Application of TechFit to prioritize feed technologies in Sinana District of Bale Highlands, Southeastern Ethiopia

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The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads an associated project on monitoring, evaluation and impact assessment.

Introduction

Livestock production is an integral part of the mixed crop-livestock farming system of Bale highlands. Livestock ensures the availability of quality nutrition and income for the farming community throughout the year. Besides, livestock are sources of agricultural inputs such as draught power and manure as a source of organic fertilizer and useful for transportation purpose. Hence, livestock and crop production are interdependent in Bale highland where livestock holding was observed to have significant effect on crop cultivation (Solomon *et al.,* 2009). Dominant livestock species of Sinana district are cattle, sheep, goats, horses, donkeys, mules and poultry (Dawit Abate *et al,* 2012 unpublished data). Most farmers in Sinana district rear sheep due to suitability of environmental condition for sheep production and presence of the locally adapted Arsi-Bale breed of sheep and multiple uses of sheep. Sheep production is important for the livelihood of the farmers as a source of income, meat, skin and manure as well as a means of risk avoidance during crop failure and their cultural function during festivals. Low income farmers rear sheep due to ease of production and high production efficiency that enabled them to generate immediate cash for different payments like tax, school fee, and purchase of agricultural inputs like fertilizer, improved seed and herbicides.

Assessments conducted in Bale highlands in general (Solomon, 2004; Worku et al., 2008) and Sinana district in particular (Dawit *et al.,* 2012 unpublished data) showed that feed shortage, lack of knowledge on feeding and management of sheep, water shortage and disease problems are the major constraints affecting sheep production in the district. All the above feed resources assessment reports showed that the overall shortage of feed and the seasonal fluctuation in the quantity and quality of feed are the main challenges facing livestock production in the area. In the mixed crop-livestock farming system of Sinana district, livestock are predominantly fed crop residues and crop aftermath especially during the dry period when feed shortage is a critical problem (Solomon *et al*., 2008; Dawit et al., 2012). Thus, improvement of livestock production in general and sheep production in particular in Sinana district requires enhancing availability and quality of feed resources throughout the year using suitable feed technology interventions.

In Ethiopia, different useful feed technologies have been identified by research and recommended to mitigate the feed shortage problems. However, the results achieved so far are not satisfactory mainly due to poor adoption rate of identified and recommended feed technologies because of lack of systematic approach for prioritizing available feed technologies for a particular location. This results in unnecessary wastage of resources and efforts without any remarkable impacts on the farming community. Moreover, Sinana district in particular and Bale zone in general have less exposure to feed intervention technologies to improve sheep and other livestock production. Hence, identifying appropriate technologies and promotion of these technologies for the area is imperative. Techfit is a tool developed to prioritize and select best fit technologies from wide range of options potentially available for farmers. The tool is used for scoring and ranking of different feed technologies taking into consideration the existing situation of the farming system of the area. It enables to identify and recommend appropriate technologies for a given situation within a short period of time. Therefore, the objective of this work is to rank and prioritize best fit feed technologies for Sinana district of Bale highlands with special emphasis on intervention for improvement of feed problems for sheep production.

Methodology

Description of the study area

The study was conducted in Sinana district of Bale highland. Sinana is located at about 430 km southeast of Addis Ababa. The land coverage of the district is approximately 163,854 ha. The altitude of the area ranges from 2200 to 2600 m.a.s.l. The average annual maximum and minimum temperatures are 21^0c and 9^0c, respectively. The rainfall pattern is bimodal with annual precipitation ranging from 750-1000 mm. Two cropping seasons are known in the study area and these are locally known as *Bona (*from August to December) and *Ganna (*from March to July). Livelihood of the farming community of the area is based on mixed crop-livestock production, where cereal crop faming is dominant. Livestock population of the districts is estimated to be 210,445 head of cattle, 25,850 sheep, 15,780 goats, 20,943 donkeys, 5,788 horses, 3,001 mule and 50,320 poultry (Sinana District Office of Livestock Development and Health, 2012)

