Integrating Feeding And Productivity: Scaling Out Livestock Input And Output Processing Technologies For Smallholders

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***Abstract*—Bahir Dar Agricultural Mechanization and Food Science Research Center (BAMFSRC) adapted three small scale mechanization technologies that help improve livestock productivity. These technologies (baler, feed chopper and milk churn) were scaled out and demonstrated to farmers in West Gojjam Zone of Amhara region. Feedbacks were collected from sample farmers who participated in the demonstration activities. Data was analyzed using descriptive statistics. The baler was preferred for reducing labor and time of transport, the chopper recognized for the ability to reduce feed wastage by increasing palatability and the milk churn was chosen for reducing burden on women as it can be operated by every family member. The financial analysis showed that milk churn has a marginal profitability of 166% and 167% compared to that of the traditional churns of gourd and clay pot, respectively. Hence, wider scale promotion of the technologies is required to deliver the benefits of these technologies to the smallholders. A suitability map is developed for any rural development or livestock affiliated organization to undertake scale up and scale out of these technologies in the region.**

Keywords—pre-scale up, hay press, engine driven chopper, milk churn, financial analysis

Introduction

Ethiopia, manages the largest livestock population in Africa, about 29 million cattle, 24million sheep and goat, 18million camels, 1million equines and 53 million poultry [1, 2]. Besides, the country has a diverse topographical and climatic condition, making it suitable for various cattle production. More than 75 % of the total livestock population is supported by the highlands of Ethiopia, which covers about 45 % of the total land area of the country [3]. The Amhara region has about 30% of the total livestock population (i.e., 10.5 million cattle, 8.2 million sheep and 5.1 million goats [4].

Livestock production has an important economic, functional (dairy, meat, draught labor and transportation) and cultural significance in Ethiopia [5]. Cattle produce a total of 3.2 billion liters of milk and 0.331 million tones of meat annually [6,7]. In addition, 14 million tones of manure are used annually primarily for fuel. About six million oxen provide the draught power required for the cultivation of cropland [8, 9]. Livestock production accounts for 40-80% of farmers' income in Ethiopia [10,5,2,11] and provide manure and transportation services [5]. Livestock serves as a savings account or a way of building assets. Also, livestock ownership denotes social status [11]. In general, livestock ownership ensures varying degrees of sustainable farming and economic stability [5] and it is one of the major livelihood activities in the region. Livestock are therefore closely linked to the economic, social and cultural lives of millions of resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability.

The problem

Ethiopia has a huge potential to be one of the key countries in livestock products (milk, meat and skins) owing to [12] the ownership of large population of milk cows (9.9 million) in the [7], a conducive and relatively disease free agro-ecology, particularly the mixed crop–livestock systems in the highlands that can support crossbred and pure dairy breeds of cows [13], a huge potential for production of quality feeds under rainfed and irrigated conditions, existence a potentially large domestic market [14], existence of a large and relatively cheap labor force and opportunities for export to neighboring countries and beyond. Given that most of the countries farming society is involved in animal rearing activities, and the existing potential for cattle development, it is easy to imagine that the animal production sector in Ethiopia can contribute significantly to the poverty alleviation and improving the nutritional status in Ethiopia.

However, livestock productivity in Ethiopia and in particular the Amhara region is the lowest (even compared to African average) due to poor availability and access to livestock feed [16], insufficient health service and lack of improved breeds [16,11]. If any change is to be expected on current status of livestock production and product processing, due attention should be given to the sector and improved and appropriate technologies should be made available for users. As a result, concerted efforts should also be made to introduce such technologies at relatively wider scale, in a very short possible time. One of the high potential intervention areas in the supply of improved cattle production technologies is the delivery of improved feed processing technologies. BAMFSRC has adapted and evaluated different technologies for handling and partial processing of animal feed at small scale level. On-farm researches were conducted on the technologies (hay or straw baling equipment, Straw and hay chopping machine and milk churn) and the feedbacks in general were, promote at a wider scale. Hence this research activity was initiated to a) to demonstrate baler, chopper and milk churn technologies for dairy enterprises and small scale farmers, b) to promote these technologies for the majority of small scale farmers of Amhara region, and c) to provide recommendations for larger scale adoption of these technologies.

