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Agricultural Actors, Networks, and Farmer Identity:
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Introduction: Conservation Agriculture and Lesotho

Commonly characterized as one of Africa's most highly eroded landscapes, efforts to conserve Lesotho's soils have a long, and deeply contested history (Showers, 2005). Since large scale production of maize and wheat began in the colonial era, signs of severe erosion have been reported. Showers (2005) argues that colonial interventions to reduce erosion have exacerbated, rather than alleviated these issues. Activities to combat erosion and improve agricultural productivity in the latter half of the twentieth century have made limited progress and yields have been declining since the mid-seventies (Sicili, 2010). Soils in Lesotho are prone to both severe sheet and gully erosion, and the loss of top soil contributes to declining fertility. Replacement of soil nutrients with artificial and organic fertilizers has not been adequate to replenish fertility, contributing to the overall decrease in yields over time. Agricultural production in Lesotho has also been determined to be especially sensitive to climate change, with disruptions and changes in weather patterns increasing the variability and severity of rainfall (Dejene et al., 2010). Given that the majority of the population remains engaged in smallholder agricultural production, methods to improve agricultural productivity and soil conservation are critical to reducing poverty and stimulating local economic development.

Conservation agriculture (CA) as a system of 1) minimizing soil disturbance, 2) rotating and mixing crops and 3) maintaining a permanent soil cover has been a focus of sustainable intensification programs in Lesotho (Sicili, 2010; Dejene et al., 2011). Various domestic and international actors, including the Food and Agricultural Organization (FAO), several large international NGOs (World Vision and the Red Cross), the Lesotho Ministry of Agriculture and Food Security (MAFS), Lesotho National Agricultural Research Center, and numerous local organizations have sought to promote conservation agriculture through various projects across the country and collaborate with one another through a CA Task Force encouraged by the FAO and founded in 2005. In partnership with the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) Long Term Research Activity 9 (LTRA-9): "Developing Sustainable Smallholder CAPS in Southern Africa", managed by the University of Tennessee, the Cross Cutting Research Activity 8 (CCRA-8) on technology networks have investigated the mindsets and networks of agricultural service providers and farmers in the Botha Bothe District of northwestern Lesotho.

The Botha Bothe District offers an interesting entry point for examining perspectives on conservation agriculture due to its diverse landscape and previous experiences with the introduction of CA. Containing lowland, foothill and highland areas, the district offers a broad range of agro-ecological and climatic conditions, resource access, and farming practices. Farmers in different geographic areas within the district face varying challenges in farming practice (Moore et al. 2012). Complimenting this internal diversity, the district shares a long border with South Africa, presenting additional opportunities for access to information and resources from diverse production perspectives.

CA has been promoted through several different methods in Botha Bothe District. Religious groups and NGOs have primarily promoted *likoti* among smallholder farmers. This method involves the digging of planting basins or holes into which farmers place organic or artificial fertilizer and seeds. While relatively labor intensive compared with conventional tillage methods, including tractor and oxen-drawn plow systems, the *likoti* method has been demonstrated to provide yield and profitability increases (Sicili, 2010). In particular, the religious organization Rohobothe has become a primary promoter of *likoti* in Botha Bothe. MAFS has also promoted the adoption of CA through *likoti* and through the use of tractor-mounted and oxen drawn implements for 'field CA'. These implements allow for a less labor intensive CA production method than the digging of *likoti*. The MAFS leases out these implements to farmers wishing to use CA methods on their fields. However, there is not enough minimum till equipment for lease to make this an option for a majority of farmers in the region.

The University of Tennessee has been actively working in Botha Bothe since 2008, beginning research activities through a grant funded by the United States Department of Agriculture and as a part of the SANREM CRSP since 2009. Through these research activities, various experimental plots to determine the best mixes of crops and production practices to achieve success with conservation agriculture have been established in Botha Bothe and southern Lesotho. This has included experimentation with different types of implements and production techniques, calculating costs of production associated with various methods, evaluation of field trials in different agro-ecologies, and the impact of training activities on adoption of CA (Eash et al., 2012; Bisangwa et al., 2012, Wilcox et al., 2012). Social research conducted as part of the SANREM project included a 430 household baseline survey of Botha Bothe District households in 2010 to better understand current production practices, food security, and general livelihoods of the local Basotho (Bisangwa et al., 2012; Wilcox et al., 2012). Additional research conducted in partnership with the Technology Networks CCRA-8 managed by Virginia Tech examined farmer identities and the perspectives of agricultural service providers (Moore et al., 2012).

In general, ethnographic and quantitative research finds that there is a diverse network of agricultural service providers supporting agricultural production in Botha Bothe District (Moore et al., 2012). Given that production conditions vary widely between lowland, foothill and highland settings, farmers have developed different strategies for successful farming in their communities. Likewise, the agricultural service sector has different approaches for working with lowland, foothill, and highland farmers. Service providers in South Africa also play a significant, though less understood role in providing farmers with agricultural inputs and information.

Based on these findings, the SANREM CRSP Technology Networks CCRA-8 has partnered with the LTRA-9 team to conduct a more focused comparative investigation of farmers networks in different agro-ecologies, how these networks relate to current mindsets and practices for agricultural production, and current prospects for CA adoption based upon these characteristics. Through this study, we have sought to identify:

1. Differences in perception of agricultural production practices between farmers in various agro-ecologies and service providers/community agents
2. Key agricultural resource contacts for farmers in different agro-ecologies
3. Associations between individual and farm level factors and production mindsets
4. Factors such as network activity, network contact, and mindset which may impact adoption and dis-adoption decisions for CA
5. Network structure at a national, district, and community level
6. Relationships between network structure and beliefs about CA practices

It is our hope that this study will help us identify the key agents for agricultural knowledge promotion in these different contexts in order to facilitate a change in mindset toward, and sustained adoption of conservation agriculture.

Sampling:

The technology networks survey research was implemented through a two-phase process. Initially, a cluster sampling strategy was used by the LTRA-9 team in December 2010 to administer 430 household surveys in Botha Bothe (Wilcox et al., 2012). The cluster sampling methodology used census data to target important agriculture livelihoods and locations where CA activities were promoted to generate a sample of 10 villages. These villages represented a mix of the diverse agro-ecologies in the District and included two lowland, three foothill, and five highland villages. The focus of the survey was on row crop production, farm livelihoods (including training activities, employment, etc.) and more basic demographic data (for example, age, education, and household composition). Regarding the network data, this survey provided the information to construct the basic contact (ego) networks of farmers from across the district through a network module and included a set of attitudinal statements to measure farmer knowledge and beliefs about certain agricultural production practices. A follow up survey, conducted with one highland community (Ha Sefako) and one foothill community (Ha Tabolane), took place in January 2012. During this follow up survey, the team was successful in capturing over 90% of the original sample, including 59 of 63 households in Ha Sefako and 77 of 88 households in Ha Tabolane. Farmers were asked to identify their contacts for agricultural information and resources, and this information was used to expand the network up to the next level using a snowball sampling method. Specifically, contacts identified five or more times were interviewed as community agents or service providers, and individuals who were reported three or more times by this initial set of agents were also interviewed. This resulted in an additional snowball sample of 38 community agents and service providers located in Lesotho and South Africa.

The communities selected for this sub-sample represented many of the characteristic differences between highland and lowland/foothill communities identified through the ethnographic and baseline surveys. Ha Tabolane, the foothill community, is relatively close (20 km) to the provincial center of Botha Bothe. Buses provide transport to and from Ha Tabolane several times a day. The area also has reasonable access to the South African border, with the nearest border crossing about 30 km from Ha Tabolane, another 10 km beyond Botha Bothe. Ha Sefako, the highland community, is relatively isolated. Located at least a three hour overland ride from Botha Bothe, most transport in the area is by foot or on horseback with limited options to use buses or public transportation. The village is approximately 45 minutes by vehicle from the South African Border Post at Qwa Qwa. Phuthaditjhaba, South Africa lies another 10-20 minutes by vehicle beyond the border and is the nearest urban center for the village, and is an important market center to access production inputs for those with the documentation and resources to cross the border.

Conditions for agricultural production also differ significantly between agro-ecologies. Specifically, in Ha Sefako farmers confront climatic limitations, including a shortened growing season and reduced range of crops which can be grown. Early frosts and snowfall limit highland farmers to a single growing season and many rely on livestock for a considerable portion of their livelihood. In Ha Sefako, access to land is controlled by the chief and has been reported as a source of generational conflict. Youth often find it difficult to access good land, and older members of the community typically have access to produce on the best plots. Due to long distances to urban centers, accessing inputs for agricultural production can be a major challenge. While the MAFS has a Resource Center in Matsoiang, which is accessible from Ha Sefako and most of the highland communities surveyed, farmers report that the resource centers often do not have the inputs they seek. Farmers are often dependent on a few community members who have a vehicle to transport supplies from Botha Bothe town and urban centers in South Africa. By contrast, lowland and foothills farmers, including those in Ha Tabolane, have greater access to inputs and markets for their agricultural products, and have increased flexibility in crop production in that they are able to plant two crops per season. While a number of farmers have access to land in Ha Tabolane, many lack the financial resources to keep the land in cultivation. Those who lack resources often need to work on the

fields of others in order to purchase inputs, and often suffer consequences for late planting or lose the opportunity to plant at all.

