A Cross-Cultural Examination of Measurement Invariance of Smallholders in Kenya, Uganda, Mali, & Lesotho

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(ABSTRACT)

Cross-cultural research requires tests of measurement invariance to determine if different populations have equivalent latent constructs. A psychometric assessment of the Agricultural Production Perspectives Scale (APPS) was necessary to determine the validity of the scale constructed and whether data from multiple countries could be compared. Using 918 farmers sampled from Kenya, Uganda, Mali, and Lesotho, I conducted exploratory factor analysis and scale reliability tests to determine whether the item loadings and factors were equivalent across populations. No factor structure could be obtained across country or agroecological populations. The data were reanalyzed within each agroecology to determine localized factor structures. Results indicate that a *market driven* factor and *agrarian driven* factor tend to emerge across multiple agroecologies suggesting some emergence of latent variables. Recommendations for scale revisions are included to increase reliability and measurement invariance.

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Introduction

Peasant or smallholder farming is a way of life for the majority of citizens in third world countries. These family farms continue to persist as non-wage households, despite issues of low crop productivity and profitability (Nash, 1968; Shanin, 1973; van den Ban, 2011). Two ideologies support these family farming systems. Some farmers produce cash crops, referred to as *conventional agriculture*, for the market (Wolfe, 1975; Vergopoulos, 1978). Others exist as a social and cultural opposition to the market economy, in which farmers grow diverse crops to directly sustain their families, a production ideology recognized as *risk averse agriculture* (Foster, 1965; Bradby, 1982). Farmers attempting to minimize risk (avoid market involvement) will work harder, consume less, or seek outside supplementary income to sustain their enterprise (Long & Roberts, 1984). However, hard work and consumption do little to minimize soil degradation and negate decreased production, which have been worsening for several decades (Moore et al., 2014a; Moore, et al., 2014b; Vanlauwe, et al., 2006; Swift & Shepard, 2007; Giller et al., 2009). There is a third perspective on farming labeled *conservation agriculture* that increases profits and generates sustainable practices over the long-term. Adoption of this perspective requires knowledge sharing and support systems. To date, conversation agriculture has not been widely adopted in third world countries.

Researchers at Virginia Tech's Office of International Research, Education, and Development – Sustainable Agriculture and Natural Research Management (OIRED-SANREM) collaborative research support program are interested in understanding mindsets or frameworks held by farmers, community leaders, and extension agents in the developing world to better communicate strategies for the transition to a more sustainable agriculture. Moreover, their goal is ultimately to transfer knowledge that guides small farmers away from conventional and risk-averse agriculture toward conservation agriculture.

To test agricultural frameworks, Lamb, Moore, and colleagues of SANREM developed a questionnaire, known as the Agricultural Production Perspective Scale (APPS), which contains twenty items about agricultural production perceptions. Each question was created based on previous rural sociological research (see Swenson & Moore, 2009: Appendix A). The APPS developers clustered items into three ideologies: conservation agriculture, risk-averse agriculture, and conventional agriculture. Moore and colleagues then administered the APPS in multiple countries. However, the questionnaire has never been validated as a cross cultural instrument, which is necessary to compare results across different populations.

Researchers often administer surveys in populations not targeted during initial design and usage. Although this can save time, money, and resources, such an approach disregards potential cultural differences across populations. Researchers have advocated for measurement equivalence/invariance (ME/I) as necessary for the cross-cultural usage of surveys and assessments (Bagozzi & Edwards, 1998; Steenkamp & Baumgartner, 1998; Vandenberg & Lance, 2000).

When measurement equivalence is established, different populations perceive, interpret, and understand items in the same manner; when measurement equivalence is absent, populations respond to items in ways that indicate populations are systematically different. This is not a function of mean-level differences of the manifest items, but a function of the latent variable conceptual interpretations across different populations. Items must be written with clarity and reflect the latent variable each is attempting to measure. However, items can be interpreted as a function of culture, knowledge, or frame of reference whereby different populations may systematically interpret an item based on underlying conceptualizations. This will be reflected in differences in factor structures. Measures are required to be invariant before comparing results across cultures (Steenkamp & Baumgartner, 1998). Otherwise, conclusions drawn may be biased or invalid because the measure holds different meaning within each population.

My primary goal is to perform a psychometric assessment of the APPS. OIRED-SANREM researchers have collected data in Mali, Lesotho, Kenya, and Uganda. By assessing the reliability and validity of the APPS, I will be able to ascertain the quality of the measure itself. Subsequent tests of ME/I will identify items and factors that are equivalent across populations and those that are culturally biased. Psychometric validation and tests of ME/I is critical as OIRED-SANREM will be returning to these countries in 2014 to collect follow-up data. These knowledge frameworks and items may need to be adjusted, removed, or reinterpreted before new data is collected.

OIRED/SANREM

The Office of International Research, Education, and Development (OIRED) at Virginia Tech creates and implements projects to raise the standard of living in developing countries. Their portfolio consists of over $92 million in grants and contracts, partnerships with over 80 universities and institutions, and research projects conducted in 44 countries around the world. A subset of OIRED, the Sustainable Agriculture and Natural Research Management (SANREM) collaborative research support program, focuses exclusively on improving the livelihoods and food security of small farmers in the developing world through science. Funded in large part by the United States Agency for International Development (USAID), SANREM is currently running projects in 13 countries across Africa, Asia, and Latin America. Much of their work involves knowledge and technology transfer to: increase income, empower stakeholders, support gender concerns, improve soil quality, enhance resource management, increase local support, improve market access to small farmers, and promote sustainable environmental practices.

SANREM's current research in Africa includes work in Mali, Lesotho, Kenya, and Uganda. The major objective is to introduce conservation agriculture production systems (CAPS) which increase smallholder agricultural productivity and food security through cropping system methodologies that include minimal tillage, crop rotations, and year-round soil cover. Conservation agriculture is a stark contrast to conventional and risk-averse agriculture described below.

Agricultural Frameworks

Technological frameworks in agriculture are shaped through the actors within a complex adaptive system (Bijker, 1995; Clark & Murdock, 1997). Over time, three frameworks have emerged: conservation agriculture, conventional agriculture, and risk averse agriculture (Ekboir, 2003; Coughenour, 2003; Pleog, 2008; Swenson & Moore, 2009; Lamb, Moore, & Christie, 2010). These types are outlined below as noted by Lamb and colleagues (2010) & Moore and colleagues (2012):

Conservation Agriculture. Maintenance of soil health, control of soil erosion, and improving crop yields are critical objectives of conservation agriculture. CAPS is founded on three important principles: minimizing soil disturbance, maintaining a permanent vegetative cover, and rotating crops. As weed and pest management can be difficult at onset, farmers experiment with different fertility inputs and crop management methodologies for optimal crop output.

Conventional Agriculture. Agricultural producers relying on conventional production methods are motivated solely by maximizing profit and crop yields. Planting decisions are based on marketability of specific crops and most farmers commit to specializing in production of particular commodities. These farmers find value in fertilizer, chemical pesticides, and herbicides based on perceived break-even points. Moreover, mechanized production (e.g. tractors) is used for both land preparation and harvest. Maximizing production involves multiple passes of tillage equipment before and during production. These agricultural producers minimize input costs through labor saving techniques and support scientific research that improve crop yields and profits.

Risk Averse Agriculture. Risk averse agricultural producers achieve autonomy and independence by growing crops for market production *and* household sustenance. Decisions by risk averse farmers are highly contextualized and often involve multi-functionality or co-production. This may take forms of intercropping systems, spreading crops and inputs in different locations, or relying on additional off-farm income. These producers rely on social networks to access resources for production, as opposed to purchasing products from the marketplace. The risk averse mentality is the predominate framework in the four countries of study, but as this is highly localized to each individual agro-ecosystem, it requires careful examination of the contextual perspective.

Agricultural Production Perspectives Scale

Farming practices differ based on region, knowledge, experience, accessible inputs, and risk. Flinn and Johnson (1974) were the first to empirically assess that farmers hold distinct ideologies about farming practices. Rural sociological research has historically addressed technological frameworks based on qualitative analysis and case studies. Since the 1980's, Moore began identifying and quantifying unique perspectives on farming practice ideologies from his years of research and collaboration with farmers from countries around the world (see Moore, 1984; Moore, 1989). He created items and has attempted to cluster these different farming perspectives into meaningful ideological factors.