Materials and Methods

Technologies demonstrated and pre-scaled up

Fig 4. Vertical baler

Vertical hay press (baler)

This machine is designed to manage animal feed for better feed storage and utilization. The machine is mainly fabricated from wooden bars reinforced with metallic brasses. It can bale 10.1kg of hay with a baling time of 14.1min, with average bale output of 45.2 $kghr^{-1}$ and a bale density of 86.5 kgm^{-3}. The hay press has a bale area of 1.33m^2 and bale weight of 181kg [17].

The baler delivers compact and high density bale (hay or crop residue) suitable for transport, feeding and storing purposes. It helps the labor hour requirement of traditional straw handling system. The benefits of the baler are managing animal feed (straw, hay), improves animal husbandry, maintains feed quality, can serve as income generation activity and compatible with zero grazing practice. The user groups can be all livestock raring farmers specially those participating in improved dairy or fattening practices.

Specification

Overall dimension (LXWXH) (cm) = 154X54X145

Weight (kg) = 88

Pressing rate (kg/hr) = 45.20

Bale density (kg/M^3) = 85.50

Bale size (m^2) = 0.33

Mechanical hay and straw chopper

It is engine powered mechanical feed size reduction device. It can be used for chopping of hay, straw, stalk and any other green or matured animal feed material. The chopper enables facilitates use of available feed resources by increasing palatability as the feed is reduced to a reasonable size.

Fig 2. Engine driven chopper

The chopper has optimum performance at a drum speed and feed rate values for both maize stalk and grass of 1200rpm 540$kghr^{-1}$, respectively. The average size reduction percentage using these optimum combinations was 92% and 79.5% for maize stalk and grass, respectively. The machine performed well with output rate ranging from 420 to 660$kghr^{-1}$ and specific energy requirement of 11 to 20 KJ kg^{-1} output [18].

Horizontal axis (revolving type) milk churn

The revolving butter churn is made of metals and plastics. It is cylindrical in shape and has two fixed flat type beaters located at the center on opposite side of the central shaft. A hand operated revolving round iron bar through ball bearing at each opposite side drives the beater. The ring is made of round iron and sheet metal, grips tightly the plastic container and the ring is tightly adjusted by a pair of bolts. The driving mechanism and cylindrical plastic are attached together through the ring shaped attachment. It is easy to assemble and Fig 3. Milk churn

Specifications

Overall dimension (L*W*H) (cm) = 51*46*42;working volume =15 Liter; Churning time average = 21-31mins farmers reported 24mins; Weight =15 kg and power source= single person

is for churning butter from cream or yogurt. Equipped with strong metallic framing and comfortable hand crank, simple plastic barrel is designed to assist small dairy producers in milk churning process. It reduces working time and improves butter recovery efficiency by reducing butter loss [19].

Location

Site and farmers' Selection

Dairy areas (four woredas') were identified with the suggestion of West Gojam Zonal experts. As a result, B/Dar Zuria, Mecha, Burie and Jabitenan woredas were identified as milk producing areas. Ultimately, 8 kebeles with more production in the above woredas' were selected for demonstration and promotion. The technologies were distributed for two years to invigorate interest of farmers. In the second year, additional demonstration was offered to newly and already trained farmers along with the delivery of manual feed chopper.

FREGs

In order to facilitate lateral extension for awareness creation and technological use and subsequent adoption, 6 farmers research and extension groups (FREG's) were established. FREG is a technology promotion approach brought by JICA and institutionalized in most of the country's research extension or demonstration and other outreach programs to the smallholders. The approach uses a group of farmers (ranging 10-25) to demonstrate various technologies where part of them became active participants as they provide land and other inputs. The rest of the FREG members actively involve from training to evaluation of the technology or technology performance. The FREGs were established in the three woredas' where technologies were distributed; namely, Mecha, Burie and Jabitenan.