Sampling Method

Selection of *Kebeles*

Before actual site selection, representatives of the research team from Sinana Agricultural Research Center (SARC), International Livestock Research Institute (ILRI) and International Center for Agricultural Research in Dry Areas (ICARDA) held detailed discussions with the Woreda and Zonal Offices of Livestock Development and Health about the project including its objectives and considerations for selection of *Kebeles* and focus group discussant farmers. Accordingly, out of 18 *kebeles* found in the district, three were selected purposively for the application of the TechFit tool. Selection of the kebeles was based on their farming system i.e. mixed crop-livestock production (high sheep population), dominant crop production (lower sheep population) and mixed crop-livestock production (intermediate sheep population). In addition, accessibility of the k*ebeles* to infrastructure, especially road, was also considered for selection. Accordingly Selka *kebele* for mixed crop-livestock production (high sheep population), Sambitu *kebele* for dominant crop farming (lower sheep population) and Walta'i Barisa *kebele* as an intermediate were selected. Those selected sites were visited by researchers and experts prior to farmer selection and data collection. Geographical descriptions and number of participant from each selected *kebeles* were indicated in Table 1.

Table 1: Geographical description of the selected *kebele's* and number of participants

No	Kebeles	Altitude	GPS Coordinate	Number of Participant		
				Male	Female	Total
1	Selka	2457m.a.s.l	$07^0$02'00.4"N and $040^0$13'15" E	13	4	17
2	Sambitu	2454m.a.s.l	$07^0$05'23.4"N and $040^0$33'41" E	12	0	12
3	Walta'i Barisa	2453m.a.s.l	$07^0$09'21.2''N and $09^0$56'50.3''E	11	3	14

Selection of Participants Farmers

For the selection of participant farmers, researchers from SARC travelled to the area and discussed in detail with development agents of respective *kebeles* on the work of the project and how to select farmers who would participate in group discussion to assess availability of attributes such as land, labour, cash/credit, inputs and knowledge and to give context attribute scores for the area.

Participant farmers were selected based on their land holding categories by development agent of respective *kebeles*. Accordingly17, 12 and 14 farmers from Selka, Sambitu and Walta'i Barisa *kebeles* were selected respectively. In addition, age and gender were considered during participant farmer's selection.

Data Collection Methods

Checklist was used to collect information about the context attributes of farmers. Farmers gave values from 1 to 5 for availability of or access to land, labour, credit/cash, input delivery and farmer's knowledge and skill. Highest availability of attribute scored a value of 5 whereas lowest availability scored 1. They were encouraged to discuss and debate on the score they gave for each attribute and they gave score for availability of each attributes with justification. This context score was also made by the experts and the results conformed to that of the farmers. Different issues farmers raised during discussions was recorded and used as input for the scoring made by the researchers on context relevance and scope for improvement. In addition, information generated on cost of land lease, input cost (forage seed and fertilizer price), sale price of straws and green grass, labour cost and price of agro-industrial by product were used in cost benefit analysis.

Data Analysis

Context relevance scoring of technologies were done with the value of 1-6 (1 for lowest and 6 for highest relevance). Using combined result of context relevance of the technology to the area and score of impact potential of this technology in addressing feed problem issues on a scale of 1-6 (1 for lowest impact and 6 highest impacts), technologies were pre filtered. Those technologies with high total score for context relevance and impact potential were carried forward to the main filter. Scores given by the farmers on context attribute (availability of land, labour, cash/credit, material input and knowledge) and the scores given by experts on technology attributes (requirement of each feed technology for land, labour, cash/credit, inputs and knowledge) were fitted to the TechFit template prepared for prioritization of feed technologies.

Total scores were calculated by adding the products of technology attribute and context attribute scores for each of the five attributes plus the score for scope for improvement of the attributes (or the technologies given the attributes). Scoring scale of scope for improvement range from 1 to 5 (1 for lowest and 5 for highest). Total scores recorded from combination of technology attribute, farmer's context attribute and scope for improvement were used for ranking and prioritizing of the technologies at main filter, where technology with high total score got top rank. Context attribute scores were made depending on availability of major technology limiting attributes such as land, labour, credit/cash, input delivery and farmer's knowledge and skill.

Cost-benefit analysis of top ranking technologies was carried out by taking into account the input costs of the technology and the value of the outputs expected from application of the technology. Total cost expended and benefits accrued from implementation of the technology was estimated (Annex 2). Finally benefit to cost ratio (BCR) was computed to arrive at overall decision whether a given technology is economical or not. A given feed technology declared economical if the quotient of benefit to cost ratio is greater than or equal to one (BCR≥1 and it is considered uneconomical if the BCR is less than one (BCR<1).