Swenson and Moore (2009) created an initial set of items that involved physical inputs (e.g. herbicides, fertilizers, and equipment) and knowledge inputs (e.g. farming practices attitudes, conservation agriculture techniques, and herbicide application) to assess production perspectives. Lamb, Moore, & Christie (2010) revised and simplified the scale to 20 items and administered the APPS (see Table 1) to farmers and non-farm agents in Mali, Lesotho, Kenya, and Uganda.

Psychometric assessment of the APPS scale will be useful in a number of ways. First, reliability and validity estimates must be determined to identify the quality of the APPS measure. Reliability is a measure of the consistency in performance or mental appraisal. Measurement error can weaken or strengthen relationships and reduces reliability. Validity assesses whether an assessment measures what it purports to measure. Validity analyses of the APPS will provide information on the relationship between items and their latent variables. Lastly, factor analyses will test ME/I of the APPS items across cultures and whether farmers from these countries can be meaningfully compared. These tests will provide researchers with information to recognize that systematic differences across populations may be a function of culture.

It should be noted that this this paper uses a data-driven analytic approach. Although the APPS is conceptualized according to three frameworks, this is ultimately an empirical study testing the validity of the scale and its items. If the items do not load onto these three agricultural factors, I will assess item emergence and loadings, restructuring the scales according to interitem correlations and loadings. This process, which focuses on data-driven psychometrics, has the potential to increase the validity of the scale over the conceptualized framework and provide clarity to individual perceptions of farming practices. Items will also need to systematically load on factors across cultures to assess measurement equivalence.

Common Sources of Measurement Invariance

Cross-cultural research is difficult. Many barriers exist including: population specific items, language/translation issues, and knowledge structures/frame-of-reference. Moreover, gender, age, region, and culture may vary as a function of the populations assessed. Such differences are not accurate reflections of mean level comparisons if item interpretation is based on different latent (cognitive) constructs.

ME/I testing has become more important for theoretical comparisons and has grown in practical usage as well (Little, 1997; Van de Vijver & Leung, 1997; Steenkamp & Baumgartner, 1998; Chen, 2008). ME/I verifies if different cultures ascribe different meanings to items (Mifont, Duckitt, & Cameron, 2006). Cross-cultural research can be even more problematic if ME/I has not been conducted - leading to inaccurate inferences and conclusions (Vandenberg, 2002; Vandenberg & Lance, 2000).

Culture & Agroecology. Cultural differences primarily focus on comparing psychological constructs across different populations (Van de Vivjer & Leung, 2000). Cross-cultural ME/I underlies one fundamental question: are individuals systematically, regardless of region and culture, utilizing the same cognitive frame of reference when completing an assessment? For instance, the term "intelligence" is perceived by parents in Kenya as the ability to do things in the household that needed to be done without being asked (Harkness & Super, 1977).

An additional concern is whether test differences across cultures are due to true differences or biases. ME/I can establish when cross-cultural differences represent true differences of an underlying construct or are systematic biases within a specific population (Steenkamp & Baumgartner, 1998).

Cultural values are often reflected in an individual's perceived importance of various antecedents (Wasti, Tan, Brower, & Onder, 2007) For instance, Wasti and colleagues (2007) were concerned whether culture was reflected in the operationalization of constructs related to trust. They took to using ME/I to assess Mayer and colleagues' (1995) trust scale across U.S., Turkey, and Singapore, but found the scale had poor psychometric properties, in which tests of ME/I would be inappropriate.

Historically, researchers have explored group differences by race, ethnicity, and culture. ME/I has examined differences between black and white participants in employment test validity perceptions (Chan, 1997), reactions to employment testing (Chan, Schmitt, Sacco, & DeShon, 1998), and Five-Factor Model generalizability (Collins & Gleaves, 1998). Research has also tested for cross-cultural differences such as individualism vs collectivism (Wendt, Euwema, & van Emmerik, 2009) and across Eastern vs. Western populations (Zhang, Fokkema, Cuijpers, Li, Smits, & Beekman, 2011). However, cross-cultural differences have not been examined in similar characteristic populations, such as rural farmers in sub-Saharan Africa.

Primary differences across groups within Mali, Lesotho, Kenya, and Uganda are a function of *agroecology*: climate, land, and soil composition combined with the dominant farming system. Perceptual differences on the APPS may be due to the climatological needs of the population itself. Farmers in these regions may be forced to specialize in specific crop growth or even livestock production for sustainability purposes, which can further shape one's beliefs about best farming practices.

There are seven distinct agroecologies to compare and test for ME/I. Kenya and Uganda have high production and low production environments based on soil composition and rainfall. Mali has two agroecologies based on travel accessibility. Three agroecologies with varying agroecological features exist in Lesotho. All four countries are in sub-Saharan Africa. At the data collection sites, Mali, Kenya, and Uganda farmers live in Africa's savannah region. Only Lesotho is different – located in the mountain and temperate grasslands. Provided below are a more detailed representation of the land composition and historical farming practices for each country. In addition, each region has subsections that describe the agroecologies specific to that region.

Mali Region. Mali is diverse; language, culture, and geography divide its 10 million residents into a dozen ethnic groups. The majority of Mali's economic growth stems from agricultural production and gold mining (Smith, 2001). Data were collected among the Dogon farmers living on the Seno plain, an area with difficult growth conditions due to soil erosion and limited rainfall (Bayala et al., 2011). This region consists of rolling plains and sandy soils with farmers who focus primarily on dryland farming and herding livestock.

Data were collected in four villages: Koporo-pen, Oro, Diallassagou, and Lagassagou. The agroecologies are remarkably similar across all four sites. Villages will be clustered and analyzed according to proximity to an all-weather road.

All-Weather Road Accessibility. Diallassagou and Lagassagou lack access to an all-weather road, which facilitates communication and increases access to transportation of goods. Koporo-pen and Oro have such transportation access which assists in intervillage communication and input purchases. In addition, Koporo-pen and Oro are located proximally (within a few miles) to an agricultural research station. This station provides knowledge and inputs to farmers. In addition, these researchers were more likely to visit Koporo-pen and Oro since it required little traveling. Diallassagou and Lagassagou were much more isolated and did not have easy access to the agricultural research station.

Lesotho Region. In Lesotho, land ownership conveys prestige because farmlands are a means of agricultural production (Dana, 1997). Land for successful agricultural production is difficult to obtain because Lesotho has severely eroded landscapes (Showers, 2005; Lamb et al., 2013). Moreover, increases in human and animal populations have reduced the amount of suitable terrain for food production and grazing, respectively (Dana, 1997). Lesotho's agroecology often forces labor migration of farmers, particularly to South African mines. For smallholders that remain and continue to farm, agricultural productivity and soil conservation should be an important component of farming practices.

Data were collected in the Botha Bothe District comprised of lowland, foothill, and highland agroecologies (Lamb, et al., 2013). Each of the ten distinct villages have varying levels of access to other regions. Some, like Ha Tabolane, are close to a provincial town center; others, like Ha Sefako, are relatively isolated. Farmers in Lesotho also have access to South African resources and contacts, which could allow for information transfer and agricultural production assistance (Moore et al., 2012).

Lowlands. The lowlands include the villages of Ha Rasekila and Maloseng. Lowland and foothills communities are similar and farmers in these regions have greater access to inputs and markets for agricultural production than those in the isolated highlands. As lowland and foothill farmers are more accessible, most NGO and government projects tend to work with these farmers, as such, lowland farmers are more open to interaction with outsiders compared to the remote highland farmers. Perhaps this is why lowland farmer often show eagerness toward adopting new technologies, especially when new technologies involve receiving inputs.

Foothills. Foothill communities include Ha Tabolane, Joala Baholo, and Mokotjela. This region is largely described in conjunction with the lowlands area above. One village of note, Ha Tabolane, is described in greater detail below and represents much of the foothills villages. Ha Tabolane is within 20 kilometers of the Botha Bothe provincial center, with buses running daily between the two. This area is also close to the South African border. Ha Tabolane farmers do not struggle with access to land. Yet, many lack financial resources to sustain farming and maintain cultivated land. Many of these farmers will work on others' fields in order to purchase inputs for their own land. This often leads to negative consequences such as late planting or losing the ability to plant at all, which can be detrimental for food sustenance and cash cropping.

Highlands. Five highland villages in total were surveyed: Ha Sefako, Ha Mou, Phamong, Mafika Lisiu, and Manoeleng. Farmers in these regions were noted as not only being more remote and inaccessible, but more difficult to work with. Highland farmers also are less inclined to adopt new technologies or experiment with new methodologies than lowland farmers. Because of the difficulties of farming in this region and limited access to resources, farmers utilize what is available including organic fertilizers and compost to reduce the need to import artificial fertilizers.