Data collection and analysis

Data was collected from a randomly selected 50 participants in the five kebeles (Bachima, Woinma,Mankusa, Kudmi and Kudchi) of the three woreda's. The sample respondents from Bachima, Woinma,Mankusa, Kudmi and Kuchi account for 24%,24%, 20%, 14% and 18% of the total respondents, respectively. The women account for 28% of the farmers. One kebele (lowest administration level in Ethiopia) was rejected as the farmers have not used the technologies due to staff turnover during the period (2013-2014).

Open ended questionnaires and checklists for the three technologies were used as data collection tools. Data is analyzed using descriptive statistics such as frequency, t-test and others using MSexcel 2007, SPSS V16 and Stata 11 software. Besides, qualitative data analysis using content and interpretative methods is employed. The average age of sample respondents is 41yrs with a STD of 8.13yrs. The minimum and maximum ages are 30 yrs and 62yrs respectively.

Assumptions: Market price of butter was estimated as ETB 60. A man day labor cost of ETB 60 for working averagely10hours is considered per individual laborer. Three months summer time was assumed to consider the difference in length of time for churning. In total 13weeks of summer time churning length and 39 weeks of winter churning time are considered. Constant (straight line) depreciation is considered for all churns and 10 years service life is assumed for horizontal axis churn.

Results and Discussion

Demonstration: At first the three technologies were demonstrated and training was given to 201 male and 19 female farmers and 5 female and 19 male agricultural professionals**.** FREGs (6) were established in the three (3) woredas. Moreover, six (6) milk churns and three (3) balers were distributed to the users in the 3 woredas. Ultimately, these technologies were offered to the farmers for long term (one year) free of cost. Monitoring was conducted after 3 months in order to ensure utilization of the technologies. Thus, the research team found that milk churn was being used by five of the kebeles where milk production was ample good while the farmers in Jiga kebele stored it and never used due to lack of motivation, facilitation and monitoring from Das (Development Agents) that have left for other areas. In the second year, a team conducted in order to assess the utilization and status of the technologies and concurrently delivered manual chopper that was being promoted in WLRC (Water and Land Resources Center) watersheds in order to create basket of technology choices and encourage utilization. However, almost all farmers recognized the engine driven (mechanical) feed chopper and showed no interest for the manual chopper even if it is better than the traditional system of chopping as it is comfortable and safe during chopping. Ultimately, the team delivered refresher training for those trained last year and demonstration to new ones on the four technologies including manual chopper as well as collected feedback on the technologies. This time (during the refresher training), people from small scale and micro enterprises, agricultural experts (25 male and 5 female) and farmers (121 male and 29 female) participated in the training.

Technology I- Baling

Traditionally crop residues including maize stalks are transported by using manual labor (carriage by individual shoulders), pack animals or using carts. The major transportation method is by humans (shoulders or heads). This condition requires significant labor and time to transport as only small size of crop residue can be transported in a single round due to the huge volume. Besides, crop residues like teff straw create irritation of the skin resulting in discomfort and hence carriage of a small amount using some covering clothes or animal skin. Along the transportation, animal feed storage is one of the stages that result in wastage. Crop residues are traditionally piled on a raised bed on the land and on raised bed above ground usually between trees or on top of roof in case of like maize stalk.

Farmers' feedback on vertical baler

Majority of the farmers (95%) indicated the presence of problems (large area and wastage in many forms) in storing animal feeds. Since the baler can help tying of larger mass of the residue with small volume. It helps to transport much quantity in a shorter period of time especially by using carts. It also helps to pile a larger quantity of residue in a small sized area. Weight of the baled feed is considered normal light by 15% while normal by 82.5% of the farmers. Limitations considered for continual use of the technology are the need to use ropes (17.5%), need for labor for baling (5%) and heaviness of the baler (7.5%). In order to increase wider adoption of the technology reduction is the weight is crucial. Ownership can be privately (12.5%), in groups (67.5%) and custom hiring by anyone including the government (7.5%).

