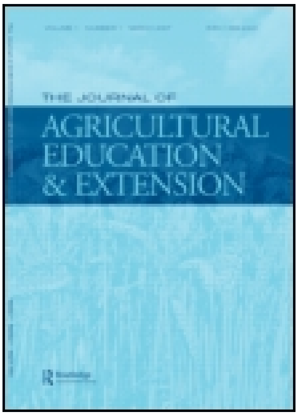

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Multiple Knowledges for Agricultural Production: Implications for the Development of Conservation Agriculture in Kenya and Uganda

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Multiple Knowledges for Agricultural Production: Implications for the Development of Conservation Agriculture in Kenya and Uganda

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ABSTRACT Purpose: *This article investigates the extent of multiple knowledges among smallholders and connected non-farm agents around Mount Elgon in Kenya and Uganda in order to build the communicative competence needed to scale up conservation agriculture production systems (CAPS).*
Design/methodology/approach: *Our methodological approach examines local conditions through the analysis of farmers and non-farm agents' perceptions of agricultural norms and practices or technological frames across four sites. Responses to a list of 20 questionnaire items characterizing three ideal types of technological frames (conservation agriculture, conventional modern agriculture, and risk averse agriculture) were analyzed through inter-group comparisons and multiple regression.*
Findings: *The findings indicate that there is a fundamental gap between the perspectives framing the knowledge of farmers and those of the service sector/community agents with respect to agricultural production norms and practices. Specifically, agricultural service providers and other community agents are significantly more supportive of conventional modern farming than farmers, and significantly less supportive of mixed crop and livestock farming; however, farmer perspectives also vary across sites.*
Practical implications: *Recognition of multiple knowledges, their relationship to agro-ecologies and the technological frame gap between farmers and non-farm agents is important for effectively negotiating dialog among farm and non-farm knowledge networks.*
Originality/value: *Our exploration of variation in local knowledges provides insights into how individual proclivities, adaptation to the agro-ecology, and a supporting set of network partners contribute to the mindset changes needed for establishing CAPS.*

KEY WORDS: Conservation agriculture, Communicative competence, Agricultural knowledge, Smallholder farmers, Local production practices, Social networks, Innovation systems, Technological frames

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Introduction

Shared understandings underlie the communicative competence needed to facilitate achievement of sustainable productivity in agricultural production systems faced by climate change and market volatility. However, not everyone shares the same understandings. Differences in how actors make sense of their context profoundly affect communications designed to improve producer capacities (Leeuwis and Aarts 2011). This article investigates the extent of shared understandings among smallholders and connected non-farm agents around Mount Elgon in Kenya and Uganda. It seeks to clarify how agricultural production knowledge is distributed among network actors. Our objective is to increase awareness and legitimate the diversity of local knowledges that can be used to facilitate development of solutions to agricultural production problems. In this case, we are interested in smallholder adaptation of conservation agriculture production systems (CAPS).

Conservation agriculture (CA) is largely a new concept in East Africa. However, experience from other parts of the world teaches us that developing and scaling up CAPS for smallholders requires facilitating a change in mindset within a supporting network of agricultural production partners (Ekboir 2002; Hobbs 2007; Wall 2007). Facilitating the dialogue necessary to achieve these changes depends on the capacity of CAPS promoters to communicate effectively with and enhance communication among existing networks of farmers, agricultural service sector providers and community agents. We believe that effectively negotiating these interactions to integrate the three conservation agriculture principles (minimum tillage, maintaining a permanent crop cover, and intercropping/crop rotations) into local production practices involves: (1) building an understanding of existing (local and scientific) knowledges concerning best agricultural norms and practices; and (2) identifying key actors and their resource and communication channels in the local agricultural production network.

Usually it is assumed that agricultural extension agents trained as subject matter specialists at agricultural colleges bring in new ideas and transfer them to farmers. Non-governmental organizations (NGOs) have also been identified as sources of new knowledge. Meanwhile, farmers have learned from their families and neighbors what works locally. The intent of this article is to explore and legitimate the dynamic interaction between these knowledges in order to facilitate their potentials for sustainable local agricultural innovation.

The Research Problem

The analysis presented here was inspired by the experience of hosting feedback workshops for smallholder farmers and local service providers on the findings of social network research conducted in four communities in western Kenya and eastern Uganda (Moore et al. 2012). In each locality, discussions appeared to be driven by the underlying presence of multiple knowledges and ways of knowing. The majority of agricultural service providers are trained (educated) in conventional production practices (Kibwika, Wals, and Nassuna-Musoke 2009). For the most part, formal schooling focuses on science as if it was fixed and did not evolve with new findings. From this perspective, knowledge is seen as a body of abstract 'facts' memorized from the lectures of professors or from reading textbooks.