The highlands, especially Ha Sefako, experience various climatic issues including a shortened growing season and reduced number of crops that can be successfully grown in this region. The highlands experience frost and snowfall that limits production to a single growing season, with a reliance on livestock as a livelihood. Although data were not collected to compare frameworks by age, it could be of notable importance that the chief allocates land whereby younger members find it much more difficult to gain access to quality land.

The highland area is also more isolated than the other communities. Ha Sefako is a three hour ride to Botha Bothe and transportation is normally by foot or horseback as there is limited access to public transportation. Access to South Africa is much further than the foothills as well. Regardless, access to urban market centers are important for production inputs and selling of goods. Because the local resource center often lacks needed inputs, farmers usually depend on the few community member with vehicles to transport supplies between the highlands and the Botha Bothe center or urban centers of South Africa.

Kenya & Uganda Region. Data from Kenya were collected in the Bungoma and Trans-Nzoia Districts, located in western Kenya. Data were collected in Tororo and Kapchorwa of eastern Uganda. All four localities are near the Kenya/Uganda border and within various proximities to Mount Elgon.

High Production Zones**.** Trans-Nzoia and Kapchorwa are considered high production zones. Both are located near Mt. Elgon, known for its fertile, volcanic soil. This area also has greater overall rainfall than the other two zones (Moore et al., 2012). Historically, the Trans-Nzoia people are native pastoralists, or livestock farmers – individuals who produce livestock and sometimes grow crops for the specific purpose of feeding livestock. In the beginning of the twentieth century, colonization brought the benefits of coffee and maize production introducing sedentary agriculture (Anderson & Throup, 1985). Kapchorwa, like Trans-Nzoia, has many native pastoralists who have just begun adopting agriculture in the past fifty years.

Low Production Zones**.** Bungoma and Tororo are the two southern sites. These zones are thought to have lower production potential because the soil composition is poor and primarily sand-based. Rainfall here is also more variable. Bungoma is traditionally a mixture of agriculturalists and pastoralists. Unique to this region, Tororo is recognized as a fishing and farming-based culture.

Agroecology Summary. In total, there are two agroecologies within the Kenya and Uganda region, and three agroecologies within Lesotho. Production may vary in Kenya and Uganda as a function of the rainfall conditions and soil composition. Lesotho's agroecology may not only vary due to rainfall and soil differences, but be dependent on proximity to towns and available inputs.

Mali's villages do not have *true* agroecological differences. However, access to an all-weather road may produce systematically different results for farmers in regards to production, market mindset, and scarcity of inputs. Mali, in this case, might be less a function of agroecology and more of external influence.

Assumptions about Measurement Invariance

Classical Test Theory (CTT) assumes that an observed score is a composite of true score and error score components; the true and error scores are assumed to be uncorrelated, allowing for decomposition of observed score variance into its true and error score variances (Lord & Novick, 1968). Manifest variables attempt to capture the true score variance, but measurement errors can confound the variable of interest. Application of CTT aims to establish the reliability and validity of items/scales. Reliability and validity provide evidence that manifest items reflect proposed underlying latent constructs (Nunnally, Bernstein, & Berge, 1967). Once a manifest to latent variable relationship is found, ME/I discovers the extent that manifest item properties generalize across populations.

Measurement invariance is based on each individual item being unbiased across populations. For example, if Caucasian students experience higher engagement than peers of other races, the test may suffer from item bias. Such biases will directly affect construct validity (Borsboom, Mellenbergh, & van Heerden, 2002). According to Shealy and Stout (1993, p. 198), “test bias occurs if the test under consideration is measuring a quantity in addition to the one the test was designed to measure, a quantity that both groups do not possess equally.” Thus, populations may systematically interpret an item differently, producing biased responses. Bias is not intrinsic to the instrument, but is indicative of the characteristics of individuals from each cultural population (van de Vijver & Tanzer, 1997).

According to Vandenberg & Lance (2000), measures require three assumptions that are rarely tested. First, latent constructs should be equivalent across populations. In other words, two populations must hold the same frame of reference. Otherwise, latent constructs are incomparable. Second, the relationship between a latent construct and its operationalization (e.g. item) must be equivalent across populations. Non-equivalency of relationships across populations suggests the relationship is population specific and may lead to different interpretation of specific items. Finally, manifest variables have the same degree of nonsystematic measurement variance across populations. Violations of any of these assumptions convolute between-population comparison interpretations, making the measure highly suspect (Drasgow, 1984; Vandenberg & Lance, 2000).

Factorial invariance has been tested in many different research areas including scale development/validation issues (e.g. Byrne & Baron, 1993; Byrne, 1994; Finch & West, 1997), cross-cultural comparisons (e.g. Dumka, Stoerzinger, Jackson, & Roosa, 1996; Little, 1997; Ryan, Chan, Ployhart, & Slade, 1999), scale translations (e.g. Byrne & Baron, 1994; Smith, Tisak, Bauman, & Green, 1991), racial/ethnic differences (e.g. Chan, 1997; Collins & Gleaves, 1998), gender differences (e.g. Byrne, Baron, & Campbell, 1993; Byrne & Shavelson, 1987; Stacy, MacKinnon, & Pentz, 1993), and age (e.g. Marsh, 1993). ME/I has also been used in various research domains including organizational behavior (e.g. Lievens & Anseel, 2004), marketing (e.g. Agarwal, 1993), and healthcare (e.g. Zhang et al., 2011). However, no research has examined cross cultural differences in rural farmers, specifically those in Africa.

ME/I is often used to test cultural sensitivity of a measure for scale development. New measures are difficult to create, especially when cultural influences may bias such measures (van de Vijver & Leung, 2000; Vandenberg, 2002). Thus, psychometric testing of the APPS will indicate if items are culturally sensitive and will allow for reformulation or elimination of such items for future research.

In the current research, measurement equivalence is important to identifying if individuals from different agroecologies within Kenya, Uganda, Lesotho, and Mali, answer items using the same frame of reference. More specifically, do agroecological comparisons within country indicate ME/I? Achieving ME/I will allow for meaningful cross-cultural comparisons; Absence of ME/I will provide insight into potential causes of non-invariance and allow for readjustments to the current scale for future data collection in 2014.

Archival Data Collection

Participants

Subjects were comprised of male and female farmers in rural regions of Mali, Lesotho, Kenya, and Uganda. Farmers are recognized as individuals whose livelihood comes from farming. Interviews and surveys occurred on the same timeline for all sites. Conservation agriculture practices were introduced to each site at approximately the same time as the APPS assessment's administration, except Lesotho, who were introduced to conservation agriculture by a national extension program.

In total, there are 1002 male and female farmers across all research sites. [Table 2] shows the farmer distribution by country, gender, and agroecology. Gender was approximately equally distributed across Mali with males accounting for 49.58% of the sample and females accounting for 50.42% of the total sample. In Lesotho, females represented 65.29% of all individuals surveyed. Kenya (n=161) and Uganda (n=191) had 352 farmers surveyed, with a 52.84% female representation. Across all sites, females accounted for 57.21% of all participants, influenced largely by Lesotho's population.

Data Collection Procedure

Mali. Mali data were collected in 2011 in the Seno plain. Two villages were chosen (Koporo Pen and Diallassagou) for their recent involvement in conservation agriculture production and two villages (Oro and Lagassagou) were local controls. Data were collected by targeting household samples of 30 men and 30 women in each region by selecting from a list provided by each village chief. This sampling accounted for 25 to 80 percent of all farming households in the villages, but are a function of opportunistic sampling, not random sampling.

Lesotho. Data were collected in 2010 by using census data to target agricultural regions that promoted conservation agriculture. Cluster sampling methodology produced an initial 430 household surveys in Botha Bothe from 10 different villages (Wilcox et al., 2012). Lesotho's survey was unique from Kenya, Uganda, and Mali. Pilot administration of the APPS found that farmers in Lesotho did not understand Likert scales. On the five-point scale, all respondents answered in the extremes of "agree" or "disagree," with no responses in the "somewhat agree" and “somewhat disagree” categories. As such, the researchers changed the Likert scale for the actual sample in Lesotho to a three-point scale. As such, these results cannot meaningfully be compared across Kenya, Uganda, and Mali in regards to mean differences.