Studying Networks and Beliefs: Research Methods

The technology networks research project is interested in two key themes: 1) knowledge and beliefs about agricultural production and 2) size, composition, and structure of farmer and agricultural service sector networks. In order to understand agricultural knowledge and beliefs in Botha Bothe, a list of 20 attitudinal statements was developed which reference various production practices. These statements were designed to characterize three ideal types of agricultural norms and practices (technological frames) likely shaping agricultural production perspectives: conservation agriculture, conventional agriculture, and risk averse agriculture[1]. Respondents were asked about the extent to which they agreed or disagreed with each statement. Responses were recorded on a 3-point Likert scale: (1) disagree, (2) neutral, and (3) 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). Frequency distributions were constructed to examine patterns of beliefs and means were tested for significant differences in perspective between agents and farmers in various agro-ecologies.

To construct farmer networks, a position generator network survey instrument was used. The position generator method, developed by Lin and Erickson (2008) asks respondents to identify their interaction with individuals of various occupations, in this case those with occupations relating to agriculture. In this way, the position generator provides a structured method for inquiring about the professional network related to farming. The notion of the professional network represents the relationships between individuals engaged in various aspects of agricultural production for their livelihood (Wolf, 2006). Specifically, we were interested in the network for the exchange of agricultural information, ideas, and resources. Examining the professional network related to farming involves a wide range of individuals beyond the researchers, extension agent, and farmers identified by the technology transfer model. Key informants who helped develop the survey instrument reported that individuals such as input suppliers, tractor owners, tractor service suppliers, religious leaders, women's groups, farmer group leaders and youth leaders also played a key role in circulating agricultural information and resources within local communities. Subsequently, a list of 19 different actor categories was developed to query farmers

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[1] ***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.

regarding their agricultural production networks. Farmers were asked about whether they exchanged or acquired information and/or resources, as well as questions about the quality and frequency of exchange with each individual contact. The full list of actors identified can be viewed in Appendix 1.

Networks were analyzed from several perspectives. Data from the household and technology networks service sector/community actor surveys was entered in the traditional cross-sectional format in order to conduct basic statistical analysis of the network actor attributes, beliefs about agricultural production, and adoption of conservation agriculture. Several key factors were controlled for in these analyses: agro-ecology, gender and farm size. Second, egocentric network analysis was used to describe activity in farmer networks for accessing agricultural information and resources and to identify the most common contacts of farmers by locality. These results were then used to conduct compare means testing for significant differences in knowledge, beliefs, and behavior of farmers with and without these contacts. For example, 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 those farmers in different communities, and to those with and those without extension agent contacts in a given location.

During the follow up interviews with farm households in Ha Tabolane and Ha Sefako, it was realized that some of the most important contacts of farmers (in terms of frequency of a reported contact occurring in the local population) for agricultural information and resources included farmer group leaders, counselors, religious leaders, youth leaders, and/or tractor owners who were also farmers themselves in their local communities. As a result, some of the individuals interviewed for the agricultural community agents/service provider surveys were from farm households who had been previously included in the general household survey. For the purposes of our analysis, in instances when this duplication occurred and we wished to compare the perspectives of agents and farmers, we have dropped the initial household surveys for these interviewees in favor of the responses provided during their more in depth interview about their role as a community agent. However, in the case of conducting village or farm household level analyses, we retained these respondents in the household data with the recognition that similar community level actors likely exist in communities where no follow up work for the network research was conducted. By taking these two approaches, we expect to most parsimoniously capture the dual role played by these important community agents/farmers.

Finally, 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. Agent types were matched 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 two 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, the network mapping of reported relations is presented according to the focus sites of Ha Tabolane and Ha Sefako.

Ethnographic research was also an important aspect of studying farmer networks, and contributed to forming testable hypotheses for our quantitative investigation. This research included a set of semi-structured interviews conducted in August 2011 (Moore et al., 2012). Moreover, to the greatest extent possible during the follow-up interviews with agricultural service providers/agents, some open-ended questions were asked to elicit important themes regarding differences between agricultural service providers, farmers, and farmers in the different agro-ecologies.

Comparing Knowledge and Beliefs:

During ethnographic interviews, many respondents identified major differences between highland and lowland farmers regarding their production practices, constraints, and attitudes toward farming (Moore et al., 2012). Correspondingly, many non-farm agents stated that they had developed different ways of working with highland and lowland farmers. Highland farmers, it was argued, were more remote and difficult people to work with. More isolated highland communities have had to make use of what they have, and more commonly use organic fertilizer and composting methods to reduce the costs associated with bringing in artificial fertilizer from Botha Bothe or South Africa. Highland farmers were also perceived as less inclined to adopt new technologies or to experiment, while lowland farmers are often eager to adopt new technologies, especially when these technologies are accompanied by inputs (Moore et al., 2012). Farmers in lowland and foothill areas, being more accessible and open to interaction with outsiders have more commonly been the recipients of aid through NGO and government projects. As some described, these farmers were more likely to depend on the receipt of such inputs for production. Based upon these distinctions in farming practices in the different agro-ecologies, we hypothesized that there would be demonstrable differences in composition of farmer networks, as well as the attitudes and beliefs represented by highland and lowland areas. We also hypothesized that there were likely to be significant differences in farmer versus agent/service provider perspectives.

In order to better understand these local mindsets and perspectives, we used factor analysis to identify underlying dimensions of co-variation between the different indicators relevant to conservation agriculture, risk averse agriculture, and conventional agriculture. Using principle components factor analysis with varimax rotation, items for risk averse and conventional agricultures were identified leading to the extraction of two underlying dimensions. These two dimensions of agricultural production norms and practices cut across the localities, and various roles in agricultural production. The first factor can be summarized as “farm households are market driven” and is composed levels of agreement/disagreement with the following statements:

- Planting decisions are always based off current market prices
- Crops should only be grown for sale
- One should strive to grow the most on one’s fields
- Earning off-farm income is more important than a large harvest

Once this variation is accounted for, a second factor emerged “successful farming is capital intensive”. This factor is composed of the following statements:

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

Preliminary analyses also indicated that there was a pattern of correlations among the responses with respect to Conservation Agriculture (CA). These included significant positive Pearson correlations (at the .05 level) between maintaining cover crops and tillage causes erosion (.17), maintaining cover crops and crop rotation (.12) and tillage causes erosion and crop rotation (.13). Factor analysis was conducted on these three items and a nascent or emerging perspective of conservation agriculture was identified. While this factor lacks the explanatory power of the other two, it provides a measure of the developing mindset for conservation agriculture production.

The ‘market-driven’ and ‘capital intensive farming’ factors have eigenvalues of 1.5 and 1.66 respectively, while the conservation agriculture factor has an eigenvalue of 1.2. The individual factors are more similar in the ability to account for co-variation of the items which compose them; the market driven factor accounting for 46 percent, the capital intensive farming accounting for 49 percent, and the conservation

agriculture factor accounting for 42 percent of the co-variation among the items. Further analysis examined the reliability of these factors using Cronbach's Alpha. Although the alphas for all but one of the indicators are considered too low to be reliable indicators (market driven at .6, capital intensive farming at .49, and the conservation agriculture at .35), the face validity of the items makes them meaningful indicators of underlying patterns of beliefs about agricultural production.

Using these factors, we compared the perspectives of farmers and agents in Botha Bothe District through the construction of cross tabulations to examine distributional patterns within different groups and through compare means testing to highlight significant differences.

Table 1: Mean scores for Botha Bothe farmers in different agro-ecologies and service sector/community agents level of agreement on farming mindset factors

Factor	Lowland	Foothill	Highland	Service sector/ community agents
Market Driven*	1.90[a]	1.90 [a]	1.90[a]	2.12[b]
Capital Intensive Farming*	2.71[a]	2.73[a]	2.73[a]	2.00[b]
Conservation Agriculture*	2.76[a]	2.60[b]	2.47[c]	2.69[ab]
N	96	156	163	38

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

As hypothesized, agents appear to hold different beliefs than the farming populations they serve. Support for market driven agriculture is consistently low across farmers in different agro-ecologies, which aligns with the continued predominance of subsistence agriculture. Meanwhile, the greater support for market driven perspectives among service providers likely reflects the initiatives popularized by extension and NGOs to encourage production for local markets.

Conversely, the capital intensive farming perspective is generally more popular among farmers, but the service sector expresses much lower support. Community agent and service providers are much less supportive of capital intensive farming mindset which embraces the use of mineral fertilizers, chemicals for weed and pest control and the adoption of labor saving technologies. This can be attributed to the fact that agents are much more divided on the use of chemicals and artificial fertilizer, whereas farmers almost entirely support these perspectives. Contrary to the hypothesis that there would be remarkable differences between the agro-ecologies regarding their production perspectives, few differences were identified between the market driven and capital intensive farming perspectives. Mindsets concerning agricultural production perspectives are remarkably homogeneous among all farmers.

However, beliefs about CA follow a distinctively different pattern. Across agro-ecologies, there is some variation in the extent to which farmers express support for CA, with the lowland farmers being most supportive, foothill farmers significantly less supportive, and highland farmers expressing a significantly lower level of support than either of the lower agro-ecologies. Only highland farmers appear to be significantly less convinced of the validity of CA.

