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Kenya field work in Marsabit and Wajir Counties, 19 May 2016-28 May 2016.

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Overview of the report.

There were two main objectives in the terms of reference for this consultancy. Objective a) was to analyze the fodder value chain in the two counties of Marsabit and Wajir[1]. Objective b) was to assess the potential connection of the fodder value chain to the livestock marketing value chain, in particular though the practice of animal fattening prior to marketing. In the verbal briefing before departure to the study sites, there was also a request to provide broader advice on the more general issues of livestock marketing value chain development. In light of this, there is an additional section c) collecting some of my observations on current opportunities in the broader live animal market value chain that I noted in my visits to the two counties.

In terms of theme a), I found that there is not really a fodder value chain in either county currently in any significant form. There is fodder production in both counties and some basic fodder marketing in Wajir. The Wajir production system has been in existence longer than the Marsabit production system, though both areas have longer histories of collection of natural pastures and use and sale of collected hay. In the sites I visited in Wajir hay operations involving production and marketing began around 2013. In Marsabit they began in 2015. Wajir is more advanced in production than Marsabit, and slightly more advanced in marketing, although in both cases production is far ahead of marketing currently. In neither county did fodder production and marketing appear to be widespread. There are some early adoptors we visited in each area. In all cases I visited there was some element of donor involvement with the introduction of fodder production and to a lesser extent in marketing. In terms of theme b) using fodders for fattening for markets is understood as a concept by some of the people we interviewed, and there is some awareness of the practice in ranches in Kenya and feedlots in Ethiopia. It was raised as a possiblity, but producing fodders and using them in fattening operations was not in practice. There is an interest explicitly expressed by a few of the people we visited in seeing how the concept could be brought into practice among the more intensive livestock producers of the two counties, while recognizing that extensive livestock production remains the predominant if not almost exclusive means of livestock production currently. The idea is to add an intensive production phase to add value to animals raised in the extensive production system by moving them into a more intensive production system prior to marketing. A variant on this idea is to use fodders in support of generating a more steady supply of milk

[1] Note the original TOR identified Isiolo and the NRT as cases to consider. The itinerary that was developed in advance of the visit did not include these sites so the report is adjusted according to where visits were conducted. The final itinerary is included as appendix A.

over time using supplemental feeding in peri-urban dairy production. Moving from an understanding of the basic concept of intensive production for value addition to actually implementing the idea in these two counties will require research and extension support. The people I spoke to who were interested in the idea asked for help and advice since they were not sure how to do it. These are new ideas where the broad outlines are evident but the details remain to be filled in. ILRI through AVCD together with KALRO (and other development partners) should be able to develop targeted research on feeding trials and some basic extension messages that would lead to activities more likely to achieve sustainable success for fattening operations. Research could also help to match feed needs over changing seasonal conditions to the needs of different species in milk production while also paying attention to the price structure of the dairy market. Finally, there are opportunities for raising hay as a business, for sale to the County government, for sale to producers, and for potential use in support of Index Based Livestock Insurance (IBLI) or other livestock insurance products. Research in the specifics of that are very preliminary and some broad findings are presented in this report that can certainly be refined with further study. In terms of theme c) I will identify a few specific markets that were identified during my visit that may hold special potential for value added livestock production within the two counties as a new element of the livestock production and marketing system. As a final note which is related to but broader than this final topic, the newly surfaced road between Moyale and Isiolo (with still about 20 km to go in Marsabit and less than 10 km to go entering Moyale town) has opened up new opportunities. Some marketing options are possible now that were not before. I will try to identify some, but to highlight a theme of this final section, there are all kinds of sub markets within the livestock sector to identify and assess the potential for value added intensified production in the two counties. I almost certainly missed some in my short visit, and in any case, these are always changing as larger market forces change. So I close with a note that we need to constantly be on the lookout for market opportunities that may arise that an intensive sub-sector can entrepreneurially react to and from which producers can benefit.

Introduction to the production system:

To orient the role of fodder production in the overall livestock production system, we can begin with a brief oveview of the livestock production system in Marsabit County. I have spent more time in Marsabit county so it is the case I can describe with more detail. While Wajir does not have the same degree of 'highland -lowland' contrast I develop in this section, many of the basic points regarding the growth of towns in higher potential areas (in the case of Wajir the distinction is the relatively accessible water table leading to the potential for irrigation) compared to more remote rangelands carry through as variations on the basic theme developed in this section.

Marsabit County possesses vast lowland grazing areas that contain within them numerous water points. There are also a few highland areas that are higher potential zones, such as Marsabit Mountain, Mount Kulal, the Hurri Hills, and the borderland from Sololo to Moyale that is the start of the rise to the Borana Plateau. It is also worth noting that the area is characterized by a bimodal rainy pattern, so there are two rainy seasons and two dry seasons per year.

We can take the example of the livestock migration pattern for the Gabra of Marsabit for whom I have the most detailed understanding to begin to understand the extensive production system. Reaching back into the pre-colonial historical past for context, households moved the herd and the house into the higher elevation / rainfall areas such as the Hurri Hills during the rainy season and used seasonal ponds and streams in the hills for water and newly grown pasture and leaves on trees and bushes for grazing and browsing. As the rainy season drew to a close and the surface water dried out, herders broke their houses down, put them on camels, and moved down into the lowlands where there were permanent wells and extensive pastures that had grown during the rainy season. There was also an element of mutual protection to the highland residence during the rains, as livestock raids are more likely to be successful in the rainy season when there were many options for paths to escape that ensured access to water than in the dry season with limited water options and associated escape paths, so they also clustered in the highlands to reduce exposure to potential raids (Robinson 1984).

Over time, towns grew up around these permanent water points in the lowlands, giving us for example Kargi, Korr, North Horr, Turbi, and Merille to name but a few. The growth of the lowland towns became rapid in the 1970s and continues to this day (Tablino 1999, Sobania 1979). A new grazing pattern emerged in response. In most places, permanent settlements were established, largely composed of traditional dwellings in an outer circle with more permanent mud brick structures in the center where the commerce and mission / mosque/ schools/ health centers were found. Police posts and other administrative functions were established in these towns making them safer to reside in year round. Livestock migration patterns largely moved to a base camp – satellite camp pattern, where a core lactating herd was kept within a 10 kilometer radius around town and the majority of the herd went to remote satellite camps outside of this zone during the dry season with a subset of the household's herding labor force. The herd (and family) would often come together during the rainy season, to split again as rains ended and water and pasture became scarce. In the case of the Gabra, this basic pattern holds true, but the base camp still generally moves closer to town in the rainy season, still moving the whole home and family further from town in the dry season while still also utilizing in many cases satellite camps (McPeak 2004). In Rendille areas, in contrast, the

base camp only makes short moves within a small area if at all. In both settings, however, large parts of the herd are distant from the town in remote camps for much of the dry season. In the lowlands, livestock and milk are sold from the herds intermittenly in the small market towns like those named at the start of this paragraph (McPeak 2005, Green et al. 2006). The physical seperation of the herds makes sales more complicated in the dry season, as the animals that might be sold are distant from markets.

While this transition in mobility was occuring in the lowlands, higher elevation areas were also undergoing change. Originally established in the colonial era, the town of Marsabit did not have a very large permanent population during the colonial years. One of the earliest groups to permanently settle in Marsabit were the Burgi, who were brought in from Ethiopia by the colonial government to establish a basis for permanent cultivation on the mountain (Sobania 1979). The shoulders of the mountains were seasonally used by Rendille, Samburu (usually in alliance with the Rendille), Gabra, and Borana herders at various times. The growth of service provision in towns such as Marsabit, Sololo and Moyale combined with the impact of herd losses in droughts in the mid 80s, early 90s, late 90s, and repeatedly about every 4 years until now. This has led to progressive waves of settlement in the higher potential areas of the County by families of pastoral origin, largely from the lowlands of the county. In addition, the political turmoil that has periodically taken place in Ethiopia also has led to intermittent flows of Boran into the higher elevation areas of Marsabit County. The current situation is that there is a distinct community of Gabra largely resident in the area of Marsabit town oriented towards the north-west and center, a community of Boran oriented towards the north east and center of the mountain, a Rendille-Ariaal-Samburu community oriented towards the south-east (from Songa) to the south-west (Hulahula) of the mountian, and a Burgi community close to town on the north / northeast side of the mountain. The town center is an ethnic mix of people from all parts of Kenya and elsewhere (Roba and Witzenburg).

I spent a little time dwelling on this context to make the following contention. The role of fodder production is, with the exception of drought events as will be elaborated below, not likely to have much of a role to play in the lowland extensive livestock production system. Lowland production will remain based on bringing the animals to where there is water and feed in adaption to seasonal changes in availability. Herds will continue to be multi species, composed of 2/3rds of female stock, and managed to produce a steady supply of milk to support household consumption. Livestock will continue to be sold from household herds with a rough pattern of one head of smallstock (goats and sheep) sold per month to support household consumption needs and larger stock, predominantly cattle but at times camels, sold to meet larger needs such as health, education, or marriage expenses. The economic logic of the study area will continue to be dominated by the logic of the 'caloric terms of trade' where an equal cash value of milk/ meat compared to the same cash value of grains finds the grain offering caloric values multiple times larger than that generated by the livestock products. Milk will also continue to be sold in the small towns after being brought in from the rangeland areas, but is largely if not exclusively destined for the local market given the vast distances to cover to move it out of this market and the lack of any kind of cold chain for milk products in this setting. At a few points in this visit, it was expressed to me that it was unclear how fodder production could transform traditional extensive production systems. So let me state clearly; I don't think that fodder production and value chains can directly transform extensive production systems in

the lowlands in any significant way. Rather, the main opportunity lies in the higher potential areas, either the more highland areas in Marsabit or the lowland areas where irrigation is possible in Wajir. There is an opportunity to build a new set of value added practices into the overall production system and produce within these counties higher weight animals that might be particulary attractive to higher return markets. A variant of this production opportunity would be to use the fodders to support more stable and higher levels of milk production in peri-urban production settings where there is existing and potentially unmet demand for milk.

In my estimation, the situation with the potential to be changed by the production of fodders is that found in the higher elevation / higher rainfall areas and these areas are connected to the lowland production system in ways that can be strengthened. I would concentrate production and marketing activities in these areas. While there are a few areas of Marsabit, Sololo, and Moyale where rainfed and / or irrigated crop cultivation is viable, there are many more that have been settled where rainfed cultivation is possible, but is a highly risky prospect. People settling on the shoulders of the higher elevation areas have largely had the experience of failed crops, focused on maize and bean production, that rarely lead to significant harvests and often lead to harvests that are entirely fodder crops as no grains or beans are produced. What we observed are initial steps towards hay production as a business with a potential supporting role for other animal production objectives. The more settled population could potentiallyembrace what fodder production as an explicit objective instead of it being the default back up plan for crops that fail to fully mature. The rainfall and irrigation requirements of the fodder / hay production systems seem much more in line with the rainfall patterns / water table accessibility levels that are found in these areas. They also appear to hold the potential to create new value added production opportunities in the Counties that are linked to the production opportunities in the lowlands and areas where access to irrigation water is more difficult. That is the case I will be trying to build in this report for Marsabit County and Wajir County.

A) Fodders.

AM) Fodder in Marsabit.

AM1) The fodder production system in Marsabit County

Fodder production is relatively new concept in Marsabit. However, two related concepts have been in place in the area that share a similar logic. First, there is a long history of cutting natural pasture and bringing it to animals for home production. This has been a relatively small scale activity, more commonly found in the higher potential areas, and to my understanding was generally practiced by women in support of family owned livestock – particularly home based dairy animals and calves. One of the contact fodder growers we interviewed in Sololo explicitly referenced her desire to grow hay as an alternative to climbing the steep terrain around Sololo town in search of grass to bring to animals, saying that the search for natural hay was exhausting and dangerous.

Another practice of note is the *kalo* system in Boran culture, and the more general practice in many of the cultures of the study area to reserve particular grazing areas. To focus on the case of the *kalo, t*raditionally this was a grazing area left for the use of lactating and / or sick animals near the residences of the households. These have increasingly become fenced in

areas using tree branches to form the walls. There has been debate in Boran culture as to whether these *kalo* areas should be individually owned or communually owned. The traditional leadership of the *Gada* –and age set based governance institution (Legesse 1973)-has pronounced that individual *kalo* are not consistent with Boran culture but communal *kalo* are acceptable (Bassi, Oba). These kinds of reserve areas arose in our discussions with Boran hay producers as the cultural category of the places where they produced hay. I focus here on the *kalo* but note leaving specific areas ungrazed by design is observed in other parts of the County by other ethnic groups as well.

To the more specific question of the economic rationale of hay production in Marsabit County, three distinct reasons arose in our discussions with people about this topic. We can think of these as three distinct reasons people articulated when asked why they were interested in starting hay production. The first reason was a long term growing disillusionment with the cultivation of maize and bean crops that failed more than they succeded. There was a sense that they had given this a try over the past 25-35 years and it was either not working as well as it did in the past[2] or just plain did not ever really work. There was a sense that it was time to try growing something else and the idea of hay for sale seemed worth a try. The second reason for adopting hay production people identified was in response to the drought series over 2009-2011 in northern Kenya. A few different motivations were noted as a result of this drought. First, Marsabit County harvested hay on top of the Hurri Hills and made it available for emergency feed while also sending out for fodders from Naivasha. This introduced the idea of moving feed to livestock in a drought year when moving livestock to feed was increasingly problematic was seen to have had some success.[3] Second, some people with financial resources in the droughts reported they bought very thin animals at very low prices from producers in the lowlands, restored their body condition using hay and even fattened some for market, and made very big profit margins on their resale in the livestock market. Margins to fattening operations can be very high in droughts. The third reason people identified in Marsabit county was the possibility that the completion of the tarmac road up the south side of the mountian could make more intense dairy production more viable and access to distant livestock markets less problematic. A common site from 1980 to the mid 2000s was a line of young women from Karare, Parkeshon, and Hula Hula walking up the mountain carrying milk to sell in Marsabit in the morning and walking home with empty containers in the evening, which is up to a 40 kilometer round trip walk. With the new road going in, and I speculate perhaps the impact of universal primary education, it was reported that the milk is going to town on vehicles rather than being walked in by young women and girls. There is interest in using places in the middle altitude ranges of the mountian as zones of collecting milk from the lowland and middle altitude production systems to send to higher altitude Marsabit town, perhaps after processing to improve milk hygeine and obtain a higher price per liter. I also was hearing reports that the

[2] There is often the theory advanced that in the 70s and 80s cultivation was more successful as the fog bank on the top of the Mountain in the rainy seasons was thicker, lasted longer in the day, and lasted more days. The increased settlement on the mountain and encroachment into the forest is said to have reduced forest cover on top of the mountain leading to less moisture capture, reducing the odds of cultivation being successful.

[3] I would note that when I lived in Marsabit in the 2000 drought there was some provision of animal feed concentrate in Marsabit District by people with whom I shared the compound and I had a distinct impression that there was unmet demand for animal feeds in this drought.

travel time to get livestock from the County to the Nairobi market had been reduced dramatically. This raised the possibllity that animals fattened for sale would arrive in Nairobi in better condition thus preserving more of the value added in the County.

The introduction of fodder production, or hay as a business, by the USAID funded REGAL AG project was the predominant focus of our mission to Marsabit. I would note at the outset that REGAL AG is not the only agency focusing on the fodder production opportunity and we will note some of the others later in the report in more detail, as we also found the WFP, the county livestock office, KALRO, and others were actively involved in fodder production activities. This next section describes what we saw when visiting producers and markets in Marsabit County on our trip for AVCD .