Kenya & Uganda. Data from Kenya and Uganda were collected at the same time in 2010. These samples are included together because all four regions are along the Kenya-Uganda border. Separate NGO groups handled each region. In Tororo, Kapchorwa, and Trans-Nzoia, a sampling frame was created by obtaining records of the head of household of each sub-county within each region. Stratified random sampling was conducted to ensure enough female head of households were interviewed. The NGO in Bungoma (NGO SACRED) collected data by interviewing farmers previously worked with and then asked for names of other farmers to interview. To balance gender, interviews were alternated between men and women.

Analysis

Measurement invariance was to be tested through a cross-cultural comparison of populations within agroecologies of Mali, Lesotho, Kenya, and Uganda. Before testing for measurement invariance, exploratory factor analyses (EFA) were carried out in SPSS 22.0 to identify factor loadings specific to each country. Factor analysis is a function of the relationship between manifest items and latent variables. This relationship is analyzed and produces an estimated factor score. This score is estimated in an EFA because true scores are unknown. Mali, Lesotho, Kenya, & Uganda were analyzed using principal axis factoring with direct oblimin rotation. Principal axis factoring (PAF) is the recommended EFA method and was subsequently used in my analyses (Costello & Osborne, 2005). Direct oblimin is a type of oblique rotations that allows components to be correlated, which is important for assessing newly constructed scales.

Results

Exploratory factor analyses were initially run at the country level. Of the 1002 farmers, 84 farmers (8.4%) had missing data. Listwise deletion was used during each analysis. Listwise deletion was chosen over pairwise deletion because factors were being generated from the initial twenty variables and listwise is the default setting in SPSS when running factor analysis. This can produce conservative results, but my criteria for item removal were less stringent. I also could not impute items based on scales because analyses indicate that items do not load according to these scales so there was no logical basis for inserting missing data.

I ran an EFA using PAF with oblique rotation. I retained factors with an eigenvalue greater than 1 and verified this choice by examining a scree plot. The next step involved looking at both item loadings and communalities. Rule of thumb indicates that items should load on a single factor at .6 or higher. No item should load highly on multiple factors and any modest loadings on other factors must be at least .2 less than that items highest factor loading. Communalities are the extent that an item correlates with all other items. Low communalities (below .4) indicate a variable may have difficulty significantly loading on a factor.

Initially, I ran analyses by removing all variables with communality below .3 and no high item loadings on factors. I re-ran the analysis and verified that a strong factor structure and high communalities emerged. However, each subsequent analysis produced low communalities or weak loadings. I continued to remove variables based on these criteria, but in each instance, it resulted in all items being deleted due to weak loadings and/or low communalities. I devised a new strategy that assessed the factor structure dropping items one by one and rerunning analyses.

Variables were removed by selecting an item each analysis with a low communality and low loadings across all factors. Analyses were rerun after each weak item was dropped until a sound factor structure was achieved. This factor structure required sufficient item loadings on each factor and no cross-loadings across factors. One suggestion for determining item loadings is dependent on sample size. For instance, a sample size of 50 would require all items in the factor to load .75 or higher, but a sample with 350 only requires .30 loadings. For this paper, sample size ranged from 96 to 177. Item loadings for these agroecologies needed to be approximately .40 to .55, with larger samples requiring smaller loadings. However, preliminary analyses suggested that item loadings and factors retained were not meaningful with the more stringent cutoff. Thus, item loadings across all agroecologies were considered *sufficient* when the item had a factor loading was .4 or higher.

After a good factor structure was found, a theoretical approach was done to identify the relationship between sets of items on a factor. If the items could be meaningfully interpreted, then the latent construct was labeled accordingly. If the items were not theoretically justified or comprehensible, then the items were considered to be a function of chance covariation and the factor was dropped.

Finally, after a sound factor structure was obtained and labels were constructed, I performed analyses of scale reliability. Cronbach's alpha (α) is a measure of internal consistency or estimate of reliability of the psychometric properties of a test. The rule of thumb for scale validation suggests alpha should achieve a minimum score of .7 for an item set to be considered satisfactory. Internal consistency below .6 is considered poor, and less than .5 is unacceptable. Scale construction should be higher than this minimum because the factors constructed are sample-dependent. Scales were assessed via Cronbach's alpha and latent constructs were considered uninterpretable if the scale did not achieve a .6 or higher reliability. Weak factors will still be labeled but the item intercorrelations are too poor to indicate a latent factor structure and suggests a large portion of unexplained variance.

The factors within each country across agroecologies ranged from .443 to .748 on internal consistency. Only Mali achieved scale reliability above .6 (on two of four factors). Lesotho, Kenya, & Uganda did not demonstrate reliable scales. Low reliability suggests that scales are measuring more than one construct.

Mali produced a three-factor model (see Table 3). The first factor, *market driven*, contained three items and accounted for 20.09% of variance. A *market driven* structure indicates that farming practices and beliefs revolve around a framework where farmers aim to maximize profits, by choosing crops that maximize sales, selling crops, and/or earning additional income through off farm work. The second factor contained three items and is considered a *mixed crop-livestock production* factor, accounting for 12.80% of variance. Diversification is important to farmers, whereby one can distribute risk across areas or production. Livestock provide value to such farmers and residues to livestock is a “best-use” strategy, otherwise residues are considered to be wasted. The final factor included two items, accounted for 10.95% of variance and is based on conventional modern farming. A *conventional modern farming* factor represents the framework where farmers use a combination of herbicides, pesticides, inorganic fertilizer, and/or land preparation through mechanical inputs. There were no cross-loadings on the three factors and each factor had a sound theoretical basis. I then tested scale reliability of each of the three factors. Neither the *market driven* factor (α =.691), the *mixed crop-livestock production* factor (α =.526), nor the *conventional modern farming* (α =.496) achieved satisfactory scale reliability.

A two factor structure emerged in Lesotho (see Table 4). The first factor contained three items and was *market driven* accounting for 20.93% of variance. The second factor also contained three items, explained 12.57% of variance and reflected a *conventional modern farming* factor. There were no cross loadings. The *market driven* factor (α =.586) and *conventional modern farming* factor (α =.443) failed to achieve satisfactory scale reliability.

Kenya and Uganda also had a two factor structure emerge (see Table 5). Three items comprised the *market driven* factor and explained 19.32% of variance. The second factor had two items and indicated *mixed crop-livestock production*. This factor accounted for 14.08% of variance. Scale reliability found that the *market driven* factor (α =.520) and *mixed crop-livestock production* factor (α =.542) also failed to achieve adequate scale reliability.

Measurement invariance is violated because these variables failed to find a similar factor structure and item loadings across countries or within countries across agroecologies. The overall factor structure and scale reliability within each country were too poor for scale validation to confirm and test a model across agroecologies. As such, there is not enough justifiable evidence to pursue confirmatory factor analysis (CFA).

As conducted in a variety of other studies, measurement invariance planned to test the following hurdles: invariant covariance, configural invariance, metric invariance, and invariant uniqueness (Bagozzi & Edwards, 1998; Cole & Maxwell, 1985; Vandenberg & Lance, 2000). Because CFA's could not be run across countries, testing for measurement invariance was also impossible.

Thus, a new plan was developed. I ran EFA analyses within each agroecology and performed reliability analyses of each agroecological factor. Scales within each agroecology might be more coherent and reflect the local mindset. If these agroecologies produce better factor structures, data could be meaningful compared – not at the country-to-country level, assessed within agroecologies comparing villages or individuals.

Within Country/Agroecology EFAs

Nine agroecologies in total were analyzed through exploratory factor analysis. Data were analyzed through two different processes. First, I began the EFA with all twenty initial variables, performing deletion of items based on item loadings within the pattern matrices and communalities. I attempted to obtain a sound factor structure with reliable scales. I then repeated the process with the conservation agriculture variables removed at onset, starting with a set of fifteen items. This second analysis was performed to counteract potential noise in factor loadings, as the majority of farmers had limited knowledge and practice of conservation agriculture. Again, items were dropped systematically until a sound factor structure could be reached.

The factor structure results appear to vary as a function of the initial items. As such, good factor structures were usually dependent on whether the scale started with all twenty items or the fifteen selected items. When a good factor structure emerged using both methods, and the structures were different according to initial items, then the factors that produced the most coherent structure, theoretical basis, and highest reliability were retained.