The effects of this immutable form of knowledge are that it brackets scientific observation and hypothesis testing in a manner such that they are largely discarded. Consequently, many 'educated' non-farm stakeholders do not recognize new findings or variability in the application of knowledge as scientifically legitimate. When confronted with farmer responses to a set of items on farming practices, a group of agricultural officials felt that we 'didn't formulate the question properly' and therefore the farmers misunderstood and 'got the responses wrong'.

Farmers also grapple with the issue of multiple knowledges and how this informs their beliefs about agricultural production. For example, in Trans-Nzoia District farmers readily recognized that they applied knowledge from multiple sources, and that at any one time their practices usually conflicted with recommendations of one or more of these sources. As such, current practices evolved from application or adaptation of different techniques to suit their production needs. In contrast, Bungoma farmers described agricultural production as constrained by their environment. The lack of moisture and need to feed crop residues to livestock and poultry are believed to prevent establishment of a cover crop or otherwise maintain soil cover, and thus a farmer cannot support the notion of maintaining a permanent soil cover.

Perspectives of immutable knowledge are not limited to local officials and farmers; they are found in the literature on local knowledge as well. In a balanced accounting of the knowledges of fishers and biologists in Chile, Schumann (2011) meticulously examines how and why science and local knowledge differ. However, when analyzing the quality of their respective knowledges she uses the centralized and written characteristics of Western science as the standard. The perspective that Western science should be the standard measure of all knowledge has been repeatedly challenged over the past decades (Verran 2002; Rist et al. 2007; Shapin 2008).

Indeed, production of knowledge in local networks has been found to be equally or even more relevant than science for agricultural production (Darré, Le Guen, and Lemery 1989). A study by Crona and Bodin (2006) identified patterns of correlation between the distribution of local ecological knowledge held by resource users and the social networks for communication of resource-related knowledge. This suggests that network relations embody relevant know-how which is taken into account locally.

CA does not fit well with memorized knowledge. It is based on principles of adaptation which require that knowledge be something that grows and evolves with the situation. Studying knowledge as if there were a standard against which it could be ranked or arranged pre-empts a comparison of knowledges-in-themselves. Indeed, seeking such universal knowledge about knowledge leads one to take sides in a battle over local truths, each with their own sources of validity.

Given the current contested nature of agronomic science (Sumberg and Thompson 2012), it is worthwhile considering how local agricultural production network clusters articulate effective technological frames (Bijker 1995). From our field experience, we believed that the debates within the literature were not simply academic in nature. However, could we empirically document the confrontation between knowledge systems among local actors? If so, what would the presence of locally contested knowledges imply for facilitating processes of technology transfer and technology development?

We seek to answer these questions through analysis of the variation in local knowledges (technological frames) between and within groups of local agricultural actors, and the subsequent investigation of sources of this variation. Our analysis is theoretically grounded in the existence of multiple knowledges (Sousa Santos 2007) generated through sense-making processes among actors engaged with their local agro-ecologies. We see the diversity of knowledges as dependent on this experience and the consequent interpretations of local context. Recognizing the legitimacy of alternative knowledges and sense-making frameworks provides a foundation for negotiating a more resilient agriculture.

In the next section, we describe the agro-ecologies of the four research sites that provide the living material for sense-making. This will be followed by a section on our survey research and analytic methods. The next section presents descriptive statistics followed by an exploration of four regression analyses depicting four sources of variation in knowledge (agro-ecological conditions, network connectivity, personal characteristics, and resource endowments). The final section discusses the implications of our empirical investigations for facilitating processes of technology transfer and technology development.

The Agricultural Production Context

The research sites are part of a Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program project with smallholder farms in eastern Uganda and western Kenya. The four sites represent a cross-section of ethnically and agriculturally diverse production systems in which to study the experimental development and scaling up of CAPS (Odhiambo, U. Norton, and J. Norton 2011; Wyoming SANREM Project 2012). The research is being conducted in four locations: Bungoma and Trans-Nzoia Districts in western Kenya; and Tororo, and Kapchorwa/Kween Districts in eastern Uganda. These sites are clustered around Mt Elgon, an extinct volcano which spans the Kenya and Uganda border. The northern sites, Trans-Nzoia and Kapchorwa, have a single growing season and are considered higher potential regions due to their more fertile volcanic soils and higher rainfall. Conversely, Bungoma and Tororo have two growing seasons characterized by long and short rains, and are thought to be the lower potential due to their poorer, sandier soils and more variable rainfall.