Analysis of Tables 2 through 4 allows us to consider the sources of variation separately. Of the three CA principles, rotating crops enjoys the most universal support among farmers and agents (Table 2). Support is significantly higher among lowland, although this difference is not materially significant given that all groups express near universal support for this principle of CA. The strong support for crop rotation is an important foundation for building broad based support of CA, as other principles are likely to be more controversial.

Table 2: Percentage of and mean value for farmers and service sector/community actors within Botha Bothe by level of agreement or disagreement with the statement that:

Rotating crops is always best practice		Agree	Neutral	Disagree	Means
Chi-square = 13.73 Statistically significant at the .05 level	Lowland (n=96)	99	1	0	2.99[a]
	Foothill (n=156)	90	5	4	2.86[b]
	Highland (n=163)	88	7	6	2.82[b]
	Service Providers (n = 38)	89	11	0	2.89[b]

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

Table 3: Percentage of and mean value for farmers and service sector/community actors within Botha Bothe by level of agreement or disagreement with the statement that:

Cover crops should be maintained on my fields		Agree	Neutral	Disagree	Means
Chi-square = 7.339 Not statistically significant	Lowland (n=96)	89	7	4	2.84[a]
	Foothill (n=156)	84	9	7	2.77[a]
	Highland (n=163)	79	9	12	2.67[b]
	Service Providers (n = 38)	89	5	5	2.84[a]

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

Examining the issue of maintaining cover crops, some differentiation begins to emerge between agro-ecologies (Table 3). Specifically, highland farmers are less likely to support this principle of CA. Moreover, a larger portion of farmers are undecided about the issue across localities. Nevertheless, the vast majority of farmers and service providers support maintaining cover crops.

That tillage causes erosion is by far the most divisive principle of CA (Table 4). While a majority of lowland farmers, foothill farmers, and agents agree that tillage causes erosion, large minorities who disagree in each category are also identified. Highland famers are even more divided on this issue, with a plurality in disagreement, and the largest percent of farmers of any agro-ecology remaining undecided. Significant differences in mean scores between groups and the statistically significant Chi-square statistic indicate that support varies both within and between agro-ecologies.

Table 4: Percentage of and mean value for farmers and service sector/community actors within Lesotho by level of agreement or disagreement with the statement that:

Tilling causes erosion		Agree	Neutral	Disagree	Means
Chi-square= 22.605 Statistically significant at the .01 level	Lowland (n=96)	66	15	20	2.46[a]
	Foothill (n=156)	53	12	35	2.17[b]
	Highland (n=163)	39	16	45	1.94[c]
	Service Providers (n = 38)	63	8	29	2.34[ab]

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

Examining variation within the farming population:

A plausible explanation for the variation in degree to which farmers in the different agro-ecologies support CA is that overall exposure to CA production methods has not been consistent across localities, with the lowlands receiving the greatest levels of exposure and the highlands the least. A number of different factors, such as gender, farm size, agricultural production perspective, and contact with particular agents in local networks may also play a critical role in both support for CA and technology adoption. The following sub-sections concern themselves with exploring these different characteristics of the farming population and how they relate to CA beliefs and adoption.

Impacts of gender and farm size on mindsets and CA perspectives

Individual and farm level characteristics may be highly important to beliefs and perceptions about agriculture and the adoption of CA. The following analysis documents the range and variation in gender and farm size and then relates it to perspectives on agricultural production. Farmers are classified as large or small at approximately the midpoint of the range of farm size, with farmers who cultivate less than 1.2 hectares considered small farmers and those who cultivate more than 1.2 hectares as large farmers. Data for land cultivated was missing for 38 households in the dataset, spread across localities. In these cases, missing values were replaced with the mean for the village to which the household belongs, and then classified into large and small categories as called for by the stated criteria.

Table 5 helps to demonstrate some of the basic differences in agro-ecology between the villages surveyed in Botha Bothe District. Although the differences in average land sizes are not statistically significant, there is a general trend that highland farmers tend to have larger land holdings than the foothill and lowland farmers, with the exception of the Ha Mou and Phamong communities. More women than men were interviewed during the survey process, as enumerators needed to interview the individual available. Many Basotho men continue to migrate to urban areas or to work in the mines in South Africa, although the latter occurs less frequently than in the past. This leaves women to manage the farms. This imbalance in the interviewees thus reflects the realities of farm management in Lesotho.

Table 5: Composition of village samples by gender (in percentage) and farm size (in percentage with mean values)

Agro-ecology	**Village**	**Gender***		**Farm Size**		
		Male	**Female**	**Small Farm** (<1.2 ha)	**Large Farm** (>=1.2 ha)	**Mean**
Lowlands n=96	Ha Rasekila (n=37)	46	54	49	51	1.37
	Maloseng (n=59)	34	66	46	54	1.40
	Subtotal	38	61	47	53	1.41 [a]
Foothill n= 162	Ha Tabolane (n=88)	33	67	67	33	1.10
	Joala Baholo (n=41)	20	80	54	46	1.26
	Mokotjela (n=33)	55	45	36	64	2.30
	Subtotal	34	66	57	43	1.37 [a]
Highlands N=166	Ha Sefako (n= 63)	33	62	35	65	1.86
	Ha Mou (n=15)	20	80	93	7	0.55
	Phamong (n=9)	22	78	89	11	0.90
	Mafika Lisiu (n=59)	36	64	41	59	1.80
	Manoeleng (n=20)	45	55	45	55	2.38
	Subtotal	34	66	46	54	1.70 [a]
	Total	**35**	**64**	**50**	**49**	**1.51**

Note: Different letters within the same column are statistically different. * One of the villages in the highlands has missing data on the gender of 3 respondents.

Table 6 surfaces some differences between men and women farmers, but there are no differences in any of these perspectives with respect to farm size. Men are significantly more supportive of a market driven outlook and the practice of rotating crops. This could indicate that men have greater access to markets and are more likely to be exposed to training activities on the issue of crop rotation. We will look more in depth at these possibilities when comparing farmer networks by gender and agro-ecology in later sections.

Table 6: Farm and individual level characteristics impact on mindsets and CA beliefs

Agricultural Production Mindsets:	Men	Women	Small Farmers	Large Farmers
Market Driven*	**1.98[a]**	**1.84[b]**	1.93[a]	1.84[a]
Capital Intensive Farming	2.68 [a]	2.72[a]	2.72[a]	2.68[a]
Conservation Agriculture	2.59[a]	2.53[a]	2.57[a]	2.53[a]
Conservation Agriculture Beliefs:				
Cover crops should be maintained on farmer fields	2.7[a]	2.74[a]	2.73[a]	2.70[a]
Rotating crops is always best practice*	**2.93[a]**	**2.81[b]**	2.85[a]	2.85[a]
Tillage causes erosion	2.15[a]	2.07[a]	2.13[a]	2.06[a]
N	148	273	209	215

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.

Farmer Networks for Agricultural Information and Resources

Describing variation in local networks further assists us to better understand local dynamics regarding CA beliefs and adoption. Using the cross-sectional data obtained from the household survey, a basic analysis of the farmer ego (individual) networks in each site was performed. Given the geographic variation between the research localities, we were interested in whether or not agro-ecology contributed to differences in the size and composition of farmer networks. One of the most basic network statistics calculated at the individual farmer level was individual (egocentric) network degree. Network degree is simply a count of the number of contacts a farmer reports. This was calculated for contacts through which agricultural resources (such as fertilizer, seed, agrochemicals, veterinary or tractor services) and agricultural information, advice, or consultation is accessed. Interestingly, we found that farmers across the localities had a significantly higher (at the .05 level) number of contacts for agricultural resources than agricultural information. However, the average number of contacts for both resources and agricultural information are low, at 1.12 and 1.49 respectively. Thus, it seems on average farmers are generally dependent upon only 1-2 sources of agricultural resources and information.

Across agro-ecologies, the range for the number of resource and information contacts is small and varies between 0-3 to 0-4. However, some distinct patterns emerge which suggest that there are differences in the activity of resource and information networks between the lowland, foothill, and highland agro-ecologies. Table 7 demonstrates that lowland and foothill farmers have significantly more contacts for agricultural resources than highland farmers. Meanwhile, it appears that farmers in both the highlands and in the lowlands tend to have more contacts for agricultural information, although this difference is not statistically significant.

Table 7: Information and resource network degree by agro-ecology

Network Activity	Lowland	Foothill	Highland
Resource Degree*	1.62[a]	1.55[a]	1.34[b]
Information Degree	1.19[a]	1.01[a]	1.18[a]
N	96	162	166

Notes: Different letters indicate that the T-Tests for differences in means are statistically different within their locality at the .05 level. Star indicates a row in which statistically significant differences can be identified

The composition of farmer information and resource networks seems to vary only to a limited extent between localities (Tables 8 and 9). Urban vendors are by far the most important contacts for resources, particularly in the lowland and foothills. Tractor owners, extension and neighbor/friend are next in line. As for sources of information, extension and neighbor/friend become more important contacts.