Results and Discussion

Farmers context score

Farmers gave scores for availability of land, labour, cash/credit, inputs and knowledge as indicated in Table 2. Availability of land is different among the *kebeles.* It was highest in Selka followed by Sambitu and lowest in Walta'i Barisa. Farmer's accessibility to labour, material input and knowledge were similar for all the three *kebeles*. Availability of labour is fluctuating in the area with high labour requirement during peak cropping activities, particularly harvesting. Daily payment for labour was estimated to be 25, 24 and 26 ETB at Selka, Sambitu and Walta'i Barisa *kebeles* respectively. Farmers of Sambitu *kebele* have better access to credit/cash than the others. Among all attributes input delivery was identified to be the main problem of the study area, which might be related with unaffordable price, inconsistency of supply and unavailability of some inputs like improved breeds of animals.

Table 2: Context attribute scores (1-5)* for the three *Kebeles*

No	Attributes	Selka	Sambitu	Walta'i Barisa
1	Land	5	4	3
2	Labour	3	3	3
3	Credit/cash	2	3	2
4	Input delivery	2	2	2
5	Knowledge and skill	3	3	3

*1 = lowest and 5 = highest

Technology screening at pre-filtering stage

A total of 38 feed technologies categorized under different groups (Annex 1) were screened based on their context relevance and impact potential for the area at pre- filtering stage. Technologies with lower relevance and impact potential for the area to address issues of feed problems were dropped (Table 3), whereas 18 technologies that got higher total scores were carried forward for further evaluation at main filtering stage using scores for technology attributes, farmers' context attributes and scope for improvement.

Table 3: List of dropped technologies at pre-filtering stage with justifications for dropping

No.	List of technologies	Reasons or dropping
1	Feeding of bought in legume crop residues	- Selling of legume crop residues is not common in the area
2	Supplement with home-produced local brewers' waste	- Production of local brewer waste is minimal due to dominant inhabitant of the area is Muslim who do not used brewers
3	Supplement with bought in local brewers waste	- Availability of local brewery waste is very low in the study area.
4	Use leaves and/or pods of farm trees (e.g. *Acacias, Milletia* etc)	- Availability of these trees are very limited
5	Commercial dairy supplements	- Commercial dairy supplement is not available - Targeted dairy production is not common in the area
6	Use of oats grain and hulls for supplementary feeding	- Grain production of oat is not common
7	Poultry litter	- Commercial poultry farm is not available in the area
8	Making hay from cultivated perennial fodder with specialist seed (e.g. alfalfa, Rhodes)	- Perennial fodders seed is not easily assessable by farmers - Farmers of the area don't have interest to allocate their land for perennial fodders - Establishment of perennial fodders is relatively difficult
9	Fodder tree leaf meal	- Production of fodder tree meal is minimal due to lower availability of the fodder tree in the area
10	Fodder trees - dual purpose (Pigeon pea)	- This crop is not well adapted to the area
11	Use of improved perennial grass-legume mixture (e.g.Rhodes-alfalfa	- Incorporation of legumes into grass is expensive and difficult

	forage or hay)	- It demands land for long period and inputs not available
12	Thinning (e.g. maize and/or sorghum - cutting green at knee height)	- Sorghum production is not practiced - Maize cultivation is minimal and targeted for use as green fodder
13	Use of tops, leaf strips (e.g. maize or sorghum)	- Sorghum production is not practiced - Maize cultivation is minimal and targeted for use as green fodder
14	Use of enset and/or banana leaves and by-products	- The ecology is not appropriate for banana production - Enset production is also minimal
15	Crop/forage intercropping (sorgum/cowpea for dry areas and maize/labab for wetter areas)	- The crops are not well grown in the area
16	Root and tubers - use of byproducts	- Availability is very low
17	Root and tubers - dedicated use	- Availability is very low
18	Vegetable waste	- Production of vegetable is minimal
19	Complete feed-TMR (mash, block, pellet)	- Provision of the service is not available - High price
20	Buying baled hay (e.g. oats/vetch, Rhodes grass, meadow etc.)	- Not available

Prioritization of potential feed technologies at main filtering stage

Out of eighteen (18) technologies carried forward and evaluated at main filtering stage, ten to twelve top ranking technologies were selected for each *kebele* based on context attribute, technology attribute and scope for improvement (Tables 4, 5 and 6 for Selka, Sambitu and Walta'i Barisa *kebeles* respectively). Overall results showed that the prioritized technologies were almost similar across all locations which might be due to similarity of the context attributes of the farmers (i.e. farmers' access particularly to labour, cash and knowledge). Technologies with lower requirement for land, labour, cash/credit, input and knowledge had higher probability of being selected. Hence, most prioritized technologies as a remedy to the problems of feeds in quality, quantity and seasonality for the study area were those which demand less land, labour, cash, input and knowledge.