The most common fodder crop we encountered was *Cenchrus Ciliaris*, commonly called buffelgrass in the United States. It is a grass that has a long history of growing naturally in East Africa and by some reports is indigenous to Kenya. The origins of the seeds used in the Marsabit plantings by REGAL AG came from Baringo, where they are currently being produced for seed. The origin of the Baringo seeds in turn appears to have been KARI / KALRO Kiboko.

Photo 1: Buffelgrass, *Cenchrus Ciliaris*

The next most common fodder crop we encountered was *Eragrostia superba*, or Maasai lab grass. This also was explained as coming from Baringo and before then from Kiboko station. Both the buffelgrass and the Maasai lab grass were possible to cultivate under exclusively rainfed conditions in most of the higher elevation fields of Marsabit County.

Photo2: Maasai lab grass, Erogrostia Superba.

We heard some reports of Sudan grass and Napier grass but did not encounter any in Marsabit though we did in Wajir and will report on this later. There were reports that these two more water intensive grasses may be currently produced in Kalacha Goda, a natural spring creating irrigation near Kalacha town, and along Lag Balal, a seasonal river that flows towards the Chalbi Desert between Kalacha and North Horr towns. We were not able to verify this and it merits further investigation. The other kind of hay production we encountered was taking what grows in a field that is not seeded with a particular species, cut it, dry it, and use it for hay. In some contexts, this amounts to taking what is produced by 'mowing the lawn' and turning it into hay bales, in others it is harvesting what is in a field. Note the 'mowing the lawn' variant was taking place on the compound of the secondary school in Karare, in the Kenya Broadcasting Company's compound in Marsabit, and in the lawn around the Jarima Hotel where we stayed while conducting this consultancy!

Photo 3: Cut hay ready for baling in the Secondary School compound in Karare

Photo 4. Protected pasture of mixed species with straying cow soon to be chased out in Sololo.

The first area we visited was Karare, where Angelina was working with Regal AG on the fodder production and Regal IR on a dairy production unit. I have known Angelina since the late 1990s, and I know Angelina has for many years run various dairy marketing operations. Angelina lives in the 'Scheme' part of Karare, where the original African Inland Church irrigation infrastructure was set up and her father was one of the original founders of Karare town.

Angelina built a hay barn and below in Photo 5 is the view of the exterior of the barn from in front of her house (facing east). This is followed by a photo of the interior of the barn with hay stored from the crop that was planted in November 2015. She was intending to use the hay in support of the dairy. The hay is first harvested and left to dry in the field as in Photo 3 (she is intending to harvest the grass you see in Photo 3 and put it in the barn seen in Photos 4 and 5). In the case of the cut grass seen in Photo 3, she gave the secondary school 35,000 KSH to rent the tractor and harvester to cut the grass on their compound. The field produced 1,600 bales the first time she harvested (some of those bales are seen in figure 2). I believe the first time the grass was manually harvested. She estimated there would be 600 this season and she had used the tractor to harvest. The difference in volume is due to the type of rainy season experienced, not the harvest technique.

Given these figures, machine harvesting costs between 22 (if 1,600 bales) to 60 (if 600 bales) KSH per bale. The grass that is cut by machine is then hand baled, with workers being paid 400 KSH per day to bale, each being able to produce about 50-60 bales per day, where bales are put in a baling box and then hand tied with twine. That works out to about 8 KSH per bale for labor. Some additonal cost is due to the purchase of twine which was not specified but said to not be very large. She was not as oriented towards marketing these bales as some of the other producers discussed later, but as a estimate of the price in the market, bales of this kind were selling for at least 400 KSH per bale. That implies a gross profit of 370 to 332 KSH per bale.

Photo 5 : Angelina's Hay Barn in Karare

Photo 6: Hay inside the hay barn from the short rains 2015 crop in May 2016, Karare.

Angelina was one of the members of the ATIRI milk production cooperative that was a collaboration with KARI and was in operation when I lived in Marsabit in 1999-2002. It went out of business at some point following my time in Marsabit. I asked Angelina what made that not succeed and what would make the proposed milk production operation succeed. Her answer was that the ATIRI project was a cooperative and suffered from the management problems of cooperatives. The current initiative was to be run by herself, and she felt confident that was more likely to succeed. She was targeting a daily volume of 3000 liters of milk. She was intending to buy cattle milk at 90 KSH per liter, process it, and sell it for 120 KSH in the Marsabit market. The current price of unprocessed milk was 90 KSH per liter in the Marsabit market. Her rationale for buying it in Karare for the Marsabit price was to ensure that she had a steady local supply; they could sell it to her in Karare for 90 KSH per liter or pay to transport it to market and then still get 90 KSH per liter. She also was hoping to move into camel milk, which she hoped to be able to sell in processed form in Marsabit for 150 KSH per liter.

Photo 7. Foundation for the dairy processing plant in Karare Kenya.

Our next stop was with Pastor Charles of the Mile 62 Hay Barn near Marsabit town. He began hay production 3 years ago, before receiving assistance from Regal AG. He was harvesting naturally growing pasture similar to what we just considerd for Angelina, and was hoping to increase his scale of operations. He reported at that time, he was harvesting 4 acres of natural pasture and making around 10,000 KSH per year ($100 per year) and storing the hay in a metal barn similar to the one seen above in Photo 5.

REGAL AG had built a hay barn on his property, and also had provided him with some equipement (see photo gallery 8). The model was explained to us that a central barn managed by an individual with equipment would collaborate with a network of smaller producers who would also store their produced hay in the barn and potentially have access to this equipmen. He described himself as director of employees for the farm.

Photo gallery 8: Left column, hay barn, right column, mechanical hay baler (and Steve and Simon)

In the barn, there were currently around 75 bales. Each bale was worth around 400 KSH, for a total inventory value of around 30,000 KSH.

He was beginning to plan the harvest for the current standing crop which had a little more growing and drying to do. He estimated the standing crop he would harvest was 600 to 1000 bales, and he was harvesting from the Police line compound, the Jarima hotel (where we were staying), and the Kenya Broadcasting Company compound in addition to his 4 acre plot. Since we don't have a good estimate of the surface area, we can't calculate a yield per acre in this case.

He was pricing units that were hand baled at 400 KSH per bale and these generally were 12-13 kilograms per bale. That works out to 32 KSH per kilogram using the midpoint of 12.5 kg per bale. Taking the midpoint of the estimate of the standing crop of 800 bales at 400 KSH per bale that is 320,000 KSH in revenue for this harvest season.

He also was starting to produce the machine baled units now that he had the baler. These weighed around 25 kg per unit and he was selling at 700 per unit. That works out to 24 KSH per kilogram, less than was charged for the hand baled units per kilogram. It was unclear if this was by design or a pricing inconsistency as I did not do the per kilogram calculations until after the visit. This could be followed up on in further visits.

Currently he is growing some buffelgrass and harvesting the seed. He first planted it in the long rains of 2013; note that this is before the REGAL AG effort. He reported that in the first season, there is no harvest, as you let it grow and drop seed to establish itself, then you can begin to harvest at the end of the second rainy season.

The seed is said to sell for up to 1000 KSH per kilogram. To harvest it, he pays labor to manually collect the seed 500 KSH per day. We were not able to arrive at an estimate of the kilograms of seed collected per worker per day, so that remains a question to investigate. He did estimate that he could get 100 kilograms of seeds per acre. As a cross-check, a Texas buffelgrass seed producing company estimates seed production in the 20 to 70 kg per acre per year range so the 100 kg per acre estimate might be a bit high. If we assume there are two harvests per year – one per rainy season- each harvest with 100 kg of seed times 1000 KSH per kg that is 100,000 KSH per harvest, 200,000 KSH per year, or around $2,000. He noted he had on hand somewhere between 50 and 100 kilograms of buffelgrass seeds so there may be issues with marketing the seeds to resolve in the future. A topic for further research would be gaining further precision on estimates of returns that are possible in the fodder seed market, as well as the overall functioning of the fodder seed market, which is currently not getting much attention and could be a topic of more analysis going forward.

Over the past few years he has sold hay to some of the wealthier merchants in Marsabit who have large dairy herds. He also noted that he has had people come from as far as Gus and Maikona to buy his fodder in the past (these are towns in the lowlands on the border of the Chalbi desert).

He also reported he has planted beans for stover in the past, where these are sold for 1000 KSH per bale and he can get 200-250 bales per acre which converts to 200,000 to 250,000 KSH per acre per year, or around $5,000 to $6000 per hectare for revenue. That does not take into account the cost of labor or seed. Assuming beans are more water demanding and produce only one marketable crop a year (not based on any evidence but my speculation) these estimates could be taken as revenue per year. Note one of the cautions on the Texas seed production advisory sheet is that buffelgrass is nitrogen and phosphorus demanding. Some kind of rotation with a nitrogen fixing legume could help address the nitrogen part of this concern.

An interesting note on his entrepeneurial strategy is that he was hoping to buy a Fresian cow and begin milk production on his farm. His objective was not to move into dairy, but to demonstrate for others the potential for hay fed high performing dairy breeds to lead to increased profits in this production environment. In essence, he was trying to create demand for his hay by demonstrating the potential of hay fed high performing dairy animals.

He was currently buying hay and hay bales from producers in a 1-2 kilometer radius of his barn. He is buying them at 150 KSh per bale and selling them at 400 KSH per bale for a per bale margin of 250 KSH. In some cases, he has taken a tractor as far as Dirib Gumbo to buy from producers further from his barn and bring it back to his farm. He has been trying to rent the county tractor at a rate of 1000 KSH per hour, but has been having problems getting access to the tractor.[4] This would mean he would break even on anything more than 4 bales of hay per hour of tractor rental.

We discussed the challenge of getting the right kind of tractor for the equipment he had been given, noting that the mechanical bailer needed both the power train drive and the hydraulic hook up to move parts up and down. It was not clear that the equipment available would necessarily be suited to the configuration of the equipment he had received.

Our next visit was to Habiba, who had a field of buffelgrass and Maasai lab grass that she first seeded in November 2015. She had seeded 12 of 100 total acres that she had available in this area. She used tractors to till the 12 acres, and broadcast the seeds. She explicitly noted that in the past she has tried to cultivate maize and beans in this area and has come to the conclusion that that is not going to work and something else needs to be tried. She has an idea of running a feedlot, and has an application into REGAL AG to support her in this effort. She would like to explore whether it makes sense to buy animals from down in the Chalbi basin and bring up to her site on the mountain in Badassa for fattening. She is considering fattening either 100 head of cattle for 6 months or 200 head of goats for 3 months. Her field is next to a gorge, which she says has water for 4-5 months of the year and she is considering building a dam to see if she can extend the time that water is available. Her major constraint to clearing more of her land for seed production is that bush clearing is time consuming and labor intensive. There also is no hay storage currently at the site where she is growing the fodder. She noted that animal, bird, insect, and theft are currently not major problems she is experiencing in the production of the fodder crop. She was just beginning to harvest seeds when we visited her. She has not harvested yet so she has not yet come to an estimate of the size of her harvest per acre. It was unclear whether the fattening operation she envisioned would use the standing fodder for grazing to fatten the animals or whether it would be harvested, baled, and given to animals. The lack of a storage facility was identified as an issue to confront in the future. She is open to technical advice on the options before her on the fattening operation. The Wajir value chain report has a list of some of the higher end meat butchers other fattening operations are targeting in Nairobi and she might benefit from being put in contact with them to get specificaitons on what they would be looking for her to produce.

[4] It was suggested that this had to do some with the exclusion of Pastor David from the ethnic networks that ease access to tractors. He is from Meru, and is thus an outsider to the dominant ethnic groups that are present in Marsabit County politics.

This could be an opportunity to connect Marsabit producers to a higher return value chain than they are currently using, and could serve as an example if it can be made to work.

Photo 9: Buffelgrass and Maasai Lab Grass in Habiba's field. Paul, Simon, Habiba, Steve.

Our next visit was to the Guleid farm in Sololo. The barn on this farm has a 10,000 bale capacity and has recently been completed. He has been harvesting using hay boxes and the hand baled units wiegh 7-12 kg each. He aims for 12 kg per bale. He pays 250 KSH per bale when he buys them from producers in his network. During our visit there were around 72 bales in the storage unit that had opened last month (April 2016). He had rebaled some manually baled units with the mechanical baler he had recently received to see how it operated. These averaged 26 kg when baled. The manual bales he sold 500 KSH per bale and they were in the 12-13 kg range per bale. This works out to around 40 KSH per kg for manually baled units. The machine baled units he was selling for 600 per unit, which works out to 23 KSH per kg. Again, it is unclear if this difference in pricing per unit by size is deliberate or inconsistent unit pricing; by rebaling the traditional bales he actually decreased his revenue under the current pricing scheme.

He also was looking into tractor options as he had also received the suite of equipment illustrated in photo 7. He had found a private tractor operator who provided an estimate of 1,500 KSH to bale all of the cut hay using the mechanical baler, though it was uncertain if the

tractor had the hydraulic fitting needed to operate the baler.[5] He also noted that he had discovered not all tractor drivers know how to operate a tractor for hay and baling; he had found one person in the area who learned this skill in Naivasha and he and Pastor Charles were communicating to see how they could get this person to collaborate with each of them.

He had 20 acres total to work with, and 8 acres were under hay. Of the 8 acres under hay, two acres had been seeded with Buffelgrass in November 2015. Note that the 2 acres were seeded with 15 kg total of seed, which was less than the technical advice of 10 kg per acre reported in the meeting with REGAL AG.

To hand harvest it, he paid 5 people 300 KSH per day to bale for about 3 weeks. If we have a five day work week, that is 4,500 KSH per person or 22,500 KSH labor total for baling and also I believe cutting (though that should be checked). He noted that he harvested 300 bales in the season before he had the store, so we will calculate the labor costs on that basis. At 400 KSH per bale, that is worth 120,000 KSH in revenue, which leaves 97,500 KSH revenue after paying labor. Though this margin is high, the productivity of labor seems somewhat low in this case, however, as 5 people working 15 days for 300 bales means each person averaged 4 bales per day, or was paid 75 KSH per bale. Note this payment rate per bale is almost 10 times what Angelena reported above (8 KSH per bale). This merits follow up investigation to get a better sense of the contrast of variability in manual labor productivity compared to machine productivity in contrast to the respective costs of each.

The equipment that he got was through Rhino Agrimark, and they did provide technical advice and maintenance training. He also got training from REGAL AG on linkage to small farmers as producers connected to his storage unit.

He had not started seed harvesting yet. He had gotten fodder seeds in the past from the Ministry of Agriculture and Livestock, and he had gotten seeds this past November from REGAL AG. It became apparent seed harvesting was at least a season off as the seeding of November 2015 largely was not successful.

His plan for the future was to sell hay and possibly add in a dairy operation. He noted there were no commercial dairy operations in the area currently. Cattle milk sold for 90 KSH per liter and camel milk sold for 75 KSH in the local market.

He anticipated harvesting the hay at the end of June when the moisture content was less. He has gotten 200 to 300 bales from his land in the past per cutting. If that is from the 8 acres, that is 25 to 38 bales per acre per harvest. Selling them for 500 per bale, and assuming 2 cuttings per year, we can estimate annual revenues of 20,000 KSH to 30,000 KSH per year. In this case our estimate of the per hectare revenue per year is in the $618 to $926 range. This is less than the revenue per hectare calculated for the bean stover above. One possible explanation is that he did not harvest on all 8 acres in the past so the per acre estimate is too low.