Table 8: Percentage of farmers reporting resource contacts by agro-ecology

Rank	Lowland	n=96	Foothill	n=162	Highland	n=166
1	Urban Vendor	43	Urban Vendor	51	Urban Vendor	32
2	Tractor Owner	23	Tractor Owner	29	Tractor Owner	22
3	Neighbor/Friend	22	Extension	20	Extension	20
4	Extension	21	Neighbor/Friend	15	Neighbor/Friend	17

Table 9: Percentage of farmers reporting information contacts by agro-ecology

Rank	Lowland	n=96	Foothill	n=162	Highland	n=166
1	Extension	42	Neighbor/Friend	25	Extension	34
2	Neighbor/Friend	25	Extension	21	Neighbor/Friend	22
3	NGO	20	Family Member	14	Urban Vendor	11
4	Religious leader	16	NGO	12	NGO	10

Next, we compared the composition of farmer networks by agro-ecology and between the two research focus communities of Ha Tabolane and Ha Sefako (Tables 10 and 11). A greater percentage of farmers in Ha Tabolane report resource contacts than in Ha Sefako, with 56% of Ha Tabolane farmers reporting that they acquire resources from an urban vendor. This is not surprising given the geographic proximity of Ha Tabolane to Botha Bothe. By contrast, the tractor owner is more frequently reported in the highland region of Ha Sefako. In this case, the tractor owner in this community plays a dual role as both a provider of tractor services and as one of the few community members with a vehicle for the procurement of inputs from South Africa and Botha Bothe. For acquiring information, extension agents, friends/neighbors, and NGOs are the most important contacts across localities.

Table 10: Percentage of farmers reporting resource contacts in focus communities

Rank	Ha Tabolane	n=88	Ha Sefako	n=63	All Other Localities	n=274
1	Urban Vendor	56	Tractor Owner	29	Urban Vendor	41
2	Neighbor/Friend	28	Urban Vendor	27	Neighbor/Friend	21
3	Tractor Owner	19	Neighbor/Friend	22	Tractor Owner	21
4	Extension	13	Extension	19	Extension	20

For the lowland agro-ecology and the individual village of Ha Tabolane, the position of religious leader enters into the top four identified information contacts. After reviewing the data, we suspected that this reflected the training activities of Rohobothe Mission, an important promoter of CA in the region. However, during the network follow up surveys it was also revealed that local pastors play an important role in sharing information about agriculture production. Unfortunately for the household survey data, the level of disaggregation is not adequate to separate these influences.[2]

Table11: Percentage of farmers reporting information contacts in focus communities

Rank	Ha Tabolane	n=88	Ha Sefako	n=63	All Other Localities	n=274
1	Extension	19	Extension	38	Extension	32
2	Neighbor/Friend	16	Neighbor/Friend	21	Neighbor/Friend	27
3	Family Member	10	Family Member	10	NGO	14
4	Religious leader	7	Agrochemical	10	Religious leader	12

Having established a high level of overall similarity between the types of contacts in the sites, we were also interested in whether or not farmers in particular localities would be more or less likely to report contact with different types of contacts for agricultural resources and information. Tables 12 and 13 compare distribution of agent contact by agro-ecology and tests for significant differences in distribution between agro-ecologies for contact with particular types of agents.

As expected, there are some significant differences in access to resource contacts between regions. More farmers in the lowlands and foothills report access to an urban vendor for agricultural resources compared to the highlands. This is again consistent with the geographic proximity farmers in both areas have to these agents. Interestingly, the difference in accessing neighbors/friends for resources is also significant, with more lowland and foothill farmers reporting contact. This does not entirely align with qualitative descriptions of the regions, where it was reported that farmers in the highlands were predicted to have greater incidence of contact with neighbors and friends for resources through pooling and/or sharing arrangements due to the challenge of accessing resources. An alternative explanation may be that resource scarcity actually discourages this type of sharing, contrary to the belief espoused by agents and service providers in the ethnographic research.

[2] During the follow up survey, disaggregated data was collected to distinguish between these important actors in order to more accurately model local networks.

Table 12: Percentage of farmer contact with various resource agents by agro-ecology

Agro-ecology:	**Agent Contacts**							
	Extension		Urban Vendor		Tractor Owner		Neighbor/Friend	
	Contact	None	Contact	None	Contact	None	Contact	None
Lowland (n =96)	21	79	43	57	23	77	22	78
Foothill (n=162)	15	85	51	49	20	80	29	71
Highland (n=166)	20	80	32	68	22	78	17	83
Chi-Square	2.25		12.61**		.286		6.26*	

Notes: One star indicates that the Chi-Square statistic is significant at the .05 level. Two stars are significant at the .01 level

On the other hand, contact with extension and with tractor owners for resources is more equal across the production regions, and underlies the cross cutting importance of these individuals across agro-ecologies in providing resources to farmers. With regard to CA, the high level of contact with tractor owners in the farm population is something that must be taken into account as this contact will likely be displaced or at least transformed by the mainstreaming of CA.

Differences for distribution in information contacts across agro-ecologies (Table 13) follow a different pattern than resource contacts. For information contacts, the only agent for which a significant difference in the distribution of contact could be identified is extension. Specifically, a larger percent of lowland and highland farmers report contact with extension than foothill farmers. Moreover, while contact with NGOs and religious leaders appears to be slightly higher in the lowlands, the lack of significant difference indicates that exposure to these agents is not necessarily determined by locality. Contrary to the qualitative characterizations of highland and lowland communities, farmers in the highlands appear to be no more likely to report their neighbors and friends as sources of information than in any other region.

Table 13: Percentage of farmer contact with various information agents by agro-ecology

Agro-ecology:	**Agent Contacts**							
	Extension		NGO		Religious Leader		Neighbor/Friend	
	Contact	None	Contact	None	Contact	None	Contact	None
Lowland (n =96)	42	58	20	80	16	84	25	75
Foothill (n=162)	21	79	12	88	9	91	25	75
Highland (n=166)	34	66	10	90	8	92	22	78
Chi-Square	13.3**		5.3		4.6		0.47	

Notes: Two stars indicate that the Chi-Square statistic is significant at the .01 level.

Overall, these results have several implications for our further analysis of networks and beliefs about agricultural production. There appears to be strong consistency between the networks represented by Ha Tabolane and Ha Sefako with regard to their respective regions. This is encouraging because it verifies our initial hypothesis that using these focus communities would position the research to make more general comparisons about the differences in network composition between agro-ecologies. Also, the composition of farmer information and resource networks is quite different, and these will likely need to be studied separately to understand particular network flows. With the exception of neighbors and friends and extension, farmers do not have the same key contacts for resources and for information. Nevertheless, the importance of extension across localities suggests that the views presented by extension agents have a broader audience than any of the other identified community agents or agricultural service providers, and should be a focal point for later investigations of the relationship between network contacts and mindsets. Finally, the relative equality in access to information contacts is highly relevant to the exploration of variation in beliefs about CA. Since levels of exposure to different key contacts for information are comparable across agro-ecologies, exposure alone cannot be posited as an adequate explanation for this described variation in beliefs. The relationship between network exposure, agro-ecology, and beliefs about agricultural production is more complex. Further inquiry should investigate how principles of CA are negotiated within local discourses of agricultural production. The following sub-section examines individual farm characteristics, such as farm size and gender and interaction with specific contacts for information impact local agricultural perspectives.

Relationship between gender, farm size and agricultural production networks

We were also interested if network degree and composition were significantly different between men and women and small and large famers. Men have more contacts for agricultural information (Table 14). This may suggest that men are freer to make information contacts and may be more likely to be exposed to new ideas through these contacts. Moreover, results from the previous section indicated that men are also more market oriented and more likely to have opportunities to market agricultural products and use cash resources. However, this potential explanation is not consistent with the finding that women are more likely to report contact with an urban vendor than men. It was also found that men are significantly more likely to obtain information about agriculture from neighbors and friends than women. The significance of this finding should be explored in greater detail during restitution sessions.

Regarding small versus large farms, the only significant difference in network activity is that small farmers have more contacts for agricultural resources. This is somewhat surprising, as it is often expected that larger farmers will have greater access to resources. However, as indicated by the analysis of land sizes by agro-ecology, highland farmers typically have slightly larger landholdings and have more barriers to accessing resources. As highland farmers produce fewer crops, they may also have reduced demand for accessing resources from multiple contacts. Small farmers also appear to be more likely to access resources from neighbors and friends, which may also be contributing to their greater overall number of contacts for resources. Further testing to compare the distributions for men and women farmers and small versus large farmers were also conducted, revealing no significant differences in the distributions between groups.

Table14: Farm and individual level characteristics impact on mindsets and CA beliefs

Network Activity:	Men	Women	Small Farmers	Large Farmers
Resource Degree*	1.44[a]	1.51[a]	**1.59[a]**	**1.39[b]**
Information Degree*	**1.25[a]**	**1.05[b]**	1.13[a]	1.11[a]
Network Resource Contacts:				
Extension	.21[a]	.16[a]	.20[a]	.17[a]
Urban Vendor*	**.36[a]**	**.45[b]**	.44[a]	.39[a]
Tractor Owner	.18[a]	.23[a]	.21[a]	.22[a]
Neighbor/Friend*	.23[a]	.23[a]	**.27[a]**	**.18[b]**
Network Information Contacts:				
Extension	.34[a]	.28[a]	.31[a]	.31[a]
NGO	.10[a]	.14[a]	.15[a]	.10[a]
Religious leader	.11[a]	.09[a]	.09[a]	.10[a]
Neighbor/Friend*	**.38[a]**	**.16[b]**	.22[a]	.25[a]
N	148	273	209	215

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.