The selected technologies for Seleka and Sambitu *kebeles* include crop residues improvement (6), improved forages (2), supplementation (2), feeds from cropping system (1) and balanced feeds (1) categories, while technologies selected for Walta'i Barisa *kebele* include crop residues improvement (5), improved forages (1), supplementation (2), feeds from cropping system (1) and balanced feeds (1) categories. 'Feeding of home grown legume residues' got highest total score at all locations followed by 'use of weeds, cut grass, tree leaves', 're-threshing and mixing of crop residues before storage and feeding' and 'hand chopping of crop residues' at Selka and Sambitu *kebeles*, whereas it was followed by 're-threshing and mixing of crop residues before storage and feeding', 'use of weeds, cut grass, tree leaves' and 'hand chopping of crop residues' at Walta'i Barisa *kebele*. The ranking of the remaining selected technologies were slightly differing among *kebeles*. 'Use of improved annual grass-legume mixtures' and 'treatment of crop residue' were not among the top ranking categories at Walta'i Barisa *kebele*. In addition, scores made on scope for improvement also have great impact on the technologies being selected since combined result of technology attribute, farmer's context of attribute and scope for improvement for technologies were used in the ranking process.

Technologies with higher requirement for land, labour, cash/credit, inputs and knowledge got the lowest rank. For instance 'use of improved annual grass-legume mixtures', 'treatment of crop residue' and 'supplement with UMMB got relatively lower ranks among the top ten technologies because they are dependent on availability of either land, labour, cash, material input or knowledge. There are some technologies such as use of 'improved annual grass-legume mixtures' with high context relevance to the area but got very low scores due to their high requirements for most attributes. Use of such technologies might be feasible in the study area because of relatively better availability of land and inputs (forage seeds) in the area, as compared as places in the country, and considering their potential to address biomass and quality issues of available feed resources. This shows the need to be more specific when giving scores for availability of inputs to the particular inputs needed by each feed technology instead of giving just one score for different types of inputs.

Table 4: List of Feed Technologies Prioritized Using the TechFit Tool for Selka *Kebele*, Sinana District

List of Technologies	**Total Score**	**Rank**	**Remarks**
Feeding of home grown legume residues	73	1	• This technology demands less land, cash, material input and knowledge whereas its requirement for labour is easily affordable by farmers. • Farmers' preference to use legume crop residues is high due to its nutritional advantages over cereal crop residues

Use of weeds, cut grass, tree leaves	68	2	• Farmers in the study area use weeds (wild oats) from their farmland and cut grasses on the edges of their farm. Thus it can be more easily adopted.
Re-threshing and mixing of crop residues before storage and feeding	67	3	• Most farmers commonly collect straw at harvesting time and re-thresh and mix before storage and feeding to make more suitable for storage and feeding the animals • This technologies is familiar in the area and it needs strengthening to cover the whole farmers
Hand chopping of crop residues	61	4	• Crop harvesting is dominantly done by combine harvester and chopping is important to make the straw convenient for feeding to animals
Supplement with agro-industrial by-products (wheat bran, wheat middling, oilseed cakes, pulse crop milling by-products such as lentil bran and hulls, etc.)	55	5	• Important technology for market oriented livestock production (fattening and dairy production) • Supplementation of draught oxen and fattening animals with home prepared concentrates (flours of roasted barley and emmer wheat, grain screenings) and purchased agro-industrial by products is practiced by some farmers of the study area. • It demands cash and input
Fodder trees (Sesbania, Leucaena, Tagasaste, Gliricidia)	55	5	• Potential options to address biomass and seasonality issues of the feed • Demands labour than other attributes
Smart feeding (targeted use of bought-in concentrates to target productive animals)	54	6	• This technology is new and demanding cash, input and knowledge for implementation • Farmers needs to be capacitated through different approach like training, improvement of credit accessibility and input supply • Demands cash, input and knowledge
Machine chopping of residues	54	6	• This technology is cash intensive, while its demand for input is also higher than other attributes
Generous feeding of crop residues	52	7	• It could be applicable to the area because of ample production of crop residues
Supplement with UMMB	51	8	• This technology is demanding cash/credit and input • Establishment of local processor of UMMB is important to improve farmers accessibility to the technology
Treatment of crop residues (e.g. urea treatment)	46	9	• This technology is demanding labour, cash, input and knowledge. • Crop residues are major feed sources in the study area and improvement of nutritional quality and intake through urea treatment is important.
Use of improved annual grass-legume mixture (e.g. oat-vetch forage or hay)	42	10	• Demand for land and labour is high and followed by input cash, and knowledge. • The technology has a potential to overcome biomass and quality issues.

