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Agricultural Actors, Networks and Mind-sets:
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Scaling up conservation agriculture production systems (CAPS) for smallholders requires facilitating a change in mindset within a supporting network of agricultural production partners. Entering into the dialogue necessary to achieve these changes depends on the capacity of CAPS promoters to interact and communicate effectively with the existing network of farmers, agricultural service sector providers, and community agents. Effectively negotiating these interactions to create innovative ways to integrate the three conservation agriculture principles (reduced tillage, maintaining a permanent crop cover, and crop rotations) into local production practices will require: (1) an understanding of the current (local and scientific) knowledge and perspectives concerning best agricultural norms and practices; and (2) identifying the relevant actors and their resource and communication channels in the local agricultural production network. As a contribution to building communicative capacity, this working paper presents findings from the study of four local networks involved in CAPS research by the SANREM CRSP Long-Term Research Activity in East Africa (LTRA-10).

Introduction

The LTRA-10 Project, titled "CAPS for smallholder farms in eastern Uganda and western Kenya", selected a cross-section of ethnically and agriculturally diverse production systems in which to study conditions for the experimental development and scaling up of CAPS (Odhiamba et al 2011; Wyoming SANREM project 2011; LTRA-10: CAPS for smallholder farms in eastern Uganda and western Kenya 2011). The research is being conducted in four locations: Bungoma and Trans-Nzoia Districts in western Kenya and Tororo, Kapchorwa, and Kween Districts in

[1] Virginia Polytechnic Institute and State University
[2] Appropriate Technology-Uganda
[3] Moi University
[4] Manor House Agricultural Center
[5] SACRED-Africa
[6] Makerere University
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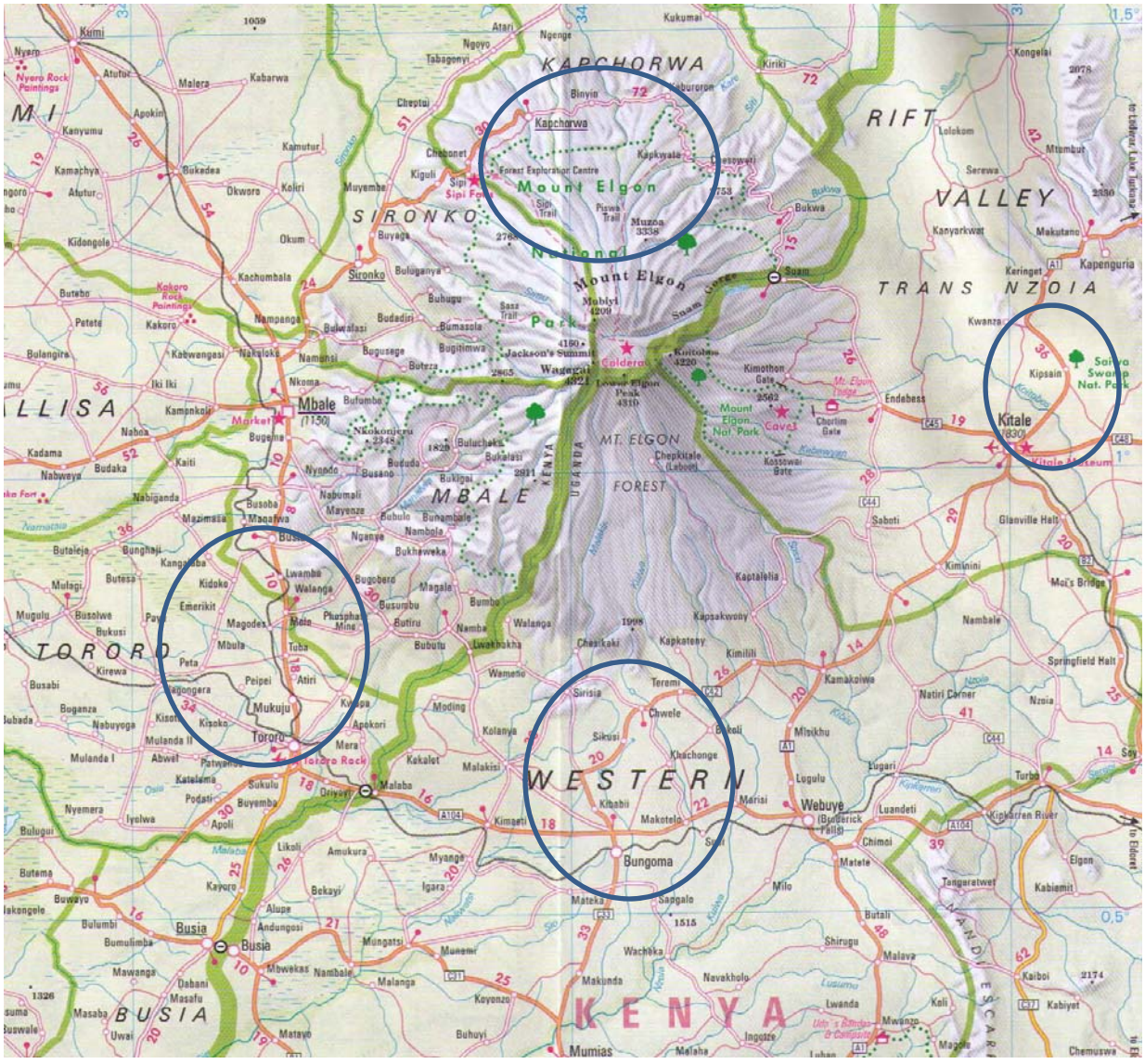
eastern Uganda. As can be viewed in Figure 1, these research sites are clustered around Mt. Elgon, an extinct volcano which spans the Kenya and Uganda border. The northern sites, Trans-Nzoia and Kapchorwa are considered higher potential regions due to their more fertile volcanic soils on the slopes of Mount Elgon and higher overall rainfall. Conversely, Bungoma and Tororo are thought to be the lower potential areas due to their poorer, sandier soils and more variable rainfall.[8]

Figure 1: Map of Research Sites in the Mt. Elgon Region



(Nelles Map, 2011)

[8] This said, it is important to realize that Bungoma remains a key maize producing region in Kenya.

Beyond the geophysical variation between the sites, there are important cultural and infrastructural characteristics that should be noted. The Sabiny people of Kapchorwa and Trans-Nzoia are native pastoralists who have adopted agriculture in the twentieth century, in many cases due to colonial influence. In particular, the gently sloping plains and fertile soils of Trans-Nzoia District were recognized as ideal for coffee and maize production and large colonial landholdings were established throughout the first half of the twentieth century (Anderson and Throup, 1985). By contrast, agriculture has only been adopted in Kapchorwa in the past fifty years.

South of Mt Elgon, the Bukusu, a clan of the Luhya ethnic group, comprise the majority in Bungoma District and are traditionally agriculturalists and pastoralists (Humanitarian Policy Research Group, 2008). Across the border, the Molo and Kisoko research areas in Tororo District are mostly home to the Jophadhola and Iteso ethnic groups. The Jophadhola have ties to the Jaluo or Luo tribe in Kenya, mostly found south of Bungoma District and nearer to Lake Victoria (Mango, 2002). Traditional livelihoods of the Jophadola include fishing and farming. The locations are also connected from an infrastructural perspective. Specifically, many of the inputs for commercial agricultural production in Kapchorwa are imported from Kitale, the major urban center in Trans-Nzoia. While Kapchorwa is only 50 kilometers from Kitale, there are no good roads running directly between them through the mountains, nor is there an effective inland port for the legal trading of goods between the two sites. As a result, hybrid maize seed produced in Kitale must pass through Bungoma, then the Malaba port of entry to Uganda through Tororo and up to Kapchorwa.

Sampling Methodology

The sampling methodology for the technology networks research involved a two-phase process. Farm household baseline surveys from the four sites provided the ego networks of farmers for this study. A second survey of agricultural sector and community agents identified during a follow-up household survey expanded that network to the next level using a snowball sampling method.

From June to September 2010, the LTRA-10 team conducted the initial baseline survey of 790 households. Of these households, 395 were administered surveys which contained a Technology Networks data collection module based on the methodology outlined in the SANREM CRSP Working Paper “Research Framework for Technology Network and Gendered Knowledge Analyses” (Lamb, et al 2010).

Although the survey focus and data collection instruments were maintained across the four LTRA research sites, there were some variation in sampling methods as the process was headed up by three different NGOs, each adapting to their selected research communities. In Uganda, the NGO Appropriate Technology Uganda (AT Uganda) developed a quasi-experimental design. In the Kapchorwa and Tororo sites, one sub-county was selected, and within each sub-county on-farm trials were established in one or two parishes. In Tororo, Molo sub-county was selected for the technology networks survey. The survey area covered two parishes. In Kapchorwa, the research spanned two districts, Kapchorwa and Kween. Kween District was selected for the Technology Networks research, and the surveyed parishes were Kwosir and Kere. Kwosir currently hosts two on-farm demonstration plots. The residents of Kwosir and Kere are mostly newcomers to the area, having emigrated from the plains of Kapchorwa District during the late

1980's due to political unrest (Lamb, 2011). Kween District was formerly part of Kapchorwa, but was designated as a separate district in 2010. Kapchorwa town meanwhile continues to serve as the main urban center accessed by the residents of Kween. Throughout this text we will commonly refer to this entire area as Kapchorwa, as this name is still more readily recognized, especially in agricultural development research (Lamb, 2011).

During the 2010 baseline, a list frame was created by obtaining records of household heads from each sub-county and then preforming a stratified random selection from each list. Particular attention was given to ensuring that female-headed households were included in the sample. This was accomplished by first identifying 50 households in which the male household head would be interviewed. Second, all the solely female-headed households were interviewed and these made up the first households of the group of 50 households where women were to be interviewed. When a household could not be located during the survey, substitutions were made in the field for similar households.

This overall strategy involved slight modifications in Kenya. In Bungoma, the NGO SACRED Africa identified farmer groups with whom it had worked with previously and used these groups as a base from which to build their sample outward. The resulting surveyed population was widely distributed between Bungoma South and Bungoma West and clustered around two different market centers. In Bungoma South, the main trade center was Bungoma town, but Bungoma West utilized the Chwele market. During the original household interviews, enumerators were instructed to alternatively interview men and women in a particular geographic area in order to ensure gender balance.

In Trans-Nzoia District, Kenya, the peri-urban populations of the Kibomet and Milimani sub-locations were selected for the technology network study, so research efforts were focused on this population in the network surveys. As in Uganda, list-frames were created from local records, female household heads identified, and substitutions were made in the field if households could not be located. Due to the proximity of Kibomet and Milimani locations to Kitale town, these sites are referred to as Kitale throughout the text. Research from these particular sites cannot be appropriately extrapolated to represent Trans-Nzoia District at large.

Across the sites, mixed teams of men and women were employed as enumerators. They were hired from each community in order to ensure familiarity with the local language and geography. The enumerators were trained by the staff of the respective NGOs managing the projects in each of the sites. Despite the differences between the methodologies adopted by the different organizations, the processes followed by each of the NGOs were sufficiently thorough to create a sufficiently representative samples of the populations for each of these regions.

Household networks

From February through April 2011, a second survey on food security and social networks was conducted with these same households (Lamb, 2011). During this survey over 80 percent of the original farm households were interviewed. A snowball sampling method was utilized in each sites to generate a list of who to contact for the agricultural service sector/community actor interviews. Any individual whose name was reported more than five times was interviewed. These actors were also asked about their contacts, and if a name was enumerated more than three times these individuals were also interviewed. In all of the sites, some of the participants in the

household survey were identified as agricultural production support actors. In these cases, the interviewee was removed from the farmer list and included amongst the agricultural service sector/community agents. Using this methodology, an additional 74 service sector/community agent interviews were conducted. In the analyses for this working paper, some household respondents were dropped due to missing data.

Table 1: Sampling distribution for Farm Household and Service Sector/Community Agents Surveys

Site	Farm Households Interviewed	Service Sector/Community Agents Interviewed
Tororo	93	15
Kapchorwa	97	19
Bungoma	75	19
Kitale	79	21
Total	344	74

In many ways, these samples of the farming populations and their service sector/community agents are likely to be broadly characteristic of the larger administrative units from which they have been drawn. However, they were not selected with that intent or methodological precision. These samples were selected to represent the targeted populations of the SANREM CRSP Long-Term Research Activity-10 in East Africa. Extrapolation of findings from these samples to the full extent of the administrative units in which they reside may not be justified. This would depend on the extent to which the network identified coincides with that of the full administrative unit. Indeed, one of the findings of this study is that locality matters and as such local investigation of network relationships and technological frames is required to best understand how to proceed to ensure effective communication and durable utilization of external concepts and practices. Nevertheless, the approach and methodology used here are replicable and can be adapted for other localities as the need arises.