Impact of contact with different agricultural network members and gender on agricultural mindsets and adoption of CA

Table 15 explores some of the top reported agricultural information contacts to determine whether farmers who have contact with these agents are more or less likely to be supportive of different agricultural perspectives. The findings demonstrate that individuals who interact with certain agents are more and less inclined toward mindsets of market driven, capital intensive farming, and conservation agriculture.

Table15: Agricultural Production Mindsets and Top Reported Agent Contacts

Agricultural Production Mindsets:	**Agent Contacts**							
	Extension		NGO		Religious Leader		Neighbor/Friend	
	Contact	None	Contact	None	Contact	None	Contact	None
Market Driven*	**1.98[a]**	**1.85[b]**	1.94[a]	1.88[a]	1.82[a]	1.9[a]	1.93[a]	1.87[a]
Capital Intensive Farming*	2.63[a]	2.73[a]	**2.54[a]**	**2.73[b]**	**2.52[a]**	**2.72[b]**	2.71[a]	2.70[a]
Conservation Agriculture*	**2.78[a]**	**2.69[b]**	2.63[a]	2.54[a]	**2.68[a]**	**2.53[b]**	2.58[a]	2.54[a]
N	130	293	55	369	42	381	102	322

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.

Specifically, individuals who interact with extension agents are more likely to support a market driven and conservation agriculture perspective. This is not surprising given current extension foci on encouraging farmers to produce for agricultural markets and the introduction of small-scale CAPS through both the *likoti* method and mechanical CA implements, and could be taken as evidence of extension agents successfully transferring these perspectives.

Alternatively, farmers who are in contact with NGOs and religious leaders (such as Rohobothe Mission) are significantly less supportive of a capital intensive farming perspective. This position aligns with efforts made by these organizations to encourage the use of manure as an alternative to artificial fertilizer and the promotion of the labor-intensive *likoti* production method. In addition, those farmers in contact with religious leaders are also significantly more likely to support a CA mindset, which is also consistent with the widespread CA promotion efforts undertaken by Rohobothe. These significant differences may also reflect the selection of clientele by these organizations, in that overall these groups seek to target those farmers who are most in need from a food security standpoint and are thus least likely to have access to the technologies which characterize the capital intensive farming perspective.

Given the significant differences in support for a CA mindset between farmers who reported contact with extension agents and religious leaders, we also conducted tests to compare distributions and means for particular beliefs about CA. These included crop rotation, maintaining cover crops, and whether tillage causes erosion.

Table 16: Percentage of and mean value for farmers who have contact with an extension agent by level of agreement or disagreement with the statement that:

Rotating crops is always best practice		Agree	Neutral	Disagree	Missing	Means
Chi-Square 3.26 Not statistically significant	With Contact (n=130)	95	8	2	1	2.92 [a]
	Without Contact (n=294)	90	1	5	2	2.82 [b]

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

Table 17: Percentage of and mean value for farmers who have contact with a religious leader by level of agreement or disagreement with the statement that:

Rotating crops is always best practice		Agree	Neutral	Disagree	Missing	Means
Chi-Square 1.09 Not statistically significant	With Contact (n=42)	95	2	2	0	2.93 [a]
	Without Contact (n=382)	91	3	4	2	2.84 [a]

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

Consensus about crop rotation among farmers is, as reported in our initial analyses of differences between agro-ecologies, quite high. Not surprisingly, closer examination of the differences between farmers reveals few significant differences. Notably, support for crop rotation is significantly higher among agents who report contacts with extension agents, although this difference is not materially significant given the high levels of agreement with crop rotation.

Table 18: Percentage of and mean value for farmers who have contact with an extension agent by level of agreement or disagreement with the statement that:

Cover crops should be maintained on farmer fields		Agree	Neutral	Disagree	Missing	Means
Chi-Square 3.24 Not statistically significant	With Contact (n=130)	86	6	8	0	2.78 [a]
	Without Contact (n=294)	82	7	9	2	2.69 [a]

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

Table 19: Percentage of and mean value for farmers who have contact with a religious leader by level of agreement or disagreement with the statement that:

Cover crops should be maintained on farmer fields		Agree	Neutral	Disagree	Missing	Means
Chi-Square 3.96 Not statistically significant	With Contact (n=42)	83	2	14	0	2.69 [a]
	Without Contact (n=382)	83	8	8	2	2.72 [a]

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

Table 20: Percentage of and mean value for farmers who have contact with an extension agent by level of agreement or disagreement with the statement that:

Tillage causes erosion		Agree	Neutral	Disagree	Missing	Means
Chi-Square 4.14 Not statistically significant	With Contact (n=130)	55%	13%	32%	1%	2.22 [a]
	Without Contact (n=294)	48%	11%	38%	3%	2.04 [a]

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

Table 21: Percentage of and mean value for farmers who have contact with a religious leader by level of agreement or disagreement with the statement that:

Tillage causes erosion		Agree	Neutral	Disagree	Missing	Means
Chi-Square 6.86 Not statistically significant	With Contact (n=42)	69	7	21	2	2.43 [a]
	Without Contact (n=382)	48	12	38	2	2.06 [b]

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

For maintaining cover crops, no significant differences in means or distribution could be identified for farmers who have contact with extension agents or religious leaders. This is likely due to the broad consensus this principle receives among the farming population.

Addressing the more divisive issue, 'tillage causes erosion' more distinctive patterns regarding contact with extension and religious leaders are identified. Although the difference in distributions by contact for both types of agents, there is a significant difference in that those reporting religious leader contact are significantly more supportive of this belief. Moreover, there is a similar pattern of those with extension contact being more supportive of tillage causing erosion, although this difference is not statistically significant. The increased support of farmers with religious leader contact points to the probable strength of religious leader activities in promoting a whole-hearted commitment to conservation agriculture. Consequently, while fewer individuals report religious leader contact, they appear to be a key actor in the promotion of a conservation agriculture mindset, especially on the controversial point of the role of tillage in soil erosion.

Adoption of CA Technologies:

The data on CA mindsets, networks, gender and farm size becomes even more intriguing when paired with adoption data collected for Botha Bothe District. The baseline survey collected data about CA adoption over two growing seasons, and revealed that while a considerable number of farmers within Botha Bothe District have already adopted CA, adoption has not been consistent across localities nor necessarily sustained over time.

Figure 1: Adoption of CA across localities

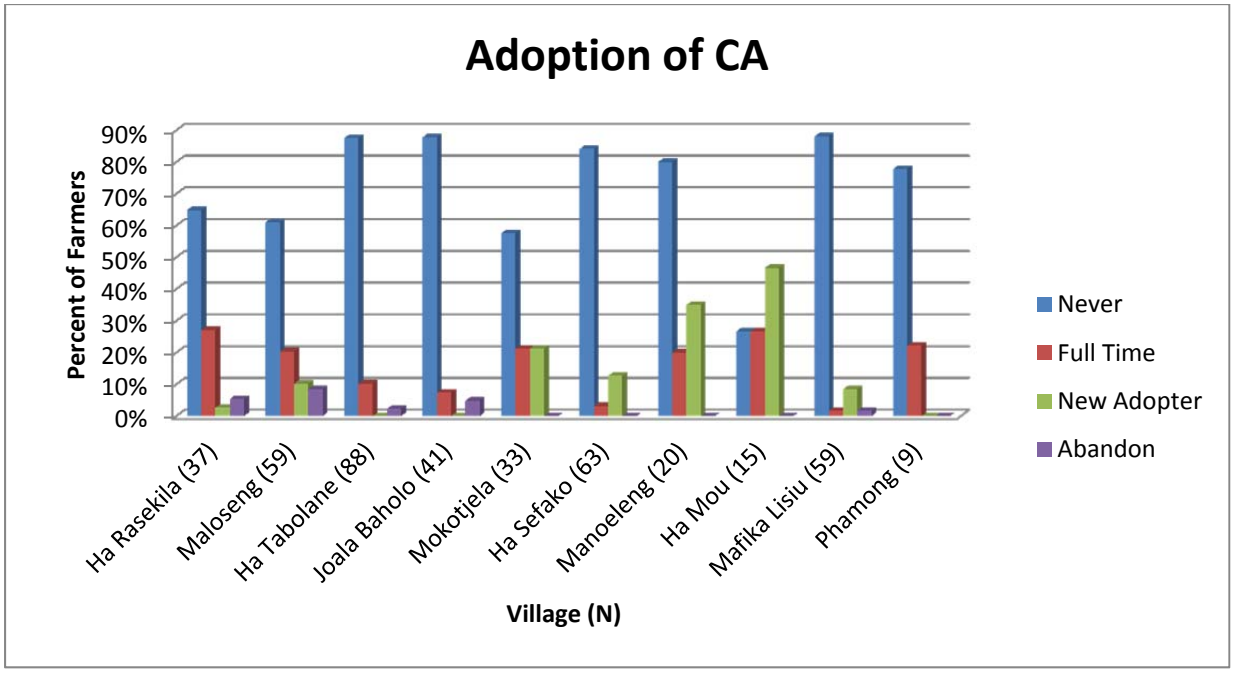


Figure 2 demonstrates the variation in adoption of CA across the villages included in the sample. Clearly, the majority of farmers have never adopted CA. In this survey, a 'full time' adopter is considered a farmer who has practiced CA on his or her fields the past two consecutive seasons. New adopters are those who are have started practicing CA in the current season and the abandon category refers to farmers who used

CA the previous season but have chosen not to use CA in the current season. No data was collected on whether farmers had practiced CA before the previous season and since abandoned the practice.