Table5: List of feed technologies prioritized using the TechFit tool for Sambitu *Kebele*, Sinana District

List of technologies	Total score	Rank	Remarks

Feeding of home grown legume residues	72	1	• This technology demands less land, cash, material input and knowledge whereas its requirement for labour is easily affordable by farmers. • Farmers preference to use legume crop residues is high due to its nutritional advantageous over cereal crop residues and knowledge where its requirement for labour is easily
Use of weeds, cut grass, tree leaves	68	2	• Farmers in the study area use weeds (wild oats) from their farmland and cut grasses on the edges of their farm
Re-threshing and mixing of crop residues before storage and feeding	67	3	• Most farmers commonly collect straw at harvesting time and re-thresh and mix before storage and feeding to make more suitable for storage and feeding • This technologies is familiar in the area and it needs strengthening to cover the whole farmers
Hand chopping of crop residues	60	4	• Crop harvesting is dominantly done by combine harvester and chopping is important
Fodder trees (Sesbania, Leucaena, Tagasaste, Gliricidia)	56	5	• Useful technology to address biomass and seasonality issues. • Labour demand could be high
Generous feeding of crop residues	55	6	• There is ample production of crop residues.
Supplement with agro-industrial by-products (wheat bran, wheat middling, oilseed cakes, pulse crop milling by-products such as lentil bran and hulls, etc.)	51	7	• Important technology for market oriented livestock production (fattening and dairy production) • Supplementation of draught oxen and fattening animals with home prepared concentrates (flours of roasted barley and emmer wheat, grain screenings) and purchased agro-industrial by products is practiced by some farmers of the study area. • This technology demands cash and input
Smart feeding (targeted use of bought-in concentrates to target productive animals)	48	8	• This technology is new and demanding cash, input and knowledge for implementation • Farmers needs to be capacitated through different approach like training, improvement of credit accessibility and input supply
Machine chopping of residues	48	8	• This technology is cash intensive, while its demand for input is also higher than other attributes
Supplement with UMMB	48	8	• This technology is demanding cash/credit and input • Establishment of local processor of UMMB is important to improve farmers accessibility to the technology
Use of improved annual grass-legume mixture (e.g. oat-vetch forage or hay)	43	9	• Demand for land and labour is high and followed by cash, input and knowledge. • It is applicable and potential technology to overcome biomass and quality issues.
Treatment of crop residues (e.g. urea treatment)	41	10	• This technology demanding labour, cash, input and knowledge. • Crop residues are major feed sources in the study area and improvement of nutritional quality and intake through urea treatment is important.

Table 6: List of Feed Technologies Prioritized Using the Techfit Tool For Walta'i Barisa *Kebele*, Sinana District.

