Constraints and Opportunities Among Small Scale Peri-Urban Dairy Farmers in the South Eastern Kenya Rangelands

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Abstract *In Kenya's semi-arid regions, small scale farmers are becoming adaptive and resilient by embracing dairying as livelihood-support activity against expert's advice. In order to improve their dairying, the farmers are adopting improved dairying technologies, which have direct impact on milk yield, household's income generation and dairy development. However, dairying in these semi-arid regions is faced with numerous constraints that impact negatively on dairy production and livelihoods of the farmers. The objective of this study was to determine the constraints the farmers faced and mitigation measures being initiated. The study was carried out in two peri-urban environs in agro-ecological zone IV in Machakos and Makueni Counties and 150 farmers were interviewed. Self-practiced dairying and forage technologies were listed and constraints affecting each were studied. Farmers' perception of the constraints affecting each technology was analysized and then the constraints' levels as perceived by the dairy farmers were ranked. Lack of awareness or knowledge of the technology and extension services and the high costs for initial purchase or implementation and maintenance were ranked high for most of the technologies. Improvement of extension services to create awareness and improve understanding, together with improvement of access to credit were acknowledged as some of the mitigation measures to enhance the utilization of these adaptive technologies for increased milk production and sustainable livelihoods of the dairy farmers.*

Keywords: Adaptations, Constraints, Mitigation

1. Introduction

In Kenya, agriculture remains the main source of livelihood for majority of the rural people [4] and it is critical in meeting food security and realizing better livelihoods of the people [1][17]. The agricultural sector also plays a major role in the Kenyan economy by contributing about 26% of Gross Domestic Product (GDP) [18].

The animal agriculture sub-sector is equally important as it contributes directly in strengthening the household-economy, food production, employment and poverty relief among other benefits. It also allows resource-poor households and vulnerable groups especially women, who do not own land, to accumulate assets, like small animals [17][26][29].

The livestock holdings are varied, depending on ecological, demographic and socio-economic influences [17]. Generally most of these smallholding enterprises only meet the basic subsistence needs of the households especially in the semi-arid regions. However, in the recent past, there has been a more pronounced change in land-use towards market-orientation especially in the semi-arid environs close to the growing urban markets. In addition, there is also an accelerated trend of both intensification of the dairy enterprises and adaptive approach by the farmers for them to become resilient. For example, these farmers are embracing dairying as livelihood-support potential activity contrary to the expert's advice that ASALs are only suitable for Zebu rearing [8][17] .

Dairy farming, being adopted, is an essentially high-income generating agricultural activity that contributes about 3.5% to the Gross Domestic Product (GDP) in Kenya [9]. Further, it also supplies milk to the households while the surplus milk is marketed to different clients, like government institutions, hotels and individuals among other clientele. Considering the benefits that are accruing to the dairy farmers, it is worthy to note that dairy farming in the semi-arid environment of south eastern Kenya has high potential for economic and social development.

With desire to increase income through commercialization of dairying, the farmers have endeavored to adopt adaptive innovations in order to improve milk production of the intensified dairy enterprises in these semi-arid regions.This commercialization of dairy farming has led to increased use of intensive systems to rear cows in their farms. However, the farmers and other stakeholders acknowledged that such intensified dairying systems are posed with numerous constraints, challenges and threats when it comes to animal and feed management.

This study was therefore aimed at establishing the constraints, challenges and threats that the peri-urban dairy farmers were facing that affected their resilience, innovative and adaptive nature of the households in these south eastern Kenya rangelands.

2. Methodology/Methods and Materials

2.1. Study Sites

The study was carried out in the peri-urban environs of Machakos Town, Machakos County and Wote Town, Makueni County - which lies between longitude 37.16^{o} - 37.38^{o}E and latitude 1.31^{o} - 1.47^{o}S. These two peri-urban environs are representative of semi-arid regions of south eastern Kenya rangelands. The peri-urban environ of Machakos Town, Machakos County lies in Upper Midland agro-ecological zone 4 (UM4) while peri-urban environ of Wote Town, Makueni County falls within Lower Midland agro-ecological zone 4 (LM4) [5][14]. In addition, these two sites have medium altitude ranging from 900m asl on Wote Town to 1300m asl on Machakos Town [5][14].

These peri-urban semi-arid regions are climatically challenged. For example, they receive bi-modal rainfall ranging from 550 - 900 mm/annum – which is very erratic and unreliable. This unreliable rainfall, coupled with high ambient temperatures (16 - 24^{o}C) and evaporation rates, causes frequency of drought and crop failure to be common in every 2-5 years [1][17]. In addition, the challenges are exacerbated further by the high human population growth – which is exerting pressure on the available grazing lands, leading to emergence of landless market-oriented small scale peri-urban dairying in semi-arid regions of the south eastern Kenya rangelands.

2.2. Sampling Method and Data Collection

The survey targeted households carrying out dairying as a livelihood-support activity within locations in peri-urban environs of Machakos and Wote Towns. The locations were selected in the northern, eastern, southern and western side of each of the two towns to ensure inclusivity of the farmers in each of the peri-urban environ.

Multi-stage sampling technique was used to select the sample size of households. Stratified purposive sampling was used in the first stage for selection of the two divisions from the two counties in which ASARECA's "*Harnessing crop-livestock integration to enhancing food security and livelihoods resilience to effects of climate variability and change in East and Central Africa"* project had been implemented since 2010. Then purposive simple random sampling to select proportional number of farmers from a list of farmers engaged in the ASARECA project in the locations in each of the two counties was used in the second stage.

One hundred and fifty 150 households (seventy from Central Division, Machakos County and eighty from Wote Division, Makueni County) were selected and interviewed by cross-sectional household visits with the help of a semi-structured interview schedule that was pre-tested and adjusted in line with the objectives of the study. Information collected included; household demographic and farm characteristics, constraints and challenges of adopted technologies and their mitigation measures. Data collection techniques included direct questioning, informal discussion and field observation of some constraints that affected the dairy farmers and the adopted technologies in the sampling sites and households. Data was collected from November 2012 to August 2014.