[5] The pricing in the tractor market seemed at times to be quite inconsistent. As a rough outline, it seemed the private tractors charged more than the county tractors, but the county tractors were allocated by a logic other than purely payment for an hour of service. Getting a better sense of the pricing for tractor services and what determines access to these services merits further work. In addition, the relative value added of these kinds of interventions would be worth further investigation. Given the labor abundant profile of Marsabit Mountain, it was not always clear to me what the logic was behind the increased provision of tractors and other capital intense equipment; perhaps there is a labor availability problem?

We noted during our visit that the seeding operation of the buffelgrass in Nobember 2015 did not go as planned in Sololo. Two issues appear to have been at play. One, the suggested seeding ratio is 10 kilograms of seed for 1 acre, and he used 7.5 kilograms per acre. Two, there was little evidence of buffegrass in the field. Investigating this situation, we found the only buffelgrass we could find was growing along the fenceline. It appeared the seeds had either blown or washed away from the field and were caught in a few cases by the fence line. The field had a slope to it as well, so the first rains may have washed it away.

Photo 10. Buffelgrass along the fenceline in Sololo, hay barn in the background.

Photo 11: Field where buffelgrass was to grow

This might indicate that broadcasting of buffelgrass seeds might not work in some settings. In Wajir, hay producers indicated that they dig shallow trenches and cover the seeds with a thin layer of soil. On the Texas seed company website, they suggest tilling the soil, broadcasting the seed, and then dragging something like a chain or a 2 by 4 over the seeds and soil once they have been spread.

For another perspective on the production question, we discussed future projections and use of the barn for storage. He indicated he expected to harvest 5000 bales over the course of the year from the full 20 acre farm. That implies a higher level of productivity per acre than we just reported. Again assuming three cuttings per year that is 83 bales per acre per cutting and 250 bales per acre per year. That corresponds to an estimate of 125,000 KSH per acre per year, or $3090 per hectare per year. From a production standpoint, 250 bales at 12 kg per bale is 3000 kg per acre per year, or 7,410 kg per hectare per year.

We followed our meeting with Guleid with a meeting with Fatouma, who is a member of the Tulu group. They are a group of contact farmers who sold to Guleid last year. They were offically formed in November 2015 and have 20 members. They have a fenced in area that has natural pasture growing in it. They sold 100 bales of hay last dry season at 250 KSH per bale, 50 of them to Guleid and 50 to other people. They would like to work towards having a fattening operation. Weeds are a problem and they would like help figuring out how to manage the weeds and trees and bushes that are in their field. Their field is fenced, but located next to a water pan used by livestock so they are looking to have a stronger fence. They have not gotten any training in production from the REGAL AG project, and this could be an avenue going forward for the value chain project. We brought up the idea of there being a storage fee for the contact farmers to put the hay in the barn that Guleid manages as an alternative to selling to him at 250 KSH for him to resell at 400-500 KSH per bale. That was not met with all that much

enthusiasm by Guleid. He stated his goal is to fill the barn to the 10,000 bale capacity by producing 4000 bales each year and buying 1000 for a period of two years. It was not entirely clear what would happen then.

Finally, when we returned to Marsabit, we visited other organizations active in the area of livestock productoin. There are all kinds of experiments going on in the area which is good news. KALRO has done some work with feed for chickens from Balanities seeds, the County livestock office was working on molasses and urea feed blocks and salt blocks, there were experiments with prosipus seeds and acacia seeds, Regal IR had some work with feed choppers that cut up maize and beans for feed, and there were a few people talking about accessing concentrates in the highlands for use in the north. It is great that there is all this interest and experimentation, but there is a danger that it will end up as a few scattered activities that don't get directly compared and evaluated. It would be helpful if the ILRI applied research approach, perhaps in cooperation with KALRO, conducts some side by side trials on the different possible interventions and starts identifying least cost rations that are associated with different species and production objectives. The fodders that have been the focus of this discussion could be paired with these more protein rich feed sources. What is the right mix? We don't have research results to answer that question right now, but we do have people starting to ask these kinds of questions. If we start the resarch now, we might be in a good place to share findings in the next few years as this activity grows.

For fodder production in Marsabit, I recommend that AVCD work in the coming few years on three main topics. One, some monitoring of fodder production in the fields we visited and other producers should be structured and implemented. My estimates of productivity and profitability are rough estimates. More rigorous research on yields would develop more of an evidence base for fodder production. On this topic we also should probably spend some time comparing seeding techniques, as that emerged as an issue in this visit. Two, ILRI and KALRO have some capacity to do nutritional analysis of the fodders produced either in lab work or using Near Infrared scanners. That would further develop our understanding of the potential for these fodders to improve animal nutrition. Different mixes off rations should be evaluated from an animal nutrition and weight gain efficency standpoint. Three, fodder production as it is currently being introduced is targated at producers who are large land holders and relatively wealthy. Research could help us understand what would be needed to increase adoption of the smaller producers, such as Fatouma and her group introduced on the previous page. Finally, storage of produced fodder by smaller scale producers needs to be investigated and improved. The giant barns REGAL has built are not really a replicable model for smaller scale producers. Some research on affordable storage designs could help develop the fodder value chain; I will return to this on the hay marketing recommendations as it relates to this element as well.

AM2) Fodder market potential in Marsabit.

With some early challenges, it appears fodder production is being established in Marsabit County in an early phase. While there will still be production challenges to meet in the future if this practice is to become more widespread, we turn now to the question of is going to be done with the fodder if it is produced. Some of the possible uses have been indicated in our narrative so far. Others will be added drawing on other parts of the visits conducted as part of this consultancy. With regards to marketing I have less to describe as there was not much marketing that had taken place yet. Most of the people were in their first or second season of production

so were currnently trying to figure out market opportunities. Much of the discussion related to marketing was speculation about what marketing might look like going forward.

The fodder market as a value chain does not appear to exist at this point in time in Marsabit. There is production of hay and some opportunistic selling of hay. There are people who come to these producers in search of hay and they are able to sell it to them. To the best of the knowledge of the people we interviewed, there is not a distinct fodder market currently in Marsabit County. There are efforts to build such markets around the hay barns we visited, and there is some infrastructure to store hay at the newly renovated markets supported by REGAL, but there is not yet a distinct fodder market. The demand for fodder now and in the future falls into the following categories.

Dairy. Three of the producers described above had identifed a potential link of fodder production to dairy marketing. One had further linked increased dairy production to improved dairy hygeine through processing and packaging. These are clearly promising movements, as dairy plays a central role in the diet of people in this area, and as they have moved to town, they have lost some access to dairy products but not their preference for these products. In addition, as the new road nears completion, new possibilites that were not feasible before are becoming feasible for milk production and transport to higher value markets. Camel milk in particular has been identified as a target value chain by the REGAL IR project. Note that the camel milk price of 75 KSH per liter in Sololo stands in contast to the target price for the Karare production of 150 KSH per liter. Camel milk is an underdeveloped market and Marsabit might play more of a role in this market as the ability to collect the camel milk from lowland camels, process it in middle altitude centers such as Karare, and send it on vehicles destined for markets with clear demand such as Nairobi is a distinct opportunity that now exists. From the second part of the consultancy in Wajir, it was reported that Gabra women from the Sololo area trekked to Wajir with male camels and bartered them for heifers at a two bulls for one heifer ratio. The barter took advantage of the fact that Gabra camels have more meat per liveweight than Somali camels, and Somali camels are better milk producers than Gabra camels. Their stated goal was camel dairy production in Sololo area. This was reported anecdotaly to me and would be worth seeing if it can be tracked down in Sololo. This kind of innovation could be linked to the hay barns and fodder production in mutually beneficial ways.
For dairy, I recommend work on four aspects of dairy production. First, KARI (now KALRO) did some work on improving milk quality in the past. This could be revisited and updated given the new transport accessibility of the County. What production practices are possible that lead to higher milk quality – and relatedly is there evidence that there is a willingness to pay a higher price per unit for improved milk quality on the demand side? Second, AVCD could collaborate with KALRO and the Livestock Department to fund milk production trials linked to fodder production in the County perhaps at the KALRO research center. AVCD should also establish a research protocol to monitor production practices and returns for the dairy operations in the area. There is a lack of information about the optimal mix of feeds that would be the least cost rations for milk production. Third, AVCD should look into the distinctions between the smallstock milk market, the cattle milk market, and the camel milk market in both the production and marketing side. The production and markeing strategy that is the most

profitable might differ by species and site; this could be a topic of research. Finally, given the gendered pattern of milk marketing (it is generally the domain of females) research could be conducted to investigate the gender implications of more intensive dairy development. What might be the implications for intra-household patterns of income generation, and how should our extension messages be delivered in a situation where livestock are generally owned by males and the milk that comes from these animals is controlled by females?

Animal Fattening. This is a new practice in Marsabit. Currently, fattening is taking place on the ranches of Laikipia, the Taita Taveta ranches, and in the Ethiopian highlands. Animals that are being sourced in the lowlands are being taken to higher potential areas, brought up in bodyweight, and sold at a higher price per head with more meat per carcass. The question that we are presented with is how do we bring the fattening operations to the scale where producers in the higher potential areas of Marsabit County are able to profitably conduct these operations? Further, how do we ensure these operations are accessible to different wealth categories of producers? What we are trying to do is develop practices that allow the profits from value added fattening to be captured by producers in the County. The questions that were posed by Habia are the kinds of questions we should be able to research and answer. Does it make more sense to fatten cattle or goats? How long should they be fattened for maximum profit? What should be the feed ratio mix in terms of fodders, concentrates, and supplements? What is the balance between mixes that maximize daily weight gain and mixes that are least cost rations for maxiumum daily weight gain? How do I access higher potential livestock markets that will pay a premium for animals that are fattened? And some further questions that did not come up include how to manage the risk of losses in fattening operations though animal death, disease, quarantine, adverse market shifts, and theft / losses in transit among other sources of production risk. Note the KALRO / KARI station has some experience with animal feed trials, and the director of livestock production for Marsabit County has also a lot of ideas for how to move this forward. This is a good opportunity to bring the ILRI scientific experience on this topic to a new setting. Might it be worth bringing in Augustine Ayantunde in to help define the parameters of feeding trials, as this is something he has been quite successful in conducting in West Africa?
So for recommendations in the domain of animal fattening, I suggest AVCD develop some combination of ILRI research expertise with KALRO research expertise and conduct some feeding trials to develop the evidence base on animal fattening in this production environment. The questions outlined in the previous paragraph will require focused research effort to answer.

Selling Hay to Producers and in Markets for maintenance. There is some evidence that there is demand in livestock markets for hay. People come with the animals from some distance and the night before and, if animals are not sold on a given day, the following night need feed for the animals. This will probably not ever be a very large market, but it could be a steady market for some share of the fodder produced, and would probably be a good way to help rotate some of the stock where storage capacity constraints are an issue. Producers may also have higher demand for hay at the end of the dry season when pastures have become scarce and animal condition is declining. Another potential market is in the areas where animal traction is practiced, as there is a benefit to getting traction animals on a good plane of nutrition prior to

the start of the rainy season so they are ready for the exertion that comes with plowing. Feed may lead to better condition at the earliest possible time for planting, which may be needed given unpredictible rainy season duration. There is some animal traction practiced in Marsabit County, particularly among Boran cultivators.

Selling Hay to IBLI customers. The Index Based Livestock Insurance (IBLI) program is moving to a new phase. In this phase, they are experimenting with deliving the indemnity payout at the end of a failed rainy season rather than at the end of the failed rainy season – dry season pair. The concept is that earlier delivery of the indemnity payment (if triggered) will allow purchases to protect the livestock asset rather than wait until the livestock asset is lost and then seek to replace it. Research (Pastoralists Livelihoods Initiative, 2007) has shown that asset protection costs less than asset replacement. The binding constraint at the moment is the volume of feed needed to allow this to become a viable option in Marsabit County. Below, we will illustrate for Wajir County the scale of the challenge. We illustrate this with Wajir County as they are further along than Marsabit County both in terms of fodder production and hay storage facilities.

Selling Hay to NGOs and Government. As part of the Drought Cycle Management plan, counties are purchasing hay to store against the next drought event. NGOs are also active in buying fodders when a drought event occurs. The magnitude of the storage capacity and production capacity in Marsabit County has a long way to go before it will be adequate to deal with another drought event such as 2011. Part of our research agenda could be to identify what would be needed to maintain the core breeding herd through a drought event, and conduct some preliminary cost benefit analysis of the costs of up front preparedness in production and stockage against the benefit of averted drought losses. Some preliminary steps towards this are outlined below for Wajir.

One potential downside to relying on government purchase is that rather than relying on a functioning market where there is a willing buyer and seller of fodder meeting, it enters a realm where people with barns have a production objective to make them full of hay and then wait for the government to come buy them. Further, the logic of who has their hay purchased by government may be determined by forces other than market based issues of price, quality, and speed of delivery. Selling to the government should be a part of the portfolio, but will be extremely limited in potential compared to the more market driven dimensions outlined above.

As noted above, the storage of produced fodders is a topic that needs to be researched. I recommend that AVCD defines this as part of their research agenda. Construction of hay storage structures and their relative effectiveness in conserving hay quality is a topic that merits explicit research expertise. The high cost barns put up by REGAL AG we visited are certainly one model, but they are not likely to be affordable by many people in this area. What different designs might we identify and test out in this area? Can we figure out a relatively low cost but effective way of extending different kinds of storage structures? We also could have AVCD run some economic estimates to see what is the cost benefit ratio to building some of these structures, and estimate if the internal rate of return and length of time to break even are compatible with the kinds of micro-credit loans that are accessible in the study area. I also recommend that AVCD monitors the returns to the hay markets in the area and tracks the

profitability of different hay sub-markets. More collaborative work with the IBLI team might also help identify the potential for both aspects of the ILRI research portfolio to productively collaborate and mutually benefit.

AW) Fodder in Wajir

AW1) The fodder production system in Wajir.

As before, I will present a description of the situation based on my observations, followed by a set of recommendations based on those observations. As before, I will address fodder production and after that turn to fodder marketing. The fodder production situation in Wajir differs from that which was presented for Marsabit in two important ways. The first is the production environment. Whereas in Marsabit the increase in altitude corresponded to higher potential for rainfed fodder production, in Wajir the decrease in altitude to the low point of Wajir makes irrigated fodder production possible as the water table is accessible. The second difference is the time over which fodder production has been practiced. It is something that has a longer history in Wajir. There is more evidence that the question of whether fodder production is feasible in the County has been answered. The answer is quite clearly yes, people have figured out how to produce fodder in the irrigated areas. However, what is also evident is that the focus on production has been given higher emphasis than the questions of storage and marketing. The situation we encounted in Wajir is best characterized by large piles of hay being stored under trees as more hay grew in the fields. There is some growing discouragement as there is a reduced incentive to harvest the current crop of hay only to stack it next to unsold hay from previous campaigns.

In my opening day meeting with the County officials, it was stated that the county has a goal of 200 hectares under fodder production. We will return to this below. We also discussed the county's current implementation of building strategic hay stores. It is within the context of this expansion of production and storage capacity that we will develop the cases of the individual visits to the producers.

The first visit was to Makthar farm. He has been growing the hay we were looking at for 3 years and grass for sale for 7-8 years. The whole farm was about 10 acres and was fenced. It is a mixed production system, with fodders interspersed with crops such as watermelon and sesame and tree crops such as papaya. Given this, it was hard to accurately estimate the area under fodder production as it was scattered though the fenced in area with other crops.