The localities also represent a broad range of agricultural development. Agriculture has been practiced for the greatest length of time in Bungoma, while Trans-Nzoia has the most developed infrastructure for modern agricultural production. The main urban center in Trans-Nzoia, Kitale, has over 100 agrovet shops and is home to divisions of major international seed companies, including Kenya Seed and Western Seed. By contrast, adoption of sedentary production systems is more recent at the Ugandan sites. The rapid adoption of agriculture in Kapchorwa in the past 50 years has been highly successful in terms of rapid increases in production, but this has not been without ecological consequences and has resulted in high levels of soil erosion. During focus groups in Tororo, residents reported a largely hunter-gatherer lifestyle until the late 1970s followed by a relatively short period of success in the cultivation of maize and beans (Lamb 2011). Since the mid-1990s, cassava has been continuously cultivated as the main staple. With the exception of Tororo, maize is the staple food in each of the sites and the most commonly identified problem of farmers across localities has been soil fertility decline. Consequently, there is a cross-cutting need for sustainable intensification of agricultural production and a significant opportunity for the development of CAPS to improve food security.

Research Methods

Our methodological approach is to examine local conditions through analyzing how agricultural technology options are perceived as measured by statements designed to characterize agricultural norms and practices or technological frames. This research is part of a larger project analyzing the social networks of farmers and non-farm agents (Moore et al. 2012). We see farmers as routinely engaged in network discourses concerning agricultural production knowledge as described by Darré, Le Guen, and Lemery (1989). Consequently, facilitating a technological transition to CA involves entering into dialogue with these network actors on their own terms. Doing so requires that we recognize the distinctive content of local discourses that shape the introduction of new technologies. In future work we will apply social network analysis to specify the associated network clusters. Here we explore the knowledge content of various network actors using conventional statistical analyses. However, we do apply social network measures of undirected relationships (or contacts) along which dialogue between actors may occur to test the significance of farmer and non-farm agent relationships in comparison with more traditional measures of farmer attributes (resource endowments, personal characteristics, and agro-ecologies).

In researching CAPS for smallholders in the Mt Elgon region of Kenya and Uganda, we designed a participatory network study in which 344 farm household men (162) and women (182) and 74 non-farm agents (predominantly male) were interviewed. Participants were asked about their networks for obtaining agricultural information and resources, and their knowledge about agricultural production. These data were analyzed regarding the most common network contacts of farmers, characteristics of network structure and local knowledge. Findings were reported back to research participants through feedback workshops held in each community (Moore et al. 2012).

We begin this analysis by examining the distribution of various knowledge formulations among farm and agricultural service sector/community actors on agricultural production norms and practices. In order to gauge their general perspectives, respondents were read a battery of 20 statements. A list of all 20 questionnaire items is included in Appendix A. These statements were designed to characterize three ideal types of technological frames: conservation agriculture, conventional modern agriculture (which involves market-oriented production using improved seed, mechanical implements, fertilizer and agrochemical use and often mono-cropping), and risk averse agriculture (characterized by distribution of risk between multiple methods of production, and sustaining the farm household by avoiding market dependence).

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

Preliminary analyses indicated that there were no consistent patterns of correlation among the responses with respect to CA. Respondents saw each of the three principles of CA as independent concepts, indicating that a conservation agriculture technological frame is not yet formed amongst survey respondents. This is not surprising given that

CA is largely a new concept in East Africa. Subsequently, items for the conventional and risk averse agriculture technological frames were analyzed together using a varimax rotation. Two underlying dimensions were identified and extracted. These two dimensions of agricultural production norms and practices cut across the four localities, linguistic/cultural differences and various roles in agricultural production.

The first factor can be described as characterizing conventional modern farming using purchased inputs and is composed of agreement with the following three statements:

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

After accounting for the dimension of conventional modern farming, the second factor accounts for co-variation associated with profit and food security tensions present in mixed farming systems and is composed of:

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

The 'conventional modern farming' factor has an Eigen value of 1.52 and accounts for 51% of the co-variation among the three items. The 'mixed farming' factor has an Eigen value of 1.36 and accounts for 68% of the co-variation between the two items. Although the alphas of 0.51 and 0.52 (respectively) are not strong, the face validity of the items and their consistent co-variation within each of our targeted communities makes them meaningful indicators of underlying patterns of technological frames shaping agricultural production knowledge.