Technology II- feed chopping

Traditionally, the farmers (47%) provide their animals all feeds without chopping while only 1.9 % chop the feeds (crop residues and grasses). Maize stalk, the major feed in the areas, is given to the cattle as it is and sometimes little chopping is done. It actually results in great wastage but it is used for energy. Axe or sickles are the traditional chopping equipments. In case of chopping of maize stock, it takes 2-3hrs to chop a feed sufficient for four (4) cattle (table 1).

Table 1. Traditional feed chopping

	N	Minimum	Maximum	Mean	Std. Dev.
Length of chopping (hr)	29	2.00	3.50	2.81	0.49
Cattle size feed chopped (no)	22	3.50	7.00	4.57	0.58

In general it has a great contribution since it reduces volume for both transportation and piling

The technology is best suited for transportation of feed. However, they indicated the need to create awareness to the larger community during grass harvesting, create conditions where community piling could be done in a specific place, continuous monitoring and evaluation by local experts.

Farmers' feedback on mechanical chopper

All of the farmers have appreciated the engine driven chopper a super performing and have requested the delivery in groups or custom hiring system. All of the farmers have interest to adopt either in groups or through custom hiring from wealthy households. Engine driven chopper helps to chop a greater quantity within short time period of time. It creates greater palatability. However, the manual chopper has low output thou it is better than traditional system. Even if most of the farmers (79.6%) stated that the technology is perfect some have pointed out modification recommendations that mostly relate to attributes of the technology (Rogers, 2003). These feedbacks include the need to improve the quality of the body or production material (9.3%), reduction of weight of the chopper (3.7%), better or maximized (3.7%) and better small sized output (3.7%). With regard to ownership, the chopper can be acquired either in groups of 3-5 persons or more.

Technology-III milk churner

Traditional butter production system is undertaken as follows (Fig 4)

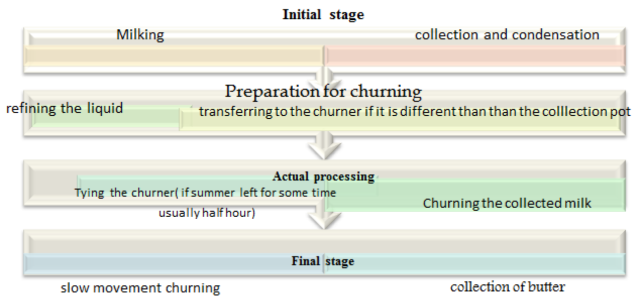

Fig 4. Traditional churning system

Traditional churns and service period

Farmers use the traditional churns clay pot (52%), gourd (2%) and both (46%) for churching milk. Clay pot has an average service year of 2.6 years with an average cost of ETB 36.33. A paired t-test showed that clay pot churner has on average higher price than gourd churner (t=10.82, p=0.00). The gourd churner has an average service year of 2.5 years with an average cost of ETB 20.12 (Table 2). A paired t test showed that clay pot churn has averagely higher total service year than gourd churn (t=4.46, p=0.0001).

Table 2. Service period

Local churner type	Length of service year of the churner (yrs)				
	Number	Minimum	Maximum	Mean	STD
Gourd	26	1.00	3.50	2.52	0.50
Clay pot	48	0.50	5.00	2.50	1.13

Period waited for churning

Farmers indicated the need to collect milk for churning. In general, the average days of collection of milk for churning during winter and summer are 4 ¼ days and 6 ½ days, respectively (table 3). It takes on average 86 mins and 145 mins to churn 11 lit of milk to make 1.1kg of butter during winter and summer, respectively.

Table 3. Milk production in the traditional system

Variable	Mean	Std. Dev	Min	Max
Milk collection period during summer(days)	6.51	1.21	4.5	10
Milk collection period during winter (days)	4.27	1.21	2.5	7
Summer traditional churning time (mins)	144.6	49.68	45	240
Traditional winter churning time (mins)	85.92	33.65	45	180
Volume of yoghurt at a churn (mins)	11.03	2.11	6	15
Volume of butter extracted (lit)	1.11	0.27	0.38	1.5

Compatibility of traditional churns

The farmers (12%) considered clay pot better than gourd for churning and cleaning while few (2%) indicated that gourd is better than clay pot for cleaning. Others (8%) have indicated that selective purchase can enable acquiring of better traditional churns for both churning and cleaning. Overall, most of the farmers (78%) described that traditional churners are not comfortable [20] for both churning and cleaning.