2.3. Data Analysis and Presentation

Data were coded, processed and analysized using SPSS version 11.5 and Ms Excel software for descriptive statistics. A characterization was done using cross-tabulation tables to compare the proportion of constraints affecting each of dairying and forage technologies amongst the peri-urban dairy farmers. Basic descriptive statistics such as frequency of occurrences and percentages of constraints were computed to summarize the extent of the level of constraints affecting the peri-urban dairy farmers. The level of constraints was measured by the number of farmers perceiving the constraints divided by the total number of the farmers and then expressed as a percentage. Results were presented in frequency and percentage tables for each technology adopted by the peri-urban dairy farmers and the constraints were ranked for each technology.

3. Results and Discussion

Demographic and Socio-economic Characteristics of the Dairy Farmers

Households (n=150) were dominantly male headed (80%). These male heads were likely to adopt new innovations as they have higher desire to adopt new innovations and have better control of resources compared to female heads. This is consistent with the view that female-headed households were less likely to use new technologies [3][9].

In addition, most household heads were 51±3 years of age. This implied that most household heads were experienced. This is in line with that age determines experience of adopter of technology [3]. Thus it was expected that older farmers were likely to adopt new innovations. However, the study reveals that a sizeable proportion of the farmers were youthful – who are more innovative. The implication is that they were also more likely to adopt the new innovations. This is consistent with view that young people are more flexible in deciding for change than aged people [12] and may adopt improved technologies more than elders. However, younger farmers may not adopt modern agricultural production technologies, especially capital intensive ones as they might not have adequate resources to do so [12].

In addition, most household heads had gainful occupations and therefore, they were assured of income for economic activities. This assurance of continuous flow of income was likely to influence adoption of improved innovations. This finding concurs with view that stable income increases the probability of adopting improved agricultural technologies in dairying and forage production [19][9][12].

Most households had medium family size (3-4 members). This medium family size was likely to limit family labour available for the intensive dairying. This forced many households to engage employee (s) on temporarily or permanent basis. This was likely to be a major impediment in adoption of labour-intensive innovations as the skilled permanent labour is expensive. This concurs with the view that modern technology adoption and efficiency of small holdings in developing countries is employee-labour based and expensive [21].

Most household heads were literate as they had attained secondary and post-secondary education. This meant that they could easily understand concepts of innovations. Thus most farmers were expected to improve their likelihood of adoption of the innovations. This finding concurred with the view that literate farmers are more innovative and easily understands concepts and principles of innovations taught [27][2][9].

The land sizes of the households were small. On average, land size was 1.2ha and 6.4ha in Machakos and Wote town's peri-urban areas respectively. Land fragmentation, bound to negate dairying, was common in both counties, with 43.3% of the households having more than one parcel of land. The fragmented land units owned by a household were distantly far (averaged approximately 2 Km).

Most households had insecure land tenure systems in both counties. This was attributed to the finding that only a small proportion of the farmers (26.4%, n=150) had secure free-hold land tenure system, while the rest of the households had ancestral land tenure system - which was not adjudicated and allotment papers issued, and these households felt insecure in their land ownership.

Access to extension was low (33.3% in Machakos Town and 20.7% in Wote Town). This was bound to impacted negatively to adoption and utilization of new innovations.. This is attributed to lack of platforms to train and educate farmers so that they can understand of the concepts and principles of the new technologies. Further, access to credit for most farmers was limited. Most farmers complained of unfavourable interest rates and harsh penalties to defaulters. This discouraged the farmers from accessing credit from the financial institutions and was bound to negate dairying in these semi-arid regions of Kenya. This finding was consistent with view that high poverty levels among farmers and lack of access to credit make it almost impossible for them to afford technologies [12]. This is particularly so given that most modern dairy and forage technologies are expensive. This made it difficult for the farmers to acquire and utilise them without assistance in the form of affordable credit facility.

In addition, most households had vast experience (>10 years) in dairying but, however, they had not adopted the co-opeartive concept in the livelihood strategies in these areas. This experience in dairying was useful in adopting new innovations and bettering their skills in dairying. This was consistent with view that households with past experience in dairying are able to have better control of the risks in dairying by diagnosing and controlling diseases and management of dairy cattle [11]. Further, experience improves decision making and resource allocation as it can make it better as result of the learning curve of the farmer.

3.1. Dairy Cattle Technology and its Constraints among the Dairy Farmers

Table 1. Constraints affecting adoption ofDairy Cattle Technology (n=150)

Constraints	Frequency	Percent	Rank
Lack of Access to relaible Source of Dairy cattle	102	68.0	II
High initial purchase price of dairy cattle	78	52.0	IV
Lack of Access to Improved breeding practices	67	44.6	VI
Lack of adequate feedstuffs	124	82.6	I
Disease and parasites attack and occurences	70	46.7	V
High Maintenance cost of the dairy cattle	92	61.3	III
Lack of Access to credit/Fund	56	37.3	VII
Expensive breeding practices (AI, ET)	42	28.0	VIII

The study revealed that most of the households surveyed had adopted dairy cattle technology. This was consistent with the findings that dairy cattle technology is the key in increasing milk production, improving household income and the nutritional standards of the household members in these semi-arid regions[17]. Advancement in dairy development is associated with increased milk yields. This includes rearing of the improved dairy breeds like Friesians, Ayrshires etc among other dairy improvement requirements. However, the finding is consistent with previous finding that adoption level of the dairy cattle technology, number of dairy cattle (mainly females) kept and average milk produced was comparatively low in these two study sites [20][17]. This could be attributed to many constraints and challenges the peri-urban dairy farmers were facing in their dairying enterprises.

The study revealed that adoption of the dairy cattle technology was prevented mainly by lack of adequate feedstuffs (82.6%). This was common in the semi-arid regions, where feedstuff scarcity is frequent and the farmers felt highly challenged in adopting the heavy feeders - dairy cattle if no better fodder crops were planted. The next constraint was lack of access to reliable source of dairy cattle (68.0%). This concurs with view that unreliable source of dairy cattle is a impediment to dairying and intensification of smallholder livestock systems in the tropics[13]. This is attributed to the fact that there are limited sources of pure exotic breeds or improved cross-bred cattle in these two counties. With the collapsing of the dairy ranches in Machakos and Makueni Counties, most dairy farmers are faced with challenge of having an access to reliable source of proven dairy cattle. However, the able farmers bought their improved dairy cattle from Central Kenya and Rift valley regions of Kenya.