This chart provides some important context for our preliminary investigations of the relationship between adoption and agricultural production mindsets. Viewing from left to right, the first two villages are lowland villages, the next three foothill, and the remaining villages located in the highlands. Most new adoption activity is concentrated in the highland areas, while the greatest portion of farmers practicing CA full time and who abandoned CA between the most recent growing seasons are located in the lowlands. Table 16 confirms that patterns of adoption vary significantly between localities. Differences in types of adoption activity in the given localities suggest that the introduction and dissemination of CA technologies may be at different stages in different localities.

Table 22: Percentage of farmers by adoption status according to agro-ecological zone

Agro-ecology		Adoption Status			
		Never	Full Time	New Adopter	Abandon
Chi-Square: 30.187 Significant at the .01 level	Lowland (n=96)	63	23	7	7
	Foothill (n=162)	81	12	4	2
	Highland (n=166)	80	8	12	1
	N	324	54	34	12

There appear to be regional differences regarding the adoption of CA. Obviously, adoption rates are highest in the lowlands, with over one-fifth of farmers reporting as full time adopters. However, during the current season approximately as many farmers had started using CA as those who had stopped. In the foothills and highlands, the percentages of full time adopters are lower but there are more new farmers picking up the technology than abandoning it. There appears to be the most new adoption activity in the highlands. From the ethnographic research, we know that there has been more exposure to the ideas of CA in the lowlands, but that various actors have increasingly been working to promote CA in the foothills and highlands. The statistically significant difference in distribution of adoption and the general pattern of higher adoption in the lowlands with greater new adoption activity in the highlands seems to support that there is a regional progression of adoption of CA.

Table 23: Percentage of farmers by adoption status according to gender

Gender		Adoption Status			
		Never	Full Time	New Adopter	Abandon
Chi-Square: 0.747 Not statistically significant	Men (n=148)	74	14	9	3
	Women (n=273)	78	12	7	3
	N	324	54	34	12

Table 24: Percentage of farmers by adoption status according to farm size

Farm size		Adoption Status			
		Never	Full Time	New Adopter	Abandon
Chi-Square: 3.157 Not statistically significant	Small Farm (n=215)	74	13	8	4
	Large Farm (n=209)	78	12	8	1
	N	324	54	34	12

While there appears to be a regional trend in adoption activity, patterns do not emerge between genders (Table 23) or farm size (Table 24). Distributions of adoption status between different genders and farm sizes are remarkably similar, and significant differences are not identified in either case. This would seem to indicate that CA is a technology accessible to both women and men. Men do report slightly higher percentages of adoption. Moreover, CA technology seems to be applied by both smaller and larger farmers with similar consistency.

Differences in network contacts and network activity may have a more powerful explanatory role in contributing to the adoption of CA. This is supported by the general finding that individuals who had adopted CA (n=100) have significantly more contacts for agricultural information than those who and have never adopted (n=324). When first attempting to explore the differences between full-time adopters, new adopters, and those who abandoned CA reported in the survey, we found no significant differences. This may be due at least in part to the very small sample sizes (n = 37 for new adopters and n=12 for farmers who abandoned CA). One of the weaknesses of the survey is that those who had abandoned CA in prior seasons were not captured in the 'abandon' category, meaning that the figure for those who have abandoned CA likely underestimates the number of farmers who have abandoned CA in total. What is reflected is merely farmers who had used CA during the previous season and not in the current season. However, there is no guarantee that these farmers would not decide to use CA again in the future. New adopters, on the other hand, only include those who started using CA in the current season. Given the short time frame for the study (two seasons) it may be appropriate to view these two categories together as a group of one-time adopters. Indeed this interpretation seems to be supported by the fact that there are similar trends in the data for these two categories. When the new adopter and abandoned CA categories are combined to create a category for one-time adopters, some significant differences emerge (Table 25).

Table 25: Production mindsets, network activity, and traditional farming practices according to adoption status

Factor	Full-time Adopters	One-time Adopters	Non-Adopters
Production Mindsets:			
Market Driven	1.81[a]	1.94 [a]	1.90[a]
Capital Intensive Farming*	**2.58[a]**	**2.81[b]**	**2.70[ab]**
Conservation Agriculture	2.63[a]	2.59[a]	2.53[a]
Network Activity:			
Information Degree*	**1.48[a]**	**1.39[a]**	**1.02[b]**
Resource Degree	1.57[a]	1.58[a]	1.46[a]

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

One of the most interesting findings is that one-time CA adopters are significantly more likely to hold a capital intensive farming perspective than full-time adopter or non-adopter farmers. This suggests that the community of farmers experimenting with CA is approaching CA with a mindset which prioritizes artificial fertilizer, agro-chemical use, and labor saving technologies. Support for a capital intensive farming perspective could potentially conflict with the current focus on the *likoti* CA method promoted in Botha Bothe District, and aligns with the common complaints of many farmers that CA is too labor intensive. A preliminary policy and program implication of this result is that CA technologies may need to be better adapted to meet the demands of this different constituency of the farming population.

In addition to understanding mindset and network activity differences between CA adopters, we were also interested in whether or not particularly important contacts for CA adoption could be identified within farmer networks. Clearly, extension and religious leaders are the most important contacts for full-time CA adopters (Table 26). However, a larger percent of new adopters are accessing information from extension and NGOs, with a much lower portion in contact with religious leaders. It may be that extension and NGOs have become an increasingly important source of information for CA. Chi-Square statistics further indicate that the differences in distributions by adoption status are significant for religious leaders, NGOs and extension. Another interesting pattern is that among individuals who abandoned CA, the percentage reporting contact with religious leaders and extension is much lower than the new or full-time adopters. The lower contact reported among farmers who abandoned the technology may be an indication that these farmers were not adequately supported through the process of adopting CA. However, given the small number of individuals in the abandon category, we should be careful to make too many generalizations.

Table 26: Percentage of adoption status by network agent contact

Adoption Status	Extension		NGO		Religious Leader		Neighbor/Friend	
	Contact	None	Contact	None	Contact	None	Contact	None
Full CA Adoption (n =54)	41	59	26	74	41	59	13	87
New Adopters (n=34)	47	53	26	74	18	82	26	74
Abandon CA (n=12)	33	67	25	75	8	92	33	67
Never used CA (n=324)	33	67	9	91	4	96	25	75
Chi-Square Statistic	8.789*		19.694**		72.457**		4.589	

Notes: One star indicates that the Chi-Square statistic is significant different at the .05 level. Two stars are significant at the .01 level

While differences in distribution among different categories are not significant for neighbors and friends, differences between groups do suggest some important emerging patterns. Specifically, the community of full time adopters have a much lower percentage of individuals who say they access agricultural information from neighbors and friends, meaning that these individuals—who we know on average to have a much higher number of information contacts-must be accessing their information outside this most familiar set of relationships.

An interesting point to note is that both one-time and full time CA adopters may have been receiving input subsidies (artificial/organic fertilizer and seeds) during the time this survey was conducted, especially in the event that the farmer learned CA techniques from the Rohobothe Mission. Rohobothe, through the FAO, provided farmers with seeds and fertilizer on loan up until July 2011 (when FAO's CA focus shifted to the southern part of the country) with only a minimal success rate in farmers repaying

their loans. Indeed, a number of the farmers who reported learning CA from Rohobothe stated that they had never been asked to repay their loans, but rather to share their knowledge and yields with those interested and less fortunate in their local community. This data was collected before the provision of inputs was discontinued. The fact that farmers were effectively subsidized to practice CA may help to explain why such a high percentage of farmers who interact with religious leaders are sustained adopters.

Combined with the findings regarding mindsets and network activity, these data suggest that there may be some material differences between the communities of full-time adopters, and those who have used CA only once in the past two seasons. The latter have a more favorable perspective on capital intensive farming and seem to be relying more on extension and NGOs as opposed to religious groups for obtaining information. Similarly, this latter community appears to be more likely to report contacts with neighbors and friends as sources of agricultural information. Following the logic of homophily, conversations regarding CA held by new adopters and those who abandoned the technology between the past two seasons are more likely being held between individuals who are of similar education and background. Subsequently, beliefs about CA are likely being contested in this more familiar setting rather than through external interventions.