List of Technologies	Total Score	Rank	Remarks
Feeding of home grown legume residues	63	1	• This technology demands less land, cash, material input and knowledge whereas its requirement for labour is easily affordable by farmers. • Farmers preference to use legume crop residues is high due to its nutritional advantageous over cereal crop residues and knowledge where its requirement for labour is easily
Re-threshing and mixing of crop residues before storage and feeding	57	2	• Most farmers commonly collect straw at harvesting time and re-thresh and mix before storage and feeding to make more suitable for storage and feeding • This technology is familiar in the area and it needs strengthening to cover the whole farmers.
Use of weeds, cut grass, tree leaves	56	3	• Farmers in the study area use weeds (wild oats) from their farmland and cut grasses on the edges of their farm
Hand chopping of residues	55	4	• Crop harvesting is dominantly done by combine harvester and chopping is important to conveniently feed the straw to animals
Generous feeding of crop residues	49	5	• Straw production is excess due to high cereal crop production in the area and applicability of this technology is high
Fodder trees (Sesbania, Leucaena, Tagasaste, Gliricidia)	47	6	• Important options to solve quality and seasonality problem of feed. • May have high labour demand
Supplement with agro-industrial by-products (wheat bran, wheat middling, oilseed cakes, pulse crop milling by-products such as lentil bran and hulls, etc.)	46	7	• Important technology for market oriented livestock production (fattening and dairy production) • Supplementation of draught oxen and fattening animals with home prepared concentrates (flours of roasted barley and emmer wheat, grain screenings) and purchased agro-industrial by products is practiced by some farmers of the study area. • This technology demands cash and input
Machine chopping of residues	44	8	• This technology is cash intensive, while its demand for input is also higher than other attributes
Smart feeding (targeted use of bought-in concentrates to target productive animals)	42	9	• This technology is new and demanding cash, input and knowledge for implementation • Farmers needs to be capacitated through different approach like training, improvement of credit accessibility and input supply
Supplement with UMMB	41	10	• This technology is demanding cash/credit and input • Establishment of local processor of UMMB is important to improve farmers accessibility to the technology

Cost benefit analysis

Twelve top ranked technologies were analyzed for their economic advantages using benefit cost ratio (Table 7). Technologies with quotients of benefit to cost ratio greater than or equal to one were considered as economically advantageous. Benefit cost ratio (BCR) of feeding of home grown legume residue which came at top of all technologies across all location was 1.38, 1.36 and 1.22 for Selka, Sambitu and Walta'i Barisa *kebeles* respectively. Among the selected technologies; use of weeds, cut grass and tree leaves, hand chopping of residues, treatment of crop residues and machine chopping of residues have value of BCR below unity (Table 7). Higher total cost needed for the implementation of these technologies due to additional expenses leads to lower benefit cost ratio (Annex 2). Use of improved annual grass-legume mixture (e.g. oat-vetch forage or hay) scored highest BCR value 1.74 and 1.71 at Selka and Sambitu *kebele,* where 'fodder trees (Sesbania, Tagasaste, Gliricidia)' scored highest BCR of 1.25 at Walta'i Barisa *kebele*. However, the current results need to be interpreted with caution as most of the values used in the cost-benefit analysis were based on assumptions.

Table 7: Cost benefit analysis of three top ranked technologies at three *kebeles* in terms of benefit cost ratio (BCR)

Technology Prioritized	**Benefit cost ratio(BCR)**		
	Selka *kebele*	Sambitu *kebele*	Wata'i Barisa *kebele*
Feeding of home grown legume residues	1.38	1.36	1.22
Use of weeds, cut grass, tree leaves	0.86	0.85	0.85
Re-threshing and mixing of crop residue before storage and feeding	1.18	1.09	1.08
Hand chopping of residues	0.79	0.77	0.76
Supplement with agro-industrial by-products	1.02	1.08	1.15
Generous feeding of CRs	1.36	1.22	1.18
Fodder trees (Sesbania, Tagasaste, Gliricidia)	1.32	1.28	1.25
Smart feeding (targeted use of bought-in concentrates to target productive animals)	1.03	1.09	1.15
Treatment of crop residues (e.g. urea treatment)	0.68	0.61	-
Use of improved annual grass-legume mixture (e.g. oat-vetch forage or hay)	1.74	1.71	-
Machine chopping of residues	0.60	0.58	0.58
Supplement with UMMB	1.09	1.12	1.13

Conclusions

Contribution of the livestock sector to livelihood of farming community of Sinana district is high. However, production and productivity of livestock is hindered by problems of feed shortage (both in quality and availability). Shrinkage of grazing land due to expansion of crop land put heavy pressure on the livestock sector. The dominantly used feed resources are mainly crop residues, which are derived from the cropping systems. In order to alleviate feed shortage problems and enhance the contribution of livestock to the livelihood of the farming community, different technologies were generated by the research system. However, the adoption rate of these technologies has been disappointingly very low due to lack of systematic approach for prioritizing the recommended technologies for specific locations. TechFit has been developed to alleviate this problem in prioritizing suitable feed technologies for specific locations as reported here. It has helped us to identify and prioritize feed technologies that are applicable and suitable to the different kebeles in Sinana district. In general, it is a robust tool for screening and excluding feed technologies that are not relevant in a particular context and for prioritizing those technologies that are relevant and potentially applicable in a given area.