Farmers' feedback on horizontal axis milk churn

The horizontal churn is preferred for reduction of labor (tiresome) and possibility to be handled by even the men and young family members (40%). Reduction of burden on women (4%) as in traditional methods it is the women who would properly do that and its capacity to separate more butter than the traditional methods (44%) as other benefits of the technology. The reason for better production of butter was attributed to rotation of the whole milk as the same time that is not possible in traditional systems. Further, the farmers (66%) confirmed that churn operation is simple. Further, the most vital advantage of churn is enabling extraction of butter that is marketed easily than milk. This is very crucial especially during fasting days and months where milk is mostly wasted.

The quality of butter extracted using modern churn is thought better by (62%) as the churning leads to better drying. It takes on average 38mins and 23mins to extract butter using the modern churner for a milk of same size, summer and winter (table 4). They liked the possibility to access the churner from local markets. Price of the churn (ETB 679) is both considered within the purchasing capacity of farmers (48%) and as the same time expensive (36%).

Table 4. Churning period for Churner

Season	No.	Churning time length (mins)			
		Mean	Std. Dev.	Min	Max
Summer	33	37.58	15.52	15	75
Winter	33	23.06	8.85	12	50

Labor productivity of churn

The increase in labor productivity was calculated as the amount of output per unit time of labor input for both traditional and modern churning systems. Hence, labor productivity was increased from 0.444kg/hr to 1.804kg/hr of butter output. Besides, reduced burden of women and drudgery on compatibility of both operations is the advantage of using the horizontal axis churn. Other benefits from using the horizontal churn are saving labor and reduction of tiresome (60%), ability to be handled by any member of the family (58%) and extraction of butter that could have been lost (22%) if traditional system was used.

Financial analysis

Financial analysis was conducted to analyze the comparative advantage of the churns (table 5).

Table 5. Financial profitability of the churn

	Traditional churn		Horizontal axis churn
	Clay pot	Gourd	
Average yield of butter (Kg)	**57.72kg**	**57.72kg**	**57.72kg**
Adjusted price (ETB10% /kg)	**58*60**	**58*60**	**58*66**
Gross benefit of butter (ETB/yr)	**3480**	**3480**	**3828**
Costs of labor (ETB/yr)	**780**	**780**	**192.5**
Cost of churner (ETB/yr)	**14.53**	**8**	**67.9**
Maintenance cost (ETB/yr)	**-**	**-**	**6.79**
Total costs that vary (ETB/yr)	**794.53**	**788**	**267.19**
Net benefit (ETB/yr)	**2685.47**	**2692**	**3560.81**

The financial analysis does not include benefits like quality of butter, compatibility and other qualitative issues as measurement was difficult. The financial analysis showed that the net benefit obtained from the horizontal milk churn much better than those from traditional methods.

The marginal profitability analysis (table 6) showed that for every 1ETB invested on horizontal axis churn, farmers can recover their 1ETB plus 1.67 ETB/per kg of butter. The result confirms investment on milk churn by farmers who at least churn on weekly basis or bi-weekly will recover their investment costs within a year. Farmers recommended the possession for farmers that have three or more local dairy cows or that have hybrid cows or organized dairy farmers.

Table 6. Marginal profit analysis

Technology		Varying costs	Marginal cost	Net benefit	Marginal net benefit	MRR
Traditional Churn	Gourd (G)	788		**2692**		
	Clay pot (CP)	794.53		**2685.47**		
Revolving churn		**267.19**	**520.81$_G$**	**3560.81**	**868.81$_G$**	**167 %**
			527.34$_{CP}$		**875.34$_{CP}$**	**166 %**

Overall, during demonstrations and monitoring activities, the felt needs or priority of farmers were investigated for the technologies. A pair wise ranking was conducted to investigate the priority needs of farmers among the technologies introduced. The pair wise ranking of 16 farmers (9 male and 6 female) made in the second year during monitoring indicated the priority for engine driven chopper (table 7) and milk churn was a second priority.