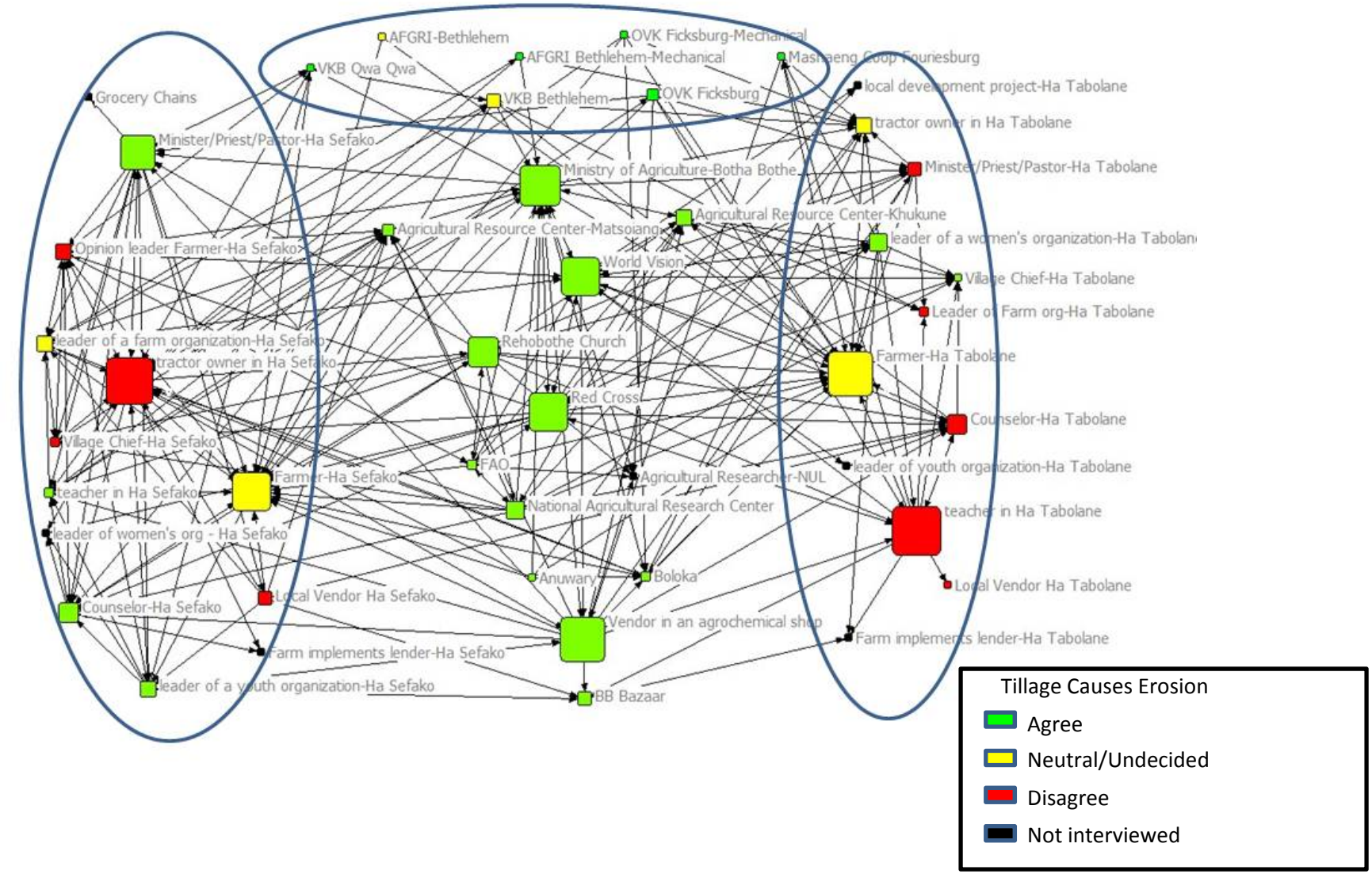
Total Network Analysis:

Farmer data from Ha Sefako and Ha Tabolane was matched to the agricultural service sector/community agent data to generate a model of the agricultural information network for highland and foothill/lowland communities in Botha Bothe District. Figure 3 provides a visualization of these networks. Agents are color-coded according to agreement with the statement that tillage causes erosion. The circles indicate which agents are based in Ha Sefako, Ha Tabolane, and South Africa, respectively. The remaining agents work at the district level in Botha Bothe.

The network map provides an opportunity to visualize groups in the agricultural production network and how they relate to one another. To keep the map and network analysis as simple as possible, we have taken the node values for network contact from all of the Ha Sefako and Ha Tabolane farmers and used a single node to represent them. As such, this map seeks to model connections between community agents and agricultural service providers rather than individual farmers (as was the focus of the previous section). The centrally located agents are those with a regional focus and generally serve both highland and lowland/foothill communities, while agents coded in orange and yellow reflect those who live in or work exclusively with the communities of Ha Sefako and Ha Tabolane respectively. The navy nodes represent MAFS and its Resource Centers which serve all highland and foothill/lowland communities studied during this research. In making generalizations about agricultural networks, we should thus expect that various villages are likely to vary with regard to the local actors who are active in that particular area, but that the meso-scale MAFS, NGOs, national organizations, and South African and Botha Bothe agricultural vendors would operate in similar fashion with regard to other sampled communities. This is important as the following analyses of the Botha Bothe agricultural information network will examine structural network conditions at both levels toward the goal of describing the important actors in the way this network functions.

During basic analyses of network structure the objective was to identify key individuals or groups 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 this analysis, two measures of centrality have been used: degree and betweenness centrality (Knoke and Yang, 2008). Degree centrality is 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

Figure 3: Botha Bothe Agricultural Production Networks and Beliefs about “Tillage Causes Erosion”



measure of the popularity or notoriety of an individual in the network based upon their number of contacts. 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 (Knoke and Yang, 2008).

This analysis uses both undirected and directed measures of centrality 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. 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. On the other hand undirected centrality measures can be somewhat biased in the incidence of an individual who reports a lot of contacts, but no one else reports that contact and vice versa. To provide additional information about when this occurred, we present directed centrality scores as a secondary measure. The following tables present the most important actors by site according their scores for degree and betweenness centrality.

Table 19 reports the top ten ranked members for degree centrality for the Botha-Bothe agricultural production networks. Measures of in-degree and out-degree indicate the number persons who reported that contact, and who that contact reported, respectively. These do not necessarily equal the total degree centrality, for in almost all cases there is some degree of overlap between the contacts an individual reports and the contacts which report that individual. A severe imbalance between indegree and outdegree could indicate that an individual may have an inflated perspective of their role in the network.

The tractor owner in Ha Sefako is the actor with the highest degree for information contacts. This is likely due to the critical role the tractor owner plays in the Ha Sefako community elaborated in the section on farmer contacts. The rest of the top ten actors are mostly involved at the district or national level. With the exception of the MAFS however, there seems to be a bit of an imbalance for the individual NGOs and religious groups who report more contacts than report for them. There are a number of ties at the local level, for degree centrality, though Ha Sefako agents have more contacts on average than those from Ha Tabolane. Later tables compare locality specific contants.

Table19: Degree Centrality

Rank	Agent ID	Degree Centrality	In-Degree	Out-Degree
1	Tractor owner in Ha Sefako	22	15	13
2	Ministry of Agriculture and Food Security-Botha Bothe	21	13	14
3	Vendor in an agrochemical shop	18	5	14
4	Red Cross	16	6	14
5	Rehobothe Church	16	4	14
6	World Vision	15	9	11
7	Minister/Priest/Pastor-Ha Sefako	15	8	11
8	Teacher in Ha Tabolane	14	6	10
9	Counselor-Ha Sefako National Agricultural Research Center Opinion leader Farmer-Ha Sefako Matsoiang Resource Center	13	9 7 3 11	8 11 12 7

Interestingly, Table 20 indicates that local level actors have higher betweenness centralities than their District and/or regional counterparts. This makes some sense as these local contacts may at times serve a "gatekeeper" function for District and regional organizations to provide information to farmers and local network members. Key local agents include a teacher in Ha Tabolane, the Ha Sefako tractor owner, Ha Sefako pastor and counselors in both communities. However, the directed betweenness scores (which take into account the reported directionality of the information flows) push the Ha Sefako tractor owner, MAFS, World Vision, and the Ha Sefako Pastor higher in the rankings. It is encouraging that the directed betweenness and betweenness centrality measures show a considerable degree of consensus in most cases, giving us a sense of confidence that this set of actors are most likely those who can facilitate or control information flows between network actors.

Table 20: Betweenness Centrality

Rank	Agent ID	Betweenness Centrality	Directed Betweenness
1	Teacher in Ha Tabolane	88.52	89.33
2	Tractor owner in Ha Sefako	85.06	217.65
3	Vendor in an agrochemical shop	78.32	113.53
4	Ministry of Agriculture and Food Security-Botha Bothe	69.91	189.81
5	Red Cross	66.39	83.59
6	World Vision	65.34	122.26
7	Minister/Priest/Pastor-Ha Sefako	56.54	111.10
8	Rehobothe Church	48.39	74.84
9	Counselor-Ha Tabolane	27.84	32.20
10	Counselor-Ha Sefako	25.99	36.31

Network Centrality in Research Communities:

One of the key objectives from the outset of this paper has been to explore the differences between highland and lowland/foothill agricultural production networks. Tables 21 and 22 compare the top degree and betweenness centrality scores between the two localities.