Findings on Agricultural Knowledge

The analysis of the difference in mean values for the two factors for general agricultural production norms and practices indicates that size of farm and contact with extension agents do not differentiate the technological perspectives of farmers (see Tables 1 and 2). However, the analysis does demonstrate a significant difference between the perspectives of farmers and those of service sector/community agents. Service sector/community

Table 1. Mean scores for level of agreement on basic farming perspectives according to small and large farmers and service sector/community agents.

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

Notes: Different letters within the same row are statistically different.
Rows marked by * signify that T-test scores are significantly different at the 0.05 level.
Higher composite scores signify greater levels of agreement with the technological frame concept indicated by the factor.

Table 2. Mean scores for level of agreement on basic farming perspectives according to small and large farmers with and without contact with extension, and service sector/community agents.

	Farmers w/o contact	Farmers with contact	Service sector/community agents
Conventional modern farming**	7.05^{ab}	6.83^{a}	7.57^{b}
Mixed crop-livestock farming**	4.60^{a}	4.38^{ab}	3.96^{b}
N	189	155	74

Notes: Different letters within the same row are statistically different.
Rows marked by ** signify that T-test scores are at least significantly different at the 0.01 level.
Higher composite scores signify greater levels of agreement with the technological frame concept indicated by the factor.

agents are more likely than farmers to agree that successful farming requires the use of modern chemical inputs and machinery. Conversely, these agents are less likely than farmers to believe that cash cropping should be integrated with livestock and poultry production. These findings indicate that there is a fundamental gap between the perspectives of farmers and those of the service sector/community agents with respect to agricultural production norms and practices across the four sites. Specifically, agricultural service providers and other community agents are significantly more supportive of conventional modern farming than farmers, and significantly less supportive of mixed crop and livestock farming. This is consistent with the hypothesis that this non-farm agricultural population has been educated from a conventional farming perspective and this remains the perspective they advocate even at the expense of mixed farming norms and practices that local networks have negotiated to sustain local farm livelihoods.

Conservation Agriculture

The following tables examine the perspectives of farm and non-farm agricultural agents with respect to the three principles of CA controlling for farm size and contact with extension agents. These analyses will use single indicators, allowing us to dissect the components of CA as they are perceived across and within each region. For purposes of tabular presentation, the analysis is restricted to only three categories (‘agree’ and ‘strongly agree’ are combined into ‘Agree’; ‘Uncertain/neutral’; and ‘disagree’ and ‘strongly disagree’ are combined into ‘Disagree’).

We begin by considering the item measuring perceptions of the CA principle of crop rotation: ‘Rotating crops is always best practice.’ Crop rotations are perceived by nearly all agricultural sector actors (farmers, service sector and community agents) as a best practice (see Table 3). The statistically significant difference in mean values found between farmers and service sector/community actors, is not substantively significant as all mean values were above 4.5: between ‘agree’ (4) and ‘strongly agree’ (5). Overall, there is a shared consensus on the importance of crop rotations in all four study communities. General support for the principle of crop rotation across the sites provides an important foundation for the introduction of the more specific rotational requirements advocated by conservation agriculture.

On the other hand, perspectives on the CA principle of maintaining a permanent vegetative soil cover are polarized. Respondents were asked whether they agreed or

Table 3. Percentage of and mean value for (a) small and large farmers compared to service sector/community actors and (b) with or without extension contacts by level of agreement or disagreement with the statement that:

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

Notes: Chi-square not significant.
Different letters indicate that the T-tests for differences in means are statistically different at the 0.01 level.

disagreed with the statement that 'One should maintain a permanent crop cover'. Seventy-three percent of the service sector/community actors agreed, while over one-third of farmers (more often the larger ones) disagreed; and another one-third were uncertain (see Table 4). Consequently, there is a major disagreement between farmers and their advisors over the issue of maintaining crop cover.

The third principle of CA is the minimization of soil tillage and appears to be the most controversial issue with respect to agricultural knowledge, norms and practices. There is substantial disagreement over whether 'Tillage causes land degradation' and much less uncertainty than for soil cover. Disagreements appear to be within categories of actors, rather than between them (see Table 5). The agricultural service sector/community agents are less in agreement than with the other two CA propositions. In contrast, many more farmers are in agreement than was the case for maintaining soil cover (between 40 and 50%). However, the distribution is such that there is no statistical difference in mean values, either across localities or within any particular one.

Factors Shaping Local Agricultural Production Knowledge

In this section, we use four regression models to explore the sources of variation for measures of local knowledge and understanding among farmers in the Mount Elgon

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

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

Notes: Chi-square = 65.232 significant at the 0.001 level for difference between small and large farmers and agents.
Different letters indicate that the T-tests for differences in means are statistically different at the 0.01 level.