Egocentric Network Data Collection

Data on social networks was collected using egocentric methods that measure relative network strength based on individual reporting of their direct contacts in social networks. For the Technology Networks module, a position generator method was used to collect data on farmer contacts for obtaining agricultural information, advice and resources. The position generator method asks individuals about their relationships with members of different occupational/social categories, which in this case are associated with agricultural production (Lin and Erickson, 2008). As such, developing a locally adapted list which makes sense to the local people is crucial to the survey. In order to do this, local Advisory Committees (a group of farmers and NGO representatives that LTRA-10 has been consulting with throughout the research process) were called upon to assist in developing a list of supporting agricultural sector and community actors. The list was then validated by focus groups in Kenya and Uganda facilitated by members of the SANREM Management Entity in conjunction with local country personnel in June and July 2010 (Christie 2010; Moore 2010). The contributions of the local advisory committee and the focus

groups indicated that a wide variety of individuals often contribute to providing agricultural information, advice, and resources which extends well beyond the typically studied technology transfer network of extension agents, agricultural researchers, and farmers. These included members of the local community such as shopkeepers, market vendors, government parastatals, teachers, preachers, and local community group leaders. The module included in the 2010 household baseline survey asked farmers about different aspects of their relationships with these agents (see Appendix A).

Technology Networks

The technology networks research project is interested in two key areas: 1) knowledge and beliefs about agricultural production and 2) size, composition, and structure of farmer and agricultural service sector networks. This implies the utilization of two different types of statistical analysis.

First, data from the household and technology networks service sector/community actor surveys was first entered in the traditional cross-sectional format in order to conduct basic statistical analysis of the network actor attributes and beliefs about agricultural production. Two key factors were controlled for in these analyses: size of farming operation; and contact with the extension service. Within sites there was a considerable range in farm size that may have a distinct impact on farmer networks, ideas, and beliefs. Consequently to control for this potentially significant source of variation, farmers were designated as either small or large depending upon landholding size. For Tororo, Kapchorwa, and Bungoma examination of the frequency distributions of farmers suggested that 3 acres and lower was a reasonable cutoff to be considered a small farmer. Given the generally larger landholdings in Kitale a similar cutoff was identified at 5 acres. In order to explore the extent to which contact with traditional extension services influence farmer perspectives, farmers were also divided into those who had contact with traditional extension (e.g., government) agents and those who did not. In the statistical analyses of knowledge, beliefs and perceptions about agricultural production, the views of agricultural service sector/community agents are compared to small and large farmers, and to those with and those without extension agent contacts.

Second, to conduct total network analyses for the sites, matrices to report the relational data in the networks were constructed. Math programming was used to transform data from the cross-sectional format to construct these matrices. A script in MATLAB matched agent types to their corresponding descriptive information about their relationships with other agents. These matrices were then submitted to UCINet for analysis and Netdraw for the design of network maps for each of the four sites (Borgatti et al, 2002). In the final section, relationships between knowledge and beliefs about agricultural production are explored in the context of network relationships. For clarity of presentation and given the lack of significant differences in the findings between farmers, the network mapping of reported relations only uses the large and small farmer categories.

Farmer and service sector/community agent perspectives

In order to gauge the general perspective of farm household heads, their spouses, and various agricultural service sector/community actors on agricultural production norms and practices, a battery of 20 attitudinal statements was read to them. These statements were designed to

characterize three ideal types of agricultural norms and practices (technological frames): conservation agriculture, conventional agriculture, and risk averse agriculture[9].

Respondents were asked about the extent to which they agreed or disagreed with each statement. Responses were recorded on a 5-point Likert scale: (1) strongly disagree, (2) disagree, (3) uncertain/neutral, (4) agree, and (5) strongly agree. Factor analysis (principle components) was conducted on each group to determine the underlying patterns of co-variation among the items, in order to identify more robust and reliable measures (IBM® SPSS®, 2011).

Preliminary analyses indicated that there were no consistent patterns of correlation among the responses with respect to Conservation Agriculture (CA). Respondents saw each of the three principles of CA as independent concepts, indicating that a conservation agriculture technological frame is not-fully formed amongst survey respondents. As such, in the following section these items are examined independently of one another to understand predispositions for Conservation Agriculture among these three factors.

Items for the Conventional and Risk Averse Agriculture technological frames were found to provide more coherence when analyzed together as evidence that they were often seen as interrelated, albeit sometimes opposed, perspectives as formulated in day-to-day discourse. Using varimax rotation, two underlying dimensions were identified and extracted. These two dimensions of agricultural production norms and practices cut across the four localities, linguistic/cultural differences, and various roles in agricultural production. While more statistically robust (and more locally adapted) factors could be identified within each site, these two factors were distinguishable across sites so we have used them to investigate inter-site similarities and differences between agricultural service sector/community agents and smaller and larger farmers, as well as farmers with or without extension agent contacts.

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[9] ***Conservation Agriculture:*** Conservation agriculture producers are concerned with controlling erosion and maintaining the health of their soils while improving yields. The ideal type producer is fully committed to the three principles of Conservation Agriculture Production Systems (CAPS): minimizing soil disturbance, maintaining a permanent vegetative cover, and rotating crops. Conservation agriculture producers are also willing to experiment with different mixes of fertility inputs and methods for weed and pest management to find optimum yield outcomes.
Conventional Agriculture: The conventional agricultural producer is motivated by the need to maximize profit and/or yields. As a result, producers are committed to specialization in particular commodities and base their planting decisions on the marketability of their final crop. Often accomplished through large-scale monocultural production systems, conventional agriculture producers will apply fertilizer, chemical pesticides, and herbicides up to the point it is profitable for them to do so. Conventional agricultural methods also emphasize mechanization of land preparation and harvest. This includes tilling the soil before, and often during, production. These producers will be interested in the development of labor saving technologies to lower input costs and will advocate the use of science to improve yield and profit margins.
Risk Averse Agriculture: The risk averse producer strives for autonomy and independence in agricultural production for food security. This involves a careful balancing of productive activities to ensure the sustainability of the farm household. Characteristics of different risk averse producers are highly contextualized, but often involve smallholder systems in some form of multi-functionality or co-production, often mixed livestock-crop systems. However, this may also include reliance on off-farm income in addition to farming, a decision to spread crops and or inputs across different locations, or the use of intercropping systems. To access resources necessary for production, risk averse producers prefer to rely on their personal networks for exchange rather than purchase their goods from the open market.

The first factor can be described as characterizing conventional modern farming using purchased inputs. It can be formulated in this way – "successful farming requires the use of modern chemical inputs and machinery" – and is composed of agreement with the following three statements:

- Farm labor should be replaced by more efficient herbicides and machines
- Applying chemical pesticides is always necessary
- Inorganic fertilizer is best to improve soil quality

After accounting for the dimension of conventional chemical based farming, the second factor accounts for co-variation associated with traditional mixed farming food security systems. It can be summarized as indicating that "cash cropping should contribute to livestock and poultry production" and is composed of:

- Crops should only be grown for sale
- Crop residues should only be fed to livestock and poultry

The 'conventional modern farming using purchased inputs' factor has an eigen value of 1.52 and accounts for 51 percent of the co-variation among the three items. The 'traditional mixed farming (crop/livestock) production systems' factor has an eigen value of 1.36 and accounts for 68 percent of the co-variation between the two items. Although the alphas of .51 and .52 (respectively) are not particularly strong, the face validity of the items and their re-current co-variation at the local level makes them strong and meaningful indicators of underlying patterns of beliefs about agricultural production.

Findings on Agricultural Perspectives:

The analysis of the difference in mean values for the two factors for general agricultural production norms and practices indicates that size of farm and contact with extension agents have little impact on these technological perspectives of farmers (Tables 2 and 3). However, the analysis does demonstrate a significant difference between the perspectives of farmers and those of service sector/community agents. Service sector/community agents are more likely than farmers to agree that successful farming requires the use of modern chemical inputs and machinery. Whereas these agents are less likely than farmers to believe that cash cropping should be integrated with livestock and poultry production. Size of farm has a weak negative although significant correlation (at the .05 level) with the mixed farming factor, suggesting small farmers may be more comfortable with this traditional practice. Small scale farmers use land as a limited resource in a manner that distributes risks because they are less protected against unpredictable weather events and market fluctuations compared to large scale farmers. Modern chemical-based farming is not correlated with farm size.

These findings indicate that there is a fundamental gap between the perspectives of farmers and those of the service sector/community leaders with respect to agricultural production norms and practices across the four sites. Specifically, agricultural service providers and other community agents are significantly more supportive of conventional modern farming than farmers, and significantly less supportive of mixed crop and livestock farming. This is consistent with the fact that this non-farm agricultural population has been educated from a conventional farming perspective and this remains the perspective they advocate even at the expense of mixed farming

practices that promote local farm livelihoods. The general pattern remains when these data are analyzed within each community, although statistically significant differences are rare, and only in Kenya (modern chemical-based farming in Bungoma at the .01 level, and mixed farming in Kitale at the .05 level).

Table 2: Mean scores for Kenyan and Ugandan farmers and service sector/community agents level of agreement on basic farming approaches

	Small farmers	Large farmers	Service sector/ community agents
Conventional modern farming *	6.85 [a]	7.02 [a]	7.57 [b]
Mixed crop-livestock farming *	4.44 [a]	4.54 [a]	3.96 [b]
N	137	207	74

Notes: Different letters within the same row are statistically different.
Rows marked by * signify that T-test scores are significantly different at the .05 level.
Higher composite scores signify greater levels of agreement with the technological frame concept indicated by the factor.

Table 3: Mean scores for Kenyan and Ugandan farmers with and without contact with extension, and service sector/community agents level of agreement on basic farming approaches

	Farmers w/o contact	Farmers with contact	Service sector/ Community agents
Conventional modern farming *	7.05 [a]	6.83 [a**]	7.57 [b]
Mixed crop-livestock farming *	4.60 [a**]	4.38 [a]	3.96 [b]
N	189	155	74

Notes: Different letters within the same row are statistically different.
Rows marked by * signify that T-test scores are at least significantly different at the .07 level; ** signifies the .01 level.
Higher composite scores signify greater levels of agreement with the technological frame concept indicated by the factor.

Conservation Agriculture

The following tables examine the perspectives of farm and non-farm agricultural agents with respect to the three principles of Conservation Agriculture controlling for farm size and contact with extension agents. These analyses will use single indicators, allowing us to dissect the components of Conservation Agriculture as they are perceived across and within each region.

We begin by considering the item: “Rotating crops is always best practice.” Crop rotations are perceived by nearly all agricultural sector actors (farmers, service sector and community agents) as a best practice (Table 4). For purposes of tabular presentation, the analysis is restricted to only three categories (“agree” and “strongly agree” are combined into “Agree”, and “disagree” and “strongly disagree” combined into “Disagree”). A statistically significant difference in mean values was found between farmers and service sector/community actors, but this is not

substantively significant as all mean values were above 4.5 between "agree" (4) and "strongly agree" (5). The lowest mean values at the community level were 4.3 for "farmers without extension contacts" and "small farmers" in Bungoma, and 4.4 for "farmers with extension contacts" in Kapchorwa. There is a shared consensus on the importance of crop rotations in all four study communities.

Table 4: Percentage of and mean value for (a) small and large farmers compared to service sector/community actors and (b) with or without extension contacts by level of agreement or disagreement with the statement that:

a. Rotating crops is always best practice	Agree	Uncertain /neutral	Disagree	Mean values
Small Farmers (137)	92.7	6.6	0.7	4.51 [a]
Large Farmers (207)	93.7	4.3	1.9	4.55 [a]
Service sector/community agents (n=74)	95.9	2.7	1.4	4.84 [b]
b. Effect of extension contact				
Farmers w/o extension contact (n=189)	93.7	4.2	2.1	4.54 [a]
Farmers with extension contact (n=155)	92.9	6.5	0.6	4.53 [a]

Notes: Chi-square = not significant.
Different letters indicate that the T-tests for differences in means are statistically different at the .01 level.

It was noted during the feedback sessions with local stakeholders that the concept of crop rotation understood by farmers at the time of survey may not be identical to that which is generally advocated by conservation agriculture. Specifically, conservation agriculture typically promotes cereal/legume rotations in order to add nitrogen back to the soil. Many farmers on the other hand, may practice cereal/cereal rotations, such as maize to millet, due to food security concerns or in an effort to break the pest and disease cycle. Nevertheless, general support the principle of crop rotation across the sites provides an important foundation for the introduction of the more specific rotational requirements advocated by conservation agriculture.

Table 5: Percentage of and mean value for (a) small and large farmers compared to service sector/community actors and (b) with or without extension contacts by level of agreement or disagreement with the statement that:

a. One should maintain a permanent crop cover	Agree	Uncertain /neutral	Disagree	Mean values
Small Farmers (137)	27.7	40.9	31.4	3.01 [a]
Large Farmers (207)	24.2	34.3	41.5	2.82 [a]
Service sector/community agents (n=74)	73.0	10.8	16.2	4.03 [b]
b. Effect of extension contact				
Farmers w/o extension contact (n=189)	24.3	38.6	37.0	2.88 [a]
Farmers with extension contact (n=155)	27.1	34.8	38.1	2.92 [a]

Notes: Chi-square = 65.232 significant at the .001 level for difference between small and large farmers and agents.
Different letters indicate that the T-tests for differences in means are statistically different at the .01 level.