Mali

All-Weather Road Accessibility. Farmers who had access to an all-weather road in Mali produced a two factor structure (see Table 6). The first factor included four items and accounted for 35.10% of variance. This *agrarian driven* mindset focuses on the best agricultural production practices, usually passed down through cultural or familial practices. For instance, planting staple crops and timely weeding are considered important for farmers that are agrarian driven because these processes have been effective in the past. The *market driven* factor emerged based on two items and accounted for 11.67% of variance. Scale reliability found that the *agrarian* *driven* factor achieved satisfactory reliability (α =.765) but the *market driven* factor had poor scale reliability (α =.526).

All-Weather Road Poor Accessibility. Farmers in Diallassagou and Lagassagou were quite distant from the research station and an all-weather road, lacking the inputs and knowledge sharing that the station could provide. Six items loaded across two factors (see Table 7) accounting for 35.86% and 20.42% of variance explained. The first factor consisted of four items and was labeled *market driven*. One item, “Land is one’s heritage to be preserved for future generations” loaded negatively on this factor. This suggests that *market driven* farmers are maximizing profits, regardless of the impact these practices have on soil. The mindset focuses on the present and ignores land preservation for the future. The second factor, *mixed crop-livestock production*, contained two items. I then tested scale reliability and found that the *market driven* factor (α =.765) and the *mixed crop-livestock production* factor (α =.737) achieved good reliability. Within Diallassagou and Lagassagou, there appears to be two distinct frameworks.

Mali Comparisons and Summary. Road access produced two factor structures in both sets of villages with some notable differences. For instance, Koporo-pen and Oro, villages with access to an all-weather road, held strongly to *agrarian driven* perceptions such as planting staple crops and timely weeding - which were unimportant to farmers in Lagassagou and Diallassagou. “Land is one’s heritage to be preserved for future generations” is a convoluted variable as it has high positive loadings on the *agrarian driven* factor for all-weather road access and high negative loadings on the *market driven* factor for villages without an all-weather road. Perhaps preserving land for future generation is culturally/heritage driven through the village and land preservations negative relationship with growing crops for sale is due to the essential need to maintain an independent lifestyle that market participation can disrupt.

The *market driven* factor did not produce a reliable scale in the all-weather road villages, but was an important component for those villagers who do not have access to such a road. It is likely that limited road access requires any marketplace trips to be successful. From a psychometric standpoint, the low scale reliability of the *market driven* factor in the all-weather road villages is a result of two items loading on the factor compared to four items in the no all-weather road. Lastly, only farmers in Diallassagou and Lagassagou cared about *mixed crop-livestock production*, which was done through diversification of improving soil conditions through fertilizer and investing in livestock.

Overall, Mali does not have reliable factor structure across agroecologies. Although the factor structure is different across these agroecologies, farmers in Diallassagou and Lagassagou (no all-weather road) had two reliable factors emerge. This is in opposition to Koporo-pen and Oro, in which only the *agrarian driven* factor achieved significant reliability.

Lesotho

Lowlands. The lowlands had three factors emerge with eigenvalues greater than one (see Table 8). The initial factor accounted for 19.41% of the variance, second factor 17.16% of the variance, and last factor 10.88% of the variance. The first factor retained three items and operated as *market driven* production by focusing on growing crops for sale and earning supplemental off farm income, instead of increasing crop production. Moreover, the item, “It is better to grow staples within the household or community than purchase them” negatively loads on this factor indicating that it is more beneficial to simply purchase staples than spend time and land growing them for consumption. The second factor, *anti-conservation agriculture*, contained two items and is a derivative of the *mixed crop-livestock production* factor, one in which farmers have been confronted with the threat to diversification by conservation agriculture. No-till agriculture and keeping crop residues on the land are foundational to conservation agriculture, a stark contrast to this second factor. The third factor contains two items and is *agrarian driven*, focusing on planting staple crops and reinvesting agricultural income. After these three theoretical frameworks were identified, scale reliability was examined. The *market driven* factor (α =.628), *anti-conservation agriculture* factor (α =.663), and *agrarian driven* factor (α =.559) did not achieve good scale reliability – though the first two factors were considered acceptable.

Foothills. EFA in the foothills produced a two-factor solution (see Table 9). The foothills village farmers had three items load on the *market driven* factor, which explained 31.19% of variance. The second factor had two item loadings: It is better to grow staples within the household or community than purchase them and chemical pesticides are necessary. These two items accounted for 9.92% of variance. After careful consideration, these items had no theoretical basis for a latent construct. These items are considered to be a function of chance covariation and were dropped from subsequent analyses. The *market driven* factor was tested for scale reliability and produced an adequate structure (α =.631).

Highlands. The highlands had a two factor structure emerge (see Table 10) with 25.88% and 15.10% of the variance explained, respectively. The first factor consisted of three items that indicated a *market driven* factor; the second factor consisted of two items and relied on *conventional modern farming* practices. Conventional modern farming relies on chemical inputs such as herbicides, pesticides, and fertilizer to maximize crop production. Mechanical inputs are often used as well including tractors or tillage equipment to expedite farming processes.

Each of the factors were tested for reliability. The *market driven* factor (α =.603) had acceptable reliability, but the *conventional modern farming* factor (α =.421) had unacceptable reliability. Thus, Lesotho's highlands resulted in an interpretable one-factor solution.

Lesotho Comparisons and Summary. Lesotho's agroecologies produced factor structures that were both similar and unique. Across lowlands, foothills, and highlands, farmers in Lesotho are highly concerned with market dependence. This is interesting, not only because the *market driven* factor varies slightly by agroecology, but also because the highlands, which are much more remote than lowlands and foothills, still appear to grow crops with the intention of selling. "Crops should only be grown for sale**"** was a dominating item across agroecologies and both the lowlands and foothills agree that "earning off-farm income is more important than a large harvest." More discerning is that "planting decisions are always based off of current market prices" loads for the foothills and highlands, but not the lowlands. This item is a common loading for the *market driven* factor and suggests that farmers in the lowlands grow crops for sale, but lack the foresight to choose the crops that may facilitate in greater financial gains. The agroecologies of the lowlands and foothills are much more similar than the highlands, but the factor structure indicates that the foothills and highlands farmers are more similar than those in the lowlands.

Beyond this *market driven* factor of production with the intent to sell, factor structure was relatively weak in each agroecology. The lowlands appeared to have a second factor, *anti-conversation agriculture,* emerge with adequate reliability. However, when only two items load on a factor, concerns are raised whether the factor is a function of manifest item chance covariations as opposed to latent constructs. All other factors had poor reliability and were relative to the individual agroecology as no items or factors except for *market driven* loaded across agroecologies.

Kenya & Uganda

High Production. Kenya and Uganda's volcanic soil zones (see Table 11) produced two factors through six retained items. The first factor, *conventional modern farming*, contained four items that explained 22.62% of variance. Not only did this factor include all the chemical input items, but also suggested that plowing is an important component of farming practices. The second factor containing two items that explained 15.52% of variance and was considered a *mixed crop-livestock production* factor. Farmers here grow crops for sale and the crop residues are fed to livestock, essentially resulting in complete crop usage. Reliability tests indicate that the *conventional modern farming* factor (α =.609) achieved adequate reliability, but found unacceptable reliability for the *mixed crop-livestock production* factor (α =.491). The poor reliability may be due to chance covariation, especially since the crop residues to livestock variable had a low communality.

Low Production. The low production zones in Kenya and Uganda had three factors emerge across six items. The first factor, *conventional modern farming*, accounted for 16.61% of variance, the second factor, *agrarian driven,* accounted for 13.72% of variance, and the final factor accounted for 9.49% of variance. The *conventional modern farming* factor contained two items that relied on chemical pesticides and inorganic fertilizer to increase production. Growing the most on one's land and planting staple crops support the *agrarian driven* mindset that many farmers consider important. The third factor contained two items consisting of one positive and one negative item loading. No conceptual basis exists between preserving land for future generations and increasing food production over buying. Moreover, preserving land for future generations had cross loadings on all three factors, though not significantly high enough to drop the item. These two items were considered to have chance covariation and were dropped from future analyses. The best factor structure emerged with only four of the twenty initial items and two of the four items loaded on their factors below the .6 threshold. Cronbach's alpha indicated that the *conventional modern farming* factor (α =.477) and *agrarian driven* factor (α =.459) loadings are below the required threshold for meaningful interpretation.

Kenya & Uganda Comparisons and Summary. Kenya and Uganda were unique in that only a one-factor solution emerged in the high production villages and no-factor solution emerged in the low production villages. The *conventional modern farming* factor was important to both high production and low production farmers, but was only interpretable for farmers in the high production villages. Perhaps this is due to the small number of item loadings on each factor as chemical pesticides and inorganic fertilizer are important to all villagers. Yet, the high production villages also value herbicides and mechanization inputs, including those that facilitate plowing. The volcanic soil may require more aeration due to compacted soils compared to the low production zones' sandier soils.