Photo 12: Buffelgrass in Wajir

He said he did get training from ALDEF when he began producing fodder, and thought the origin of the seed he used was in Kiboko. He was trained to use a Jembe to create a small trough in the soil into which the seeds were placed before being covered. Some pests he has encountered are grashoppers, birds eating the seeds, and Marabout Storks who ate it during a drought.

He made himself a baling box, and has bales that are from 8 to 12 kilograms per bale. He sells them for 500 KSH per bale, so an average of 50 KSH per kg. He indicated that there is a benefit to the overall farming operation he is conducting; when he started farming he had 15 goats now he has 40, cattle went from 4 to 11 over the 15 years he has been farming.

He harvested 100 bales following the last short rains. Some of those bales are the ones seen in picture 14. At the time we were visiting he was actually pulling up some of the buffelgrass to put in sesame. There was a new sesame mill in Wajir, and he was exploring the opportunties of sesame seed sales. Overall, the farm was mixed in production, with papaya, watermelon, fodder, and sesame all in evidence currently.

Photo 13: His baling box

Photo 14: Unsold hay stored under a tree

Photo 15. The pump and well that brought the water up

His father dug the well, and he reported that clashes in the rangelands brought them here in 2001. He bought the pump seen in the picture in Wajir, and there are 3-4 mechanics in Wajir town who are able to service and repair this kind of pump. It takes about 5 liters of fuel per day to run and a liter of fuel is 100 KSH. He does not have to run it every day and estimates in a week he spends 1,800 to 2,000 KSH on fuel. Note in the upper left of the photo the pile of empty water bottles; those were fuel containers used to get the fuel to the pump.

He identified the opportunity of animal fattening and is looking into it. The sesame seed mill in Wajir is creating locally available sesame seed cake, so that could potentially be a complement to the grasses he is producing. He also noted he does produce dairy for the market in Wajir town. He produces 5 liters a day in the dry season when conditions are more difficult and 10 liters a day when conditions are good. The hay and water support the dairy production. Cattle milk was reported to be 180 KSH in the market, so that is 900 KSH per day in drier times, 1,800 per day in wetter periods. From the fuel estimate above, 2 days of milk sales in the dry season would cover a week of fuel costs (and it is assumed fuel for the pump is generally not needed in the wet season).

He was originally to store his fodder in the shed of the person we visited next, but that storage facility is full from the production of the other farmer's field alone. He reported he has been promised a shed by the government. When I asked if the shed presented a management problem if it was placed on one person's land and a group was meant to use it he replied that the management would not be a problem since it was managed by the person who owned the land it was placed on. That comment and the next visit reinforced the idea that the collective management of fodder stores that are placed on particular individual's land is not apearing to

be a highly successful approach. In most cases it seemed to default to the ownership of the person to whom the land it was built on belongs.

Photo 16: Crop mix with sesame in background, paypaya in middle, and fodder crops in foreground

He also had experimented with Sudan grass and napier grass. These are more water demanding, and were not covering a very large area. He did indicate that he thought for the most part he would plant the more rainfed buffelgrass and some Maasai lab grass in between the papaya plants and minimize the use of irrigation to water the fodder plants. Note the contrast between the buffelgrass in the background of the next picture with the Sudan grass in the foreground; the buffelgrass seems much more robust. However, it was reported that napier and Sudan grass had a niche market in Wajir, as that is what was fed to the donkeys who pull the carts in town, and there are a lot of donkey carts in town!

Photo 17: Napier (Sudan?) grass in Wajir in foreground, buffelgrass in background.

The next farm we visited was the one SNV / ILRI supported in the past, Muungano Makaror. The farm is a fenced in area of 5 acres with a motopump at the well. This farm has a storage unit with a storage capacity of 300 bales and it was currently holding 300 bales. An earlier brief (Grace and Koen 2014) described this as a farming group, but I understood it to be a family farm at the time of my visit. They also described the fenced in area as 6 acres, though it was reported to me as 5 acres. I did not notice these inconsistencies at the time as I read the Grace and Koen report following my visit to Wajir. I am not entirely sure, but I think it could have been a group in that multiple producers were to place their hay in the shared barn in the original design with each producing on their family plot, but perhaps there was a sense that the production unit I observed was for an association and I missed that piece of information in my questioning.

In any case, he reportedy harvested 300 bales per season and harvested twice for 600 bales this past year. On 5 acres that is 120 bales per acre per year, or 1440 kg per acre per year at 12 kg per bale, or 3,557 kg per hectare per year. Grace and Koen (2014) report figures for this farm for 2014 that imply a harvest of 133 bales per acre per year, or around 4,000 kg per hectare per year (they had 800 bales per year estimated for this farm on 6 acres). These seem relatively consistent given different kinds of rainy seasons from year to year and different estimates of the size of the plot. In either case, 5 or 6 acres, it is to be understood that it is a mixed cropping system overall and not all 5 or 6 acres is devoted exclusively to fodder crops.

He speculated he could harvest monthly during the rains and could be able to harvest 5 times in one year at 250 bales per harvest for a total of 1,250 bales for a year for the 5 acres. The implied 250 bales per acre per year with each bale at 12 kg is 3,000 kg per acre per year or 7,410 kg per hectare per year. Note this is the same as we calculated for Guleid in Sololo. To put this in perspective, an estimate from a Texas seed producer indicates an average of 6,818 kg dry matter per acre for buffelgrass (which converts to 16,840 kg per hectare per year) in

Texas production conditions (www.buffelgrassseed.com). The Wajir speculative harvest level is about half of the upper bound Texas pasture estimate. It is worth stressing again that the farms in Wajir were not monocrop fodder farms, they were growing all kinds of other things at the same time as the fodders.

To stay with the estimate of 600 bales per year, the county pays him 500 per bale, the NGOs pay 700 to 800 when they buy. He views the County and NGOs as the target market. Again, the bales are about 12 kilograms each, so he is charging 42 KSH per kg to the county and 63 KSH per kg to the NGOs. In cash terms the 600 bales per year if sold to the government brings in 300,000 KSH per year (60,000 KSH per acre) to 420,000 KSH per year (72,000 KSH per acre), which converts to around $1,500 to $2,100 per hectare per year in revenue.

In terms of crop production, the current production level of 600 bales on 5 acres per year converts to 120 bales per acre times 12 kg per bale or 1440 kg per acre per year which converts to 3557 kg per hectare per year.

The core problem with the revenue calculations provided above is that he is not selling all of his production at either price, the County or the NGO price, and he is reducing production levels rather than harvest more hay that can't possible fit in the already stuffed storage shed on his land. The harvests are real but the revenues outlined in the paragraph above are to date largely hypothetical.

In 2014, KLMC built the storage shed on his land. He knows it was built for the cluster of hay producing farmers in the area, but notes that the shed is small so the hay from the other producers does not fit once his is stored. That is certainly one way of interpreting this outcome.

Photo 18: Full hay storage barn.

Photo 19: Door of full storage barn.

In terms of production he reports birds can be a problem eating seeds, and insects eat the flowers when fodders are growing in the fields. For harvesting, the father and son cut the grass. They report it takes two people 2-3 weeks producing about 30-40 bales per day[6] after one week of work cutting it to leave it to dry on the ground. To look at the bales per day contrast,this implies 15 to 20 bales per person per day. Two weeks at 5 days of work a week and 30 bales per day takes us to the 300 bales per harvest estimate reported above so this seems roughly consistent.

He describes himself as discouraged, as he viewed the county as the market for the hay he was producing and the county is not buying it. This sentiment was shared with the County livestock officials, who in our initial visit expressed the opinion that they needed a market demand for fodders outside of the government demand.

In addition, he has been conserving the seed with the idea that seed for buffelgrass could earn 1000 KSH per kilogram. This market also appears to be not functioning well, as he showed me a hut that had 40-50 full bags of buffelgrass seeds.

He has used some of the hay to fatten animals in 2014, and some farmers have come to buy hay from him to support goat milk production, buying 2 or 3 bales at a time. He also noted pastoralists have come to buy, and he sold 40 bales 7 months ago at 700 per bale. He also has sold some of the older hay to NGOs who are buying it to support people who are rethatching their roofs. He has looked into companies that are trading fodder, but so far has found that people producing fodder are not having sufficent capital to transport fodder to where there is a viable market. He thought KLMC could step in to help move produced fodder to markets.

[6] Recall that Angelina in Karare estimated 50 to 60 bales per person per day. Here in a farm where there are other production activities the estimate is 15 to 20 bales per person per day. The Guleid farm had an estimated 4 bales per person per day. The estimate of 4 bales per day seems very low. From another perspective, each person in Angelina's case was producing a bale in about 10 minutes, in Muungano Makaror each bale took about half an hour, and in Guleid farm a bale took 2 hours in an 8 hour day.

To get a sense of the local market for fodder, we visited the Korahey market in Wajir town the following morning. The market is one of three places people gather to sell fodder. There were 5-10 people selling fodder. They sell it by the bundle at 40 KSH to the bundle. I asked if the price ever changes, and the answer was no, it is always 40 KSH per bundle. They did note that the quality changes, and the fresh fodders are better but this did not play a role in determining the price. The Wajir value chain report described prices as changing by season in the fodder market, so that inconsistency remains to be investigated. I did find out that towards the end of the day they will combine bundles to make each one bigger, and thus have fewer bundles to clear by the end of the day, rather than walk back with unsold fodder. The picture is a bit off target as I was trying to be discrete, which makes for bad photography.

Photo 20: Green fodder Market Korahey market in Wajir.

The bundles in the next picture are buffelgrass, and were in a big sack that she brought in from about 5 kilometers away. She was also one of the SNV – ILRI project beneficiaries, and in her case she was provided with a solar pump for her well. Apparently there was some problem with the match of the panels to the pump needs, but I was trying to focus on the fodders. She has been selling fodder more than 10 years, and is trying to produce it now rather than go out and gather it and bring it to market, similar to the story told by Fatouma in Sololo. Her goal for the day was to sell these bundles for a total of 400 KSH, which means she needs to sell 10 bundles at 40 KSH each. Although I was only eyeballing it, it appeared to me she was selling a volume of fodder bigger than the hay bales I had been seeing at the same / lower price. However, the difference in fresh fodder dry fodder could potentially explain the difference as the fresh fodder had higher moisture content.

Photo 21: Green fodder bundles in the Wajir fodder market

We next headed to Jaijai, a town about 70 kilometers to the north of Wajir. In 2013 ALGREK (?) supported a group of 39 members to fence a 9 acre plot and develop a solar powered / hybrid borehole water source. They were trained in how to plant, bale, and irrigate fodder. We saw evidence of all four species: buffelgrass, Maasai lab grass, Sudan grass, and Napier grass. They had subdivided into 6 subgroups to manage different parts of the fenced in area. Different areas are watered on four day intervals in the dry season. The six different groups harvest and store the fodders in different parts of the field under the trees. Harvest is done with a sickle that was provided by the project. We discussed whether it would be possible to make these and repair them in Wajir, and it was thought that that might be worth looking into as a local kind of activity for the metalworkers in town to undertake with some example sickles.

Below is the sight that you encounter as you walk into the fenced in area; a huge pile of harvested fodder partially covered by plastic sheets. As you walk though the field, you find that there are at least five more clusters like this one where each of the sub-groups has accumulated unsold harvest from multiple seasons. At the time we were visiting, there were fodders that were ready to harvest, but it seemed they were discouraged from putting in the labor to harvest yet another crop with so much unsold fodder piled up already.

Photo 22: Fodder stored in Jaijai fodder production farm.

Photo 22: Close up of fodder stored in Jaijai

Photo Gallery 23: Different fodders under production in Jaijai.

They reported that in town there was construction of a hay barn by the County and the Swedish SDC (?). They were anticipating that the bales would be bought by the County at 700 per bale. Recall that the County officials are anticipating buying at 500 KSH per bale, so there is some unclear communication of expectations here. In addition, the bales here were less consistent and bale shaped than in some of the other sites. They were somewhere between bales and the bundles seen earlier in the green fodder market. It might be that they need to be rebaled with baling boxes for consistency. They mentioned some sales of the fodder directly to producers but it seemed relatively minor and they said they lacked buyers for the fodder. I asked about the plastic sheets that they were using to protect the harvested fodders from the rain under the trees. They said they were provided by the sponsor when the storage barn was not yet ready.

The borehole was powered by a hybird system, though the only part they used was the solar source. The pump was powered by 42 panels, 32 main and 10 supplemental. There were 6 tanks that appeared to be 20,000 cubic meters each. Reportedly they filled fully over the course of a day with sun. They did report that when the sun went down they stopped, and when we looked in the pump-house, we did note that there was no evidence of storage batteries. It appeared there was surplus capacity on the panels that could be used to provide some light in town potentially, but that goes beyond the scope of this analysis.

Photo 24: The construction of the hay barn in Jaijai

The storage barn was similar in size to the ones seen in Marsabit County, and were said to be capable of storing 10,000 bales of hay. Some of them were already built in Wajir County, and the stated goal was to have two in each of the four sub-counties and two in Wajir town, for

a total of 10 barns, though at times it was unclear whether this was an ultimate objective or a currently under construction existing project goal.

While this will help some with the storage situation in Jaijai, in some ways it may just move the problem out from under the trees in the field to inside of the barn in the center of town. Once this barn is full and the 500 or 700 KSH per bale has moved to the members of the group from the coffers of the County, then the same situation will arise, where ongoing production has no outlet. The overall situation is improved marginally, as there is a locally available stock of hay that can be accessed when the next drought happens and a new standing crop, and probably harvested piles of fodder under plastic, at the fenced in production area. However, there is still a need to develop a viable market for fodders in this area to absorb the supply that is currently being produced, and then consider both how to increase the efficiency of production and expand production. There is not sufficient market in Jaijai for this to work. They need to be connected to a more robust market, but we have seen above that the current market is a few people selling bundles of feed at 40 KSH per bundle in Wajir town (though that is at the end of the rainy season so is a low period of demand to be sure). Making the relatively succcessful fodder production initiative turn into a viable marketing opportunity hinges upon finding sustainable ways to market that which is already being produced. So again, we turn to our options for increasing demand.

In terms of recommendations for AVCD, I would recommend some detailed research on the production of fodders to track productivity. I have come up with some estimates of yields per acre / hectare but these are pretty rough estimates. There is a lot of work to do to investigate the kinds of yields that are possible and how different techniques and inputs correlate to different production levels. There is also work to be done on how the returns to production balance against the costs of production, particularly when irrigation costs are involved. In addition, there is work to be done on the intercropping aspect of fodder production; all places we looked at were mixing fodders and crops in the production system. There are probably some combinations that work better than others; a structured research agenda would help identify some of the more beneficial combinations of fodder and crops.

AW2) Fodder market potential in Wajir.

The practice of selling hay seems to be over 10 years old in Wajir and the practice of growing hay to sell is at least three years old if not older in some areas. It is demonstrated that it can be successful. The buffelgrass and Maasai lab grass seem particulary promising in that they seem to do well with minimal irrigation and can grow under rainfed conditions to some degree. The napier and Sudan grass have a niche market with the transport animals, mostly donkeys, that pull many of the carts that move goods around Wajir town.

The fodder market as a value chain can be said to exist in a slightly more advanced form than observed in Marsabit. There were three areas in town described as being places to buy fodder. None was very advanced, and each consisted of a few people sitting with bags of fodder in an area where it was known that fodder sellers came (reportedly for the other two; I only visited one). There is at least the physical presence of a fodder market of sorts, with production taking place out of town, sales in town, and consumers buying feeds for their own needs and taking them back to where their animals would consume the feed.

Dairy.

Of the producers in Wajir, Maktar farm was where explicit mention was made of selling milk. He noted that he was selling 10 liters a day in the good periods and 5 liters a day in the drier periods.