On the other hand, the perspectives on permanent vegetative soil cover are polarized. Respondents were asked whether they agreed or disagreed with the statement that "One should maintain a permanent crop cover". Seventy-three percent of the service sector/community actors agreed, while over a third of farmers (more often the larger ones) disagreed; and another third were uncertain (Table 5). There is clearly a major disagreement between farmers and their advisors over the issue of maintaining crop cover. During the restitution of these findings with stakeholders at each of the sites, questions were raised about the meaning of 'crop cover' as posed to respondents. A review with enumerator supervisors about how this concept was translated revealed strong consistency across sites for the initial statement and subsequent clarifications made when requested by respondents. "Crop cover' was generally translated as leaving residues on the field, or immediately planting another crop after harvest. The ultimate goal was assuring that bare soil was not exposed. It was acknowledged that a more appropriate formulation of the statement in English would be "one should maintain a permanent soil cover".

It is worth exploring these differences with respect to this concept of soil cover at the local level. Do local ecology and agricultural production norms and practices interact to shape agreement/ disagreement concerning this fundamental agricultural knowledge?

In Tororo (Uganda), the agricultural service sector/community agents overwhelmingly agreed that maintaining a permanent crop cover is the thing to do (Table 6.a). On the other hand, this conventional wisdom is not held by the farmers in that locality. Many are quite uncertain about the importance of a crop cover, and more disagree than agree. Although there is no statistically significant difference in distribution between farmers, over a third of the larger farmers disagree. Clearly contact with extension agents hasn't had much impact on farmer perspectives.

Table 6a: Percentage of and mean value for farmers and service sector/community actors within Tororo by level of agreement or disagreement with the statement that:

One should maintain a permanent crop cover		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 22.4 Significant at .001	Small Farmers (36)	25.0	58.3	16.7	3.05 [a]
	Large Farmers (57)	26.3	38.6	35.1	2.82 [a]
	Service sector/community agents (n=15)	80.0	6.7	13.3	4.13 [b]
Effect of extension contact on farmers:					
Farmers without contact (54)		29.6	40.7	29.6	2.96[a]
Farmers with contact (39)		20.5	53.8	25.6	2.83[a]

Notes: Different letters indicate that the T-Tests for differences in means are statistically different within their locality at the .01 level.

In Kapchorwa (Uganda), the situation is little different (Table 6.b). Almost three-quarters of the agricultural service sector/community agents agree that one should maintain a permanent crop cover. This is in sharp contrast to nearly half of the farmers with extension agent contacts who disagree. The majority of those farmers without extension contacts is uncertain and may not have ever considered such a practice.

Table 6b: Percentage of and mean value for farmers and service sector/community actors within Kapchorwa by level of agreement or disagreement with the statement that:

One should maintain a permanent crop cover		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 26.2 Significant at .001	Small Farmers (34)	14.7	44.1	41.2	2.68 [a]
	Large Farmers (63)	20.6	47.6	31.7	2.87 [a]
	Service sector/community agents (n=19)	73.7	5.3	21.1	3.95 [b]
Effect of extension contact on farmers:					
Farmers without contact (57)		17.5	56.1	26.3	2.89[a]
Farmers with contact (40)		20.0	32.5	47.5	2.68[a]

Notes: Different letters indicate that the T-Tests for differences in means are statistically different within their locality at the .01 level.

Table 6c: Percentage of and mean value for farmers and service sector/community actors within Bungoma by level of agreement or disagreement with the statement that:

One should maintain a permanent crop cover		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 34.4 Significant at .001	Small Farmers (29)	10.3	37.9	51.7	2.48 [a]
	Large Farmers (46)	13.0	21.7	65.2	2.46 [a]
	Service sector/community agents (n=19)	73.7	15.8	10.5	4.21 [b]
Effect of extension contact on farmers:					
Farmers without contact (40)		15.0	22.5	62.5	2.48[a]
Farmers with contact (35)		8.6	34.3	57.1	2.46[a]

Notes: Different letters indicate that the T-Tests for differences in means are statistically different within their locality at the .01 level.

Moving over to Kenya, in Bungoma we find the most polarized views (Table 6.c). Again nearly three-quarters of the agricultural service sector/community agents agree that one should maintain

a permanent crop cover. However, the majority of farmers, large and small, completely disagree, and the rest are largely uncertain. Contacts with extension appear to have little impact on these perspectives.

In Kitale (Kenya) the most moderate views can be found (Table 6.d) and contact with extension seems to have some impact on farmer views. Only two-thirds of the agricultural service sector/ community actors are in agreement with the importance of maintaining a soil cover. However, a majority of farmers with extension contacts also agree. It is mostly larger farmers and those without extension contacts who are in disagreement here.

Table 6d: Percentage of and mean value for farmers and service sector/community actors within Kitale by level of agreement or disagreement with the statement that:

One should maintain a permanent crop cover		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 5.9 Not Significant	Small Farmers (38)	55.3	23.7	21.1	3.68 [a]
	Large Farmers (41)	39.0	22.0	39.0	3.14 [b]
	Service sector/community agents (n=21)	66.7	14.3	19.0	3.86 [a]
Effect of extension contact on farmers:					
Farmers w/o contact (38)		36.8	26.3	36.8	3.16[a]
Farmers with contact (41)		56.1	19.5	24.4	3.63[b]

Notes: Different letters indicate that the T-Tests for differences in means are statistically different within their locality at the .05 level.

The third principle of Conservation Agriculture appears to be the most controversial issue with respect to agricultural knowledge, norms and practices. There is much substantial disagreement over whether "Tillage causes land degradation" and much less uncertainty than for soil cover. These disagreements however, appear to be within categories of actors, rather than between them (see Table 7). In this case, the agricultural service sector/community agents are less in agreement than with the other two CA propositions. In contrast, many more farmers are in agreement than was the case for maintaining soil cover (from nearly 40 to 50 percent). However, the distribution is such that there is no statistical difference in mean values, either across localities or within any particular one.

Again the investigation of the distribution of this technological frame perspective is more instructive at the local level where scientific and local knowledge meet the ecology and production systems. In Tororo, the general statistically supported finding is that service sector/community actors are more likely to agree that tillage causes land degradation (Table 8.a). In addition, farmers without extension contacts were the most likely to disagree that tillage causes land degradation. However, a third of service sector/community actors also disagreed and

none were neutral. Larger farmers appear to be more likely to agree, but this is not statistically significant.

Table 7: Percentage of and mean value for farmers with or without extension contact compared to service sector/community actors within each local community by level of agreement or disagreement with the statement that:

a. Tillage causes land degradation	Agree	Uncertain /neutral	Disagree	Mean values
Small Farmers (137)	48.2	27.7	24.1	3.36 [a]
Large Farmers (207)	40.1	33.3	26.6	3.27 [a]
Service sector/community agents (n=74)	62.2	2.7	35.1	3.51 [a]
b. Effect of extension contact				
Farmers w/o extension contact (n=189)	39.2	34.4	26.5	3.24 [a]
Farmers with extension contact (n=155)	48.4	27.1	24.5	3.38 [a]

Notes: Chi-square = 27.884 significant at the .001 level for difference between small and large farmers and agents. No statistical difference in T-test scores for differences in means at the .05 level.

In Kapchorwa, we find the greatest agreement with the statement that "tillage causes land degradation" (Table 8.b). Nearly three-quarters of agricultural service sector/community agents and over 60 percent of farmers with extension contacts agree. This pattern of distribution appears to confirm the hypothesis that contact with extension agents increases the likelihood of conforming to external technological frames. Still, a quarter of the agents do not agree.

Table 8a: Percentage of and mean value for farmers and service sector/community actors within Tororo by level of agreement or disagreement with the statement that:

Tillage causes land degradation		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 8.6 Not Significant	Small Farmers (36)	30.6	36.1	33.3	2.93[a]
	Large Farmers (57)	42.1	28.1	29.8	3.21[a]
	Service sector/community agents (n=15)	66.7	0.0	33.3	3.40 [a]
Effect of extension contact on farmers:					
Farmers without contact (n=54)		31.5	31.5	37.0	2.94 [a]
Farmers with contact (n=39)		46.2	30.8	23.1	3.33 [a]

Note: The T-tests for differences in the mean values within all localities were not statistical significant at the .05 level. There were no statistically significant Chi-squares for differences in distributions among only farmers at the .05 level.

Table 8b: Percentage of and mean value for farmers and service sector/community actors within Kapchorwa by level of agreement or disagreement with the statement that:

Tillage causes land degradation		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 12.2 Significant at .05	Small Farmers (34)	61.8	23.5	14.7	3.74[a]
	Large Farmers (63)	52.4	38.1	9.5	3.70[a]
	Service sector/community agents (n=19)	73.7	0.0	26.3	3.84 [a]
Effect of extension contact on farmers:					
Farmers without contact (n=57)		50.9	36.8	12.3	3.66 [a]
Farmers with contact (n=40)		62.5	27.5	10.0	3.78 [a]

Note: The T-tests for differences in the mean values within all localities were not statistical significant at the .05 level. There were no statistically significant Chi-squares for differences in distributions among only farmers at the .05 level.

The findings for Bungoma appear to be nearly reversed (Table 8.c). Even among agricultural service sector/community agents there is no majority supporting the position that "tillage causes land degradation". Indeed, an equal number of agents disagree, even more than farmers. Smaller farmers are statistically more likely to agree than are both larger farmers and agents. For the most part, however, it appears that farmers simply are uncertain about what is appropriate knowledge in regard to tillage.

Table 8c: Percentage of and mean value for farmers and service sector/community actors within Bungoma by level of agreement or disagreement with the statement that:

Tillage causes land degradation		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 17.7 Significant at .001	Small Farmers (29)	44.8	41.4	13.8	3.36[a]
	Large Farmers (46)	17.4	50.0	32.6	2.85[b]
	Service sector/community agents (n=19)	47.4	5.3	47.4	3.21 [a]
Effect of extension contact on farmers:					
Farmers without contact (n=40)		27.5	52.5	20.0	3.08 [a]
Farmers with contact (n=35)		28.6	40.0	31.4	3.00 [a]

Note: The T-tests for differences in the mean values within all localities were not statistical significant at the .05 level. There were no statistically significant Chi-squares for differences in distributions among only farmers at the .05 level.

There is much less uncertainty over this issue in Kitale (Table 8.d). Over sixty percent of non-farm agents agree that "tillage causes land degradation"; a third disagrees. A majority of farmers with extension contacts agree as well, and again, a third of them disagree. Those farmers without extension contacts are more equally distributed. Knowledge concerning the role of tillage in land degradation is contested in Kitale across all categories of actors.

Table 8d: Percentage of and mean value for farmers and service sector/community actors within Kitale by level of agreement or disagreement with the statement that:

Tillage causes land degradation		Agree	Uncertain / neutral	Disagree	Mean values
Chi-square = 2.8 Not Significant	Small Farmers (38)	55.3	13.2	31.6	3.43[a]
	Large Farmers (41)	43.9	14.6	41.5	3.17[a]
	Service sector/community agents (n=21)	61.9	4.8	33.3	3.57[a]
Effect of extension contact on farmers:					
Farmers without contact (n=38)		44.7	15.8	39.5	3.21[a]
Farmers with contact (n=41)		53.7	12.2	34.1	3.37[a]

Note: The T-tests for differences in the mean values within all localities were not statistical significant at the .05 level. There were no statistically significant Chi-squares for differences in distributions among only farmers at the .05 level.

In summary, we can say that Conservation Agriculture has not made much impression on the agricultural production systems and associated actors in these four localities of Kenya and Uganda. The concepts are not linked as indicated by the failure to find positive co-variance among the three key principles. At the single concept level, there is a clear consensus about the conventional wisdom concerning the value of crop rotations, but controversy exists between the technological frames of farmers and of non-farm agents concerning the value of crop cover. The issue of whether tillage causes land degradation does not appear to be well-understood or to have congealed around any particular set of interests. This may be because the concept itself is new to agricultural service sector/community agents.

Variations across localities

Each locality has its agro-ecological specificity. This specificity has an impact on the development of relevant local knowledge for farming and how each farming population integrates (often scientifically or commercially based) knowledge and practices coming from elsewhere. To introduce new concepts or practices to a specific locality requires taking these factors into account. Let's look again at these indicators of agricultural production knowledge and practice from this perspective.

Table 9 presents the findings for the factors indicating generic agricultural knowledge and practices described earlier. Adherence to the perspective that successful farming requires the use

of modern chemical inputs and machinery increases from Kapchorwa, Kitale, and Bungoma (in that order) to Tororo where it achieves its highest level. Interestingly the greatest disparity is found between the frontier environment of Kapchorwa and the older industrial/rail center of Tororo and appears consistent with their histories. With respect to systems integrating cash cropping with livestock and poultry production, these two localities are likewise distinguished, as are Bungoma and Kitale. Tororo and Bungoma are less likely to advocate for the integration of cash cropping with livestock and poultry production than Kapchorwa and Kitale. This may also be consistent with local cultures and histories, as the people of both Kapchorwa and Kitale have a stronger pastoral tradition. In Kapchorwa, integration of cattle and crop systems facilitates production as the slope and terrain in much of the area is ill suited to tillage by tractors.