Table 5. Percentage of and mean value for farmers with or without extension contact compared to service sector/community actors within each local community by level of agreement or disagreement with the statement that:

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

Notes: Chi-square = 27.884 significant at the 0.001 level for difference between small and large farmers and agents. No statistical difference in T-test scores for differences in means at the 0.05 level.

region. The first two models concern the underlying dimensions of conventional modern farming and mixed crop-livestock farming. The second set of models concern the two more contested understandings of conservation agriculture: maintaining a permanent soil cover and tillage causes land degradation.

In reading these tables (see Tables 6, 7, 8 and 9), the first column examines the separate impact of each set of indicators: agro-ecological zone (indicated by a set of dummy variables for research community with the advanced agricultural district of Trans-Nzoia as the referent); resource endowments (indicated by the presence of mechanical or animal traction, area farmed, wealth, extent of off-farm income, and access to credit); personal characteristics (indicated by age, sex, education, female household head, health and a nutritional indicator, percent of energy in the diet derived from staples); and agricultural production network connectivity (indicated by the existence and frequency of extension, NGO, or vendor agent contacts, the average frequency of such contacts, and the overall extent of agricultural production contacts including family, neighbors and friends, etc.). For analytical clarity, throughout this discussion we will collectively refer to agro-ecology and network connectivity as contextual factors, and resource endowments and personal characteristics as individual. The second regression column examines the combined effects of all of these variables, and the third regression column presents the best overall model identified through step-wise inclusion of significant beta coefficients. While the low R-square values for each of the models indicate that these are not powerful predictive models of whether individuals subscribe to different farming perspectives or hold certain beliefs about CA, they do allow for identification of persistent patterns among certain key individual and contextual factors associated with these perspectives.

Consider the models in Table 6 on conventional modern farming. Agro-ecological zone and network connectivity (our two contextual factors) provide the only significant groups of variables. When examined across agro-ecological zones, Tororo seems to be more positively attuned to conventional modern farming and Kapchorwa less so. The latter effect drops out when all variable groups are combined in the analysis and Bungoma becomes weakly but positively significant. Nevertheless, the significance and directionality of the impacts of agro-ecology on the conventional modern farming perspective are consistent with the experiences in each of these localities. Specifically, modern farming has been strongly desired in Tororo as key to reducing poverty and stimulating agricultural productivity. On the other hand, experience using these methods in

Table 6. Regression on conventional modern farming.

Independent variables	Variable groups Beta	sig	All Beta	Sig	Best model Beta	Sig
Agro-ecological zone						
Tororo	0.166	0.01	0.450	0.02	0.221	0.00
Kapchorwa	−0.126	0.06	0.234	0.08		
Bungoma	−0.034	0.60	0.216	0.04	0.102	0.06
Adj. R^2	0.053	0.00				
Resource endowments						
Tractor	−0.039	0.54	0.254	0.00	0.237	0.00
Animal traction	−0.087	0.12	−0.048	0.41		
Area farmed	0.007	0.91	−0.017	0.76		
Wealth index	0.016	0.80	0.084	0.25		
Importance of off-farm income	−0.081	0.14	−0.063	0.26		
Access to credit	0.153	0.01	0.089	0.16		
Adj. R^2	0.014	0.09				
Personal characteristics						
Age-respondent	0.040	0.49	0.043	0.57		
Gender-respondent	0.024	0.69	0.058	0.31		
Education-respondent	−0.007	0.90	−0.017	0.78		
Female household head	−0.015	0.81	−0.090	0.17		
Poor health	−0.117	0.04	−0.105	0.05		
% energy from staples	0.088	0.11	0.065	0.21		
Adj. R^2	0.002	0.36				
Network connectivity						
Extension contact	0.224	0.04	0.289	0.01	0.300	0.01
Frequency extension contact	−0.271	0.02	−0.378	0.00	−0.390	0.00
NGO contact	−0.013	0.91	−0.007	0.95		
Frequency NGO contact	0.164	0.15	0.156	0.17	0.185	0.00
Vendor contact	−0.100	0.22	−0.131	0.13		
Frequency vendor contact	0.032	0.77	0.099	0.37		
Average contact frequency	−0.018	0.75	0.079	0.58		
Total network contact frequency	−0.255	0.02	−0.250	0.02	−0.270	0.00
Adj. R^2	0.087	0.00				
Adjusted R^2			0.145	0.00	0.150	0.00

Kapchorwa has led to rapid decline in agricultural productivity and high levels of erosion resulting in greater skepticism of these ideas. Bungoma's weak positive attitude likely reflects the important dynamic of increasing cultivation of cash crops by modern methods at the expense of traditional cultivation methods used to maintain food security.