In the meeting with the livestock production office, they reported camel milk was selling for 150 KSH per liter and cattle milk for 180 per liter. They also noted that their goal of having 200 hectares under fodder production was linked to the goal of increasing dairy goat production.

These are strategic objectives for the County that could be supported with further research effort to fill in details on the production and marketing specifics. The County officials also reported that specialized dairy in camel milk was taking place, with one producer reportedly selling camel milk to Nairobi hospital at 240 KSH per liter. They also reported that there is a camel milk market currently being targeted in Kajiado. More efforts could be made to link the fodders that have been produced to the dairy producers in peri-urban areas. While that might not solve the situation in Jaijai which is pretty distant from town without some transport solution being found, the peri-urban producers could quite possible use the fodders to intensify dairy production.

AVCD could work in Wajir to develop evidence on the profitability of different milk markets and the impact of fodder use on milk profit margins. For example, does it make more sense to provide fodders to camels, cattle, or goats? What is the right amount to provide to each of these to maximize milk production and minimize costs? What kind of facility and collaboration would be possible in this county if there was a desire to do some comparative trials as was proposed for Marsabit above. For Wajir in particular, research on the profit margins of deliving to Nairobi hospital or Kajiado would help answer whether returns outweigh the transport costs and perhaps risk of accessing these more distant markets. Here again, for milk marketing overall, are there gender aspects to consider?

Animal Fattening.

Animal fattening was mentioned by only one the producers, but was a topic of discussion with the County livestock officers. I brought it up at one point when discussing with the Muungano Makaror farm. After looking at all of his fodder, I asked if he had ever thought about using some of it for fattening up sheep in advance of Tabaski. I described how people did this in West Africa and often received pretty decent profit margins. After considering it for a minute, he said “I never thought of that. That sounds like a good idea.”. So if Tabaski fattening ever takes off in peri urban Wajir, remember this discussion!

If there are people attempting fattening in this area, again I would recommend we track practices and returns to begin building up an evidence base on what is the optimal strategy for minimizing costs and maximizing returns. We currently do not have an evidence base to develop recommendations as it currently stands for Wajir. If possible, it might be worth seeing if the practices of the ranches where many of these animals are currently being fattened are adaptable to the Wajir production environement.

Selling Hay to Producers and in Markets.

There is clearly a steady market for fodders for the donkeys in Wajir and surrounding areas. The donkeys and donkey carts are pervasive. As these are working animals, they are not able to graze when they are pulling the carts, so there will always be some demand to fuel these animals. The market I visited for green fodder had perhaps 100 kg of fodder for sale that day, and from the description provided it sounded like it had a chance to clear over the course of the day. It was not a particulary high demand period at the time of my visit as the rainy season had recently ended and was pretty good this year. There was a lot of green on the ground and in the trees and bushes as we moved around the production areas. I would anticipate the demand and corresponding volume will increase as the dry season becomes more pronounced. The three production units I visited in Wajir all reported that pastoralists had come to them at some point in the dry season to purchase hay in some quantity, though the amounts seemed small compared to the stock on hand. There is some demand from extensive livestock producers, particularly at the end of the dry season, though it currently remains a pretty small quantity compared to the existing supply of produced hay.

Selling Hay to NGOs and Government.

As part of the Drought Cycle Management plan, counties are purchasing hay to store against the next drought event. NGOs are also active in buying fodders when a drought event occurs. This is both a market opportunity and an obstruction to the market currently. It is an opportunity in the sense that there will be purchases at some point to fill these storage barns. It is a obstruction in that producers appear to be sitting on stocks waiting for the government to purchase. Compared to Marsabit (where one producer explicitly linked hay production to dairy, another was consider buying a Fresian cow to demonstrate the use of fodder in dairy to create demand for his fodder, another had actively begun to develop a plan for a feedlot), the Wajir producers seemed to be focused on the idea that the County government was the market they were producing for. This seemed to be something of a breakdown in communicaiton, as the County livestock officials were endorsing the idea of demand from sources other than the County as future opportunities. It may have been a difference in the way the idea of hay farming was presented to the producers in the two different areas, or it may be that the Wajir farmers had tried some of these other options and they did not work very well. I did not find much evidence for the latter interpretation but it could be explored further; have they not yet tried to find and expand sources of demand for the produced hay in Wajir other than the government or have they tried and not been successful? This could be explored in more depth than I was able to reach in my short visit.

To focus on the County level demand, we can consider the current plans for construction of storage barns as presented to us during the visit. To get a sense of the fodder storage capacity of the County, Wajir is building or planning to build 2 storage barns in each of the 4 sub-Counties with an additional 2 in Wajir town for a total of 10 stores, each with a capacity of around 10,000 bales each. Our earlier estimates of the size of bales centered around 12 kilograms per bale, so that imples 120,000 kilograms per barn. With 10 barns that creates a store of 1,200,000 kilograms of stored hay capacity as an objective for the whole County. If they are bought at 500 KSH per bale, that is 5 million shillings ($50,000) of stored hay per barn, 50 million shillings ($500,000) worth of hay in the County storage units.

We will first develop this scenario on the basis of protecting a core herd of breeding animals as an example. The exercise follows the logic presented in Bekele and Tsehay (2008). Assume a 250 kilogram cow takes in 2.5% liveweight in hay to maintain condition. Assume a drought is evident at the end of a failed rainy season and feed needs begin at the start of the dry season following the failed rainy season. Thus feed is needed for 90 days until the next rains come. Each animal needs around 6.25 kg per day of hay (about half a bale ~250 KSH worth of feed), or 563 kg for the 90 day period (47 bales). If there are 1,200,000 kg available in the County, that could support 2,133 cows for three months at a value of $234 each in feed. Two months of feed would support 3,200 cows at a value of $156 each in feed. One month of feed would support 6,400 cows at a value of $78 in feed each. If we define the program to support goats and sheep, a 22 kg liveweight goat or sheep would need .55 kg per day in fodder, and we could support 72,727 smallstock at a cost of $6.88 each for one month, 36,364 at a cost of $13.75 each for two months, or 24,242 at a cost of $20.63 each for three months.

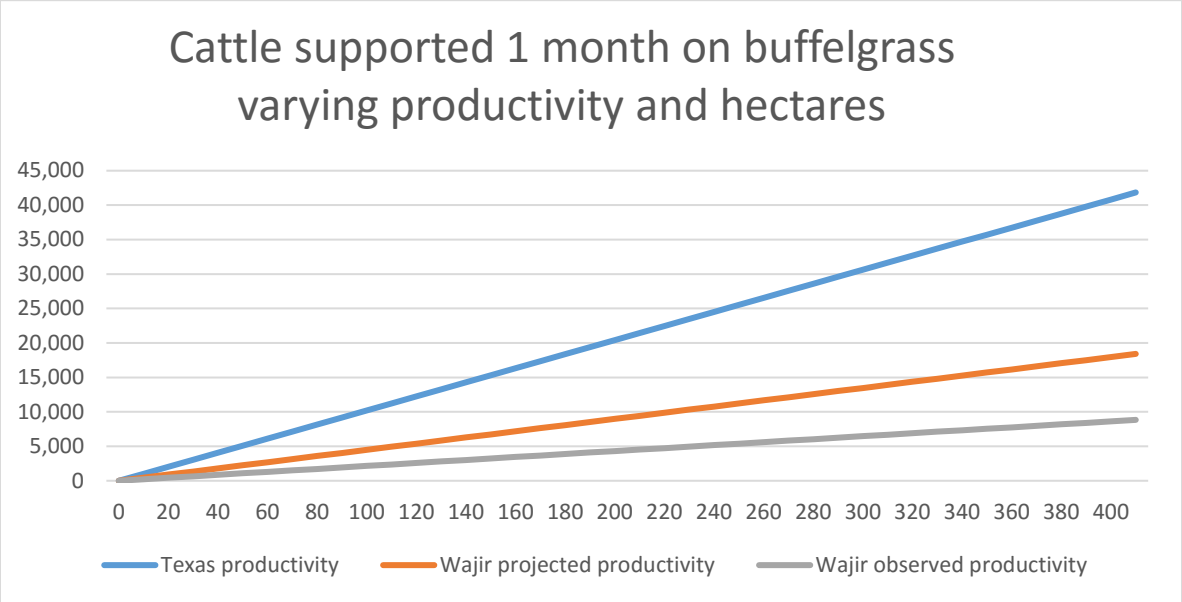
The Tufts brief presents an analysis of 8000 sheep and goats fed 250 grams of concentrate per day each in northern Kenya during a drought in 2001 and finds a cost per head of a three month feeding program of $10.29 per head with concentrate. The cost of replacement is estimated to be around $32 per animal. To conduct a similar comparison, the Wajir value chain report reports a average value for a head of cattle in the Wajir market as 25,000 KSH and for a goat 3,500 KSH. Though the margin is less, in both cases the cost of keeping an animal alive by feeding for three months is less than the cost of replacement of animals that starve in a drought ($234 compared to $250 for cattle, $21 compared to $35 for goats). Perhaps if fodder is combined with concentrate, which is easier to transport than fodder, the costs could be brought down and the overall quality of the rations increased.

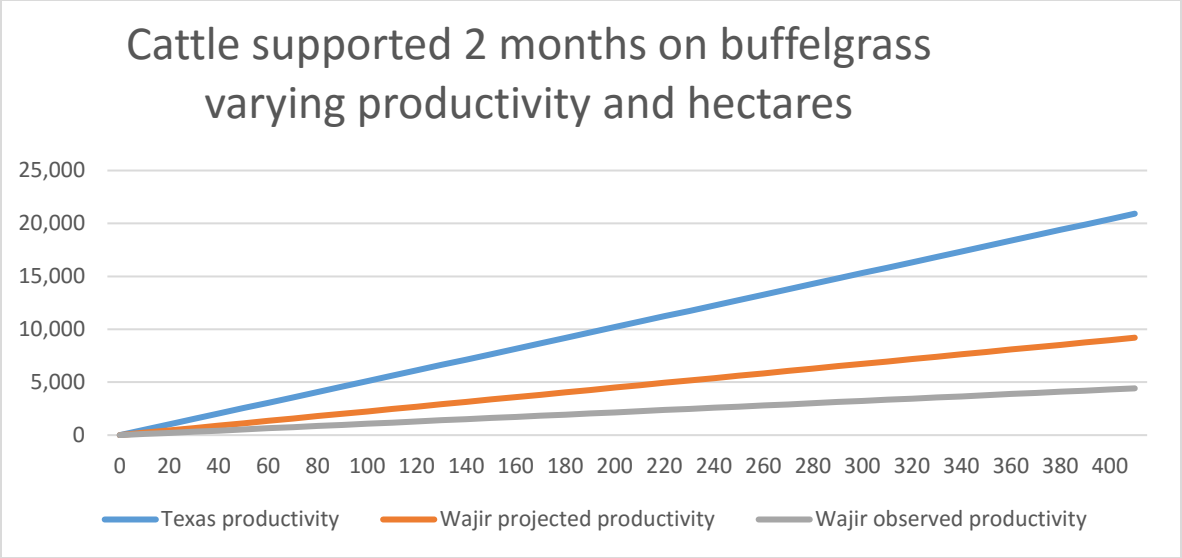
This leaves aside some important issues, like how much the quality of the fodder has declined over time in storage, the ability of the animals to maintain weight just on stored hay without any concentrate to supplement, and many other technical details that a more careful analysis and further research can address. However, as a first run of the numbers based on what we found on this mission to Marsabit and Wajir, it looks like fodder storage could be a less expensive way of protecting assets to survive a drought through feeding than the cost of asset replacement due to death in a drought. The findings here are higher cost per head that found by the Tufts researchers, but the qualitiative results are consistent with what was found in their research.

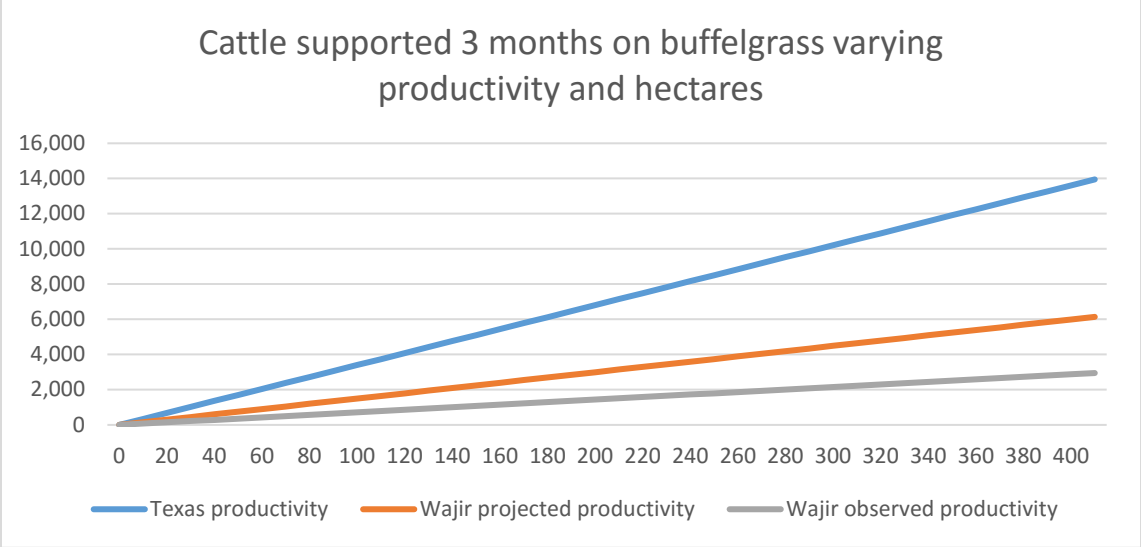
To put these livestock numbers in context and get to the scalability question, the Wajir livestock value chain report presents the following estimate of the size of the overall herd in Wajir. “There are 1.12 million animals kept among them 794,552 cattle, 1,406,883 sheep, 1,866,226 goats, 115,503 donkeys and 533,651 camels (KNBS, 2010.)” (p. 19). Even the least demanding scenario of 1 month of feed reaches less than 1 % of the cattle herd and around 2% of the smallstock herd in a given year. Longer feeding lengths will lead to lower shares of the herd supported. While it is completely unrealistic to expect the fodder production will support the entire herd of animals owned by the people of Wajir, it would seem we need larger production and storage capacity to even begin to think strategically about selectively targeting and protecting a core breeding herd through feeding (while other animals follow the traditional drought response of extensive migration). This sets in context the magnitude of the challenge

that lies ahead trying to match to scale of demand in a drought to the capacity to store hay being put in place.

As another perspective on the relationship between fodder production and livestock that can be supported in a drought, we can consider three scenarios. Here we are looking more closely at the supply of fodder. Within each of these scenarios, we contrast three different productivity levels of fodder production. The highest production level is calibrated from the Texas buffelgrass seed firm's estimate of 16,840 kg per hectare per year (reported above on page 28), which is probably derived under conditions where irrigation and chemical fertilizers are applied (Jay Angerer, personal communication) and is used as an upper bound of production potential. We can take the Muungano Makaror / Guleid production estimate of 7410 kg per hectare per year as an upper range of what is possible given the mixed farming practices in the observed farms under irrigated / higher rainfall conditions; this is what is called the Wajir projected productivity. On the lower end, we can take the 3,557 kg per hectare per year on the same farm currently (estimate on page 25); that is called the Wajir observed productivity. The charts below have the number of cattle that could be supported for the given number of months on the y axis under the different productivity scenarios (the different curves on the graph) at different numbers of hectares under fodder production (the x axis). Scenarios are developed for 1 month, 2 months, and 3 months of feed supplies.