Table 9: Mean scores for Kenyan and Ugandan farm and non-farm actors level of agreement on basic farming approaches by locality

	Uganda		Kenya	
	Tororo	Kapchorwa	Bungoma	Kitale
Conventional modern farming *	7.74 [a]	6.53 [b]	7.17 [c]	6.84 [bc]
Mixed crop-livestock farming **	5.07 [a]	6.00 [b]	5.09 [a]	6.07 [b]
N	108	116	94	100

Notes: Different letters within the same row are statistically different. Rows marked by * signify that all T-Test scores are significantly different at the .05 level. Rows marked by ** signify that all T-test scores are significantly different at the .001 level. Higher composite scores signify greater levels of agreement with the technological frame concept indicated by the factor.

Table 10: Percentage of respondents by locality according to their level of agreement or disagreement with the statement that:

One should maintain a permanent crop cover	Agree	Uncertain /neutral	Disagree	Mean values
Tororo (n=108)	33.3	40.7	25.9	3.08 [a]
Kapchorwa (n=116)	27.6	39.7	32.8	2.99 [a]
Bungoma (n=94)	24.5	25.5	50.0	2.82 [a]
Kitale (n=100)	51.0	21.0	28.0	3.50 [b]
n	142	135	141	

Notes: Chi-square = 32.385 significant at the .001 level.
T-test for differences in means significant at the .05 level for Tororo-Kitale comparison; at the .01 level for Kapchorwa-Kitale; and at the .001 for Bungoma-Kitale.

Let's consider the similarities and differences between these localities for the two controversial Conservation Agriculture items we've been analyzing above. With respect to whether "one should maintain a permanent crop cover", Kitale stands out with a majority in agreement with the statement and the highest mean value (Table 10). In contrast, half of the Bungoma agricultural sector actors disagree with the statement. This is consistent with a concern expressed by several non-farm agricultural agents and farmers that the climate in Bungoma is too dry to

produce cover crops in addition to food crops or to harvest enough biomass to provide adequate ground cover. Tororo and Kapchorwa are significantly more neutral on the issue, signifying that the use of cover crops may simply be an unfamiliar production method in these areas.

As for whether "tillage causes land degradation", Kapchorwa stands out as the strongest supporter of that perspective (Table 11) with a strong majority agreeing and the highest mean value. Likewise, reports during focus groups and qualitative interviews with service sector providers in Kapchorwa indicate that reducing soil erosion is a major concern for these farmers. A majority of respondents from Kitale and a plurality from Tororo also agree with the statement. However, both of these localities have significant minorities who disagree. Bungoma is most uncertain on the issue.

Table 11: Percentage of respondents by locality according to their level of agreement or disagreement with the statement that:

Tillage causes land degradation	Agree	Uncertain /neutral	Disagree	Mean values
Tororo (n=108)	41.7	26.9	31.5	3.13 [a]
Kapchorwa (n=116)	58.6	27.6	13.8	3.72 [b]
Bungoma (n=94)	31.9	38.3	29.8	3.06 [a]
Kitale (n=100)	52.0	12.0	36.0	3.35 [a]
n	195	109	114	

Notes: Chi-square = 33.676 significant at the .001 level.
T-test for differences in means significant at the .001 level for Kapchorwa-Bungoma and Tororo-Kapchorwa comparisons; and at the .05 level for Kapchorwa-Kitale.

Comparing the Structure and Composition of Agricultural Production Networks between Sites

Analyzing the composition and structure of agricultural production networks across the localities is a multi-step process. First, we were interested in describing the general involvement of farmers in agricultural production networks across the sites and which members of the network were the most important to farmers as sources of agricultural information and resources. Second, to conduct the network analysis, the data collected regarding farmer contacts with agricultural service sector/community agents during the household survey was matched up to the data from service sector/community agents. While the network surveys collected data regarding both resource and information/knowledge exchange, the focus for analyzing network structure in this paper is on knowledge and information exchange as the more inclusive network[10].

The Composition of Farmer Networks

Within and across the research sites, farmers do not necessarily interact with the same number or types of persons in the agricultural production network. This section compares farmer involvement in agricultural production networks, and who are the most commonly reported persons for information and agricultural resources in each of the sites. Here agricultural resource contacts were defined as relationships where something tangible is exchanged in order to

[10]Retaining inclusivity is important in light of the previously presented evidence that ideas about conservation agriculture are not fully formed and remain locally contested.

conduct agricultural production. The resources listed on the questionnaire included: seeds, fertilizer, pesticides, herbicides, tractor services, agricultural loans, veterinary services and an "other" category in which a farmer could identify an item not listed. Farmers were also asked who they exchanged advice, consultation, or information with for agricultural production. These persons more generally identified as information contacts. In many cases, a person could be both an agricultural resource and an agricultural information contact to a farmer.

Table 12: Farmer Information and Resource Contacts across Sites

Location:	Average Information Contacts	Average Resource Contacts	Range of Information Contacts	Range of Resource Contacts
Tororo (n=93)	2.76[a]	2.84[a]	0-9	0-9
Kapchorwa (n=97)	7.12[a]	3.65[b]	0-17	0-10
Bungoma (n=75)	7.33[a]	7.39[a]	0-15	0-17
Kitale (n=79)	7.51[a]	5.72[b]	0-18	0-11
All sites (n =344)	6.07[a]	4.72[b]	0-18	0-17

Note: Different letters in the same row are significantly different from each other at the .01 level

Farmers in Tororo report the fewest network contacts of any of the sites, and generally farmers in Kenya report significantly more contacts for agricultural resources than farmers in Uganda (Table 12). In the higher potential areas of Kapchorwa and Kitale, farmers report significantly more contacts for agricultural information than agricultural resources. This means that farmers in Tororo are exposed to far fewer sources of information and resources than the farmers in the other three sites. Indeed, increasing activity in farmer networks through outreach programs will likely be a key initial step for stimulating innovation in agricultural networks in Tororo.

By contrast, farmers in the other three sites already have a high number of network contacts on average. Somewhat surprisingly, farmers in Bungoma report the highest number of resource contacts, and have a roughly equal number of information contacts as the Kapchorwa and Kitale sites. The higher average number of network contacts in these sites suggests that most farmers already have access to diversity in information resources. Since farmers are already more informed, an important foundation is provided for focusing the dialogue on conservation agriculture. Nevertheless, in all four sites there are farmers who have reported having zero agricultural resource or information contacts, meaning that some effort will likely need to be made across sites for identification of these farmers, mobilization, and outreach in order to increase their access to agricultural information and resources.

In evaluating the composition of farmer networks, it is also important to identify which types of contacts are most frequently reported for agricultural information and resources, and the percentage of farmers reporting that particular contact (see Tables 13 and 14).

Across the four sites, agro-vets and veterinary service providers appear to be the most frequently reported contacts for obtaining agricultural resources and agricultural information. Extension appears to play a large role in providing information, moving to the top ranked information source and fifth ranked for material resources in Kitale. The high reporting of contact with

agricultural researchers in Bungoma for both resources and information is likely due to the sample frame applied by SACRED Africa in sampling farmer groups with whom they had previously worked. The presence of government parastatal boards is likely explained by the key activities of the National Cereals and Produce Board, the Agricultural Development Corporation, and the Agricultural Finance Corporation in providing price information, tractors and equipment and agricultural loans respectively in Trans-Nzoia District. Such government parastatals are not as well developed in the other regions. Personal contacts of farmers, such as neighbors, friends, and family members also appear to play a strong role in providing agricultural resources and information across the localities. This is an opportunity to promote farmer to farmer extension work in the process of promoting conservation agriculture.

Table 13: Top Five Resource Contacts and Percentage of Farmers Reporting Contact

Rank	Tororo	%	Kapchorwa	%	Bungoma	%	Kitale	%
1	Vet service provider	43	Vet service Provider	60	Agro-vet	71	Agro-vet	86
2	Neighbor/friend	41	Agro-vet	55	Agricultural researcher	69	Vet service provider	86
3	Agro-vet	40	Neighbor/friend	38	Vet service provider	63	Government parastatal	70
4	Weekly Market Vendor	31	Family member	37	Family member	61	Tractor owner/animal traction provider	68
5	NGO Agent	19	NGO Agent	37	Government extension agent	48	Neighbor/friend	57

Table 14: Top Five Information Contacts and Percentage of Farmers Reporting Contact

Rank	Tororo	%	Kapchorwa	%	Bungoma	%	Kitale	%
1	Government Extension Agent	42	Family member	60	Agricultural researcher	71	Agro-vet	87
2	Vet service provider	42	Neighbor/friend	55	Agro-vet	69	Vet service provider	81
3	Agro-vet	38	Vet service provider	38	Family member	64	Government parastatal	75
4	Neighbor/Friend	33	Agro-vet	37	Vet service provider	60	Neighbor/friend	68
5	NGO Agent	23	Shop in Urban center	37	Farm organization leader	52	Government extension agent	52

Upon sharing this information with farmers and service providers in each of the localities, participants in the workshops were often surprised by who were reported as the top information and resource contacts. In Uganda, the NAADS program provides agricultural inputs and

extension agents in both sites. Their representative responded with surprise that extension did not make the top five for resource contacts. Likewise, in both areas people did not view agro-vets as such a common source of information for farmers. In Kitale, workshop participants expressed concern about the quality of that information which is passing through agro-vets. In many of the sites, participants also reported that they expected farmer group leaders and women's group leaders to be more commonly reported sources of information. A general outcome in the discussions across sites was that it was important to include agrovets and to provide them with high quality information on conservation agriculture to pass onto farmers.

Total Network Structure

Once the farmer data was matched to the agricultural service sector/community agent data, a basic analysis of the network structure in each site could be performed. In this analysis, the objective was to identify key individuals or groups of individuals through whom information would be likely to pass to the greatest number of other individuals. These are likely to be the most important/influential individuals in the network. Measures of such power and influence in network analyses are typically described as measures of centrality. For our analysis, two measures of centrality were deemed especially important: degree centrality and betweenness centrality (Knoke and Yang, 2008). Degree centrality is simply a measure of the number of connections between a given actor and other actors in the network and is measured as a count of the number of contacts for any given actor based upon their self-report and the report of others being in contact with that particular actor. Degree centrality is thus a measure of the importance of a node within the network based upon the number of individuals to which a particular actor can pass information and knowledge about agricultural production. Betweenness centrality reflects the extent to which an individual can facilitate or limit communication between other nodes in a network. This is determined by calculating the number of times a particular actor is the link between actors who otherwise do not share a connection.

For this analysis, undirected measures of centrality were calculated in Netdraw (Borgatti et al, 2002). Utilizing undirected measures means that the calculation does not discriminate based on the directionality of the tie, and therefore assumes that there is some degree of information and knowledge exchange regardless of who initiates the contact between parties. Moreover, utilizing the undirected measures helps to limit the potential bias introduced by the fact that, as described in the methodology section, not all of the identified agricultural service sector providers were interviewed. The following tables present the most important actors by site according their scores for degree and betweenness centrality.

In examining Tables 15 and 16, it can be readily seen that the same types of actors are not necessarily equally important across sites. In Tororo and Kapchorwa, stockists occupy an especially important position in transmitting information. In Bungoma and Kapchorwa, the Chief has high scores for both types of centrality, but the Chief doesn't make the top four for the other two sites, indicating that local custom likely informs the level of the Chief's involvement in agriculture. Microfinance institutions and the Stakeholder Forum are identified as key in Kitale, but these actors are either not present or less utilized in the other areas.

For clarification, government sponsored extension services have different names in the different localities. In Uganda, the National Agricultural Advisory Services (NAADS) generally positions a coordinator at the sub-county level. In Kapchorwa, the NAADS Coordinator for Kween Sub-

County was interviewed and identified as playing a key role in the agricultural production network. At the time of the survey in Molo Sub-County, a NAADS Coordinator had not yet been hired. In lieu of this person, an agricultural officer was interviewed. In Kenya, extension services generate from the Ministry of Agriculture. However, between Bungoma and Kitale, these persons were identified a bit differently. Survey participants in Kitale identified extension as the Ministry of Agriculture, while farmers in Bungoma tended to refer to agricultural extension officers individually, especially for livestock and crops. The local terminology for referring to these individuals who serve an extension function is retained for accurate reporting of the networks as identified by respondents.

Table 15: Most influential actors by site according to degree centrality

Rank	Tororo	Score	Kapchorwa	Score	Bungoma	Score	Kitale	Score
1	Farm Organization Leader	20	NAADS Coordinator (Extension)	20	Farm Organization Leader	20	Ministry of Agriculture (Extension)	20
2	Government Parastatal	19	Chief	20	Chief	19	Microfinance Institutions	20
3	Urban Agrovet	19	Counselors	19	Local Vet** Pastor** Market Vendor** Extension**	18	Stakeholder Forum	20
4	Local Agrovet	19	Local Agrovet* Women's Group Leader*	18			NGO	17

Note: * and ** indicate that the actors were tied for that rank.