Due to lack of reliable source of dairy cattle, the initial prices of the dairy cattle resulted being very high, which the farmers acknowledged as a major constraint (52.0%). This is consistent with finding that dairy female cattle were very expensive [17] . Therefore, dairy farmers were forced to purchase dairy cattle from their neighbours on assumption that dairy cattle were of good quality, which at times proved otherwise. The high initial purchase price of the dairy cattle, coupled with lack of access to credit (37.3%) had its share on reducing adoption of the dairy cattle technology. This was attributed to the fact that the farmers were resource-poor with medium families which were to derive their livelihoods on smallholdings with insecure land tenure ownership. This, coupled with the lack of access improved breeding practices (44.7%) and when available, the breeding practices were expensive (28.0%), like reliable AI and ET, affected the milk production traits of the dairy cattle kept by the dairy farmers in these semi-arid regions.

The dairy farmers also felt challenged with regard to the high maintenance cost (61.3%) of the dairying enterprises. This was attributed to the fact the dairy cattle have low resistance to diseases and parasites attack, leading to farmers acknowledging the diseases and parasites attack and occurrences as a constraint (46.7%) and high cost of feedstuffs. This is attributed to fact that dairy cattle are heavy feeders – requiring huge amount feedstuffs for economical production.

3.2. Improved Breeding Practices and Their Constraints among the Dairy Farmers

The peri-urban dairy farmers acknowledged that AI is essential for increased milk production and control of breeding diseases. However, the study showed that adoption level for AI technique was relatively low in both counties. Further, the adoption level of AI was higher (21.0%) in peri-urban environ of Machakos Town compared to 5.7% in peri-urban environ of Wote Town. This was in line with fact that AI adoption index was low [6][17]. This implied that most farmers in both counties used bulls to serve

their dairy cows. Other improved breeding techniques, like ET, were not adopted by the peri-urban dairy farmers in both environs of Wote and Machakos Towns.

Table 2. Constraints in adoption of AI Breeding Technology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAccess / relaible Source for AI services	122	81.3	II
High charges for AI services	82	54.7	III
Lack of Access to AI services	67	44.7	V
Lack of knowledge/skills about timing of estrus	134	89.3	I
Failure of AI services	64	42.7	VII
High charges of repeat AI services	78	52.0	IV
Lack of Access to credit/Fund	66	44.0	VI

The adoption of AI breeding technology was highly constrained by the lack of knowledge/skills of correct timing (89.3%) of estrus. This was attributed to the fact the peri-urban dairy farmers lacked access to extension services. Therefore, the farmers lacked awareness and understanding of the concept and aspects that could enlighten them on the correct ways to detect the signs of estrus and the right time for insemination. This, coupled with lack of professional training in animal breeding and lack of access of AI services (44.7%), contributed to the low adoption of improved breeding practices, like AI and ET by the peri-urban dairy farmers.

The next major constraint the adopters of AI breeding practice was lack of access to reliable sources (81.3%) for the AI services. This was attributed to the fact that reliable semen for AI is obtained from Nairobi city, which is far from Wote and Machakos peri-urban environs. Further the fragile semen is preserved in refrigerated conditions which are not available in the rural peri-urban environs due to limited power supply in the southern Kenya semi-arid areas. This contributed to the escalating prices of the AI services since the liberalization of agriculture in Kenya in 1992. For example, previous study revealed that the charges for the AI services ranged highly between 1500/= and 4000/= per AI service[17]. These high charges (54.7%) for AI services were a constraint to the adoption of AI technology as evidenced by the high ranking (3rd) by the dairy farmers. In addition, most farmers in Wote environs, Makueni County, paid higher charges for the AI services compared to those in Machakos environs, Machakos County. This was attributed to fact that Wote Town is far away from Nairobi City compared to Machakos Town.

Further, small proportion of the farmers in Machakos (6.7%) and Makueni (6.0%) rated AI services as excellent and a good proportion rated the AI as good in both counties. However, large proportion of farmers rated the AI as fair or poor. This contributed to the high chances of AI failure (42.7%) – which was attributed to long distance of transport of semen from the sources in Nairobi, probably poor storage and incorrect timing of estrus and defective insemination. This contributed to most of the farmers repeating the AI services which were charged the same prices. This resulted to the repeat charges of AI services being very high for an ordinary smallholder dairy farmer. These high repeat charges (52.0%) were thus a predicament to adoption of AI technology as the farmers were resource-poor and lacked access to credit (44.0%) that could be used to cater for AI services. The high interest rates charged by the financial institutions for credit facilities were a major deterrent to obtaining credit. Further, the dairy farmers had limited capital to be apportioned for the competing needs of the households sourced from the formal occupation of most farmers in both study areas.

3.3. Fodder Crop Technology and its Constraints among the Dairy Farmers

With the dairy farmers adopting the landless intensive dairying enterprises they were forced to become innovative and adopt the fodder crop technology to remain resilient. However, the study revealed that adoption of fodder crop technology was relative low (35.5%, n=150) although it was on the increase since 2010 in both peri-urban environs. This increase of adoption of fodder crops was attributed to adaptive approach by the dairy farmers to mitigate the adverse climatic conditions as the environments became drier exacerbating the scarcity of feedstuffs even further. This is consistent with finding that adoption of quality fodder crops, like Napier and Rhodes grasses among others, was necessary to supply adequate and quality feedstuffs for the confined heavy feeding dairy cattle [10][17] .

Establishment and adoption of the fodder crops was faced with constraints. Water stress / inadequate supply (80.0%) to the fodder crops, coupled with rainfall failure (66.0%) and lack of knowledge about timing of planting(34.0%) during the rainy seasons, were found to greatly affect the establishment and adoption of the fodder crops in both Wote and Machakos towns' peri-urban environment (Table 3). The planted fodder crops poorly established in the fields or showed stunted growth when water stress

occurred in the rooting zones. Lack of skills (68.0%), coupled with lack of knowledge of suitable fodder crops (44.0%) and access of reliable source of fodder crops (54.0%) had lion share on the influence of establishment of the quality fodder crops. This was likely attributed to poor extension services. The dairy farmers poorly planted, through trial and error method, fodder crops that, at times, had a mismatch with the climatic conditions of the AEZ. This mismatch resulted in poor establishment of fodder crops and low yield of the feedstuffs, which became a contributory factor to low performance of the dairying enterprises. Some dairy farmers acknowledged that the high charges (49.3%) for some planting materials and lack of access to credit (42.0%) also constrained establishment and production of economical yield of forage. Occurrence of diseases and pest (22.4%) was rated the lowest amongst the constraints. This implied that the dairy farmers noted few incidences of diseases and pests that attacked the fodder crops. This was quite economical for dairying as minimal costs were spent to control them.