Despite the importance of agro-ecology, network connectivity appears to provide the greatest explanatory power. Interestingly, these data suggest that while contact with extension is important, more frequent contact actually lowers the degree to which an individual farmer agrees with the principles of conventional modern farming. Contacts with NGO agents only become relevant when controlling for agro-ecological zone and tractor ownership. The overall importance of network connectivity generally suggests that local capital intensive farming has developed in dialogue between farmers and non-farm agents despite divergent views.

Table 7 presents the regressions on mixed crop-livestock farming. Again, agro-ecological zone and network connectivity are the primary predictors. Overall network connectivity as measured by average and absolute numbers of network contacts seems to drive positive perspectives on mixed farming. Tororo and Bungoma appear less likely than Trans-Nzoia to support this more traditional farming perspective and Kapchorwa more likely. Although overall network contact tends to increase support for mixed farming perspectives, vendors, NGOs and extension agents all have a negative influence. Only when these context indicators are controlled does access to credit have a positive influence.

In both cases, contextual factors are the drivers shaping farming perspectives. The strength of the relationships between agro-ecologies and adherence to these two

Table 7. Regression on mixed crop-livestock farming.

	Variable groups		All		Best model	
Independent variables	Beta	sig	Beta	Sig	Beta	sig
Agro-ecological zone						
Tororo	−0.348	0.00	−0.052	0.89		
Kapchorwa	−0.014	0.25	0.063	0.64	0.153	0.02
Bungoma	−0.299	0.00	−0.285	0.01	−0.197	0.00
Adj. R^2	0.107	0.00				
Resource endowments						
Tractor	0.161	0.01	−0.109	0.25		
Animal traction	−0.007	0.90	0.029	0.63		
Area farmed	−0.015	0.80	−0.004	0.94		
Wealth index	0.008	0.90	−0.064	0.31		
Importance of off-farm income	−0.001	0.99	−0.011	0.84		
Access to credit	−0.013	0.83	0.138	0.03	0.126	0.04
Adj. R^2	0.008	0.19				
Personal characteristics						
Age-respondent	0.029	0.62	0.001	0.99		
Gender-respondent	−0.018	0.77	−0.071	0.21		
Education-respondent	0.053	0.36	0.024	0.69		
Female household head	0.038	0.54	0.074	0.21		
Poor health	0.012	0.83	0.017	0.75		
% energy from staples	0.021	0.71	0.011	0.84		
Adj. R^2	−0.013	0.94				
Network connectivity						
Extension contact	−0.145	0.18	−0.237	0.04	−0.140	0.01
Frequency extension contact	0.012	0.91	0.124	0.30		
NGO Contact	−0.217	0.05	−0.208	0.07	−0.116	0.05
Frequency NGO contact	0.142	0.22	0.108	0.35		
Vendor contact	0.145	0.08	0.093	0.28		
Frequency vendor contact	−0.303	0.01	−0.254	0.02	−0.201	0.02
Average contact frequency	0.196	0.00	0.279	0.05	0.229	0.00
Total network contact frequency	0.242	0.02	0.244	0.03	0.273	0.00
Adj. R^2	0.078	0.00				
Adjusted R^2			0.133	0.00	0.149	0.00

Table 8. Regression on one should maintain a permanent crop cover.