Table 16: Most Influential actors by site according to betweenness centrality

Rank	Tororo	Score	Kapchorwa	Score	Bungoma	Score	Kitale	Score
1	Farm Organization Leader	20.42	Local Agrovet	28.25	Farm Organization Leader	26.87	Ministry of Agriculture (Extension)	20.87
2	Government Parastatal	19.84	Women's Group Leader	16.93	Chief	24.44	Microfinance Institutions	20.05
3	Urban Agrovet	15.09	Chief	14.19	Local Vet	13.33	Stakeholder Forum	17.29
4	Local Agrovet	14.39	NAADS Coordinator (Extension)	14.15	Youth Leader	11.76	NGO	11.23

It is also interesting to note that in Kitale and Tororo the rankings remain consistent between the two types of centralities. By contrast, in other networks there is more variation between which agents have high betweenness centrality and which agents have high degree centrality. In Kapchorwa and especially Bungoma, there are also a number of ties for degree centrality scores. This indicates that there are a number of equally well-connected agents, rather than a concentration of a limited number of connected and influential agents in these localities. The various structure of these communication networks may affect researcher decisions about the format in which to approach various agents with information and trainings about conservation agriculture. In the Bungoma and Kapchorwa where there seem to be large numbers of highly connected agents, a collaborative meeting may be more appropriate. However, in Kitale and Tororo initiating CA approaches with more targeted meetings may be more effective before scaling up.

During the feedback workshop in Kitale, an important insight was gained concerning the high centrality measures for the Ministry of Agriculture as a central figure in information and resource networks. One of the host farmers for the SANREM experimental plots pointed out that during the year of data collection the MOA required that all farmers come in and sign up in order to receive a fertilizer subsidy, thus creating an artificial relationship. This requirement positioned the MOA between the farmer and his usual supplier. To the extent that the MOA continues these programs they can assure themselves not only of having influence because of their authority positions in the social structure, but also because of their structurally central position in the agricultural input supply network of Trans Nzoia.

Some patterns also emerge which are consistent with the previous characterization of the agricultural production systems between the sites. In the lower potential areas of Bungoma and Tororo local level actors have the highest level of importance. By contrast, in the higher potential areas of Kapchorwa and Kitale, it appears that extension agents have a more important role in the network, as indicated by the Ministry of Agriculture possessing the highest score for both degree and betweenness centrality in Kitale and by the NAADS Coordinator in a position of first in the degree centrality and fourth in the betweenness centrality ranks. To be clear, we are not expressing the view that extension agents are not important in the lower-potential areas. In fact, a closer look at the rank of extension across sites reveals that extension agents are important across the sites, as indicated in the Table 17.

As evidenced, with the exception of Bungoma for betweenness centrality, extension agents fall within the top 25% for both types of centrality (Table 17). However, this finding sheds some light on why there did not seem to be as high a transmission rate for beliefs about agricultural production from extension workers to farmers in the lower potential areas. As demonstrated, other agents in the network may be more important points for farmers to access information about agricultural production. Recalling the findings from the previous section about the impact of extension contact on knowledge and beliefs, in Kitale there was the strongest evidence that extension contact having an impact upon farmers' perspectives on conservation agriculture. This may reflect the critical position of extension in the network in possessing the highest scores for betweenness and degree centrality. As such, the structural network analysis demonstrates the importance of multiple entry points for the transmission of knowledge and beliefs about conservation agriculture in each area, and that these should be tailored to site-specific considerations.

Table 17: Centrality ranks for government extension agents across sites

Site	Rank-betweenness	Rank-degree	Total number of non-farm agent types identified
Tororo	6	6	23
Kapchorwa	4	1	24
Bungoma	8	3	25
Kitale	1	1	26

In developing strategies for scaling up conservation agriculture, different local actors need to be the primary targets in each site, but all should be taken into account. While working with the Ministry of Agriculture is likely to be very important in Kitale, in Tororo and Bungoma, farm organization leaders may be higher priority targets for transmitting knowledge about conservation agriculture to the local production network. In this manner, these tables offer a starting point for identifying the individuals which are likely to be key agents in whether or not the promotion of conservation agriculture is successful. The next step in the analysis is to impose our knowledge about the predispositions of these agents toward conservation agriculture upon the mapped network structure of information flows.

Mapping information flows and beliefs about tillage within the locality

Across localities, whether or not tillage causes land degradation seems to be the most contested belief. The following maps indicate the information flows which exist between actors and each locality and the individual beliefs of different actors in the network. Again, the farmer groups are separated into small and large farmers and the average is taken within these groups to represent agreement with the statement tillage causes land degradation. In the case where multiple agents were interviewed of a single agent type (ie multiple extension agents) were interviewed, then mode values were used to represent the beliefs of that particular agent group. The relative size and position of the nodes in the network reflects the betweenness centrality, or level of control a particular actor has over information flows between other actors in the network. Larger, more centrally located nodes have higher betweenness centrality scores while lower scoring actors make up the periphery of the network. As demonstrated in the Tororo network map (Figure 2), the majority of the central actors agrees or strongly agrees with the statement that tillage causes land degradation, a key recognition to incentivize a transition to conservation agriculture. However, several key actors, such as the Government Parastatal and Government Extension Agent are not on board. Notably however, beliefs also seem contested among more peripheral community agents who interact closely with farmers. A local savings group leader, counselor and pastor support the belief, but a local teacher and the women's organization leader disagree. Not surprisingly, both large and small farmers remain uncertain.

In analyzing the Kapchorwa network map (Figure 3), it is visible that many of the central actors support the belief that tillage causes land degradation. However, a few important peripheral actors are not on board, including the bank, tractor owner, and surprisingly the Uganda Wildlife

Authority. These latter actors pose a potentially significant opposition and should be included in any discussions of the issue.

It is clear that whether or not tillage causes land degradation is highly contested in Bungoma (Figure 4). Important allies for the introduction of CA are the Chief, Extension, and a local NGO One Acre Fund. Interestingly, the National Cereals and Produce Board and Agricultural Finance Corporation, which are housed in the same building, take opposing positions. Most importantly, many of the community agents, who interact frequently with farmers disagree or strongly disagree. Addressing community agent beliefs is thus of primary importance for changing the local mindset to be more receptive to conservation agriculture.

Whether or not tillage causes land degradation is also highly contested in Kitale (Figure 5), especially amongst the most central actors in the network. While microfinance and NGO agents agree, the Stakeholder Forum and the Ministry of Agriculture are not on board. Nevertheless, a number of more peripheral but highly important agents such as the Village Elder and Kenya Agricultural Research Institute agree. The diversity in local perspectives on this issue means that a strategy to scale up conservation agriculture should be approached carefully, and multiple strategies may need to be used for different agents.

In interpreting these maps, it is important to remember that each is a snapshot of the local production network at a particular point in time. Throughout the research process, it is expected that the networks will shift and change. Certain actors may become more or less central, and attitudes and beliefs are certainly likely to change. In sharing the research findings with participants in feedback workshops, it was emphasized that the goal of the research was to provide information about what the network looked like at the outset of the project, and to use these maps as a tool for recognizing points in the network where change is most needed and to identify individuals already positioned to effect that change.

Figure 2: Network Map Highlighting Betweenness Centralities and Position on whether Tillage causes land degradation – Tororo

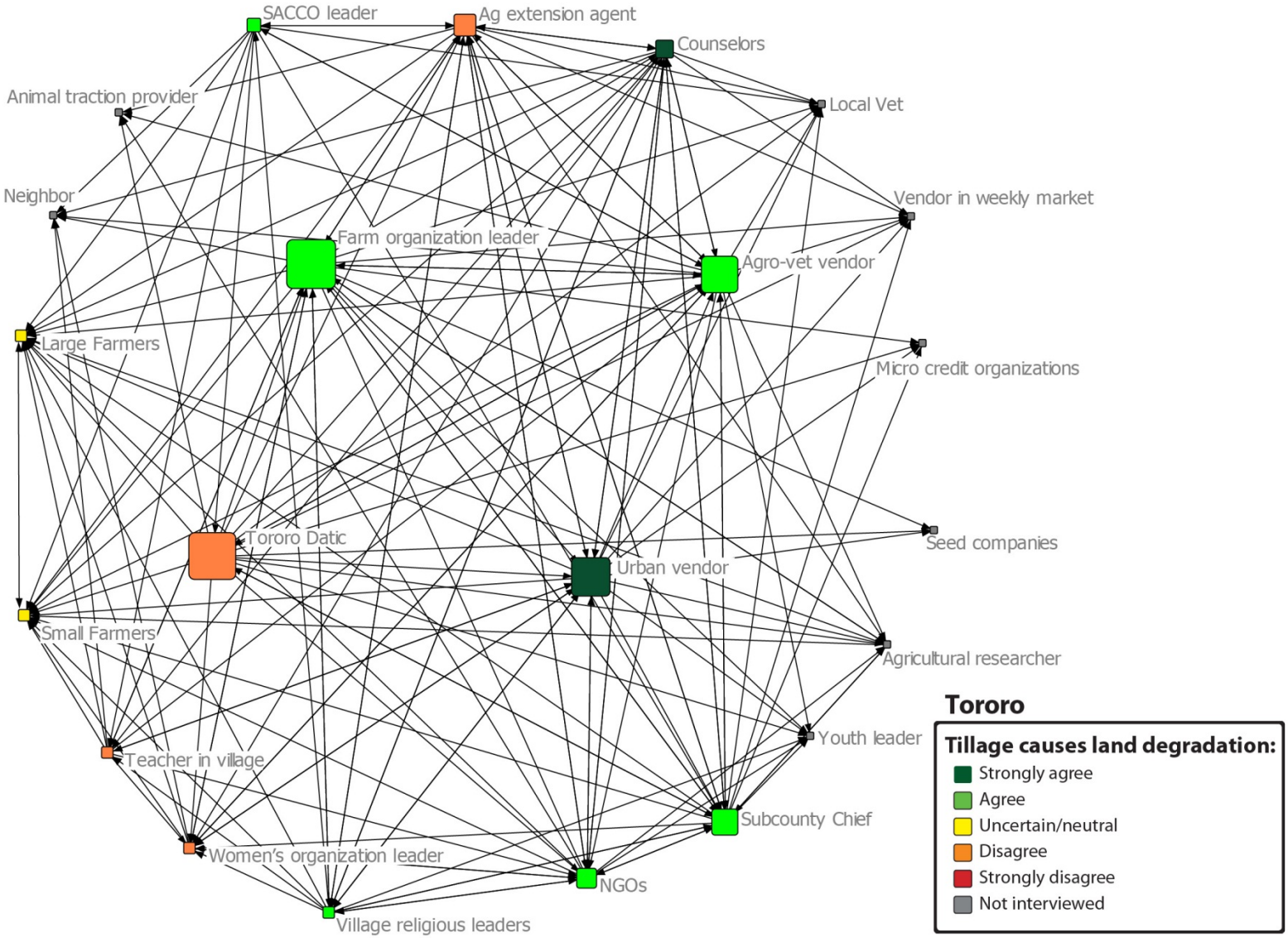


Figure 3: Network Map Highlighting Betweenness Centralities and Position on whether Tillage causes land degradation – Kapchorwa

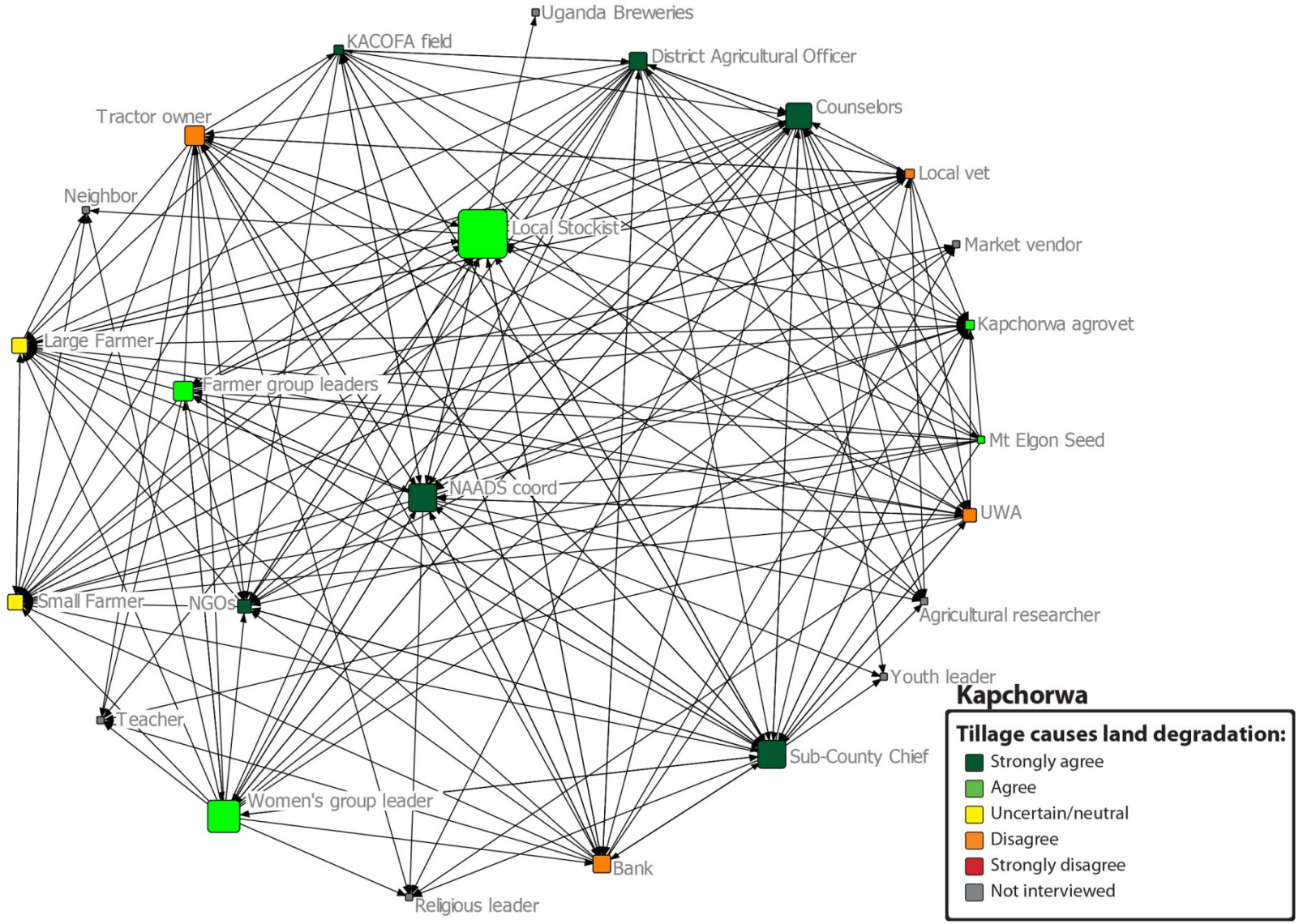


Figure 4: Network Map Highlighting Betweenness Centralities and Position on whether Tillage causes land degradation – Bungoma