Table 3. Constraints in adoption of Fodder CropTechnology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAccess / relaible Source of fodder crops	81	54.0	IV
High charge of Planting materials of Fodder crops	74	49.3	V
Lack of knowledge ofFodder crops	66	44.0	VI
Lack of knowledge about timing of planting	51	34.0	VIII
Inadequate rainfall	99	66.0	III
Water stress/Inadequate supply	120	80.0	I
Lack of Access to credit/Fund	64	42.0	VII
Lack of Acess to labour (skilled)	102	68.0	II
Occurence of Diseases and pests	34	22.7	IX

3.4. Tumbukiza Technology (TM) and its Constraints among the dairy farmers

Faced with acute water stress in the soils and the desire to produce high amounts of quality fodder crops, sizeable proportion of the dairy farmers in Machakos (40.0%) and Wote (48.8%) towns' peri-urban environment adopted the TM technique. This was consistent with finding that TM is suitable for growing fodder in low rainfall areas as it enhances soil fertility conservation and moisture retention [22]. Further, the retained moisture enhances fodder growth and its survival through the long dry spells. This concurs with view that fodder crop production using TM is superior to fodder crop production under the conventional methods [28][23]. However, a considerable number of the farmers in Machakos (25.7%) and Wote towns (10.7%) were still planting the fodder crops especially Napier grass using the conventional methods, like *Fanya Juu* terraces while a very small proportion of the farmers were utilizing a combination of the techniques.

Table 4. Constraints in adoption of TumbukizaTechnology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAccess / relaible Source of fodder crops	132	88.0	I
High Initial cost of making the Tumbukiza pits	98	65.3	IV
Lack of knowledge ofTumbukiza Technology	107	71.3	III
Lack ofAccess to extension services	94	62.3	V
High maintenance cost of TM pits	65	43.3	VIII
Insecure land tenure system	115	76.7	II
Lack of credit/Fund	72	48.0	VII
Saline Water and Water stress	86	57.3	VI

The adoption of TM was mainly constrained by lack of access to reliable source of fodder crops (88.0%). This is attributed to the finding that there was no on-farm multiplication of the fodder crops in the two sites. Thus the farmers were forced to obtain low quality planting materials from their neighbours. This constraint is compounded further by on-station multiplication being situated far from the farmers especially in Wote peri-urban environs. The TM is capital-intensive technology and requires production of quality fodder crops for better returns from the TM [22]. This, therefore, implied that dairy farmers with no access to reliable source of quality fodder crops were not likely to adopt the TM.

In addition, TM is a long lasting investment which requires secure land ownership. Insecure land tenure system (76.7%) was the next major constraint to adoption of TM as the dairy farmers felt insecure and lacked confidence in embracing the TM. This was followed by lack of knowledge of the TM (71.3%) in the two sites. This was attributed to lack of access to extension services – which was another major constraint (62.3%) affecting adoption of the TM. The adoption of TM needed creation of platform for better understanding of concept and workability of the TM technology.

The other constraint was the high initial cost (63.3%) of preparing the Tumbukiza pits. The high initial cost is attributed to the shortage of labour as family sizes were medium and the available labour was very expensive for the menial jobs of making the Tumbukiza pits. The adoption is constrained further by lack of access to credit / fund (48.0%) and high maintenance cost (43.3%) of the pits. This concurs with view that adoption of a complex innovation is reduced if costs incurred when adopting and maintaining the innovation are high [24]. The salinity of the soils and water and water scarcity (57.3%) also constrained the adoption of the TM technology as the fodder crops failed to establish or if they established they performed poorly. This discouraged the dairy farmers, especially in the peri-urban environ of Wote who invested heavily in the TM technology.

3.5. Water Harvesting Technology and its Constraints among the dairy Farmers

Most farmers acknowledged that water scarcity was a major constraint for their dairying in these study areas. This is consistent with the finding that most of the rainfall in ASALs is unreliable and insufficient as it is lost through run-off and evaporation [25]. The farmers became innovative and adopted in-field water harvesting and efficient water-utilizing technologies to reduce the vulnerability of farmers to water shortage and increase the availability and reliability of water. This is consistent with previous finding that 65% of the households had adopted water harvesting technologies [17], especially from rooftops, ground surfaces among other catchment surfaces. In addition, the dairy farmers acknowledged the need to utilize the harvested water efficiently so that the goal of having constant water supply for dairying enterprises in order to supply the required milk levels was achieved. However, adoption of water harvesting techniques was constrained among the peri-urban dairy farmers in the two study areas.

Table 5. Constraintsin Adoption of Water HarvestingTechnology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAdoption of Dairy Cattle Technology	84	56.0	VI
Lack of Adoption of Improved Fodder Crops	78	52.0	VII
Lack of knowledge ofModern Water harvesting Techniques	72	48.0	VIII
Lack of Access to extension services	85	56.7	V
High Initial cost/Charge of Water Harvesting equipments	136	90.7	I
High Maintenance Cost of Water Harvesting Equipments	111	74.0	II
Lack of Access to credit/Fund	102	68.0	III
Lack of Access to Labour (Skilled)	98	65.3	IV

The water harvesting techniques are faced with many constraints. The top-ranked constraint was the high initial cost of the water harvesting technology at 90.7%. This was attributed to the fact the purchase of the components of water harvesting and storage of the water or construction of the water collection tanks or dams or pans was very high. This was a major impediment in adopting the water harvesting technologies considering that most households were financially challenged as their incomes from their primary occupations were not adequate to meet all the financial needs of the households. The next constraint was the high cost of maintenance (74.0%) of the water storage facilities. This was attributed to poor workmanship in constructing and installing the water harvesting and storage facilities. It is further exacerbated by clogging and vandalization of the water systems. This was followed by lack of access to credit (68.0%) to the households. The respondents attributed this to lack of collaterals when securing loans from financial institutions or the high interest rates charged making them unable to service the loans.

