%) (Table 4). Therefore we can conclude that taking out livestock to

cool was indicated as a possible response to climate resilience in the future by two thirds, 91 (66% of the respondents keeping livestock in UPA. This is more plausible given two reasons: Firstly, It would be easy to take animals out to cool because as it would be costly (water, labour, transport) to have enough water to pour onto all livestock that those individuals kept in UPA.

### **CONCLUSION AND WAY FORWARD**

Dare es Salaam city is growing and so are UPA activities. These activities, on one hand provide food and income to urban dwellers, but on other hand cause problems to the urban environment. Hence, there is a need to understand the perceptions of the doers so as to design effective adaptation strategies. Specifically, the need for appropriate communication of climate risks is great in the developing world where vulnerability to climate change and variability is extensive. This assessment has presented assessment results that can be readily used by urban livestock keepers, municipal policy makers, and other stakeholders.

Given this backdrop, using a questionnaire a sample of 138 livestock keepers in UPA were asked to state whether they had any knowledge of the nine livestock related environmental problems and the actions they would take in the future to reduce/lessen the effects of environmental problems on climate change. The nine environmental problems included solid wastes, liquid wastes, pollution, chemical pollution, soil erosion, land degradation, competing land uses with other sectors, competing water uses with other sectors, and forage availability.

This assessment shows that most people undertaking UPA have little knowledge about climate risk that their activities can cause on climate. And, UPA causes several environmental problems that put urban communities at risk, which need to be addressed and managed.

Given this background, the following recommendations are made as follows. The three municipalities of Kinondoni, Ilala and Temeke through their relevant

departments (agriculture and livestock, health, planning, community development) should educate livestock keepers in UPA about the environmental problems of UPA and how to manage and lessen them. The municipalities should zone land for UPA, and commission studies on technical efficiency with a view to recommending actual number of livestock species to keep in the different density areas. The three municipalities should introduce livestock types that are less vulnerable to climate risks.

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