A few key points are worth considering. One, the County government noted in my interview with them that they have a target of 200 hectares under fodder, so we could focus attention on the points above the label 200 on the x-axis to get predictions of the outcomes if this is realized. Another constraint is that the 120,000 capacity of the anticipated hay stores in Wajir is reached under the Texas productivity scenario at 90 hectares, the Wajir projected scenario at 200 hectares (the County's target), and 410 hectares on the Wajir observed productivity scenario.

Drawing on the Wajir value chain report, "…total cultivated land is approximately 3,823 hectares." (p. 19), we can put the size of the fodder production areas in some context. If we took all the area of the currently cultivated land in Wajir reported in the value chain study and planted it with fodder that produced 7410 kg per hectare per year, we could produce 28,328,430 kg of fodder in a year. With each head of cattle needing 562 kg for a 90 day feeding window in a drought, we could support 50,362 animals with the production of one year. If we did this every year for 16 years we would have enough fodder to cover the reported 794,552 cattle population for 90 days in the case of a drought. NOTE THIS IS NOT IN ANY WAY TO BE

TAKEN AS A POLICY SUGGESTION! It is a way of examining the dimensions of the issue we are considering here.

Given the imbalance between the feasible scale of what can be produced and the possible large demand for hay in a drought event, an issue that needs to be thought through that is still not clear to me. Given such a potential imbalance between supply and demand, who gets the fodder that is stored in the County hay barns? What process is in place to prioritize who will have access to the stored hay and who will not? There does not appear to be a plan to introduce a market mechanism, which brings up the question of what will be the allocative mechanism. There is clearly an imbalance between the potential demand in a drought and any feasible production level or storage capacity that could be put in place. It would be useful to investigate what trigger points and allocation rules have been defined for the management of the stores. These should be developed to be robust now, as it is too easy to envision the allocation process becoming an arena for political contestation and source of future grievance.

Selling Hay to IBLI customers.

As noted above, the Index Based Livestock Insurance (IBLI) program is moving to a new phase. In this phase, they are experimenting with deliving the indemnity payout at the end of a failed rainy season rather than at the end of the failed rainy season – dry season pair.

In first considering this topic, I wondered if the County hay storage units might undermine the incentive to buy IBLI insurance if they gave away the stored hay for free in a drought event. The calculations presented above indicate this is not likely to be a problem if private fodder production and storage also expands. It seems reasonable to expect there will be remaining demand in the private market for fodder after the county stocks are exhausted, should there be a private market in place.

However, if this is fodder in the private market, it is reasonable to expect that those with access to capital will be more likely to be able to buy the fodders, and that prices for fodders of a given level of supply will rise during a drought. Recall the story told above about people buying animals in the last drought in Marsabit, and discovering they could fatten and resell them. Those with capital will be able to combine feed and animals in profitable ways which could increase the willingness to pay for fodder.

The promise of IBLI is to place cash in the hands of people to buy feeds at a time when they need to buy feeds and don't have cash. The targets of IBLI as originally envisioned are those housheolds near the separating threshold in asset wealth, where those above the threshold are in the zone of accumulation and those below are slowly being drawn to stocklessness. As a way to firm up the concept, we can use the rule of thumb of 4.5 TLU per captia in the household as an estimate of this threshold. The larger impact of insurance on poverty reduction is to help people near this threshold who have used cash to buy the insurance product when times were better. Now it is there to provide them with funds needed to keep their livestock alive though the dry season following the long rains and above this threshold going into the recovery phase. While we are not explicitly targeting people based on their herd size per capita, we need to keep in mind that we want the product to be affordable and available to households near this threshold.

Pricing in the fodder market will matter for the viability of IBLI as an option to protect rather than replace assets. The calcuations above for the hay storage in Wajir took the price of a

bale at 500 KSH for a 12 kg bale as the baseline. With that as a point of comparison, it was less costly to keep animals alive in a drought than it was to replace them, but not by all that much in the case of cattle. If the price per bale went to 700, what some were charging the NGOs, the cost efficiency is reversed, and it becomes more cost effective to replace cattle than to maintain them, though for smallstock it is still more cost effective to maintain than to replace even at this price. These are not market driven prices, but give us some range in which to predict where IBLI might work as hoped (lower price per bale ranges) and might not work as intended (higher price per bale ranges).

The idea we are trying to develop is to have private fodder production and marketing grow. In average and good years, these feeds can be used to support dairy production and fattening operations. Note there is some inconsistency to this proposition, as average and good years are when pastures are sufficient to abundant and animals are generally in good condition and don't need much fattening. Where it might not be inconsistent is if we add in the peri-urban element that has emerged in this report. There is potentially a zone of more intensive production that is taking shape in the areas that are connected to the extensive livestock production system but also to the urban markets of Wajir and Marsabit and potentially beyond these two markets. This is a zone that could be moved to a more intensive production system that does not rely as much on the rainfall driven changes in extensive pastures, but is more steady in both fodder supported milk production and purchasing animals and adding value before marketing them. This is a more market oriented model that sources animals from the extensive sector but has in place practices that lead to profit in both good rainfall and bad rainfall years.

These people might also become more involved in IBLI markets as they have more value added investment into the livestock; that is a topic worth investigating. Certainly they are likely to be more involved in the cash economy that would make it easier for them to purchase an insurance product.

A final thought to investigate further as this develops. If it does prove that there is a limited supply of fodder and a large demand during a drought, basic economics suggests the price of fodder will increase. This needs to be monitored as the difference between the 500 per bale price and the 700 per bale price were enough to reverse the cost effectiveness of asset protection versus asset replacement. While it is certainly pre-mature to talk about a futures market for fodder crops that are just starting to be produced, something along those lines at some point in the future might be a possible response to the problem of the price going up in a drought. That is not where we are now, but hopefully someday we might get far enough along that it becomes a relevant consideration.

In terms of recommendations for hay marketing, first I would say we should look more closely at the numbers I used above with some more detailed production data. This is again a rough cut, very back of the envelope approach to the numbers. I would want to revisit these questions with more confidence in the numbers that I am using here. I would again want to work with the IBLI team and some of the Drought Cycle Management people to investigate how these proposed interventions would work in combination and complement each other. The fundamental vision is to build in demand in good years for milk and fattening operations and build in demand for bad years for reducing the impact of droughts. My opinion is that we need

both kinds of demand for fodder production to become sustainable over time; and that focusing on good year options or bad year options alone is not as likely to succeed overall.

B) Live animal market analysis.

In the course of my discussions of fodder and fodder markets, the discussion often was focused on the live animal market opportunties. I will briefly provide some of the ideas that came out of these discussions in the two Counties.

BM) Marsabit market opportunities.

The infrastructure of the market in Marsabit has been improved. Most notably, the paved road will open up new opportunities. When we discussed in Moyale the time it took to get animals to Nairobi, they told me if they could get the animals loaded before noon, they could be in Nairobi by the next morning. When I asked about the barriers that used to make that a three day trip, they said you pay 50 KSH during the day and 200 KsH during the night per lorry and you can go straight though.

The market infrastructure has also been upgraded, though it remains to be seen if the markets will come into use as planned. Between the new market infrastructure planned to be used in Turbi and Moyale sits the unused market infrastructure in Sololo that was funded by an earlier project that already needs rehabilitation. There were concerns expressed about the design of even the newer markets that were in the process of opening. The bars of the smallstock holding pens were thought to be too far apart to hold smallstock in. The height of the camel holding area was thought to be too low for camels and there was concern camels would be able to leap over the top bar and run loose in the market creating a dangerous situation.

Discussion often focused on how they were going to try to make sure that people selling livestock came into the market to sell and did not conduct transactions outside the market. Discussion focused on how the LMA and the county council would split up the market fees and force people to use the market. There was a pronounced lack of emphasis on what was the benefit to the buyers and sellers of livestock of using the market facilities. As a customer relations strategy 'use it or else you will get fined' is a losing campaign to wage compared to 'higher prices for sellers and higher volumes for buyers – the new Moyale market has it all!'.

It was the end / just following the rainy season when I visited so market volumes were pretty low. Moyale market reported sending about 2 lorries of cattle a day, each with 22 head of cattle to Nairobi. They predicted that would pick up to about 5 camel lorries with 15 camels per lorry, 5 cattle lorries with 22 cattle per lorry, and 7 smallstock lorries with 40 per lorry. For a head of cattle, the buyer pays a cess of 100 KSH and the seller pays 100 KSH. For goats it is 50 KSH each. For camels it is 150 KSH each. The cess is currently split 70% county 30% LMA, although that seemed more a proposal than an accepted decision in discussion. There is a cross border marketing committee to prevent stolen animals being sold in the market, and you have to produce your ID to sell an animal. They also reported that there is an FM radio broadcast of market prices weekely that the governement collects and disseminates. The new market in Moyale was predicted to open July 15th.

One interesting trip we took was to what is called the 'Livestock Lodge'. This is a small fenced in compound where you can overnight with your animals before the market day. It costs 20 KSH per headfor catttle and camels and 10 KSH for goats and sheep. The group that runs the lodge also has a *kalo* about 20 kilometers from town where they collect hay to sell at the lodge. One

bale costs 500 KSH, and they had a baling box as well. They sell the manure from the lodge at 100 KSH per sack. They were also working on developing a chicken production unit both in the grounds of the lodge (eating the ticks) and across the street where they had a chicken coop and were watering and feeding the chickens.

There were market opportunties for animals flowing north to Ethiopia and on to Djibouti and across to Saudi Arabia they believed. Fattened male camels are in high demand and are being trekked north if that is correct. There was also some disscussion of a route though Sudan and into Egypt for camels as well. With the opening of the road, there was some indication that animals from Wajir and even Mandera were beginning to flow towards Moyale to take advantage of the better access to Nairobi via the paved road.

We visited the smallstock market in Moyale (the old livestock market) and found a network of Garre women who had gone out to the producers and collected very specifc kinds of sheep for the Ethiopian producers who were present in the market. The Ethiopians wanted sheep that were male, 2-3 years old at most and 30 kilograms or less. They were paying between 90 KSH to 125 KSH per liveweight. I observed one put up in the sling, the scale read 23 kilograms, it was paid at 125 KSH per kilogram, and the seller was paid 23*125=2875 in cash right there in the market. They are taking them to feedlots to fatten them. I had heard about this a few years back for goats for the chilled meat export market (Desta et al. 2006) but this was explained to be for the live animal export market through Djibouti and Berbera. In contrast, they showed me an animal estimated to be 5 years old, and the price was going to me 4000-5000 they estimated. It was a much fatter, larger animal. They explained that this animal was for local butchers and would be consumed in town. So within the same physical market, there were distinctions within the sheep market that were really submarkets that had different specificaitons and objectives. That is the kind of thing we can be looking for going forward. The young less than 30 kg sheep would not be the kind of animals to fatten. The animal targeted at the local meat market would be the kind of animal to fatten.

For Marsabit and marketing, there was a growing sense that there were opportunities that might be found looking north rather than south, particularly for sheep and camels. There was a sense that larger geo-political forces such as the disruption of camel trade in Lybia especially and Egypt to some extent had created new market openings for East African camels. The continued insecurity in Somali led there to be opening for sheep passing though Ethiopia destined for the Middle East. One other niche we discussed was the potential market for Chalbi goats. These are known for being particulary tasty animals, perhaps from the salty environment they are raised in. They are known in the Nairobi smallstock market for being of good quality. Is there any way to capitialize on this reputation by marketing to a niche market ‘genuine organic Chalbi goat’ meat? A further thought, would a finishing operation such as Habiba’s that bought the goats and fattened them up build on this foundation or would the finishing lead to a decline in the qualitative difference people associate with Chalbi raised goat meat? All these kinds of openings and opportunities could be topics for further research.

One final issue that came up, the Somali fat tail sheep was described in one meeting as loosing some of the breed characteristics and was becoming more of a fat rump sheep. I was not sure of the genetics of this, but wonder if it could impact the marketability of the sheep that are currently heading north destined for the middle east market. It might be worth getting a sense

of whether this could become an issue, positive or negative, for the marketing of sheep from Marsabit County.

BW) Wajir market opportunities.

A big part of the market they identified was Boran cattle coming from other production zones, predomoninatly those further to the north, and passing through Wajir market. Monday is the big market day in Wajir for cattle, for other species there is a market every day. The largest share of animals leaving Wajir market trek to Garissa, though others go to Taita ranches for fattening and then on to Mombassa or for export through Mombassa on trucks, some go to Ukambani and Mwangi. Some of the animals produced in Wajir county were described as recently beginning to be going to Moyale. This seemed to be a mix of more market opportunities opening further to the north through Ethiopia and increased ease of transport to the south on the Moyale Isiolo road. Currently, Kenya is described as a bigger market for livestock produced in Wajir county than is Ethiopia. Blackhead sheep, however, are largely destined for Moyale and on to Ethiopia.

Camels were described as going to Athi River for slaughter and the meat then went on to Nairobi / Eastleigh. The trekking market of camels to Mogadishu was described as currently lucrative. It takes three months to trek from Wajir to Mogadishu. Camels purchased in Wajir for 60,000 KSH could be sold for 120,000 in Mogadishu. The value chain report for Wajir reports lower prices in Mogadishu, so either prices are higher now than they were when that study was conducted or we have inconsistent information. Given a three month trekking time, such uncertainty could have a significant impact on realized margins to be sure.

One specific case I want to summarize was an egg production operation in Wajir. A form 4 leaver was in the Industrial Area in Nairobi and came upon a Kenchik training seminar. He was intrigued and attended. He went to a few more Kenchick trainings related to egg production. In September 2015 he brought 1000 chicks to the chicken coop he had built to Kenchick specifications in Wajir. He spent 320,000 CFA to build the coop and 20,000 for the transport of the chicks. ADESO and REGAL-IR helped him by buying the chicks and provided food for 2 months. He borrowed the money to build the coop and pay the transport of the day old chicks from his own personal connections. Each chicken gets 122 grams of feed per day, a 50 kg sack costs 2700 so 54 KSH per kg. That is 6588 KSH in feed per day. From the 1000 chickens, he is collecting 29 to 30 crates of eggs per day, and he can sell the crates 300 KSH per crate wholesale or 320 KSH per crate retail. That is 8,700 KSH to 9,600 KSH per day in revenue, so between 2112 and 3012 KSH above the cost of feed per day. He is running it with his family members, and is attending a school in Meru for a diploma in business administration. He has just about paid back the loan on the original coop and is looking for land to expand with a larger coop. He reports there is more demand than he can currently satisfy. He is considering buying an incubator to see if he can get that to work as a business rather than buying day old chicks in Thika. So far he has lost 9 in a stampede. They are 60 weeks old now, and they stop laying at 72-73 weeks. He is beginning to plan for the transition to a new batch of chicks to replace the older ones.