The items that loaded on the remaining factors were unique to each agroecology. No reliable scales were produced on any of the secondary or tertiary factors. Thus, inferences as to the latent structure of any other factors are not recommended. The items within each factor are likely correlations of manifest agricultural practices and do not share an underlying factor structure.

Discussion

The framework of the Agricultural Production Perspectives Scale (APPS) was one of the first of its kind to attempt to define and quantify production mindsets. The purpose of this study was to psychometrically assess the APPS and identify latent factors that could be compared cross culturally. Moreover, the current study provided a data analytical approach to item relationships and loadings within countries and across agroecologies.

Findings indicate that some factors tend to emerge across agroecologies. The most prominent factor across agroecologies is the *market driven* perspective. The *market driven* factor emerged in every agroecology of Mali and Lesotho. However, no such factor emerged in Kenya or Uganda. Primarily, this is a three-item factor that focuses on growing crops for sale, basing planting decisions on market price, and earning supplemental off farm income. These items do not necessarily emerge together in every agroecology. For instance, farmers in the lowlands do not respond to market price on planting decisions. This may be due to a framework that relies on rugged individualism. Most perplexing is the positive correlation in Lesotho's highlands of a *market driven* factor with growing the most on one's land. In itself, crop production could increase crops available for sale, but growing the most on one's lands loads on an *agrarian driven* factor in two other agroecologies. This item represents the issue when comparing factors across agroecologies: some items emerge on different factors depending on the agroecology.

Other factors emerged less successfully. The *agrarian driven* factor was identified in three agroecologies, but was only reliable in Mali all-weather road villages. Planting staple crops and growing the most on one's land were important to various agroecologies. Other items loaded on this factor as a function of the local agroecology. *Mixed crop-livestock production* emerged in Mali's Diallassagou & Lagassagou and Kenya and Uganda's Kapchorwa & Trans-Nzoia. This agricultural perspective is important where livestock are a livelihood and provide farming diversification to minimize risk. The *conventional modern farming*, that which utilizes chemicals and machinery to maximize production, was only found across Kenya and Uganda and in Lesotho's highlands. Kenya and Uganda consider these inputs important, regardless of agroecology. As such, it is likely that external agents have provided inputs in the past and introduced these methods that facilitate crop growth and reduce pests. Lesotho's highland farmers may consider these inputs important because the soil composition has less than ideal growing conditions and these farmers must travel a large distance to acquire inputs, creating the perception of value for seemingly scarce items.

From a qualitative perspective, there appear to be latent constructs across agroecologies. Farmers are often driven by market-based needs, rely on the chemicals and machinery of conventional agriculture, subsist in a risk-averse culture, or diversify crops and livestock for sustainability. This is meaningful because it indicates that agroecologies may shape the importance of these factors in each region or village. As such, this is meaningful for agents trying to change farmers' mindsets to conservation agriculture practices because these agents can address the farmers' current belief systems and needs.

Psychometrically, only the *market driven* factor should be considered across agroecologies. Other factors and item loadings are too varied to produce meaningful comparisons. Even mean level comparisons of similarly named factors are not recommended. These factors may have similar names, but the items within each factor themselves are dependent on the agroecology. For instance, the high production zones of Kenya and Uganda believe in plowing, herbicides, and machinery, whereas the low production zones do not. Although chemical pesticides and inorganic fertilizer are valued in both of these production zones, one could not meaningfully say that these are equivalent *conventional modern farming* factors.

Overall, findings suggest that no measurement structures persist across agroecologies within country. Scale-level comparisons across different agroecologies could not be assessed because the measurement structure did not support these comparisons. Items loaded according to the populations sampled and do not reflect items that can be cross-culturally compared.

Seven agroecologies were assessed across four countries in sub-Saharan Africa. Using exploratory factor analysis, I identified factor loadings within each agroecology that produced reliable structure to identify if farmers answered questions as a function of their respective agroecology. Although this does not allow for cross-cultural comparisons, it would allow for future comparisons across villages or farmers within an agroecology. Moreover, it would indicate if there are *items* that are important within all agroecologies and *factors* that emerge across agroecologies.

From the APPS, six items failed to load on any factors across agroecologies, likely due to poor item wording or lack of variance in that agroecological perspective. Five items loaded on at least one factor across agroecologies, but were unable to achieve good scale reliability. Finally, nine items loaded and produced good scale reliability in at least one agroecology. [Table 13] provides a comparative view of the factors by items across agroecologies.

Agroecologies should not be compared because the EFAs indicate no clear latent variables emerge across agroecologies. The APPS was developed based on three latent agroecological frameworks: conventional agriculture, risk averse agriculture, and conservation agriculture. In its current rendition, the latent constructs did not emerge according to these agroecological frameworks. However, some items loaded on factors across various agroecologies suggesting some indicators of farming attitudes exist. As factor loadings were not equivalent across agroecologies, a latent structure might not actually exist. The scale may not be a sign of latent attitudes, but reflection of samples of behavior.

Signs and Samples. One common point of contention towards scale construction asks whether items should act as signs or samples of behavior. Cronbach suggested that *signs* or indicators are an individual's predisposition to behave in certain ways (Cronbach, 1960). As such, items should reflect individual differences that affect behavior. The other school of thought, proposed by Wernimont and Campbell (1968) explained that signs were often haphazardly thrown into models until something useful was uncovered, and proposed that focusing on meaningful samples of behaviors would be more useful as predictors of future performance/outcomes.

In the case of the APPS, the items appear to be more representative of samples of behavior. Scales can be used to measure behavior when the samples of behavior chosen have good content and criterion validity. However, items on the APPS did not load according to conservation agriculture, conventional agriculture, and risk averse agriculture frameworks. That is not to say the APPS is not useful. Although the scale may not be useful as a latent construct predictor, it is a valuable instrument as a samples of behavior approach.

Agroecological research can be pursued in two directions. One approach would involve identifying latent indicators that different sets of farmers hold and creating items that reflect these attitudes, in short – a signs-based approach. The alternative approach would involve questions that sample behaviors of farming practices. The current framework did not produce consistent latent variables for signs. The APPS also did not sample behavior because farmers were asked overall perspectives on ideologies. Work should be done to frame the questions as attitudes if taking a signs approach or frame the questions as actual behaviors if pursuing the samples of behavior approach. Each would provide a purer measure of the constructs for the survey and recommendations are outlined below.

Recommendations for Signs-Based Scale Approach. Scales that are comprised of items to measure latent variables are considered to be a signs approach. Signs are quite common in attitude and personality scales. In the case of agricultural frameworks, items would have to be created to measure latent variables that reflect conservation agriculture, risk averse agriculture, and conventional agriculture. These items should question attitudes that lead to each agricultural framework. For instance, modern agriculture believes that "applying chemical pesticides is always necessary." Multiple items could ask about attitudes towards chemical pesticides with positive and negative outcomes. Thus, a revised scale for this item may state (1) I think chemical pesticides facilitate in crop growth (2) I would use chemical pesticides regardless of the consequences (3) If finances are tight, I would take out a loan to purchase chemical pesticides and (4) chemical pesticides would greatly improve my farm and outputs.

Recommendations for Sample-Based Scale Approach. Behavioral samples often demonstrate an individual's ability to perform a job, but does not assess an individual's maximum potential. For instance, a smallholder can demonstrate their current farming practices but cannot necessarily assess how these farming practice may operate if the smallholder had optimal soil and water conditions with unlimited inputs. Therefore, a samples approach might not be useful for testing if frameworks shift from a modern or risk-averse agricultural approach to a conservation agriculture approach. It can, however, reveal consistently practiced farming behaviors.

Pursuing behavioral samples would allow for specification of three agricultural perspectives as outlines by Lamb & Moore (2009). The questions from the APPS are relative samples of behaviors and require surface-level revisions to more accurately reflect an individual's behaviors. For instance, "one should maintain a permanent crop cover" would be translated to an individual's behavioral practices, and not attitudes about a behavior. Thus, a revised question might posit "our farm maintains a permanent crop cover every year." These work sample questions would be introduced to farmers and analyses could be run on the questions as an item-bank. Those that produce high discriminant validity and strong factor loadings could be retained and categorized by agricultural behavior practices.