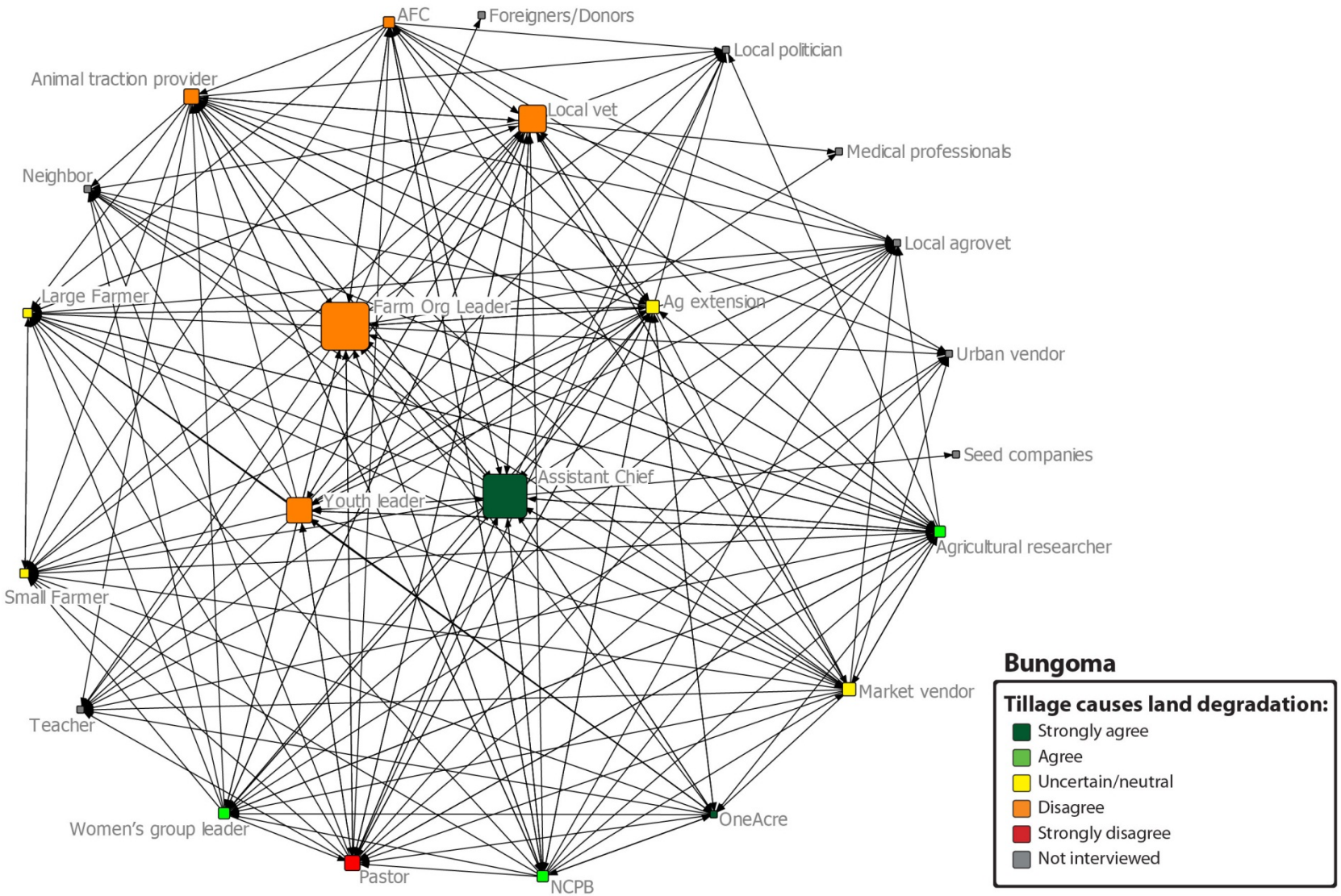
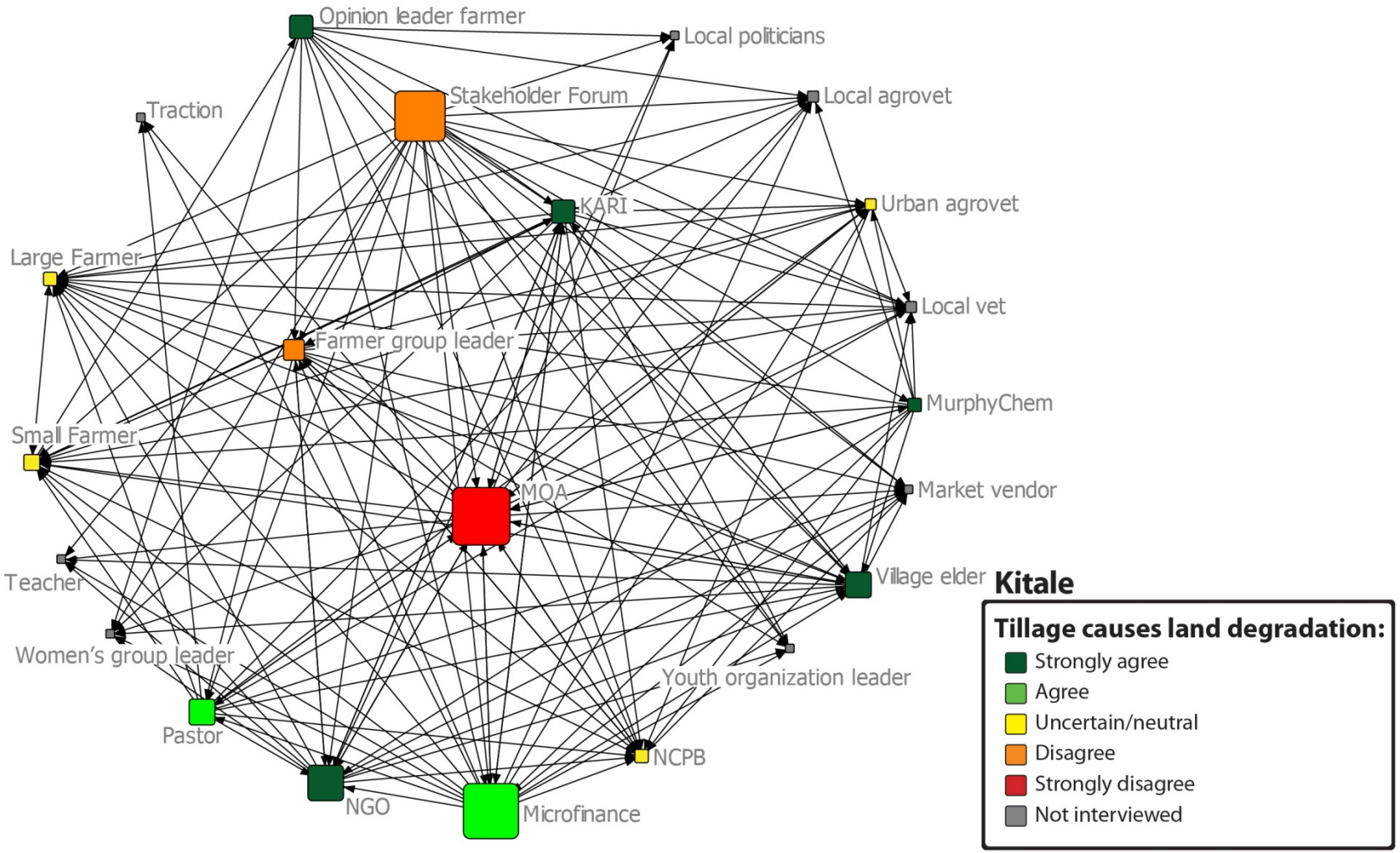


Figure 5: Network Map Highlighting Betweenness Centralities and Position on whether Tillage causes land degradation – Kitale



Summary of Key Findings

1. There appears to be a fundamental gap between the general agricultural perspectives of farmers on one hand, and the agricultural service sector and community agents, on the other.

2. Conservation Agriculture is a new concept and the components are not linked in the mindsets of either farm or non-farm actors.

3. There is a shared consensus on the importance of crop rotations both within communities (between farmers and non-farmers) and across communities.

4. Non-farm agents are highly supportive of maintaining a crop cover (soil cover); whereas farmers are most likely to disagree or be uncertain.

5. The idea that 'tillage causes land degradation' was the most divisive and controversial CA precept. There was more disagreement within categories (especially non-farm agents) than between categories.

6. There was considerable variation in perspective associated with each locality, presumably linked to the exigencies of the local ecology and production systems.
    a. Tororo appeared to be the most supportive of conventional production systems, yet most impoverished.
    b. The booming frontier productive systems of Kapchorwa, on the other hand, were the least conventional and most supportive of the idea that tillage causes land degradation.
    c. The agricultural commercial center of Kitale (along with Kapchorwa) was most supportive mixed production systems, yet also most supportive of maintaining a permanent soil cover.
    d. In contrast, Bungoma was the least supportive of mixed farming systems and also least likely to support a permanent soil cover.

7. The Ugandan sites had fewer resource providers and Tororo had limited information sources.

8. While agro-vet and vet service providers were most commonly cited as resource linkages, along with neighbors and family members, they were also among the most frequently cited sources of information as well.
    a. Only in information deprived Tororo did the extension service top the list.
    b. The more isolated Kapchorwa was best served by family members and neighbors.

9. On the basis of the network analysis, the most influential overall were farm organization leaders and the extension services.
    a. Farm organization leaders were most influential in Tororo and Bungoma.
    b. In Kapchorwa and Kitale, the extension services were tied for top billing as influential actors with Microfinance and the Stakeholder Forum in Kitale and with traditional and modern political/administrative leaders in Kapchorwa.

Incorporating Local Feedback

In February 2012, the Technology Networks CCRA facilitated workshops in each of the four localities in order to share research results, obtain local feedback, and encourage the development of strategies to promote conservation agriculture in the local agricultural production network. Generally, the workshops followed a similar format in each of the sites. As the participants entered, they were provided with a brochure summarizing the findings for their locality, a notepad, and pen. The local site coordinator welcomed the group and a short introduction to the project, principles, and conservation agriculture were provided to frame the results of the network research to be presented and discussed. In Uganda, introductions were provided by Dr. Rita Laker Ojok and David Chemusto. In Kenya, local introductions were provided by Johnstone Odera, Principal and Director at SACRED Africa Training Institute in Bungoma and Dennis Shibonje, the SANREM Project Coordinator at Manor House Agricultural Center in Trans-Nzoia. Upon entering Kenya, the lead PI for LTRA-10, Dr. Jay Norton of the University of Wyoming and the PI for the Technology Networks Cross Cutting Research Activity, Dr. Keith M. Moore joined the workshops and provided some introduction and additional comments throughout the presentation. In each workshop, a slightly more technical discussion of the agricultural research program was provided by Dr. Dominic Sikuku, the East Africa Project coordinator.

Research Associate for the SANREM Technology Network CCRA, Jennifer Lamb, facilitated the Network Discussion. The first section of the network presentation highlighted the importance of involving various members of the agricultural production network in the promotion of conservation agriculture. Then the most frequently farmer-cited contacts to obtain agricultural resources (seeds, fertilizer, agrochemicals, plowing services, veterinary services, loans/financing, etc.) and information were introduced. Following this, the presentation introduced the network map, and measures for identifying the centrality of particular agents. Next, graphs of the distribution of beliefs between small farmers, large farmers, and service providers were presented and impacts of extension contact on farmer knowledge and beliefs discussed. Finally, the network maps presented above, which bring together network structure and existing beliefs about agricultural production were presented and discussed for the ideas of “tillage causes land degradation” and “maintaining a permanent soil cover”. Throughout the workshop, participants were encouraged to provide feedback and ask questions about the results presented. In this section, reflections on the local workshops in each of the sites are provided interspersed with the network maps as presented in each workshop.