Both communities appear to have a single especially important agent in terms of both degree and betweenness centrality. For Ha Sefako, this is the tractor owner and in Ha Tabolane a teacher who is highly involved with agriculture. Counselors also play an important role in each of the sites. This is interesting as counselors were not a highly reported contact among farmers, but appear to have a very important network role in connecting communities to other agricultural agents, as evidenced by high betweenness centrality scores. Locality specific resource centers are also highly central actors in the network. Some differences in the communities are that it appears that Ha Sefako has more highly connected local agents. For example, farmer organizations, youth organizations, and an opinion leader farmer appear across the betweenness and degree centrality measures, whereas there appears to be a bit more redundancy in the Ha Tabolane network with the important role of the women's organization, counselor and tractor owner across centrality measures. This is consistent with the experience of interviewing agents in Ha Tabolane communities, where farmers reported that they did not typically work closely with other farmers, but rather for themselves. By contrast, in Ha Sefako long standing farmer and

women's groups and a more recently created youth group are active in organizing and supporting the farming activities of their members.

Table 21: Comparing influential actors in highland and lowland communities: Degree centrality

Score	Ha Tabolane Agents	Rank	Ha Sefako Agents	Score
14	Teacher	1	Tractor owner	22
12	Agricultural Resource Center-Khukune	2	Counselor	13
11	Counselor	3	Opinion leader Farmer	13
11	Tractor owner	4	Agricultural Resource Center-Matsoiang	13
10	Leader of a women's organization	5	Leader of a farm organization	12

Table 22: Comparing influential actors in highland and lowland communities: Betweenness centrality

Score	Ha Tabolane Agents	Rank	Ha Sefako Agents	Score
88.52	Teacher	1	Tractor owner	85.06
27.84	Counselor	2	Counselor	25.99
22.51	Leader of a women's organization	3	Leader of a farm organization	18.23
18.90	Tractor owner	4	Leader of a youth organization	15.69
15.58	Agricultural Resource Center-Khukune	5	Opinion leader Farmer	15.67

In the final stage of the network analysis, we return to the network maps to show how beliefs about conservation agriculture are distributed among members of this local agricultural production network. While there is a large degree of consensus among production network members regarding the use of cover crops and crop rotation (over 80% agreement) the issue of whether or not tillage causes erosion is much more contested.

Discussion of Network Centralities and Agricultural Knowledge:

The identification of the individuals with the greatest degree and betweenness centrality generally appears to be favorable to the development and dissemination of CA. Specifically, many of the top agents reported for both betweenness and degree centrality, including Rohobothe, World Vision, Red Cross, and the MAFS strongly support all three tenets of CA and already work together as members of the National CA task force. However, the primacy of local actors in the betweenness centrality rankings suggests that these agents are especially important to shaping local perspectives. Moreover, many of the most locally important actors disagree with or do not fully support a CA perspective, especially with regard to tillage.

In Ha Sefako, the pivotal tractor owner, the farmer group leader, opinion leader farmer, village chief, and local vendor are all skeptical of whether tillage causes land degradation. Nevertheless, other important and central actors including the teacher (who farms using some of the CA equipment leased from the MAFS in the lowlands), counselor, and youth leader are supportive of the belief that tillage causes

erosion. During the ethnographic research, there appeared to be a generational divide with regard to beliefs about CA in Ha Sefako. The youth leader and counselor are both young and recent college or diploma graduates, whereas the tractor owner, farmer group leader, and the opinion leader farmer have all been working together for at least twenty years as part of the Falimehang Farmer Organization. As observed by the South African pastor who works closely with Ha Sefako farmers, the younger generation have caught on and been exposed to the principles of CA, while the older group of farmers active in the community have developed systems of production which work well for them and are less inclined to support a change which would largely disrupt the production system they have organized. Nevertheless, the older generation of farmers expressed interest experimenting with CA during their interviews, but wanted to see positive results from such a system locally before dedicating too many of their scarce resources to a new method of production.

Another key point to consider is the critical role of the tractor owner in the Ha Sefako community. In addition to providing plowing services, the tractor owner also regularly travels to South Africa to purchase inputs for local farmers and operates the only grain mill in the community out of his residence. Consequently, he is a key leader and supporter for agriculture in the region. Efforts to introduce and scale up CA will need to find a way to work with the tractor owner to ensure that he does not feel threatened by CA and as he continues to serve in an important supportive role to the local highland communities. In addition to working with the tractor owner, moving support for CA from the periphery of the Ha Sefako network will require targeting the other members of this important older generation of well-connected farmers. If this is accomplished, the strength of this existing farming organization and current support for CA among local youth and actors connected to local youth indicate there is strong potential to utilize local networks to promote and scale up CA in Ha Sefako, and potentially the surrounding highland areas.

There are fewer allies for CA in Ha Tabolane. It was much more difficult to identify the local actors active in agricultural production networks in this community. Farmers reported that they did not have organized farmer groups for purchasing inputs or planning agricultural projects. Rather, there appears to be looser connections between noted farmers in the community who are frequently asked to share their opinions and offer advice. Through this process, a network of more central community agents in Ha Tabolane was identified, including a primary school teacher, an opinion leader farmer, a local pastor/farmer, and counselor. Unfortunately, these individuals all disagree with the principle that tillage causes erosion. However, there are important individuals in the community who express a commitment to CA. Leaders of women's organizations formed through Red Cross and World Vision have been highly successful in promoting the development of a very small scale CA method, the keyhole garden. Most households in Ha Tabolane have built these small vegetable gardens located next to their homes, but there is less enthusiasm for using CA methods to produce in farmer fields. This is not because farmers disagree with the principles, but rather due to the widespread perception that CA methods are too labor intensive. Moreover, the women group leaders do not appear to be particularly well-connected with other community leaders. In addition to this diversity and overall lack of community organized agricultural groups, Ha Tabolane is also currently in a transition period for its local leadership. The chief of Ha Tabolane passed away in 2011 and at the time of the field work, farmers and community agents had only limited experience working with the new chief. Results for the chief reflect the chief's responses to the household survey conducted in 2010. While residents did not expect that the new Chief would be less supportive of agricultural initiatives, whether he will give the same priority to agriculture as the previous Chief remains to be seen. Given the looser structure of the network and existing perceptions of CA in the community, it may be more difficult to scale up CA in Ha Tabolane.

Summary and Discussion:

This working paper has considered the relationships between local mindsets for agricultural production, beliefs about CA, and social networks to comment on the current process of CA development and dissemination in Botha Bothe District. Current agricultural production perspectives suggest an overall

reluctance toward market-driven production, but favor modern production methods, and an emerging support for conservation agriculture. On the whole agricultural service providers tend to hold a more market-driven and less capital intensive farming oriented approach to agriculture than the populations they serve. Support for CA remains generally high in terms of ideology, but variation in the levels of support expressed for CA between agro-ecologies indicates that lowland farmers are most supportive and highland farmers are least supportive.

Further variation in the farming population can be identified with regard to gender, farm size, network activity, and adoption status. Key findings include that farmers generally have more contacts for agricultural resources than agricultural information, and that access to information contacts is not equal between genders with women reporting significantly fewer information contacts. Moreover, the composition of farmer networks for resources and information is relatively different, with urban vendors and tractor owners playing a critical role in resource access and NGOs and religious leaders being more important for imparting information. While religious leaders are reported by fewer individuals, these contacts are associated with strong support of CA principles and sustained adoption of conservation agriculture. Extension and neighbors and friends have cross-cutting importance in farmer networks for information and resource access across localities, with extension being the most universally reported contact.

With regard to adoption patterns, evidence about the beliefs and network activity of full time adopters, new adopters, and farmers who have abandoned CA indicate that CA is moving into a critical stage of reaching a broader constituency of farmers. Farmers who have only used CA once (either in the current growing season or in the previous season) think differently about agriculture in that they are significantly more supportive of a capital intensive farming perspective and are significantly more likely to interact and obtain information from neighbors and friends. By contrast, the community of full-time adopters obtain information from sources external to the community and are significantly less supportive of a capital intensive farming approach. This has major implications for continued efforts to scale up CA in Botha Bothe, because CA technologies will need to be demonstrated to be increasingly compatible with the labor saving and chemical input principles of capital intensive farming to reach this broader constituency of the population. Consequently, the development and dissemination of CA technologies is at a critical point for mobilizing local networks to move adoption into the mainstream.

While there is a well-established national and regional network supportive of CA, a closer examination of networks at the community level reveals that many important local actors remain unconvinced. In both Ha Sefako and Ha Tabolane, the community agents with the greatest control over local information flows disagree with the key principle that tillage causes erosion. In order to promote sustained adoption of CA within communities, it is likely that efforts will need to focus on understanding and addressing the concerns with CA held by these important local agents. This may require a combination of education and facilitated discussions. It is our hope through facilitated network workshops we can further this conversation toward the development of effective strategies to scale up and promote conservation agriculture in Botha Bothe District.

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Appendix 1:

Technology Networks Farmer Contacts List – Ha Sefako and Ha Tabolane, Lesotho

Do you interact with ___for agricultural information or resources?

1. Village chief
2. Family member
3. Vendor in Weekly market
4. Vendor in shop in Urban Center
5. Vendor in Agrochemical shop
6. Local agricultural input vendor
7. Teacher in village
8. Minister/Priest/Pastor in village
9. Extension agent
10. NGO Agent
11. Agricultural Researcher
12. Local Development project
13. Tractor owner/Animal traction provider
14. Leader of farmer organization
15. Leader of women's organization
16. Leader of youth organization
17. Counselor
18. Farm implements lender
19. Cooperative
20. Other