I ran some numbers on the potential for a micro-finance loan to support this kind of operation. I used a 21% annualized rate of interest, a weekly repayment schedule, and a 10 month loan horizon. This was a template for a micro-finance loan that I was looking at in Mali as I wrote this

up and is used as a way of evaluating whether this is a feasible business to start with a microfinance loan. Assume he borrowed 340,000 KSH for the coop and the transport of the chicks, and express this in USD as $3,400. At 21% annual interest and a 40 week loan, the weekly interest payment is $14.88 and the weekly principal is $85.00 for a total weekly payment of $99.88. If the feed cost is $461.16 per week according to the numbers given above, he can sell wholesale at $630.00 per week or retail at $672.00 per week. This is a per week profit of $68.96 wholesale or $110.96 retail. The profit over the 10 months would be $2,758.55 wholesale and $4,438.55 retail, 81% and 131% of the $3,400 loan. This however is an overstatment of the potential, as the reality is that the day old chicks will not start laying until something like 20 weeks in. Even allowing for the first two months of feed and the chicks being provided by a donor, the returns become significantly negative if the debt has to be paid weekly over the 20 weeks while the chicks are maturing. If we run the calculations based more specifically on his case where there is a family loan with no interest, chicks covered by the project, feed covered for the first two months by the project, chickens starting to lay eggs at 20 weeks and laying to 73 weeks, we see that if he sells wholesale he breaks even and repays the loan in full right at week 73 and if he sells retail he repays the loan with $3,400 by week 62 and by the end of week 73 he has $2,241 profit on the loan of $3,400.

One added interesting element of the story was that he got some of his ideas from watching the show “Shamba Shape Up”. I saw an episode in Moyale, waiting for the food to come in the hotel restruant. This might be something to think about to reach the peri-urban youth in the area. What would it involve to do a Shamba Shape up show about fodder production and transformation? I noticed they visit different producers, one might be fattening, one might be doing dairy, one might be selling hay. It seemed like an intriguing option to reach all these peri-urban youth who are hanging around with the TV on. Would it be possible to show some of them some ideas that might get them to not hang around watching TV and invest time and energy in a new activity that this show exposes them to?

C) Summary and Conclusion.

The production of fodders is well underway in both Marsabit and Wajir. Underway in the sense that there are a few early adopters who are successfully producing fodders in their fields. It is in no way widespead. It is further worth commenting that the people who are producing fodder are not representative of the general population; most of the people I spoke with were at the upper end of the wealth distribution. That may be reasonable when introducing a new type of production that needs to be tested and refined. But part of the research agenda going forward would be to identify how the production of fodders can be made more accessible to people of more limited wealth.

In both Marsabit and Wajir marketing lags behind production. It seemed that more attention was given in the initial extension of this idea to the production side rather than the marketing side. There is a need to support fodder producers in making connections with people with a demand for fodder. There is also a need for creating expanded demand for fodder through intensification of livestock production. We have tried to present a few ideas in this evaluation to illustrate potential topics of further research to develop specific recommendations for producers and users of fodders. To summarize these options, the introduction of feeding operations in higher rainfall / irrigated areas could add a new value added income earning opportunity in the two counties. As noted above, the underlying theory is that there are currently value added fattening operations sourcing animals from these Counties and fattening them elsewhere. The challenge for us is to develop specific recommendations that would bring some of these value added opportunities to the residents of these Counties. The specifics of this remain to be fleshed out. It struck me in the conversation with Habiba, when she asked if it made more sense to have animals graze in the field or harvest and feed the animals, what species to fatten, and where to sell the fattened animals; we need to do some research to have evidence based answers to these questions. With regard to milk production, what are the most likely markets, what species should we target, is there enough willingness to pay that local markets are the correct market to target or should producers aim at more distant markets now that the road is improved? With regard to hay consumers, how do we expand beyond the goverenment market for drought cycle management, how can we link the fodder producers into the IBLI network, and how do we prioritize what animals will be fed in a drought? There is some evidence to begin this analysis, but tailoring production and marketing advice to specific production conditions and producer characteristics remains ahead of us for the most part. The exciting part is that there is some success to build on that I was able to observe during my visit.

In reflecting on this trip after it was over, I was again returning to the idea of storage. I think we can do more on this topic. One model was the large barn, either built by the government for storage or built by a project for a group (that seemed to default to an individual in some cases). Another model was a basic metal sheet and wood frame, smaller capacity barn, built by an individual for private use. Angelina is an example I believe. I think we could work on basic barn design and construction to increase storage capacity at the household level. We could also work to engineer the least cost / most effective storage solution that we could extend or work with people who do extension. Going with the cost estimate of the Wajir poultry operation, it would seem that it would be possible to build a reasonably effective barn for less than $3,000. For every 1000 bales stored and sold at 400 KSH per bale, that would mean a revenue of 400,000 KSH or around $4,000. If bales are bought for 200 KSH and sold for 400 KSH a capacity of 2000 would seem like a reasonable profit margin to pay back any loan used to build a barn. We can work on this, but the current direction of the county government or projects building barns for

people is somewhat limited in potential long run impact compared to training people in building and storing (and selling) the fodder they produce.

With regard to live animal marketing, there are a lot of emerging opportunities that could be researched and identified for producers in Marsabit and Wajir. The male camel market chain I found particularly intriguing. The idea that the higher return markets may be found to the north rather than the south is something that merits further investigation. Although it was somewhat beyond my focus on fodders, I did find the economics of egg production particularly interesting to look at. It did appear to me that there is a level of unmet demand in Marsabit and Wajir that could support more production units like the one I described above.

One final speculative comment. It appeared to me that the level of wealth that was flowing into Marsabit and Wajir as part of the decentralization and ramping up of the County government is leading to more buying power within the County. I was getting reports that the price of livestock and meat in the larger towns of the Counties was approaching Nairobi level. I could not verify if that was true, but given the amount of construction and expansion of Marsabit town I observed, and having some sense of the income elasticity of demand for livestock and livestock products, I hypothesize we may be seeing unprecedented spending power and demand in local markets that may absorb animals and animal products that would have gone to Nairobi in the past. I am not sure this is actually the case, but I wanted to share the theory.

It was an encouraging visit to evaluate what has been accomplished so far and consider how to build on this foundation going forward.

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D) Marsabit/Wajir Itinerary for John McPeak

Day/Dates	Planned activities		Facilitator
	Morning	**Afternoon**	
Marsabit County			
Thursday, 19th May	Discussions in Nairobi		
Friday, May 20th	Fly to Marsabit by MAF Meet County Officials - director of livestock production	Meet PREG members working in fodder (REGAL-AG, WFP, REGAL-IR etc)	Pauline/Simon
Saturday, May 21st	Visit fodder producers around Marsabit town - discussions with Muthaura (Milima Tatu)	Discussions with proposed Feedlot at Simpere Farm	
Sunday, May 22nd	Travel to Sololo and visit Gulied fodder farm /other fodder farms around Sololo	Travel to Moyale Visit Moyale market - Discussions with cattle lodging group near Moyale Market	
Monday, May 23rd	Travel to Marsabit	Wrap-up meetings with Simon/Key informants De-brief with livestock county officials	
Tuesday, 24th May	Fly Back to Nairobi by MAF		

Wajir County			
Wednesday, May 25th	Fly to Wajir Meet County Government Officials - livestock, NDMA, ASDSP	Visit fodder producers - MUUNGANO Fodder farm, Makaror fodder farm and Muktar fodder farm	Pauline/ Abdisemet
Thursday, May 26th	Visit Wajir green fodder market	Visit Jai jai Fodder farm supported by ALDEF and SDC Wrap up meetings with Key informants in Wajir De-brief with livestock county officials	
Friday, May 27th	Fly back to Nairobi	Wrap up Meeting	
Saturday, May 28th	Fly out of Kenya		

E) Appendix 2, Discussion of the implications of the findings in the two counties for potential work in Ethiopia in the future. From the Concept Note by McPeak, Angerer, Ericksen, and Little.

Narrative.

Livestock marketing systems in East Africa are experiencing rapid change. There is growing demand for livestock and livestock products, especially among the growing urban population, but also in international markets (Aklilu et al. 2013; Catley et al. 2012). This research project is focused on opportunities for people in Ethiopia to add value to livestock sourced in the extensive production areas of the country. Currently, animals are taken from the lowland production areas where extensive livestock production takes place and are fattened in highland production areas and feedlots where they are later sold at domestic and international markets (Debsu et al. 2015; Tiki and Little 2013; Little et al. 2014; Gebre-Mariam et al. 2013). The proposed research will support producers in key locations in the lowland pastoral production areas to develop intensified production practices to capture some of the value added profit that exists in the market for livestock and livestock products.

What we are proposing is to focus efforts in areas of high potential for fodder crop production within pastoral regions of Ethiopia. These areas of high potential results from differences in elevation where annual rainfall levels (for example in Borena) would be high enough to promote fodder development or where access to water resources and irrigation (for example in Afar) provide opportunities to increase fodder crop production.

What is the economic case for focusing on fodder production and intensification of livestock production systems?

1) It is already happening in terms of value added finishing and fattening. Producers are buying thin livestock in lowland areas, taking them to higher potential areas near Addis Ababa and fattening them before selling them in live animal and chilled meat export markets. We are proposing technical support to people in the settled areas of the lowlands to enable them to access this existing market opportunity and add value in the lowlands that is lost under the current market chain.

2) Settlement and the growth of towns is occurring at a dramatic pace in rangelands of Ethiopia (Little et al. 2010). Most of the residents in the towns of the lowlands are former pastoralists and retain connections to the pastoral production system. They also have a high demand for livestock and livestock products, especially milk. The milk production and marketing system as it currently is practiced is largely a byproduct of pastoral production systems. A move to more intense, and more hygienic, dairy production is possible and we propose supporting this move with targeted research that supports fodder use in dairy production systems.

3) As settlements are growing, so is the process of appropriation of land (McPeak and Little, forthcoming). In particular, in the Borana area the growth of enclosures known as *kalo*, which are customary grazing reserves, creates a production zone where producers could potentially transition from the protection of natural fodders for deferred use, to deliberate fodder production for use in intensified systems. Similar opportunities exist along the Awash river in irrigated production zones of the Afar Regional State and along the Shebelle river in Somali Regional State. The past 30 to 40 years of settlement and attempts to transition to maize and bean based cultivation has largely been unsuccessful. Recent research specifies that returns to land used in cultivation compared to livestock production are at best comparable if not inferior (Behnke and Kerven 2015). The vision here is to move towards cultivation not as an alternative to livestock production but in support of the production of fodders that can be used to create value within the livestock production system.

4) Access to feed resources is viewed as a critical element of Drought Cycle Management (DCM). As outlined in the Livestock Emergency (LEGS) manual (2014), access to animal feed is critical to minimizing the impact of droughts and requires significant advance planning. There is strong evidence that feed constraints are a major reason why producers often are forced to sell animals at greatly reduced prices, especially during long dry seasons and droughts (Little et al. 2014). In addition, there is clear evidence that the cost of keeping key breeding stock alive through feeding in a drought is less expensive

than replacing animals that die due to starvation (Abebe et al. 2008). This fact has recently been seized on by the Index Based Livestock Insurance (IBLI) product that is commercially available in parts of Ethiopia (https://ibli.ilri.org/ibli-southern-ethiopia/). They are attempting to move from an insurance model that compensates purchasers of the product at the end of the dry season following a rainy season with an indemnity that allows them to purchase replacement livestock with a model that delivers the indemnity at the end of the failed rainy season to allow them to purchase feeds that keep animals alive. For this to work, there needs to be feed available for them to buy. Currently, there is not a viable fodder production – marketing- and storage model in place to allow this to work. Our research will support the development of this fodder production, marketing, and storage system.

5) Recent developments in Ethiopia have created new opportunities for producers to make asset building investments. The presence of safety net programs provide regular cash transfers to households. While the main use of this cash appears to be to purchase food, the recipients also are using the transfers to repay loans and purchase inputs for higher return activities (Deveraux et al. 2006, World Bank, 2010, Jantsen 2012, Wheeler 2012). The Productive Safety Net Program (PSNP) in Ethiopia give regular cash transfers to poor households over a number of years. The ultimate goal is to have the recipient households graduate from the program and move out of chronic poverty. Reviews of the cash transfer programs in Ethiopia (Hoddinott et al. 2009, Devereux et al. 2010) tend to arrive at the conclusion that these programs do increase consumption and therefore well-being when transfers are at the programmed amount. However, the contention that the cash transfers will be sufficient to support 'graduation' from the program following a given period of continuous transfers is not well supported by the data. Even from the start of the program, concern was concern expressed that the mechanisms by which long term dynamic asset could be accumulated that would enable households to graduate from poverty were not well articulated (World Bank 2010). Empirical evaluations conducted in Ethiopia illustrate the goal of graduation is feasible (World Bank 2010, Gilligan, Devereux et al. 2006) when the cash transfers are linked to some form of agricultural innovation or diversification opportunity out of agriculture. This research proposal is motivated, in part, by a desire to develop agricultural innovations that will complement the PSNP efforts and provide a mechanism for long term poverty reduction and asset accumulation in the country's drylands. Through our applied research in support of development, we will refine the idea of fodder as an investment opportunity and develop intensification models for livestock production systems for people in pastoral areas to capture the benefits of value addition that are currently being realized outside of the pastoral areas.

The goals of the proposed research have two main dimensions. First, there is the refinement of an agricultural technology through applied research to respond to the question of what is meant by a high return, asset building investment in this setting. We believe that there are limited asset building investment options available to residents of the east African rangelands. The challenge outlined in this proposal is to develop a new investment opportunity that builds on emerging livestock trade opportunities and availability of small scale irrigation technology, leverages new sources of capital and reduction in credit constraints, and is at a scale that will be suited for adoption by a large number of people. We believe that through applied research, we will be able to develop an investment opportunity that is based on value-added animal fattening, value-added milk production and marketing, and fodder production as an economic activity. A second dimension is to investigate how this proposed innovation in agricultural technology interacts with the safety net, index-based insurance programs, and Drought Cycle Management programs that have recently been introduced in pastoral areas of Ethiopia.

The timing of this proposed research increases the probability of success. One reason for this is that there are signs of renewed USAID interest in supporting livestock production and marketing in Ethiopia. The PRIME project in southern Ethiopia is working towards improved livestock market functioning in pastoral regions of Ethiopia as a strategy to enhance resilience and economic growth. The LAND project is working on tenure reform in pastoral/lowland production systems and increasing the sustainability of livestock production systems that are based on mobility. Our proposed research would be able to support the development efforts of these USAID funded projects.

Another element to note is that livestock market opportunities in southern Ethiopia and northern Kenya are expanding dramatically. Peter Little at Emory University has been conducting research on cross border live animal trade in Ethiopia and the Horn of Africa generally for over 20 years and recently has documented the rapid growth in both domestic and export markets (Little et al. 2014 and 2015). Farmer (2010) also documents the significant opening in livestock trade that is occurring in Ethiopia. Desta et al. (2006 and 2011) and Legese et al. (2008) note that the livestock market chain has been reaching into the semi-arid rangelands with renewed vigor in search of livestock. Little et al. (2010) and Aklilu (2009) report that the growth in livestock marketing in Ethiopia has been rapid over the past decade and offers a window of opportunity for residents of lowland areas to benefit from this economic opening. Reviews of the prospects for intensifying the efficiency of the livestock market chain (Legese et al. 2008, Aklilu 2009) or moving to commodity based trade (Rich et al. 2008) arrive at similar conclusions; the feed market is a binding constraint to intensification in the Ethiopian meat sector. An overview of the feed market value chain has been undertaken (Gebremehdin et al. 2010) and notes that demand outstrips supply and expansion of supply is needed. Finally, further evidence of the potential for the proposed technology to have a positive impact is the intensification in the livestock sector that is already occurring in the form of finishing operations in places like Adama about 120 km from Addis Ababa (Aklilu 2009, Farmer 2010) and in Coast Province in Kenya (Mahmoud 2006). These operations are sourcing animals in the arid and semi-arid rangelands of East Africa, holding them in finishing lots or ranches to improve or increase body condition, and selling them at a higher price per head. The challenge that motivates this research is to identify ways that some of the value-added revenue that is being captured by these finishing lots could be adapted to practices used by producers in the arid and semi-arid rangelands. This requires agricultural innovation that we will support through applied research for development.