Limitations

The results indicate that countries and agroecologies are confounded. In large part, this may be a function of the questions themselves. When running the analyses, item loadings were weak, suggesting low systematic variance. Factors did not emerge across agroecologies, but items could be compared across local villages or local farmers. This cross-comparison issue likely occurs because the APPS is more reflective of individual farming practices and not scale items that reflect latent mindsets.

Sampling methodologies were also of concern. Random sampling is the best strategy for obtaining a population representative sample. However, random sampling is difficult in the real world and other strategies are often employed. Mali, for instance, used opportunistic sampling by targeting farmers from a list provided by the village chief. Lesotho used cluster sampling to obtain a list of households to survey. In the Bungoma region of Kenya, researchers interviewed farmers previously worked with and expanded to those farmers' friends.

Another methodological issue that prevented cross-country comparisons was the data collection process in Lesotho. A pilot study in Lesotho found that respondents always answered questions in the extremes (agree/disagree). None appeared to understand the "somewhat agree" or "somewhat disagree" responses or, at least, did not feel uncertainty in any responses to garner such a response. This in itself was not problematic. However, researchers decided to change the

5-point Likert scale to a 3-point Likert scale allowing only responses of “agree”, “neutral”, or “disagree.” As such, variance was reduced, and Lesotho data could not meaningfully be compared to data in Kenya, Uganda, and Mali due to scale construct issues.

Many factors shape agricultural production frameworks. Within-person variation, individual attitudes, peer influence and advice, rainfall, soil composition, input accessibility, motivation orientation, gender, and agroecology may all play roles in an individual’s attitudes and behaviors towards agricultural production methods. We need a better handle on the sources of variation to better understand what attributes meaningfully influence these perspectives.

Implications and Future Directions

The findings of this study have implications for future research in cross-cultural research. Federal grants are a necessary tool for researchers to continue providing useful research, but grant reviewers want a one-size-fits-all approach to increasing farming production, while simultaneously reducing land degradation across the world. Although the APPS experienced scale issues, it provided data showing that farming approaches are culturally influenced and silver bullet approaches will not be efficacious.

Further work will need to investigate the role of gender in agroecological frameworks. Exploratory analyses have found that women have more relationships with other farmers and with non-farm agents (e.g. village chief, NGO agents, etc.) in the community than do men. If ideologies are influenced by relationships, than it is likely that women’s frameworks may vary from men’s frameworks, which would be indicative of some of the low scale reliabilities achieved.

Future research, as expressed by Chan (2000), requires that in new applications, a measure for another culture should be developed with item sets representative of that culture's content domain. Then item sets should be presented to samples from both the culture that developed the scale (e.g. university researchers) and the local culture (e.g. farmers). This should provide a methodological approach to examining causes of measurement invariance such as cultural relativity or sensitivity of specific terms (Vandenberg, 2002).

Ultimately, it is in the best interests of researchers to create and utilize both an attitudinal scale and a behavior sampling approach. This may require improving the *communicative competence* or linguistic knowledge (grammatical and social) of researchers and extension agents to communicate better with farmers. Two scales that measure similar constructs will provide convergent validity towards farmers' attitudes and behaviors toward farming practices. Moreover, as attitudes and behavioral intent are not great predictors of behavioral practices, the scales constructed will provide incremental validity to one another. This should facilitate in learning which attitudes are consistent with behaviors and which attitudes do not reflect actual behavioral practices – a key area needed to decipher how to change behavioral intention into practices.

Conclusion

The current study was an attempt to validate the only quantified scale of agricultural frameworks. The goal was to ascertain item and factor loadings that could be compared across agroecologies within countries, and lead to future directions of between country comparisons. Items were answered as a function of the agroecology and not recognized as widely adopted agricultural frameworks or cognitive perspectives. As such, validation of the APPS did not prove fruitful, but these analyses indicate that agroecologies influence respondents' agricultural frameworks. The implications for this study suggest that the scale should be reconstructed through a signs or sample based approach to more accurately reflect latent mindsets or behavioral practices, respectively.

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Table 1: Agricultural Production Perspectives Scale

Conservation Agriculture

1) Land is one's heritage to be preserved for future generations
2) One should maintain a permanent crop cover
3) Timely weeding (before setting of seed) is important to a successful harvest
4) Tillage causes land degradation
5) Rotating crops is always best practice

Conventional Agriculture

6) Farm income should always be reinvested to grow the business
7) Applying chemical pesticides is always necessary
8) Inorganic fertilizer is best to improve soil quality
9) Planting decisions are always based off of current market prices
10) Crops should only be grown for sale
11) One should always strive to grow the most on one's land
12) Land preparation for crop production begins with plowing

Risk Averse Agriculture

13) Farm labor should be replaced by more efficient herbicides and machines
14) Engaging in multiple productive activities is always better than doing just one
15) It is better to grow staples within the household or community than purchase them
16) Farm production is necessary to feed the family
17) Spreading crops and inputs across multiple plots is always necessary
18) Crop residues should only be fed to livestock and poultry
19) The staple crop should be planted on the majority of land every growing season
20) Earning off-farm income is more important than a large harvest

Table 2: Sample Population Interviewed by Country, Agroecology, and Gender

Country	Agroecological Production Zone	Males	Females	Total
Mali	All-Weather Road Access	58	60	118
	No All-Weather Road Access	60	60	120
Lesotho	Lowlands	37	59	96
	Foothills	53	103	156
	Highlands	53	107	160
Kenya & Uganda	High Production	85	92	177
	Low Production	81	94	175

Table 3: Mali's Factor Structure across Villages

	Factor		
	Market Driven	Mixed Crop-Livestock Production	Conventional Modern Farming
Planting Decisions are Always Based off of Current Market Prices	**.728**	-.086	-.068
Crops Should Only be Grown for Sale	**.746**	-.039	.021
Earning Off-Farm Income is More Important than a Large Harvest	**.567**	.134	.070
Inorganic Fertilizer is Best to Improve Soil Quality	.018	**.768**	.011
Timely Weeding is Important to a Successful Harvest	-.151	**.400**	.102
Crop Residues Should Only be Fed to Livestock and Poultry	.178	**.492**	-.130
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	-.157	.168	**.807**
Applying Chemical Pesticides is Always Necessary	.180	-.139	**.472**

Note: Mali total sample (n=238)

Table 4: Lesotho's Factor Structure across Villages

	Factor	
	Market Driven	Conventional Modern Farming
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	.153	**.431**
Applying Chemical Pesticides is Always Necessary	-.020	**.488**
Inorganic Fertilizer is Best to Improve Soil Quality	-.167	**.524**
Planting Decisions are Always Based off of Current Market Prices	**.500**	.201
Crops Should Only be Grown for Sale	**.863**	-.204
Earning Off-Farm Income is More Important than a Large Harvest	**.434**	-.036

Note: Lesotho total sample (n=412). Lesotho scores were originally "1" disagree "2" neutral "3" agree but were changed to "1" disagree "3" neutral "5" agree to mirror scores of Kenya, Uganda, and Mali. Comparisons should be made with caution as these are more extreme scores missing the somewhat categories that a "2" and "4" generate.

Table 5: Kenya and Uganda's Factor Structure across Villages

	Factor	
	Conventional Modern Farming	Mixed Crop-Livestock Production
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	**.470**	-.025
Applying Chemical Pesticides is Always Necessary	**.580**	-.081
Inorganic Fertilizer is Best to Improve Soil Quality	**.507**	.080
Crops Should Only be Grown for Sale	.137	**.764**
Crop Residues Should Only be Fed to Livestock and Poultry	-.147	**.511**

Note: Kenya and Uganda total sample (n=352)

Table 6: Factor Structure of Mali's Villages with All-Weather Road

	Factor	
	Agrarian Driven	Market Driven
Land is One's Heritage to be Preserved for Future Generations	**.863**	.131
One Should Always Strive to Grow the Most on One's Land	**.568**	-.142
Timely Weeding is Important to a Successful Harvest	**.660**	-.031
The Staple Crop Should be Planted on the Majority of Land Every Growing Season	**.700**	.008
Crops Should Only be Grown for Sale	-.123	**.519**
Earning Off-Farm Income is More Important than a Large Harvest	.085	**.701**

Note: All-Weather Road villages (n=118) include: Koporo-pen (n=59) and Oro (n=59)