	Variable groups		All		Best model	
Independent variables	Beta	Sig	Beta	Sig	Beta	sig
Agro-ecological zone						
Tororo	−0.200	0.00	−0.224	0.24		
Kapchorwa	−0.245	0.00	−0.194	0.15		
Bungoma	−0.351	0.00	−0.399	0.00	−0.236	0.00
Adj. R^2	0.076	0.00				
Resource endowments						
Tractor	0.098	0.12	−0.100	0.29		
Animal traction	−0.108	0.05	−0.014	0.81		
Area farmed	−0.058	0.32	−0.106	0.06		
Wealth index	0.076	0.22	0.054	0.39		
Importance of off-farm income	−0.089	0.13	−0.075	0.18		
Access to credit	0.083	0.15	0.131	0.04	0.139	0.01
Adj. R^2	0.040	0.00				
Personal characteristics						
Age-respondent	0.193	0.00	0.142	0.02	0.182	0.00
Gender-respondent	0.159	0.01	0.112	0.05	0.100	0.05
Education-respondent	0.006	0.92	−0.034	0.57		
Female household head	−0.031	0.60	−0.026	0.66		
Poor health	−0.118	0.03	−0.086	0.11		
% energy from staples	0.080	0.03	0.061	0.24		
Adj. R^2	0.048	0.00				
Network connectivity						
Extension contact	−0.019	0.86	−0.044	0.70		
Frequency extension contact	0.060	0.61	0.104	0.39		
NGO Contact	−0.458	0.00	−0.386	0.00	−0.420	0.00
Frequency NGO contact	0.360	0.00	0.290	0.01	0.343	0.00
Vendor contact	0.167	0.05	0.156	0.07	0.132	0.01
Frequency vendor contact	−0.188	0.09	−0.081	0.46		
Average contact frequency	0.018	0.77	−0.029	0.84		
Total network contact frequency	0.100	0.35	0.080	0.46		
Adj. R^2	0.050	0.00				
Farming Perspectives						
Conventional modern farming	0.138	0.01	0.107	0.06	0.105	0.04
Mixed farming system	−0.014	0.77	−0.051	0.36		
Adj. R^2	0.015	0.02				
Adjusted R^2			0.157	0.00	0.153	0.00

perspectives speaks to the importance of recognizing that agricultural mindsets are highly context specific. Researchers and agents wishing to develop technologies will need to be mindful of the local context in which they are promoted. The importance of network connectivity variables indicates that local contexts involve socially constructed technological frames. The positive impact of extension and NGO contact on modern farming perspectives and negative impact on mixed farming offer evidence that a modern farming perspective is most commonly transferred by these agents. However, the reverse effects

Table 9. Regression on tillage causes land degradation.

	Variable groups		All		Best model	
Independent variables	Beta	Sig	Beta	Sig	Beta	sig
Agro-ecological zone						
Tororo	−0.073	0.27	−0.049	0.80		
Kapchorwa	−0.173	0.02	0.205	0.14	0.268	0.00
Bungoma	−0.089	0.17	−0.007	0.95		
Adj. R^2	0.045	0.00				
Resource endowments						
Tractor	0.051	0.41	0.48	0.62		
Animal traction	0.065	0.24	0.052	0.39		
Area farmed	−0.074	0.21	−0.059	0.32		
Wealth index	0.161	0.01	0.149	0.02	0.143	0.01
Importance of off-farm income	−0.023	0.68	−0.008	0.89		
Access to credit	−0.191	0.00	−0.115	0.08		
Adj. R^2	0.037	0.00				
Personal Characteristics						
Age-respondent	0.012	0.83	−0.004	0.94		
Gender-respondent	−0.142	0.02	−0.148	0.01	−0.149	0.01
Education-respondent	0.060	0.28	0.036	0.56		
Female household head	0.075	0.22	0.116	0.06	0.109	0.05
Poor health	0.007	0.90	−0.001	0.99		
% energy from staples	0.163	0.00	0.130	0.02	0.132	0.01
Adj. R^2	0.033	0.01				
Network connectivity						
Extension contact	0.085	0.46	0.028	0.81		
Frequency extension contact	−0.004	0.97	0.109	0.38	0.106	0.04
NGO contact	−0.101	0.38	−0.199	0.08		
Frequency NGO contact	0.131	0.28	0.183	0.12		
Vendor contact	0.113	0.19	0.101	0.25		
Frequency vendor contact	−0.151	0.19	−0.137	0.23		
Average contact frequency	0.058	0.35	−0.012	0.94		
Total network contact frequency	−0.029	0.79	−0.034	0.76		
Adj. R^2	−0.003	0.53				
Farming perspectives						
Conventional modern farming	−0.003	0.95	0.135	0.02	0.130	0.01
Mixed farming system	0.053	0.28	0.010	0.86		
Adj. R^2	−0.002	0.56				
Adjusted R^2			0.104	0.00	0.118	0.00

which occur with frequency of contact suggest that these perspectives may become more nuanced in stronger relationships between agents and farmers.

In the regression analyses on the two conservation agriculture indicators, we also introduced the two general agricultural perspectives as a fifth group of indicators. The first major finding to stand out is that the CA indicators are less likely to be influenced by contextual factors and more likely to be influenced by personal and resource characteristics. Nevertheless, farmers in all three agro-ecological zones are significantly less likely than Trans-Nzoia to believe that one should maintain a permanent cover crop;

although only Bungoma remains significant in the combined and best models. Resource endowments have some predictive power, but only access to credit remains in the combined and best models. Age and being a woman positively influence support for maintaining cover crops. NGO contact on its own seems to have a strong negative influence, but frequent interaction with NGO agents has a significantly positive influence, as does vendor contact. Finally, being supportive of conventional modern farming also has a positive influence.