Lack of access to skilled labour (65.3%) was another constraint. This was attributed to the fact that

construction and installation of the water harvesting technologies is not an easy task and requires skilled labour. This skilled labour was missing in both sites and this compounded by lack of access to extension services (56.7%) and awareness / knowledge of modern water harvesting technologies (48.0%) reduced the adoption of water harvesting technology. This finding concurs with the view that complex innovations are not easily adopted by people [24]. Finally, lack of adoption of dairy cattle (56.0%) and fodder crops (52.0%) technologies were acknowledged as impediments to adoption of water harvesting technologies. This was attributed to finding that households that had not adopted dairy cattle and fodder crops technologies never saw the need for investing heavily in modern water harvesting technologies that were probably costly to them.

3.6. Stall-feeding Technology and its Constraints among the Dairy Farmers

The study revealed that sizeable percentage (39.7%) of the farmers had fully adopted the stall-feeding technique. These adopters acknowledged that stall-feeding improves dairying. This concurs with a previous finding that stall-feeding has improved performance of the dairy cattle [7]. Zero grazing units and other improvised structures were used for the stall-feeding. Other form of rearing the dairy cattle included semi-zero grazing (44.3%), grazing (8.0%) and tethering (8.0%) techniques in both counties. The stall feeding was constrained in the two sites.

Table 6. Constraints in adoption of modern Stall-feeding Technology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAccess / relaible Source of fodder crops	128	85.3	I
Lack of knowledge of Stall-Feeding Technology	90	60.0	II
Lack of Access to extension services	63	42.0	V
Inadequate equipments and materials	46	30.7	VIII
High cost of construction of the Stalls	58	38.7	VI
Lack of Access to credit/Fund	65	43.3	IV
Lack of Access to Labour (Skilled)	78	52.0	III
Poor drainage in the Stall Units	48	32.0	VII

The modern stall feeding technology was highly constrained by lack of access of fodder crops (85.1%). This implied that households that had adopted fodder crops technology were likely to adopt the stall-feeding technology and vice versa. This technology confined the dairy cattle in the stalls and fed on high quality feedstuff as they didn't forage in the open fields. Thus, the surest way of utilizing planted fodder crops for better economic returns was through stall-feeding system, like zero-grazing units. The next constraint was lack of awareness / knowledge of stall-feeding technology (60.0%). This, coupled with lack of skilled labour (52.0%) and access to extension services (42.0%), affected the adoption of standard stall-feeding as the farmers lacked correct understanding of the technology and skills required to construct stalls with the proper designs. The poorly designed stalls affected the performance of the dairy cattle and the management of the zero-grazing units.

Lack of access to credit (43.3%), high cost of construction of the stalls (38.9%) and lack of adequate materials (30.7%) affected the adoption of the stall-feeding technology. This was probably accountable for finding of poor workmanship of the stalls amongst most farmers. This probably led to poor drainage of the stalls (32.0%), which was another constraint affecting the adoption of the stall-feeding technology among the peri-urban dairy farmers in the two study sites.

In order to improve hygiene of the zero-grazing the farmers were cleaning the units. However, the frequency of the cleaning up the zero-grazing units was variable amongst the farmers. 35.6% of the farmers cleaned up their zero-grazing units every day while 42.5% cleaned up their zero-grazing after two days. The rest of the farmers had no regular schedule of cleaning the zero-grazing units.

3.7. Improved Feedstuff Chopping Technology and its Constraints among the Dairy Farmers

Table 7. Constraints in adoption of Improved Feedstuff choppingTechnology (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAccess / relaible Source of chopping devices	104	69.3	I
High initial cost/charge of chopping devices	88	58.7	III
Lack of knowledge ofchopping technology	78	52.0	V
Lack of access to extension services	95	63.3	II
High maintenance costs of chopping equipments	86	57.3	IV
Lack of Access to credit/Fund	70	46.7	VI
Lack of Access to Labour (Skilled)	18	12.0	VIII
Lack of power/electricity	34	22.7	VII

Most (85.5%) of the farmers had adopted the chopping technique in both sites. This implied that the farmers acknowledged the importance of chopping of feedstuffs to avoid wastage of feedstuffs when they are fed by dairy cattle. Different equipments were used for chopping of the feedstuffs. Consistent with previous findings, p*anga* remained the commonly used equipment for chopping due to easiness of use and affordability but it was tedious and time-consuming [17]. Adoption of modern feedstuff chopping technology, like Chaff-Cutter, was minimally adopted as it constrained by many problems faced by dairy farmers. This concurs with a previous finding that more effective and time-saving equipments were lowly adopted by the peri-urban dairy farmers [17].

Lack of access of reliable source forage / fodder crop (69.3%) was ranked first among the constraints. This implied that households with no reliable source to supply forage /fodder crops were not likely to adopt the modern chopping technology. If chopping was done, it was likely done using the rudimentary device, like a *panga*. But, farmers with high forage/fodder crops were likely to adopt modern feedstuff chopping technology. The next constraint was lack of access to extension services (63.3%) and lack of knowledge of modern choppers among the dairy farmers (52.0%). This concurs with the view that extension services is useful in creating awareness[24] and understanding of an innovation before it is adopted by the adopters.

In contrary to view that when an innovation is observable, its likelihood of adoption is high [24], the observable modern choppers were not adopted as its adoption was highly constrained by high initial cost (58.7%), high maintenance costs (53.3%) and lack of access to credit (46.7%). These financial problems limited the adoption of the modern feedstuff choppers and farmers resulted in use of improvised devices and methods to chop the forage.

Lack of access to electricity/power (22.7%) also constrained the adoption of the modern choppers. This was attributed to the fact that operationalization of these modern choppers required supply of electricity while in most households in these semi-arid regions of south eastern Kenya had no power and electrified choppers could not be operated without power. Lack of skills (12.0%) to run electrified choppers were not a major impediment as the personnel can easily be trained or learn on how to operate the electrified choppers. However, the farmers acknowledged that there were high risks associated with running of electrified choppers, like chopping off of fingers.