Challenges and limitations

- Most of prioritized feed technologies cannot be used as sole diets and this created some difficulties on estimation of total costs incurred and benefits obtained due to use of a given technology.
- Cost benefit analysis was done based on assumption. Based on the degree of deviation of the assumption from the true value, there could be a risk of rejecting technologies that might be of high potential value in addressing the feed problem or accepting one that might of marginal importance.

Lessons learned

- TechFit tool helps to identify and prioritize appropriate feed technologies for a particular location with realization of the existing situation of the area within a short period of time.
- The tool is very important to identify and exclude non relevant technologies for a given area before making any intervention.

The way forward

- Provision of training for farmers to strengthen their knowledge and skill for efficient utilization of prioritized technologies is needed.
- Improvement of input supply system through cooperative and organizing farmers could be useful to address the problem of input supply.
- Improvement of farmers' access to credit/cash through development of well refined system of credit service is crucial.
- Awareness creation on saving culture and appropriate utilization of credit/cash for the farmers is important.
- Developing well refined methodology for cost benefit analysis is very important to recommend prioritized technologies based on their economic advantages.

Comparison of FEAST and Techfit Findings

The FEAST result revealed that feed shortage is a critical constraint of livestock production and productivity in the study area (Dawit *et al.,* 2012 unpublished data). Solutions suggested by the farmers to address this constraint included proper utilization of available feed resources, cultivation of improved forages and destocking. Most of the technologies prioritized by Techfit focus on crop residue improvement, which are in line with the suggestion of the farmers regarding proper utilization of available feed resources. Result of this study also indicated that production of fodder trees at all *kebeles* and use of improved annual grass-legume mixture at Selka and Sambitu *kebeles* is viable, which is also in agreement with farmers' solution of producing improved forage crops. Techfit result also showed that supplement with agro-industrial by-products, smart feeding and supplement with UMMB are potential technologies for intervention although these were not suggested by the farmers.

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Annex 1: Lists of technologies options to address feed shortage problems

1. **Improvements of crop residues**
    1.1. Machine chopping of residues
    1.2. Hand chopping of residues
    1.3. Generous feeding of crop residues
    1.4. Treatment of crop residues (e.g. urea treatment)
    1.5. Feeding of home grown legume residues
    1.6. Feeding of bought in legume residues
    1.7. Re-threshing and mixing of crop residues before storage and feeding
2. **Supplementation**
    2.1. Supplement with home-produced local brewers waste
    2.2. Supplement with bought in local brewers waste
    2.3. Supplement with UMMB
    2.4. Supplement with agro-industrial by-products (wheat bran, wheat middling, oilseed cakes, pulse crop milling by-products such as lentil bran and hulls, etc.)
    2.5. Use leaves and/or pods of farm trees (e.g. Acacias, Milletiaetc)
    2.6. Use of oats grain and hulls for supplementary feeding
    2.7. Commercial dairy supplements
    2.8. Poultry litter
3. **Feed conservation**
    3.1. Feed conservation of private natural pasture (surplus) (HAY)
    3.2. Making hay from cultivated annual fodder wth readily available seed (e.g. oats/vetch)
    3.3. Making hay from cultivated perennial fodder wth specialist seed (e.g. alfalfa, Rhodes)
    3.4. Buying baled day (e.g. oats/vetch, Rhodes grass)
    3.5. Feed conservation (SILAGE)
    3.6. Fodder tree leaf meal
4. **Improved forages**
    4.1. Fodder beet for cooler highlands
    4.2. Improved forage grasses (Napier grass, Rhodes grass)
    4.3. Improved forage legumes (Alfalfa, Desmodium spp.)
    4.4. Fodder trees (Sesbania, Leucaena, Tagasaste, Gliricidia)
    4.5. Fodder trees - dual purpose (Pigeon pea)
    4.6. Use of improved annual grass-legume mixture (e.g. oat-vetch forage or hay)
    4.7. Use of improved perennial grass-legume mixture (e.g. oat-vetch forage or hay)
5. **Feeds from cropping systems**
    5.1. Thinning (e.g. maize and/or sorghum - cutting green at knee height)
    5.2. Use of enset and/or banana leaves and by-products
    5.3. crop/forage intercropping (Sorghum/cowpea for dry areas and Maize/lablab for wetter areas)
    5.4. Use of weeds, cut grass, tree leaves
    5.5. Use of tops, leaf strips (e.g. maize or sorghum)
    5.6. Root and tubers - use of by-products
    5.7. Vegetable waste
    5.8. Root and tubers - dedicated use
6. **Balancing feeds**
    6.1. Smart feeding (targeted use of bought-in concentrates to target productive animals)
    6.2. Complete feed-TMR (mash, block, pellet)