Tororo

The Technology Networks feedback session in Tororo, held at Prime Hotel on 9 February, was attended by 24 participants, including 8 women. All of the key agents from the service sector and farmers interviewed were represented, including: agrovets, religious leaders, local stockists, farmer group leaders, women’s group leaders, the governmental parastatal Tororo Datic, NAADS agricultural agents, the acting District NAADS Coordinator, and the District Agricultural Officer. Farmers from all the SANREM farmer-managed experimental plots as well as the AT Uganda staff were also in attendance.

The session began with an introduction and prayer, and all of the participants introduced themselves. A short introduction was provided as to the survey which had been conducted the

year before, and the results were presented to the group. The presentation was paused at multiple points and the audience asked if they had reactions to any of the results or information, only a few comments were made during the actual presentation. Upon concluding the presentation, the AT Uganda staff suggested an activity where each participant could share a comment or insight about the presentation. Most of the comments, however, did not pertain to the presented results, but referred more generally to the benefits of conservation agriculture.

A few central points were raised. Service providers frequently pointed out that the statements were too simplistic and that farmer responses were unlikely to capture the intended CA practice. In particular, the service sector pointed out that while most farmers practiced crop rotation, this was driven by a desire to maintain food security, rather than soil fertility. Consequently, many service providers felt that farmers responding positively to the statement were likely only practicing cereal to cereal rotations as opposed to a cereal-legume rotation which would improve the soil. Actually, many of the farmers had discussed the use of cowpeas and, to a lesser extent, soybeans during the survey. This feedback seems to reflect a commentary on service provider perceptions of farmers, rather than farmer misunderstanding.

The acting NAADS Coordinator for Molo Sub-County repeatedly expressed strong disagreement with the statement “tillage causes land degradation”, explaining that farmers who were able to till or plow were actually far ahead of many of their peers and indeed were the most successful. According to NAADS, the benefits of tilling should be promoted and the question should have been rephrased to something like “inappropriate tillage methods cause land degradation”. This revelation resulted in an informative discussion about the purpose and practice of CA to replenish the soil organic matter carried away by tillage.

During the subsequent group work and discussion, it became clear that not everyone was on the same page with the research and project objectives. AT Uganda clarified the goals of the work as a research project in shifting the discussion away from activities for scaling up toward how to open the dialogue for conservation agriculture. Dominic provided a short description of conservation agriculture and the research activities of the project.

From this point, we had a more productive discussion as to the usefulness of thinking about agricultural production networks and communication or new and different ideas to stay abreast of conservation agriculture. The most effective activity for getting farmers and service providers to discuss how to use their networks was the group discussion of the questions: “What are the remaining technical issues for CA to be successful in Tororo?” and “Who needs to be brought together to resolve these issues?” Under this heading, one of the key problems raised was a negative perception of herbicides amongst the local service sector. Several expressed concern about the common belief that herbicides spoil the soil. Dominic explained that the herbicides used by the project were as safe as possible and had been through a rigorous approval process. Subsequently, service providers involved were interested in obtaining the lists of the herbicides used. Another concern, also regarding herbicides was raised by farmers. While the listed herbicides were approved as safe, many people repackage other chemicals and sell them as chemicals listed to be safe. The farmers and service providers requested to be trained on how to recognize counterfeit herbicides and chemicals. This would mean drawing more people into the network, such as chemical suppliers, UNADA, MAAIF, District local government, agro-vet input suppliers, farmers, extension service providers, and other opinion leaders.

Another key barrier to successful CA in Tororo identified by both farmers and service providers was the availability of implements for the introduction of conservation agriculture. Most farmers in Tororo practice agriculture with hoes, but would like to adopt labor saving technologies. CA is generally perceived as a high labor input technology. Dominic explained that the project had developed a prototype for an oxen drawn implement which would cause minimal soil disturbance, as well as to introduce modified hand hoes which would result in minimal disturbance.

Kapchorwa

The Technology Networks feedback session in Kapchorwa was held at Noah's Ark Hotel on 10 February 2012. The session was attended by twenty participants, seven of which were women. Nearly all of the individuals interviewed were represented, including Mt Elgon Seed Company, agrovets, the Uganda Wildlife Authority, the NAADS coordinator for Kwosir, the Sub-county Chief for Kwosir, the Kapchorwa District Agricultural Officer, Landcare Kapchorwa, banking institutions, farmer group leaders, and all of the farmers currently hosting SANREM demonstration plots. The only notable absence was a representative of the Kapchorwa Commercial Farmers Association (KACOFA) as the time of the workshop coincided with the opening week of the new KACOFA warehouse in Kapchorwa town. Nevertheless, the diverse set of participants allowed for a lively discussion throughout the day.

David Chemusto, the Field Coordinator for AT Uganda in Kapchorwa opened the session by asking for a prayer and having the participants introduce themselves. Following this, Rita provided a brief introduction to the project and its principles and procedures. Dominic then provided a brief description of conservation agriculture production methods and the research activities for the project.

Returning from the tea break, the presentation and discussion about the network research began in earnest. Several important distinctions were made to frame the results presented. First, the research examined both agricultural information and resource flows within the production network. It was explained that resources meant that some physical object or service for agricultural production was exchanged. The items listed on the survey were explained, including: seeds, fertilizer, pesticides, herbicides, plowing services (by tractor or animal traction), veterinary services, or animal medicines. Agricultural information contacts included sources of information as well as those providing advice or consultation. The second major distinction is that the results reported reflect the knowledge and beliefs of farmers *before* the project began. The idea was to develop a general sense of the awareness and prior knowledge of conservation agriculture principles before the research period. These clarifications helped to move the discussion along.

Participants offered several comments in the initial presentation of farmer contacts. Specifically, participants affirmed that most farmers had a greater number of information contacts than contacts to get agricultural inputs. The NAADS Coordinator was surprised to find that local stockists were a more important (or more frequently reported) source of information than extension workers, while farmers affirmed that family, neighbors, and friends were their most common sources for agricultural information. It was discussed that this showed the importance of training and bringing local stockists on board with projects and making a significant effort to ensure stockists were providing good information. Some members of the service sector saw the

strong farmer to farmer contact between neighbors and friends as an important resource in promoting farmer to farmer extension work and knowledge.

In moving to present the map, members of the service sector became strongly engaged in the conversation once more. Representatives of the bank, Mt Elgon Seed, NAADS, and the Chief all asked about their positions on the network map, and what this position reflected about their role in the network. Concepts of betweenness and degree centrality seemed to be readily understood by members of the service sector especially, and they thought that it made a lot of sense that the Chief, NAADS Coordinator and local stockist served a gatekeeper function in controlling the passage of information between other individuals in the network. David also translated this discussion into the local language to ensure that everyone was on the same page. The farmers confirmed the importance of the local stockist as an information source.

Translation also played a key role in facilitating the discussion about knowledge and beliefs about agricultural production practices, particularly in the discussion of maintaining a permanent crop cover. Farmers reported that they believed that the majority were likely undecided because they were unfamiliar with the concept. The representative of Mt Elgon Seed contributed that a permanent crop cover would interfere with fallowing, which many farmers believed necessary to allow soil fertility to replenish. At this point, Dominic explained the idea of crop cover as a dead or living fallow, and it was universally agreed that it would have been clearer to express this item as "one should maintain a permanent soil cover". Nevertheless, it appeared that in translation, with confirmation from two of the enumerators present that the meaning was maintained when translated to farmers.

Participants were more surprised by the findings regarding the statement "tillage causes land degradation". As raised by the representative of the local bank, it was believed by many that farmers would equate plowing with farming and that they have to farm to eat and therefore would disagree that tillage caused land degradation. Yet, the charts demonstrated that the majority of small farmers, large farmers, and the service sector agreed that tillage caused land degradation. It was discussed how this was an important recognition for the successful introduction of CA as a technique to reduce soil erosion.

Regarding the impact of extension contact on knowledge and beliefs, several additional insights were shared about maintaining a permanent crop cover. The question was posed: "why is it that the farmers without extension would be more likely to disagree?" The Landcare Kapchorwa representative suggested two possibilities. First, farmers without extension contact may be more likely to misunderstand the question. Second, the idea of water conservation is less of a consideration in these particular areas (Kwosir), or farmers are concerned about diseases if there is too much water. They may not understand the benefits. Farmers suggested that maintaining the crop cover faces challenges of termites, and so farmers may be likely to be uncertain or disagree because it is not currently feasible.

Subsequently, we discussed the need to map who believed what in the service sector regarding the belief that tillage causes land degradation and how to bring these individuals on board. During the workshop activities, the two groups selected the individuals they believed to be key transmitters of information and how to best use these individuals to reach farmers. Host farmers and religious leaders were key individuals not recognized on the map that both groups agreed should be brought to the forefront in using networks to increase awareness of CA. It was agreed

that host farmers should invite people to visit their plots and call meetings, while religious leaders often provide an important venue to bring in technical personnel and farmer testimonials after the religious services.

Another key area of interest addressed by the small discussion groups was the remaining problems with CA and who to bring together to resolve them. Some key concerns were the performance of Mucuna as a cover crop in Kapchorwa, and the labor intensity of maintaining a crop cover. Technical personnel expressed concern about disease build up, especially smut and maize stalk borer, if the stalks were left upon the field.

Bungoma

In Bungoma, the Technology Networks Feedback Session was held at Rosswood Hotel on 14 February. The full 24 invitees (including 10 women, although one was quite late) attended the SACRED-Africa organized Workshop on Technology Networks for Conservation Agriculture in Bungoma.

Participants were receptive to the presentation of research findings for which many of them had been interviewed. There were a few surprises but no strong criticism. In general, the participants agreed that the findings were in line with their expectations. There were a couple of points that focused more discussion: (1) the concept of "crop cover" seemed to be poorly formulated; (2) the finding that extension was not the only source of information for farmers and that there were multiple alternative sources of information; and (3) that conservation agriculture (which several participants were still unaware) was a potential option for farming in their region.

Johnstone, Jay and Dominic introduced the various dimensions of the project within which the technology networks research is being conducted. Jennifer discussed the importance of person to person relations, the necessity of identifying networks actors and their proclivities for conservation agriculture. Two networks were investigated, one focusing on the access to material resources to engage in agricultural production and the other on information resources for informed decision making.

As the findings were presented, participants remarked that they were surprised to find that extension was not ranked as the number one source of material resources since they felt they were providing physical resources. However, they were quite happy to see that they were ranked number one in information provision, although they had several competitors. There was also some surprise as to the importance of input suppliers as information sources.

The divergence of findings between farmers and non-farm agents as to whether "one should maintain a permanent crop cover" stimulated considerable debate. Although a majority of farmers disagreed with the statement, participating extension agents argued that the farmers really don't really know. Nevertheless, the dramatic divergence between the two groups (three-quarters of non-farm agents agreed with the statement) is both statistically and substantively significant. The participants continued to argue, however, that CA is a new idea and consequently the concept of 'crop cover' is not likely to be understood by farmers. Nevertheless, translations used in Kiswahili indicated the substantive meaning of maintaining soil cover: leaving residues on the field or replanting a new crop after harvesting.

Considerable discussion was also generated by farmer and non-farmer responses to the statement that "tillage causes land degradation". The findings highlight considerable divergence between non-farm agents over the issue, while farmers, both large and small were mostly uncertain. Extension argued that other non-farm service providers were poorly informed about CA practices. Several perspectives were voiced. On the practical level, some suggested that plowing was the most the appropriate technology for the region. Once you start plowing, you have to keep plowing to maintain production levels and weed control. Small farmers more frequently agreed that tillage causes degradation because they experienced it directly. They don't have any choice in their farming practices but to use the same parcels over and over creating degradation. This probably explains the interest of small farmers in composting practices. Large farmers can shift to other parcels leaving fields in fallow or replace soil losses with purchased organic and inorganic fertilizers. Furthermore, as many large farmers were tractor owners, they had little incentive to diminish the demand for their tractor services. Others took a more knowledge-based approach noting that standard college training taught one to plow the land for fertility, water and weed management, while one needed more recent specialized training to learn about the expected benefits of CA (minimum-till and no-till) practices.

The presentation of findings for farmers *with extension contacts* compared to those *without extension contacts* provoked further discussion about differences in knowledge and practice. Some participants noted that farmers lacked resources for new technology and therefore they would disagree with the new practices. It was argued that it was only through practice that farmers could build new knowledge. Others thought that the practice of maintaining soil cover competed with the use of residues for livestock feed and firewood. Still others suggested that weed control was the major issue for farmers. It was noted that those non-farm actors whose roles kept them in close proximity to farmers seemed to hold perspectives most similar to the farmers.

There appear to be major information gaps and a need for more partnerships. Some suggestions for additional actors to be included: churches, chiefs and their "barazas" among others already identified in the network were included. There was also a discussion of using mass media for communicating CA, as well as passing messages at markets and during sporting events at the stadium. It should be noted that mass media allow for awareness raising concerning complex systems like CA, but knowledge and information concerning CA practices will need to be communicated through more personalized interaction, like demonstrations, FFS, field days, workshops, etc.

Unfortunately, the small group discussion in Bungoma in which workshop participants were asked to identify key transmitters of information, important groups that still needed to be introduced to CA, and which individuals should be brought together to resolve remaining issues did not work very well. It was concluded in debriefing discussions that fatigue and the particular self-selection of small group leadership were likely to blame. Higher status late comers to the session dominated much of the discussion in the small group work.