Tillage causes land degradation is the most contested perspective and also the least well predicted in this analysis. Again, the key drivers seem to be personal characteristics. Women are less likely to agree that tillage causes land degradation unless they are the head of the household. The amount of energy household members acquire from staples (an indicator of poor nutrition) positively influences the knowledge that tillage causes degradation, as does wealth. The effect of contextual factors is more muted, presumably due to the lack of discourse surrounding this topic within farmer networks. Although Kapchorwa was least likely to support this perspective among agro-ecological zones, when all factors are combined it becomes a positive influence, as does frequency of contact with extension agents and a belief in conventional modern farming.

The overall importance of individual characteristics in affecting knowledge about conservation agriculture is consistent with the idea that a technological frame for conservation agriculture is not yet a fully formed discourse among respondents. However, the statistically significant relationship between CA knowledge and individual characteristics indicates a potential pathway for influencing the evolution of local knowledge. Indeed, this suggests that individual farmer characteristics making them more or less supportive of CA should be explored as a point of entry into dialogue within each local context.

Conclusion

The initial purpose of our investigation was to empirically demonstrate that variations in local knowledge exist and evolve as a result of network dialogues negotiating scientific and local knowledges of local agro-ecologies. As evidenced through compare means testing, there are significant differences between farmers and non-farm agents in their perspectives on conventional modern farming and mixed crop livestock systems. Among farmers these perspectives are nuanced by contextual factors of agro-ecology and their network connectivity. The fact that statistically significant sources of variation can be identified offers compelling evidence for variation in local knowledges. Furthermore, this variability does not appear limited to a simple dichotomy with Western scientific knowledge. Successful facilitation involves negotiating dialogue among these perspectives. Context matters.

The identification and verification of multiple knowledges, and the apparent gap between farmers and non-farm agents is important to recognize for the development of CAPS technologies. Differences in perspective and ways of knowing imply that farmers and non-farm agents are likely to have different concerns about CA. Within-group disagreement over the critical issue of whether or not tillage causes land degradation increases the complexity of facilitating collaboration. It appears that these negotiations should be arranged in a two-stage process. In the first instance, taking individual characteristics and perspectives into account will be paramount for establishing an empirical foothold within the local context. This should be followed by the facilitation of experiences of local sense-making within network clusters through adaption and testing of CA practices from which new local knowledge can emerge.

As the situation currently stands, however, a group of service providers do not appear to accept that variation in knowledge is legitimate. Consequently, an important activity for facilitating collaborative partnerships will be to encourage discussion among service providers about the diversity of local knowledges, emphasizing the idea that farmers' perspectives regarding various agricultural practices are not 'wrong' but rather that they represent legitimate themes in local technological frames. That this establishes a foundation for negotiating the development of CAPS mindsets should be stressed. Recognition of multiple knowledges also reinforces the building of mutual trust and network adaptive capacity. Acknowledging the distinct characteristics which underlie variation in agricultural knowledges fosters a dialectical relationship between knowledge and practice (Moore 2009). As particular features of an agricultural production system change, we can expect local knowledge to shift correspondingly.

In addition to legitimating the diversity in local agricultural knowledge systems, identifying the factors contributing to local variation in agricultural knowledge assists researchers in recognizing the role of local sense-making in social networks shaping agricultural innovations (Leeuwis and Aarts 2011; Darré, Le Guen, and Lemery 1989). As exemplified through our exploration of variation in understandings of CA, individual farm and farmer characteristics are critical to identifying individual proclivities to change farming practices. However, it appears that the mindset change needed for establishing CAPS requires adaptation to the agro-ecology and a supporting set of network partners. Consequently, even within this relatively small geographic area, how the local agro-ecology shapes farmer perspectives must be taken into account in the facilitation of strategies to scale up CA. On the other hand, the importance of network activity is reciprocal. This should be encouraging to both farmers and researchers, because, compared to more fixed factors such as resource endowments or education, seeking out information through network activity is directly within farmer control. Meanwhile, researchers also have a number of relatively simple options for stimulating network learning. Combined with increasing recognition and legitimation of local knowledge, these findings promise to empower all stakeholders in their ability to facilitate processes of sustainable adaptation.

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Appendix A: Statements concerning agricultural production norms and practices

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

See Lamb, Moore, and Christie 2010, for a discussion of these generic items developed to be adapted to multiple contexts and languages. It is recognized that not all statements will be found meaningful in every agro-ecological and discourse context.