Another opportunity for this project is that the USAID-funded GL (Global Livestock) CRSP and the LCC (Livestock-Climate Change) CRSP have been supporting capacity building throughout the world in the use of Near Infrared Reflectance Spectroscopy (NIRS) as a tool to evaluate the nutritional value of animal feeds. NIRS uses patterns in reflected near infra-red light to compare to patterns in reference data sets for a particular constituent (e.g. crude protein) to rapidly identify the composition of scanned samples. This technology will be of great assistance in accurately and quickly identifying the nutritional content of feed samples to contrast the different options open to producers who wish to provide supplemental feeding to their animals. The feed quality information can then be used in decision support tools that develop least cost rations of the available feeds to allow producers to meet production and fattening goals. In addition, the GL CRSP, the LCC CRSP have supported the development of livestock market information systems (LIMS). In fact, the system in Ethiopia was developed by our Texas A&M Agrilife partners. Data from this system summarized in Table 1 illustrates large differentials in price between thin and fat animals. The innovations we are proposing will benefit from the use of both the NIRS and LMIS foundation funded by the CRSP over a long period of time, builds out from the AMA CRSP funded IBLI project, and will be able to work with the closely related PRIME and LAND projects in Ethiopia and any future USAID work that builds on these projects.

Finally, there are a variety of agricultural technologies that exist and are used in other parts of the world to fatten animals for markets. For example, Dr. Shirley Tarawali and her collaborators at ILRI have developed a series of cowpea accessions that appear to be ideally suited as a fodder crop for the targeted area. The work of this team has largely been focused on the use of cowpea in West Africa (Singh et al, Ayantunde et al. Kristjanson et al. Tarawali et al.). The USAID funded REGAL-AG, the International Livestock Research Institute, and SNV have funded expansion of buffelgrass, Maasai lab grass, Napier grass, and Sudan grass in northern Kenya (McPeak 2016). These experiences can be built upon in the rangelands of Ethiopia. There are proven technologies that we can adapt to Ethiopian conditions. This will involve agricultural extension work, as the techniques of growing fodders, and indeed cultivation practices in general, are not something that has a widespread base of knowledge in these communities that have traditionally been almost entirely focused on livestock production—although many now pursue rainfed cultivation where climatically feasible.

Successful introduction of new feed technologies is not straightforward since a host of issues can prevent spontaneous uptake by producers. With this in mind, ILRI has developed rapid assessment tools to ensure strong producer engagement in designing feed intervention strategies. FEAST (Feed Assessment Tool) involves a structured conversation with producers along with some simple quantitative questionnaires with a limited number of respondents. Results from these are used to develop a short report outlining the key elements of the livestock system, where livestock feed fits into the system, and what producers regard as the key constraints and opportunities. FEAST is being used in a number of ILRI projects to help design suitable feed intervention strategies. A further tool under development is called Techfit. This is a tool for prioritizing feed interventions according to a series of key constraints including availability of land, labour, capital and knowledge. The tools have mainly been developed and applied for mixed crop-livestock farms but the principles are general and they would be modified for the agro-pastoral setting in this project. FEAST can be conducted rapidly, one to two days per site, and helps to systematize thinking around feed interventions. FEAST, and potentially Techfit, will be used in this project to help in design of feeding strategies.

Our first two-year phase will largely be best viewed as a pilot project with demonstration plots. IBLI has 18 sites in Ethiopia in which they are currently working. We will collaborate with the IBLI extension network to identify pilot farmers or groups willing to undergo training and try the technologies we are offering. We also intend to work with community *kalo* in southern Ethiopia to test the productivity of different fodders in these jointly managed grazing reserve areas. This effort will build on the research sites in Borana, Ethiopia where Peter Little led a LCC CRSP-funded research project on mobility and livestock market chains during 2012-2015. ILRI would provide technical support and guidance in developing the cropping trials and in monitoring the animal nutrition implications of the work. Following implementation of FEAST assessments, the project team will work with producers and other local stakeholders to design "community learning activities" involving simple feed intervention strategies. These could include testing different fattening regimes involving forage combinations, use of forage choppers to increase intake, development of different producer organization models (dispersed fattening vs. communal fattening at a central facility), and experimentation with supplements. Community learning activities involve producer experimentation with different practices and can be monitored by local researchers to generate semi-quantitative data which is useful for assessing particular practices. Design of appropriate feed interventions will involve assessment of different elements: nutritional assessment of feeding regimes and likely liveweight gains to be achieved; practical assessment of whether the logistics will work; economic assessment of whether potential economic benefits outweigh the cost of required inputs in terms of labor and materials; agronomic assessment of which forage options are most suitable for the agro-ecology of the study areas and the likely forage yields that we might anticipate. Connections to higher level actors in the livestock value chain will also be required at later stages of the project. ILRI researchers, including those from the Forage Diversity Group, will provide expertise on agronomic aspects and choice of suitable forage species. Livestock nutrition consultants (e.g Prof Adugna Tolera) will be engaged to provide expertise on the nutritional aspects of local forages and to assist in technical design of feed interventions. Value chain consultants (e.g. Getachew Legese) will be engaged to provide expertise on economic aspects of proposed interventions. ILRI scientists (including Alan Duncan) will backstop the provision of technical expertise from ILRI.

Jay Angerer and the Texas A&M AgriLife Research team will provide guidance on training in livestock body conformation and use of the livestock market information system (LMIS). The Texas A&M team developed the body condition categories used for the LMIS and trained the market monitors in assessing body condition, so would be ideally placed to train the groups. They also were critical in developing and maintaining the Ethiopian Livestock Market Information System (www.lmiset.net), thus would be ideal collaborators for this effort. Angerer and the larger Texas A&M team would also provide a training and analysis role for the NIRS equipment similar to the one they played for the previous Livestock Innovation lab RIVERS / GSFA project in Senegal with L'Institut Sénégalaise de Recherches Agricoles and earlier with the Mali Livestock and Pastoralist Initiative (MLPI) project in Mali under an associate award with the LCC CRSP. The TAMU team will also play a critical role in adapting the

NUTBAL nutritional balance software (Stuth et al. 2002) to Ethiopia conditions to provide capabilities for least cost ration development and optimal feeding strategies to meet livestock performance goals. Angerer is also collaborating with the Innovation Lab for Small Scale Irrigation (ILSSI) to evaluate the potential irrigated fodder production amounts (kg/ha), fodder quality profiles (crude protein and energy), and animal production associated with small scale irrigation in the Ethiopian highlands. Information from these efforts will support identification of practices and model development for this project.

Peter Little of Emory University (EU) will provide guidance and research on existing livestock marketing systems and land tenure and social constraints, including gender-based issues, to adopting new production technologies and market opportunities in pastoral areas. He and his Ethiopian colleagues have done considerable work on the climatic (especially drought) impacts on pastoral production and trade in some of the same market areas where our proposed project plans to work, which will facilitate site selection and provide a baseline in some locations (Little et al. 2012 and 2014; Tiki and Little 2013). Through Emory's recently completed LCC CRSP (Innovation lab) funded project in Ethiopia, Little helped to establish MA-training on lowland development and food security at Addis Ababa University and will use this experience to assist MA thesis research and training at selected university partners on this project, where we are exploring possible collaboration with Jijiga university. Finally, Little currently is involved in a Gates Foundation-funded project on the 'drivers of food choice' when East African pastoralists become more sedentary. Working with colleagues in the Rollins School of Public Health (EU), Little will draw on lessons about the food choices and their nutritional impacts as livestock keepers increasingly settle and move away from dairy-based diets. The insights from this effort will be directly relevant to this project since similar nutritional challenges will be faced as Ethiopian herder intensify production and become less mobile.

Table 1 reports average prices for livestock in Dubluk market in Ethiopia, one of the markets used by producers in the Borana plateau. The data are from July 2010 to July 2016 and were downloaded from the Ethiopia Livestock Market Information System (www.lmiset.net) data site. The data in this table motivates one set of the research hypotheses. First, note that clear differences emerge in price per head of livestock according to body conformation (note market monitors all receive training in assessing conformation so that these are generally consistent across sites and are based on a modified version of the Nicholson and Butterworth [1986] scale). This pattern is one we have seen in markets across the world where livestock are sold on a price per head basis; purchasers pay more for animals in better condition.

Table 1: Average smallstock prices, Dubluk market Ethiopia July 2010-June 2016 in Birr

	Very thin	Thin	Moderate	Fat
Goats and Sheep	256	429	641	678
With respect to moderate	*41%*	*67%*	*100%*	*106%*

1 USD in July 2010 corresponded to around 13 Birr, currently it is around 20 Birr = 1 USD.

Fundamentally, what would it take to buy animals having non-fat conformation and make them arrive at fat conformation for resale? Further, once animals are fattened, can producers use market information systems, that provide current price trends as well as a spatial representation of prices across markets, to realize the highest profit possible? A series of research hypotheses flow from these two questions.

Hypothesis 1: Technologies exist that can allow a producer to purchase an animal having a body conformation other than fat and bring them up to fat conformation for sale at a higher price per head in the pastoral areas.

Research question 1: Are the interventions better targeted at one livestock species than another? That is, is the best investment return for finishing animals found with camels, cattle, goats, or sheep?

Research question 2: For a given livestock species, is the best strategy to buy very thin, thin, or moderate condition animals to bring them to fat condition?

Research question 3: Do different feeding regimes have different outcomes in terms of cost per day and weight gain per day?

Sub research question 3: Do these 'least cost ration' input bundles change over time as environmental conditions change?

Hypothesis 2: Producers can be trained in the production, conservation, and use of fodder crops that will be an input in finishing operations.

Research question 1: Is it more effective to train people in both fodder production and finishing as complementary technologies or will comparative advantage emerge to have different groups specialize in different technological components? Will women be more likely to pick up fodder production techniques more easily than males because of more experience and responsibilities in rainfed farming?

Research question 2: Is the set of fodder crops being proposed likely to be more successful as an intercrop or as a monocrop in a given field?

Research question 3: What is the feasibility of producing and managing fodders in community *kalo* enclosed rangeland areas? Is it more cost effective and socially viable to improve natural fodder production through enclosures and regulating their uses, or to be encouraging fodder production in these enclosures?

Hypothesis 3: Producers can be trained in the use of the market information system described above for economic benefit.

Research question 1: Can producers be trained to consistently and reliably asses body conformation categories seen in table 1 and use them in making livestock purchase and fattened animal sale decisions?

Research question 2: Can producers be trained to use the market information system to make profit maximizing decisions in the spatial choice of which market is ideal for selling their fattened animals?

Hypothesis 4: Supplemental feeding is best targeted at fattening animals for markets*.

Research question 1*: Does fattening in fact outperform supplemental feeding for milk production? Does fattening outperform supplemental feeding for improved animal traction performance? Does fattening outperform supplemental feeding in drought to preserve a core breeding stock?

Cross Cutting Theme 1: Role of Gender in Livestock Systems

There are critical gender dimensions that cross cut each of the above hypotheses and research questions proposed above. Particularly important will be understanding the following:

- To what extent will fodder production for animal fattening for live animal markets rather than for increased dairy production affect women (and children's) access to food and income streams, since women are usually more directly involved in dairy herding and milk marketing?
- How will the selection of different animals for fattening affect different gender groups and their benefits, since women generally are more involved with goat and sheep trade and men with camel and cattle trade;
- Will increased fodder production add to labor burdens on women and, if so, how willing will they be to allocate additional work if men are seen to benefit from improved animal production and sales?
- How can outreach/extension activities be designed to insure that women livestock keepers are equally involved in training activities?
- How will intra-household property rights (especially between wives and husbands) affect rights to fodder and the feeding of different livestock?
- Will women be willing to expend labor on different fodder crops if those fodder products are fed to animals that they own and control their sale?

A social scientist (Little) on the team will be involved in the design of study questions and will insure that similar questions are asked both of men and women and that during analysis data are disaggregated by gender. A policy of equal representation of males and females in the composition of field research teams and project trainees will help to insure that gender-sensitive data are gathered and that project benefits are inclusive. We expect to learn much about how intra- and inter-household gender

relations affect the adoption of certain fodder crops and technologies and will build these insights into training and extension activities.

Cross Cutting Theme 2: Human and Institutional Capacity Development (HICD)

In addition to MA/MSc training at host universities, capacity will be built through methods and research skills training for counterpart research participants. We also will work with existing extension infrastructure in the study areas to provide training on fodder management best practices, tools and decision support for using market information, least cost ration formulation, and economic assessment of fattening, in addition to marketing strategies. Workshops and demonstrations will be held for community groups, cooperatives, and NGOs on feed/fodder production practices, conservation, and use, economic considerations for fattening enterprises, livestock body condition scoring, and livestock nutrition management for fattening and/or drought management.

Cross Cutting Theme 3: Human Health and Nutrition

The intensification of livestock production for increased market participation will raise several important nutritional and health issues. First, if the labor burden of women, especially young mothers, is increased than it could affect both maternal and child health with mothers having less time for breast feeding and child care. Research on dairy intensification in highland Kenya, including fodder production, showed that child nutrition and health can be negatively impacted (Njuki et al. 2015). Second, the increased sedentarization and settlement of pastoralists associated with intensification will likely result in changes in food availability and choices. In the lowlands of Ethiopia, a large proportion of household herds are likely to remain mobile with young males herding them in camps, while other family members remain in settlements. In these cases, children are likely to lose access to dairy products with evidence showing that they mainly have been replaced by storage carbohydrates, such as maize meal. Food consumption data will be gathered from household surveys and it is hoped that the incorporation of cowpeas as a fodder crop, whose nutritious leaves are important food sources for agricultural communities, will help to compensate for decreased access to milk products. In cases where increased fodder production is orientated toward dairy production and trade, the study will identify whether or not increased milk sales improve purchases of nutritious foods that benefits family (especially child) nutrition.

Finally, with increased settlement there is likely to be a growth in gastrointestinal diseases, especially as access to safe water and sanitation will likely be problems, and infectious diseases, including malaria, especially settlement and fodder production in riverine areas, such as Afar. It will be important to collect health-related data in our household surveys and work health officials if we find spikes in certain kinds of health problems.

Area of Inquiry 1: Animal-Source Food Production and Marketing.

The research activities described in this project will provide capabilities for increasing the quantity and quality of livestock feeds in Ethiopia, especially in lowland areas where quality of feeds can vary significantly throughout the year and during drought cycles. The ability to produce higher quality feeds through strategic irrigated fodder production can provide higher quality feed during the dry seasons, thus improving animal health, allowing animals to maintain body condition which results in improved reproductive health, greater meat and milk production, and opportunities for increased income resulting from the sale of fatter animals.

Area of Inquiry 2: Livestock Disease Management and Food Safety.

Although the efforts in this study will not directly address livestock disease management, the improved health and body condition of animals receiving higher quality supplemental feeds and fodders will result in healthier animals that are less impacted by disease.

Area of Inquiry 3: Enabling Policies for Livestock

Opportunities to engage regional and national policy makers to incentivize and support fodder production though improving access to irrigation water, land access, and markets.

Area of Inquiry 4: Future Livestock Systems.

These efforts will use models and develop tools to provide evaluation of practices for sustainable intensification of fodder production for livestock and opportunities for increasing the availability of

fattened animals that are more desirable for purchase in markets in Ethiopia. Improved livestock nutrition resulting from increased availability of higher quality fodders throughout the year has the potential to boost ASF production in these pastoral regions, thus increasing economic benefits for these stakeholders.

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