Kitale

Sixteen invitees (including 5 women) attended the Manor House organized Workshop on Technology Networks for Conservation Agriculture for Kitale in Trans-Nzoia District. The diverse but close-knit group held a lively discussion throughout and after the presentations. The

groups represented nearly the full range of stakeholders with the exception of agro-vet dealers, who while identified as a key source of information and resources for the farmers surveyed did not attend. While several insights for improved data interpretation were provided by the participants, overall they reported the findings to be consistent with their understandings of the agricultural sector perspectives and relationships in Kitale. Several debates were held, but the participants recognized the importance of their collaboration despite whatever disagreements they had among themselves. The discussions were informative and reflected the diversity found in the data.

Dennis and Dominic introduced the various dimensions of the project within which the technology networks research is being conducted. Jay highlighted the significance of not leaving the soil bare and the significance of this principle to conservation agriculture. Jennifer discussed the importance of person to person relations, the necessity of identifying networks actors and their proclivities for conservation agriculture. As the presentation advanced, questions arose from the attendees transforming the presentation into a more directed dialog.

When considering the most frequently cited sources of inputs and information by farmers, the Kenya Agricultural Research Institute (KARI) representative asked about the quality transmitted by these individuals, especially agro-vets. The women in attendance were particularly concerned about the quality of information from agro-vets, suggesting that it might be biased due to the commercial orientation of the agro-vets. Specifically, they expected and wished that neighbors and group leaders to be more frequently included in the network because farmers would get higher quality information from these persons. Another question was raised about why the mass media was not on the list.

Another question was about the extent to which the described network would change. It was noted that this is simply a snapshot at a particular time and the members of the network present in the meeting could work to make improvements in the connectivity, and resource and information flows of the network.

The discussion of knowledge and beliefs highlighted the split perspectives among network members and validated the research findings. Considerable time was spent discussing the distribution of agreement with the idea whether “one should maintain a permanent crop cover” amongst small farmers, large farmers, and community agents/service providers. Although large farmers are targeted by extension, they are not being taught conservation agricultural technologies. Large farmers use tractors and need to burn stalks in the monocropping production of maize. One participant noted that large farmers find that it is a waste of time to have a demonstration plot. The large farmers incorporate residues with tractor-drawn plows (they don’t have harrows). They would need much more labor to deal with the residues in any other way. Small farmers are more likely to be planting other crops with more intercropping, maximizing the output of their small parcels for food security. Some participants felt that the service sector was more in agreement since they are more aware of the practice, whereas for the farmers this is considered a relatively new concept. However, others said that most small farmers have already been trained in crop cover and conservation technologies.

The graph of the distribution of agreement with the statement that “tillage cause land degradation” also provoked considerable discussion. It was noted that small farmers were more likely to observe degradation on their parcels because of their more intensive land use.

Alternatively, large farmers often have enough land to fallow particular fields to allow for the soil to recover. Furthermore, large farmers use more chemicals, while small farmers must weed their parcels with a hoe, meaning that for cultivation large farmers are disturbing the soil to a lesser degree. Distinctions in perspective among large farmers are most likely related to whether the farmer has access to a tractor or not. The representative of the Stakeholder Forum (apparently representing larger farmers) noted that many farmers are harrowing residues back in to the soil. However, new ideas are risky, so they are not ready to minimize their tillage practices. The microfinance representative wanted borrowers to repay their loans and so was very supportive of training farmers to help them conserve their soil and consequently grow more. Much of this training is provided by international NGOs which require participation in such training in order to access other program benefits. Everyone agreed that the agrovets didn't want to irritate farmers so rarely challenged their perspectives and consequently, just got on with their business.

Two small groups responded to the following question: how can we use this network information to promote CA within the agricultural production network? Group One believed that large farmers and agrovets don't understand the three principles of CA and consequently are unlikely to practice CA. The Ministry of Agriculture (MOA), microfinance, the Stakeholder Forum and other NGOs were considered the most likely candidates for leading the promotion of CA in Trans Nzoia. There was some discussion about the best way to bring the MOA around to the basic principles of CA, but no clear strategy emerged other than some divisions had already been exposed to it. They also felt that employees of the MOA and local administration (chiefs) were missing from the network and their inclusion would ensure success. They felt the greatest challenges were traditional cultivation beliefs, decreasing landholding sizes, poor farm planning, and inadequate numbers of extension staff. It was agreed that all stakeholders need to work together.

Group Two felt that a large group of network members should be involved in promoting CA, including the NCPB, MOA, agrovets, teachers, consumers and politicians. The extension service should be promoting the whole CA package and politicians providing information on the benefits of CA for sustainable crop production. Agrovets need to have the right information about products supporting CA and the safe use of agri-chemicals. The most likely to take the lead in promoting CA would be extension, other service providers, and educational and research institutions (including MHAC). Several actors were identified as missing from the network analysis. These included educational institutions, civic leaders, local authorities/councils, cooperatives, location industries, and additional government parastatals. These include the Agricultural Finance Corporation, the Agricultural Development Corporation and their farmers. Challenges to the promotion of CA include the lack of training and equipment, problems of weed control and hard pan, and beliefs that certain crops are for cash (crop diversification). All stakeholders need to work together (MOA/KARI/Coops/AFC/farmer groups).

As the discussion proceeded, some conclusions were drawn. Many still feel that conservation agriculture is not a very clear idea – many are confused about what it means. Indeed, the MOA (both research and extension) is just now coming around to CA and learning about best practices. It appears that there needs to be some changes in approach to extension, as well as the need for new staff. There was general agreement that working together would be the best policy. The Stakeholder Forum representative suggested that an event be held with farmers and service

providers from the four networks from the four locations (Tororo, Kapchorwa, Bungoma, and Trans Nzoia) where the participants across the project could get together to share and compare experiences.

Cross Cutting Themes from Network Feedback Sessions

Across the sites, several common questions and concerns were raised about the research methodology and the practice of conservation agriculture. First, participants were interested in why the mass media was not a choice for information source. For example, many farmers reported getting information about agriculture through radio programs. This was a difficult question to address. This research was most interested in person-to-person exchanges of resources and information, believing that these channels would be most appropriate for the development of problem solving in conservation agriculture application. Conservation agriculture is a relatively new concept in all of the sites, and is not an established technology to the extent that a scalable package may be readily presented. Nevertheless, through the research, we did attempt to identify the sources of local educational radio programming, including NAADS, the MOA, and in Kenya the NCPB through the survey work, with the awareness that their particular beliefs had the ability to reach a broad audience.

Another issue emphasized throughout the workshop was the phrasing of "One should maintain a permanent crop cover". As phrased, many workshop participants felt the question was misleading or confusing—indicating a live vegetative cover at all times. During the feedback sessions, it was explained that maintaining crop cover more broadly included leaving residues on the field and/or the planting of cover crops so that the soil **should never remain bare.** In following up with survey enumerators, it was discovered that in local translation, the meaning of permanent soil cover was conveyed to survey respondents. Nevertheless, it has been suggested that the statement be reformulated in the English version to "One should maintain a permanent soil cover" so that the substantive meaning is more accurately conveyed. The Technology Networks CCRA is contemplating the methodologically appropriate moment for introducing this change in phrasing.

As for challenges to the practice of conservation agriculture, access to appropriate implements was a commonly raised issue. The sites for the research currently span the full spectrum from utilizing hand implements to tractor mounted plows for land preparation and cultivation. However, there seemed to be a misconception across sites (with the exception of Kitale) that conservation agriculture was a hand implement based technology. At this point, members of the LTRA-10 research team discussed plans to introduce a prototype for a minimum till ox plow. Meanwhile, farmers themselves have already experimented with the development of minimum disturbance hoes. Nevertheless, it appears there is also need for tractor mounted implements for conservation agriculture, especially in Kitale. A major point here for the technology networks study was the need to engage local implements manufacturers in the design, development, and distribution of conservation agriculture implements.

Appendix A: Technology Networks Questionnaire Module

Technology Networks—East Africa Baseline Survey
Agricultural Support Sector Actors
Conservation Agriculture Production Systems for Food Security

0.1 Date of Interview: ___/____/____ 0.2 Enumerator: _____

Location: 0.3 Province/District _____ 0.4 Subcounty/Location _____
0.5 Parish/Sublocation: _____0.6 Village/Town_____
0.7 Local Contact information_____

0.8 Respondent Name _____0.9 Agent type_____
0.10 Reported Occupation_____

Additional Comments and Observations:

_____
_____
_____
_____
_____
_____
_____
_____
_____

11. Identification of the quality of relations within the agricultural production network For both resource questions and the location and events question, only record the first response or primary interaction. If no resource or information (none) is accessed through interaction with a particular individual, code none and then go to the next individual.

People with which contact is made in order to conduct agricultural production activities (if no agricultural interaction, leave row blank)	a. What physical resources are exchanged through interaction?	b. What form of information is exchanged through interaction?	c. Who Initiates the contact most of the time?	d. Location and Events: Where do you interact?	e. Frequency: How often do you interact?	f. Quality: Can you trust resources/info from this source?	g. Gender
	0. None 1. Seed 2. Fertilizer 3. Pesticide 4. Herbicide/ Weedicide 5. Tractor 6. Crop finance/loans 7.Vet services AI 8.Lamd 9. Cash 10. Other_____	0. None 1. Advice or consultation 2. Only information	0. N/A 1. Always them 2. Mostly them 3. 50/50 4. Mostly respondent 5. Always respondent	0. N/A 1. Farm 2. Store 3. Office 4. Market 5. NGO Office 6. Community center 7. Farmer field day/event 8. Home garden 9. Collective garden 10. Government offices 10. Other_____	0. Never 1. Weekly 2. Biweekly 3. Monthly 4. Seasonally 5. Yearly	0. N/A 1. Always 2. Most of the time 3. Somewhat 4. Rarely 5. Never	0. N/A 1. All male 2. Mostly male 3. 50/50 4. Mostly female 5. All female
1. Village/Subcounty chief							
2. Farmers							
3. Neighbor/friend							
4. Vendor in weekly market							
5. Vendor in a shop in urban center							
6. Vendor in a agro-vet shop							
7. Teacher in village							
8. Minister/Priest/Imam in village							
9. Government Extension agent							
10. NGO/ Development Agent							
11. Veterinary Service provider							

People with which contact is made in order to conduct agricultural production activities (if no agricultural interaction, leave row blank)	a. What physical resources are exchanged through interaction?	b. What form of information is exchanged through interaction?	c. Who Initiates the contact most of the time?	d. Location and Events: Where do you interact?	e. Frequency: How often do you interact?	f. Quality: Can you trust resources/info from this source?	g. Gender
	0. None 1. Seed 2. Fertilizer 3. Pesticide 4. Herbicide/ Weedicide 5. Tractor 6. Crop finance/loans 7.Vet services AI 8.Lamd 9. Cash 10. Other_____	0. None 1. Advice or consultation 2. Only information	0. N/A 1. Always them 2. Mostly them 3. 50/50 4. Mostly respondent 5. Always respondent	0. N/A 1. Farm 2. Store 3. Office 4. Market 5. NGO Office 6. Community center 7. Farmer field day/event 8. Home garden 9. Collective garden 10. Government offices 10. Other_____	0. Never 1. Weekly 2. Biweekly 3. Monthly 4. Seasonally 5. Yearly	0. N/A 1. Always 2. Most of the time 3. Somewhat 4. Rarely 5. Never	0. N/A 1. All male 2. Mostly male 3. 50/50 4. Mostly female 5. All female
12. Government Parastatals							
13. Agricultural researcher							
14. Agricultural/Micro Finance Representative							
15. Tractor owner/ animal Traction owner							
16. Leader of farmer organizations							
17. Leader of women's organization							
18. Leader of youth organisation							
19. Local Political leaders							
20. Other to be determined							

12. Knowledge, beliefs and perceptions concerning agricultural practices

(check the cell that most closely applies for each belief).

	Beliefs concerning agricultural practices	Strongly agree - 5	Agree - 4	Uncertain/neutral - 3	Disagree - 2	Strongly disagree - 1
1.	Land is one's heritage to be preserved for future generations					
2.	Farm labor should be replaced by more efficient herbicides and machines					
3.	Engaging in multiple productive activities is always better than doing just one					
4.	Farm income should always be reinvested to grow the business					
5.	One should maintain a permanent crop cover					
6.	It is better to grow staples within the household than purchase them.					
7.	Applying chemical pesticides is always necessary					
8.	Farm production is necessary to feed the family					
9.	Inorganic fertilizer is best to improve soil quality					
10.	Spreading crops and inputs across multiple plots is always necessary					
11.	Planting decisions are always based off of current market prices					
12.	Timely weeding (before setting of seed) is important to a successful harvest					
13.	Crops should only be grown for sale					
14.	Crop residues should only be fed to livestock and poultry					
15.	Tillage causes land degradation					
16.	One should always strive to grow the most on one's land					
17.	The staple crop should be planted on the majority of the land *every* growing season					
18.	Rotating crops is always best practice					
19.	Land preparation for crop production begins with plowing.					
20.	Earning off-farm income is more important than a large harvest					

Appendix B: Bibliography

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