3.8. Silage Technology and its Constraints among the Dairy Farmers

Most farmers acknowledged that silage making is a technical technology for preservation of feedstuff. Due to difficulties of silage making, the study revealed that it had low adoption index in per-urban environs of Wote (13.3%) and in Machakos (10.7%) Towns. This is consistent with previous finding that silage making is technical and it easily results into poor quality silage[15] – which has characteristic odour, unpleasant to the dairy cattle, which discourage feed intake. This finding is consistent with view that more complex innovations are not easily adopted by clients [24]. The adopters were using polythene tube technique. This was due to their affordability and suitability compared to the trench silo technique – which was not adopted by the peri-urban farmers.

Table 8. Constraints and Threats of adoption of SilageTechnology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAccess / reliable Forage/fodder crops	96	64.0	IV
High initial Cost/charge	75	50.0	VI

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Lack of awarenes of knowledge of silage making Technology	134	89.3	I
Lack of access of extension services	122	81.3	II
Inadequate equipments and Materials	56	37.3	VIII
High risks of handling and maintaing the silo and silage	104	72.0	III
Lack of Access to credit/Fund	72	48.0	VII
Lack of Access to Labour (Skills)	78	52.0	V
Mould formation	9	6.0	IX
Rain Damage	4	2.6	XI
Termite and Rodent Damage	6	4.0	X

The silage making was mainly constrained by lack of awareness/ knowledge of silage technology (89.3%). This coupled with lack of access to extension services (81.3%), high risks of handling and maintenance of silage (72.0%) and lack of access of skilled labour (52.0%), greatly affected the adoption of silage making. This was attributed to fact that silage making is a technical technique and required education and training to create understanding and skills that was not common among the peri-urban dairy farmers.

In addition, the dairy farmers lacked adequate and suitable fodder crops/ forage (64.0%) and equipments/ devices (37.2%). These inadequacies of forage and equipments affected the adoption of silage making technology. This was exacerbated further by the high cost of equipments of silage making (50.0%) and lack of access of credit (48.0%), which made silage making unaffordable and unsuitable amongst the peri-urban dairy farmer in the two sites of study. Finally, silage making is threatened by mould formation (6.0%), termite / rodent destruction and rain damage (2.0%). This reduced the quality and quantity of silage prepared by the peri-urban dairy farmers. The adopters acknowledged that silage making was very challenging and discouraging despite the usefulness of silage product amongst the peri-urban dairy farmers.

3.9. Adoption of Hay making Technology and its Constraints among the Dairy Farmers

Most households acknowledged the importance of feed conservation through hay making. This concurs with previous finding that dairy farmers cushion significantly feed constraints by adopting hay making [15]. However, the adoption of hay making remained low in both sites, despite an upward trend. This concurs with finding that hay making was 22.3% in Wote environs and 19.3% in Machakos environs among the dairy farmers surveyed [17]. Mechanized hay making remained low (0.3%) and the standard hay making technology faced constraints in the two sites of study.

Table 9. Constraints and Threats of Hay making Technology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAdequate feedstuff	112	74.7	II
High charge of Labour for Hay making	99	66.0	IV
Lack of knowledge ofHay makingTechnology	138	92.0	I
Lack of Access of extension services	86	57.3	V
Inadequate modern equipments for hay making	102	68.0	III
Lack of Access to Modern Hay storage facilities	78	52.0	VI
Lack of credit/Fund for Hay making	32	21.3	VIII
Lack of Access to Labour (Skilled)	72	48.0	VII
Termite damage	21	14.0	IX
Rodent destruction	13	8.7	X
Mould formation	5	3.3	XI
Rain damage	5	3.3	XII

The lack of awareness / knowledge of hay making (92.0%) was ranked first among the many constraints. This coupled with scarcity of feedstuff among the dairy farmers (74.2%), lack of access of modern equipments (68.0%), high charges of skilled labour (66.0%) and lack of access to extension services (57.3%) greatly affected the adoption of standard hay making technology. This is attributed to lacked platforms among the farmers to create right understanding of hay making. This is exacerbated further by the expensive equipments and cost of engaging labour to run the equipments. The lack of adoption of modern Hay barn (52.0%) and skilled labour (48.0%) had its share in affecting the adoption of standard hay making. Only 21.3% of the

respondents perceived lack of access of credit. The hay making technology is not complex and costly. This, in line with view that less complex and advantageous innovations will be adopted by targeted clients[24]. Hay making was threatened by mould formation, termite, rodent damage and rain damage due to lack of skills and poor storage facilities among the peri-urban dairy farmers. All these threats reduced quality and quantity of the preserved and available amongst the dairy farmers.

3.10. Adoption of Improved Hay Barn Technology and its Constraints among the Dairy Farmers

The study revealed that most of the farmers had adopted the HB technology. HB was essential for preserving excess feedstuffs in form of hay or silage for future use. This is consistent with previous finding that majority (72.5%) had adopted HB technology[17] . However, most of the adopters were using sub-standard HB structures and other farmers used rudimentary structures to stored feedstuffs, like placing feedstuff on tree branches or on tree-tops (3.3%), putting them granaries (3.35%) and gunny bags (3.65%). These rudimentary forms were risky to animal health.

Table 10. Constraints in adoption of Modern Hay barnTechnology as perceived by Respondents (n=150)

Constraint	Frequency	Percent	Rank
Lack ofAdequate feedstuffs	94	62.7	II
High Initial Cost/Charge of making the Hay barns	72	48.0	III
Lack of knowledge ofModern Hay barn Technology	104	69.3	I
Lack of Access to extension services	64	42.7	V
Inadequate Suitable equipments and Materials	56	37.3	VI
High Maintenance Cost of Hay Barns	66	44.0	IV
Lack of Access to credit/Fund	50	33.3	VIII
Lack of Access to Labour (Skilled)	54	36.0	VII
Damage by Rodents/Rain/Termite	11	7.3	IX

The main constraint was lack of knowledge of modern hay barn technique (69.3%). This was attributed to the effects of lack of access to extension services (42.7%) and lack of adequate feedstuffs (62.7%). This implied that dairy farmers, who lacked correct understanding of the modern HB due to poor extension services and had inadequate adequate forage to store, had little chances of adopting the HB technology, despite the HB being an observable technology. Initial costs of constructing the HB (48.0%) and maintenance costs of the HB (44.0%), coupled with lack of access to credit (33.3%) constrained the adoption of HB financially among the per-urban dairy farmers. In addition, lack of access to construction materials of HB (37.3%) and skilled labour (36.3%) had their share in reducing likelihood of adopting improved HB among the farmers. This implied that farmers lacked or could not afford long lasting construction materials for their HB, which needed skills to construct the suitable modern HB. Finally, damage from rain, rodents and termites threatened the adoption of HB as these agents destroyed the constructed HB, reducing the efficiency and life-span.