Table 8. Pair wise ranking for prioritization

	Hay press	Milk churn	Engine driven chopper	Frequency	Ranking
Hay press				0	3
Milk churn				32	2
Engine driven chopper				64	1

Suitability analysis

Suitability map for larger promotion and adoption of the technologies was developed (Fig 5). In developing the suitability map we considered that the milk churn may be promoted to all parts of the region and more specifically we tried to include those potential dairy areas. The potential milk areas include those identified by the federal government as milksheds of the Amhara Region, Bahir Dar-Gonder milkshed and we extended it to include other potential areas of the region extending from East Gojjam. The potential suitable areas for Chopper include those areas that have the practice of storing feeds like grasses and areas with harder crop residues like maize stock. Hence, except the limitations of mobility presented by the landscape, the chopper could be promoted in all areas especially in potential maize growing areas of the region where maize stock is one of the feeds available to livestock of the smallholders. Similarly, except the case of mobility problems, which makes it somehow difficult in very steeply slopes and undulating landscapes, the baler (Hay press) could be promoted in all parts of the region. In general, we recommend the promotion of the technologies in all parts of the region as local innovations could enable production of locally adapted technologies. Based on this suitability map, any interested organization can promote the technologies to increase the livestock productivity of the smallholders.

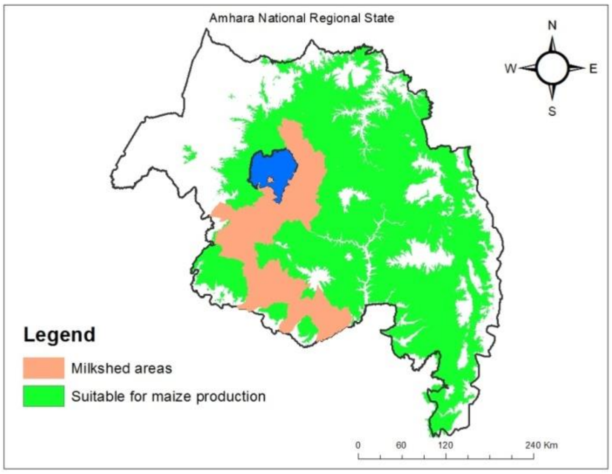

Fig 5. Potential adoption areas

Conclusion and Recommendation

Farmers have showed interest to adopt the technologies promoted and hence demand was created. Hence, enabling local level production of the technologies by providing training to the small scale and micro-enterprises, undertaking additional and wide area demonstration activities, monitoring of achievements (include milk, labor, time productivity), and creation of linkage with woreda office of agriculture, other stakeholders and farmers. In general, continuous demonstration, training and monitoring is required for mechanization technologies to be adopted and make effect. Hence, creation of appropriate innovation platforms is critical. Besides, the way forward should analyze the credit supply, ownership (including group ownership), delivery of training and design to SMEs (small and micro enterprises) and conducting Sensitization workshops to Zonal stakeholders and other NGOs working in these fields. Participation of other organizations and individuals in the beef and milk value chains is critical.

References

[1] CSA (Central Statistical Agency), 2011. Agricultural Sample Survey 2010/11 [2003 E.C.] Volume II. Report On Livestock And Livestock Characteristics (Private Peasant Holdings). Addis Ababa, Ethiopia.

[2]Sewmehon Demisse, 2012. Livestock Water Productivity (LWP) improvement in the mixed crop livestock system of Ethiopian Highlands, Amhara Region: a gendered sustainable livelihood approach to target LWP interventions for rural poverty reduction. A PhD Dissertation Submitted to Bonn University.

[3]Dejene, A. 2003. Integrated natural resources management to enhance food security: The case for community-based approaches in Ethiopia. FAO Environmental and Natural Resources Working Paper 16. Rome.