Annex 2: Approaches used to estimate cost and benefits of selected technologies to evaluate for economical merit

Technologies	**Costs**	**Benefits**
Feeding of home grown legume residues	• Estimated total cost of straw, feeding troughs and labour is 106, 103 and 115 ETB for Selka, Sambitu and Walta'i Barisa *kebeles* respectively	• Increased body weight(5 kg weight gain expected after 90 days) • Manure production increased • Total benefit obtained 140.5 ETB*****
Use of weeds, cut grass, tree leaves	• Estimated cost of grass, labour and construction of feeding troughs and other tools is 253, 258 and 259 ETB Selka, Sambitu and Walta'i Barisa respecitively.	• Increased body weight (7.5 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 218.75 ETB*****
Re-threshing and mixing of crop residue before storage and feeding	• Estimated cost of straw, feeding troughs and labour is 117, 127 and 128 ETB for Selka, Sambitu and Walta'i Barisa *kebeles* respectively	• Increased body weight (4 kg weight gain expected after 90 days) • Manure production increased Total benefit obtained 138 ETB*****
Hand chopping of residues	• Estimated cost of straw, labour, hand chopper and feeding troughs is 174, 176 and 178 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily.	• Increased body weight (4 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 135 ETB*****
Supplement with agro-industrial by-products	• Estimated cost of agro industrial by product, labour, feeding troughs and other tools is 234.8, 221.95 and 209 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily.	• Increased body weight (9 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 239.5 ETB*****
Generous feeding of Crop residues	• Estimated cost of straw, labour, feeding troughs and other tools is 107, 119 and 123 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily.	• Increased body weight (4 kg weight gain expected after 90 day) • Manure production increased • Total benefit accrued 145 ETB*****
Fodder trees (Sesbania, Tagasaste, Gliricidia)	• Estimated cost of land lease, input (seed and fertilize), labour and tools and facilities is 126.3, 130.2 and 134 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily.	• Increased body weight (7 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 167 ETB*****

Smart feeding (targeted use of bought-in concentrates to target productive animals)	• Estimated cost for concentrates, labour, feeding troughs and other tools is 297.8, 281.55 and 265.3 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily..	• Increased body weight (12 kg weight gain expected after 90 day) • Manure production increased Total benefit obtained 306 ETB*****
Treatment of crop residues (e.g. urea treatment)	• Estimated cost straw, labour, input (fertilizer, plastic sheet etc.) and for construction of silo and feeding troughs is 339.5, 377 and 384.5 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily.	• Increased body weight (8 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 230 ETB*****
Use of improved annual grass-legume mixture (e.g. oat-vetch forage or hay)	• Estimated cost of land lease, input (seed and fertilize), labour, tools and facilities is 149.2, 151.8 and 154.4 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily.	• Increased body weight (10 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 260 ETB*****
Machine chopping of residues	• Cost of machine/chopper, straw, labour and facilities/feeding trough is 218, 221 and 223 ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily	• Increased body weight (4 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 130 ETB*****
Supplement with UMMB	• Estimated cost for input(molasses, cement, concentrates, urea etc), labour and other facilities is 153, 148, 147 and ETB Selka, Sambitu and Walta'i Barisa *kebeles* respecivily	• Increased body weight (6 kg weight gain expected after 90 day) • Manure production increased • Total benefit obtained 166.25 ETB*

*****= an estimated value incurred from increased manure production is added to total benefit

Assumption: Price per kilogram weight of sheep =22.5 ETB