4. Conclusion and Implications

The male farmers, who are more receptive to adoption of new ideas, were dominant in dairy farming in the two study areas. This implied that female-headed households, who were less likely to adopt new innovations, should work closely with extension agents. In addition, most household heads were literate. This implied that they had little difficulties in understanding concepts of new technologies being extended to them. Thus the extension agents should work with less schooled peri-urban dairy farmers in the two sites.

Most of the farmers were mature at their productive age and had medium family size. This implied that they had experience and therefore, they were likely to adopt new innovations skillfully. This implied that the young dairy farmers should be educated and trained on suitable innovations in their dairying enterprises. However, labour-intensive innovations were likely to be construed by shortage of labour as family size was medium.

The farmers had insecure land rights due to the insecure land system. This was likely to affect the likelihood of adoption of capital-intensive and long lasting technologies. This meant that land adjudication and issuance of title deeds was a prerequisite for the farmers to feel secure and invest in capital-intensive long lasting investments, like adoption of TM and fodder crop innovations.

Most dairy farmers were salaried from their formal occupation. This implied that they could finance implementation of some technologies without soliciting for funds from financial institutions – whose interest rates could deter the farmers from obtaining loans from banks. Finally, the peri-urban dairy farmers had limited access to credit and extension services. This was likely to

impact negatively to the adoption of complex and capital-intensive innovations by these peri-urban dairy farmers that required adequate capital and understanding for adoption by the peri-urban dairy farmers.

Faced with livelihood-threatening challenges and the drive to produce milk to meet the high milk demand, the farmers adopted dairying as livelihood support and income-generating activity. However, the adoption index, intensity of production and milk productivity were found to be low due to unreliable sources of dairy cattle, breeding and feed and feeding constraints. This necessitated further adoption of improved dairying and forage innovations aimed at increasing their production at economical scale to meet milk demand in these ASALs' peri-urban environs.

AI, aimed at improving milk production, had low adoption index. This was mainly due to high charges, low rate of success and limited access to AI services. This implied that there is need to improve access to affordable AI services, train the inseminators and dairy farmers to improve the success of AI. This is meant to improve breeding and increase the milk production in these ASALs areas.

Feed scarcity was a major deterrent to dairying. The farmers mitigated this constraint by adopting averagely the improved fodder crop production using Napier and Rhodes grasses and Leuceana and Calliandra legumes. The establishment of these fodder crops remained poor due to rain failure and water shortage. This implied that there is need to improve water supply through water harvesting and plant drought-tolerant fodder crops. Most of these fodder crops were mainly sourced from neighbours and the distant KALRO. This implies that there is need to start on-field multiplication of most suited fodder crops in order to supply quality fodder crops whose establishment would be high when better understanding among the farmers is created through improved extension services.

Due to the drive to have good fodder crops established to solve feed constraints, water-retention enhancing tumbukiza technique was being adopted by the dairy farmers. However, the farmers' adoption index was average and largely influenced by lack of access of fodder crops and insecure land tenure system. Improvement of access of quality fodder crops through access to extension and on-field multiplication would improve adoption of TM. This coupled with land adjudication will entice the farmers to adopt this capital-intensive TM.

Faced with water inadequacy, the farmers enhanced their water supply for dairying and fodder crops by harvesting water from roof-tops, rock surfaces and underground surfaces. Major deterrents were the high initial cost and maintenance of water-harvesting structures. This implied that access to affordable credit and subsidizing the cost of the water-harvesting technologies could enhance adoption of water-harvesting technologies.

Chopping innovation was a mitigation measure for proper utilization of feedstuff by the stall-fed dairy cattle from the adopted fodder crops or crop residues. However, improved chopping devices – chaff-cutter – advocated for due to its usefulness in households with limited labour and small farm sizes- was lowly adopted in both environs. This was attributed to lack of lack of access of reliable sources of fodder crops, extension services and high cost of the choppers. This implied that chopping of feedstuff was done using the tedious and less efficient pangas. Thus there is need subsidize the cost of choppers and improve access to reliable sources of fodder crops.

Due to evolution of feeding system towards sedentary stall-feeding and high fluctuations of feedstuffs, the farmers were conserving excess forage. Hay conservation, found to be less technical, was the commonly used method compared to the more technical silage making. However, making of hay was constrained by lack of adequate feedstuffs and skills and modern equipments. This implied that there was need to improve feed supply and create better awareness of hay making through better access to extension services by the dairy farmers.

Polythene bag silage making technology was another mitigation and innovative way some farmers used to conserve excess forage. However, its adoption was highly constrained by lack of awareness due to poor access of extension services and the associated risks of silage making. This is meant that there is need for improved access to extension services to educate and train the farmers about the principles and risks associated with this technical silage making. This will create awareness and better understanding of silage making and skills in order to produce quality silage and reduce the threats, like mould formation and damage from rains among other threats.

Conserved feedstuffs easily spoil if rudimentary methods of storage, like placing feedstuffs on tree-tops or on branches of trees, are used. Most farmers adopted modern HB technology to conserve to hay, silage and crop residue or reduce the risks of aflatoxin infection. This was aimed at economizing the scarce feedstuffs obtained from fodder crops, crop residues and pastures from the limited land. This also implied that there is need for improved extension services to creates awareness and miminize the threats affecting the workability and longevity of HB.

REFERENCES

[1] Amwata DA. The influence of climate variability and change on land-use and livelihoods in Kenya's southern rangelands: *PhD Thesis, University of Nairobi, Kenya*. 2013.