[4]Aklilu Woldu And Eshete Dejen,2009. The Supply, Marketing and Trade of Live Animals in the Amhara Region. Published by Ethiopian Sanitary & Phytosanitary Standards and Livestock and Meat Marketing Program of Texas Agricultural Experiment Station/Texas A&M University System.

[5] Belete Anteneh, Azage Tegegne, Fekadu Beyene and Berhanu Gebremedhin, 2010. *Cattle milk and meat production and marketing systems and opportunities for market-orientation in Fogera* woreda*, Amhara region, Ethiopia*. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 19. ILRI (International Livestock Research Institute), Nairobi, Kenya. 65 pp.

[6] FAO, 2005. Supply Utilization Accounts and Food Balances. http://faostat.fao.org/

[7] CSA (Central Statistics Agency). 2008. Agricultural sample survey 2007/2008 (2000

EC) Vol. II Report on livestock and livestock characteristics (Private holdings). Statistical Bulletin 364, CSA, Addis Ababa, Ethiopia.

[8] Azage Tegegne, 1998, Cattle breed improvement for sustainable draft power use in Ethiopian agriculture. In: Proceedings of the first national oxen traction research and strategy workshop. P 43-52, Ethiopian Agricultural research organization, Addis Ababa (Ethiopia); ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia: EARO-1 National Oxen Traction Research Review and Strategy Workshop, Debre Zeit (Ethiopia), 3-5 December 1997.

[9] Befekadu Degfe and Birhanu Nega, 2000. Annual Report on the Ethiopian Economy: Volume 1,1999/2000. The Ethiopian Economics Association, Addis Ababa, Ethiopia, 429 pp.

[10]Adane Dinku, 2007. Soil and water conservation (SWC) Technology: Improved grazing land management, Ethiopia. Annual Report on Natural Resources Management of Chencha Woreda for 2001/2. WOCAT.

[11]Susan Ilyin, 2015. The Looming Threat of Overgrazing: Effects and Recommendations. Accessed on 22/07/2015 at www.hungercenter.org/wp./Looming-Threat-of-Overgrazing-Ilyin.pdf.

[12] Pratt, A., Staal, S & Jabbar M.,2008. Dairy Development for the Resources Poor Policy Initiative of Kenya and Ethiopia, Dairy Development Case Studies. Rome, Italy: Pro- Poor Livestock, Part 2.

[13] Ahmed, M. Ehui, S. and Yemesrach, A. (2003): Milk development in Ethiopia. Socio-economics and policy research International Livestock Research Institute, Nairobi, Kenya, Working paper, 58:47.

[14]Holloway, G.C., Nicholson, C. Delgado, S. Stall and S.Ethui. 2000. How to a milk market: A case study from the Ethiopian highlands. Socio-economics policy research working paper 28, ILRI (International Livestock Research Institute), Nairobi, Kenya, 28 pp.

[15]Funte S., Negesse T. and Legesse G., 2010. Feed Resources and Their Management Systems in Ethiopian Highlands: The Case of Umbulo Wacho Watershed in Southern Ethiopia. Tropical and SubtropicalAgroecosystems,12:47–56.

[16]ANRS (Amhara National Regional State), 2002. Woody Biomass Inventory and StrategicPlanning Project: Report on Natural Grazing Lands and Livestock Feed Resources, Addis Ababa.

[17] Abu Teffera, Solomon Tekeste and Yihalem Denekew, 2012. On-farm Evaluation and Demonstration of Different Types of Hay Press. *Journal of Livestock Research for Rural Development*, 24:1.

[18]Worku Biweta and Solomon Tekeste, 2012. A Design Study of a Motor-Driven Chopper for Chopping Crop Residue and Hay. *The IUP Journal of Mechanical Engineering*, 5(3): 68-75.

[19]Abu Teffera, 2007. On Farm Verification of Manual Operated Milk Churns. In Friew Kelemu, Omar Taha and Gessessew Likeleh (eds),2007. Proceedings of the First Agricultural Mechanization and Food Science Research Completed Research Forum. June 5-7,2007. pp71-77

[20] Rogers, E. M., 2003. Diffusion of Innovations. New York: Free Press.