[2] Caswell M, Fuglie K, Ingram C, Jans S, Kascak C. Adoption of Agricultural production practices: Lessons learned from the US. *Department of Agriculture Area Studies Project. US Department of Agriculture, Resource Economics Division, Economic Research Service, Agriculture Economic Report No. 792. Washington DC.* 2001**.**

[3] Doss CR, Morris ML. How does gender affect the adoption of agricultural innovation? The case of improved maize technologies in Ghana: J*ournal of Agricultural Economics,* 2001. 25, 27-39.

[4] FAO. Trade Reforms and Food Security: Conceptualizing the linkages. 2003.

[5] Jaetzold R, Hornetz B, Shisanya,CA, Schimdt, H, Eds.. Farm management handbook of Kenya: Vol. III (Eastern Province), Nairobi. 2007

[6] Howley P, Donoglue CO, Heanue K. Factors affecting farmers' adoption of agricultural innovations: A panel data analysis of the use of artificial insemination among dairy farmers in Ireland: *Journal of Agric. Science; Vol.4. No.6*. 2012.

[7] Kabirizi JM, Ndikurmana J, Njarui DMG, Mwilawa AJ, Minani E, Muerwa S, Zziwa E, Wanyama J, Kiyimba L.F., Makumbi G, Nattabirwa H, Itabari J., Sijali I.V., Nijimbere, A., Habonayo, G., Nizinama J., Kyeswa, c., Sikombi, E., Nakiganda A, Muyinza, H., Namagembe, A. Improving livelihoods in smallholder crop-livestock farming systems in the Eastern and Central Africa region; a catalogue of proven and practical climate smart agricultural technologies and innovations; ASARECA. 2013.

[8] Kang'ethe EK, Arimi SM, Omore AO, McDermott JJ, Nduhiu JG, Karanja A. The dairy industry in Kenya: the post-liberalization agenda. Paper Presented at the Dairy Stakeholders_ Workshop; Norfolk Hotel, Nairobi, 27th August, 2002. Tegemeo Institute of Agricultural Policy and Development. 2002.

[9] Kinambuga D. Evaluation of the constraints to profitable smallholder dairying: A case of Nakuru County, Kenya. *MSc Thesis, University of Nairobi, Kenya*. 2010.

[10] Lusweti FN, Muyekho FN, Kamau JN, Cheruiyot DT., Gitahi,F., Kungu, J. and Kute, C. Coping with feed shortages during the dry season. 2005.

[11] Makokha SN, Karugia J, Staal S, Oluoch-Kosura. Analysis of Factors Influencing Adoption of Dairy Technologies In Western Kenya.. 2007.

[12] Mamudu AA, Emelia G, Samuel KD. Adoption of Modern Agricultural Production Technologies by Farm Households in Ghana: What Factors Influence their Decisions? *Journal of Biology, Agriculture and Healthcare Vol 2, No.3, 2012*www.iiste.org

[13] McDermott JJ, Staal SJ, Freeman HA, Herrero M,Van de Steeg JA.. Sustaining intensification of smallholder livestock systems in the tropics. *Livestock science*, *130*(1), 2010 pp.95-109

[14] MoF (Ministry of Finance). Strategic Planning; Machakos and Makueni Counties. 2009.

[15] Moran J. Tropical dairy farming: Feeding management for smallholder dairy farmers in the humid tropics: Landlinks Press; 2005.pp 312-324: www.landlinks.com.au.

[16] Muriuki GB. The policy environment in the Kenya Dairy sub-sector: A review." Smallholder Dairy Project (SDP) research and development report No.2, Nairobi: International Livestock ResearchInstitute (ILRI). 2003.

[17] Mutavi SK, Kanui TI, Njarui DM, Musimba NR,Amwata DA. Innovativeness and Adaptations: The Way forward for Small Scale Peri-Urban Dairy Farmers in Semi-Arid Regions of South Eastern Kenya. *International Journal of Scientific Research and Innovative Technology***,** *Vol. 3 (5)*. 2016.

[18] Mwobobia RM, Kanui TI, Amwata DA, Nguku AS. Comparing use of ethno-veterinary products among rural and peri-urban chicken farmers in Katulani District, Kenya. *International Journal of Advanced Research.,* 2016. *Vol.4 (1): 550-558.*

[19] Nguthi FN. Adoption of agricultural innovations bysmallholder farmers in the context of HIV/AIDS: The case of tissue-cultured banana in Kenya. *Ph.D. Thesis, Wageningen University*. 2007.

[20] Njarui DMG, Gatheru M, Wambua JM, Nguluu SN, Mwangi DM, Keya GA. Dairy cattle value chain assessment: Characterization of milk production in semi-arid Kenya. Working document, Kenya Arid and Semi-Arid Land Programme (KASAL). 2009.

[21] Nyariki DM. Farm size, modern technology adoption and efficiencyof smallholdings in developing countries. Evidence from Kenya. 2011.

[22] Orodho AB. *Tumbukiza* Technology: Alternative method of napier grass production. 2007.

[23] Place F, Roothaert R, Maina L, Franzel S, Sinja J, Wanjiku J. The impact of fodder trees on milk production and income among smallholder dairy farmers in East Africa and the role of research. 2009.

[24] Rogers EM..*Diffusion of innovations 3rd Edition*. New York: The Free Press. 2003.

[25] Seré C, Ayantunde A, Duncan A, Freeman A, Herrero M, Tarawali S,Wright I. Livestock production and poverty alleviation — challenges and opportunities in arid and semi-arid tropical rangeland based systems. Proceedings of the International IGC–IRC 2008 Congress, China and Mongolia,1, pp. 19–26

[26] Swanepoel F, Stroebel A, Moyo S. The Role of Livestock in Developing Communities: Enhancing Multifunctionality. 2011.

[27] Waller BE, Hoy CW, Henderson JL, Stinner B, Welty C. Matching innovations with potential users: A case study of potato IPM practices. Agriculture, Ecosystems and Environment, 70, 203 – 215. 1998.

[28] Wambugu, C., Franzel, S., and Tuwei, P. (2003). The adoption and dissemination of fodder shrubs in Central Kenya: *Journal of Agricultural Research & Extension Network*

[29] Waters-Beyer A, Letty B. Promoting gender equality and empowering woman thorough livestock. 2010..