Table 7: Factor Structure of Mali's Villages with No All-Weather Road

	Factor	
	Market Driven	Mixed Crop-Livestock Production
Land is One's Heritage to be Preserved for Future Generations	**-.623**	.050
Planting Decisions are Always Based off of Current Market Prices	**.856**	.073
Crops Should Only be Grown for Sale	**.786**	-.116
Earning Off-Farm Income is More Important than a Large Harvest	**.614**	.079
Inorganic Fertilizer is Best to Improve Soil Quality	-.103	**.899**
Crop Residues Should Only be Fed to Livestock and Poultry	.068	**.637**

Note: No All-Weather Road villages include: Diallassagou (n=60) and Lagassagou (n=60)

Table 8: Factor Structure of Lesotho's Lowland Villages

	Factor		
	Market Driven	Anti-Conservation Agriculture	Agrarian Driven
It is Better to Grow Staples Within the Household or Community than Purchase Them	**-.519**	.182	-.020
Crops Should Only be Grown for Sale	**.869**	.134	-.070
Earning Off-Farm Income is More Important than a Large Harvest	**.517**	.047	.057
Crop Residues Should Only be Fed to Livestock and Poultry	.061	**.932**	-.079
Land Preparation for Crop Production Begins with Plowing	-.027	**.532**	.064
The Staple Crop Should be Planted on the Majority of Land Every Growing Season	.039	-.017	**.509**
Farm Income Should Always be Reinvested to Grow the Business	-.038	.035	**.754**

Note: Lowlands (n=96) includes: Ha Rasekila (n=37) and Maloseng (n=59). Lesotho scores were originally "1" disagree "2" neutral "3" agree but were changed to "1" disagree "3" neutral "5" agree to mirror scores of Kenya, Uganda, and Mali. Comparisons should be made with caution as these are more extreme scores missing the somewhat categories that a "2" and "4" generate.

Table 9: Factor Structure of Lesotho's Foothill Villages

	Factor	
	Market Driven	*(2)*
Planting Decisions are Always Based off of Current Market Prices	**.617**	.142
Crops Should Only be Grown for Sale	**.716**	-.182
Earning Off-Farm Income is More Important than a Large Harvest	**.473**	-.114
It is Better to Grow Staples Within the Household or Community than Purchase Them	-.187	**.667**
Applying Chemical Pesticides is Always Necessary	.054	**.517**

Note: Foothills (n=156) include: Ha Tabolane (n=82), Joala Baholo (n=41), and Mokotjela (n=33). Lesotho scores were originally "1" disagree "2" neutral "3" agree but were changed to "1" disagree "3" neutral "5" agree to mirror scores of Kenya, Uganda, and Mali. Comparisons should be made with caution as these are more extreme scores missing the somewhat categories that a "2" and "4" generate.

Table 10: Factor Structure of Lesotho's Highland Villages

	Factor	
	Market Driven	Conventional Modern Farming
Planting Decisions are Always Based off of Current Market Prices	**.914**	.183
Crops Should Only be Grown for Sale	**.467**	-.245
One Should Always Strive to Grow the Most on One's Land	**.449**	.054
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	.132	**.418**
Inorganic Fertilizer is Best to Improve Soil Quality	-.137	**.698**

Note: Highlands (n=163) include: Mafika Lisiu (n=59), Ha Sefako (n=60), Manoeleng (n=20), Ha Mou (n=15), and Pharmong (n=9). Lesotho scores were originally "1" disagree "2" neutral "3" agree but were changed to "1" disagree "3" neutral "5" agree to mirror scores of Kenya, Uganda, and Mali. Comparisons should be made with caution as these are more extreme scores missing the somewhat categories that a "2" and "4" generate.

Table 11: Factor Structure of Kenya and Uganda's High Production Villages

	Factor	
	Conventional Modern Farming	Mixed Crop-Livestock Production
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	**.634**	-.036
Applying Chemical Pesticides is Always Necessary	**.592**	-.191
Inorganic Fertilizer is Best to Improve Soil Quality	**.442**	.115
Land Preparation for Crop Production Begins with Plowing	**.562**	.027
Crops Should Only be Grown for Sale	.215	**.843**
Crop Residues Should Only be Fed to Livestock and Poultry	-.190	**.431**

Note: High Production Villages (n=177) include: Kapchorwa (n=98) and Trans-Nzoia (n=79)

Table 12: Factor Structure of Kenya and Uganda's Low Production Villages

	Factor		
	Conventional Modern Farming	Agrarian Driven	(3)
Applying Chemical Pesticides is Always Necessary	**.704**	-.042	-.096
Inorganic Fertilizer is Best to Improve Soil Quality	**.482**	-.029	.068
Land is One's Heritage to be Preserved for Future Generations	.248	.316	**-.568**
It is Better to Grow Staples Within the Household or Community than Purchase Them	.061	.090	**.520**
One Should Always Strive to Grow the Most on One's Land	-.098	**.575**	-.174
The Staple Crop Should be Planted on the Majority of Land Every Growing Season	.002	**.610**	.328

Note: Low Production Villages (n=175) include: Tororo-Uganda (n=93) and Bungoma-Kenya (n=82)

Table 13: Factor Table by Item, Agroecology, and Factor Label

	Mali All-Weather Road	Mali No All-Weather Road	Lesotho Lowlands	Lesotho Foothills	Lesotho Highland	Kenya & Uganda High Production	Kenya & Uganda Low Production
1) Land is one's heritage to be preserved for future generations	**Agrarian Driven**	**Market Driven (-)**					
2) One should maintain a permanent crop cover							
3) Timely weeding (before setting of seed) is important to a successful harvest	**Agrarian Driven**						
4) Tillage causes land degradation							
5) Rotating crops is always best practice							
6) Farm income should always be reinvested to grow the business			Agrarian Driven				
7) Applying chemical pesticides is always necessary						***Conventional Modern Farming***	Conventional Modern Farming
8) Inorganic fertilizer is best to improve soil quality		**Mixed Crop-Livestock**			Conventional Modern Farming	***Conventional Modern Farming***	Conventional Modern Farming

		Production					
9) Planting decisions are always based off of current market prices		**Market Driven**		***Market Driven***	***Market Driven***		
10) Crops should only be grown for sale	Market Driven	**Market Driven**	***Market Driven***	***Market Driven***	***Market Driven***	Mixed Crop-Livestock Production	
11) One should always strive to grow the most on one’s land	**Agrarian Driven**				***Market Driven***		Agrarian Driven
12) Land preparation for crop production begins with plowing			***Anti-Conservation Agriculture***			***Conventional Modern Farming***	
13) Farm labor should be replaced by more efficient herbicides and machines					Conventional Modern Farming	***Conventional Modern Farming***	
14) Engaging in multiple productive activities is always better than doing just one							
15) It is better to grow staples within the household or community than purchase them			***Market Driven (-)***				

16) Farm production is necessary to feed the family							
17) Spreading crops and inputs across multiple plots is always necessary							
18) Crop residues should only be fed to livestock and poultry		**Mixed Crop-Livestock Production**	***Anti-Conservation Agriculture***			Mixed Crop-Livestock Production	
19) The staple crop should be planted on the majority of land every growing season	**Agrarian Driven**		Agrarian Driven				Agrarian Driven
20) Earning off-farm income is more important than a large harvest	Market Driven	**Market Driven**	***Market Driven***	***Market Driven***			

Note: The 20 APPS items are in the first column. The first row contain the seven different agroecologies analyzed in this study. Factors in the table are named according to their factor label. Bolded factors have good reliability (α >.7), bolded and italicized factors have adequate reliability (.7>α >.6), and plain text factors had an unreliable factor structure (α <.6). A factor with a minus sign (-) after the factor indicates the item negatively loads on the factor.

Table 14: Item Means and Standard Deviations by Agroecology in Mali

	Mali All-Weather Road		Mali No All-Weather Road	
	Mean	SD	Mean	SD
Land is One's Heritage to be Preserved for Future Generations	4.795	.4055	4.807	.3965
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	3.923	1.1534	4.092	1.0167
Engage in Multiple Activities	4.397	1.1181	4.605	.7037
Farm Income Should Always be Reinvested to Grow the Business	4.573	.5464	4.605	.6407
Maintain Permanent Vegetative Cover	4.319	.5532	4.458	.6749
It is Better to Grow Staples Within the Household or Community than Purchase Them	4.855	.3539	4.874	.3333
Applying Chemical Pesticides is Always Necessary	3.462	1.1412	3.933	.7448
Farm Production Feeds Family	4.560	.6226	4.773	.4947
Inorganic Fertilizer is Best to Improve Soil Quality	3.638	1.1527	3.782	1.1583
Spread Crops and Inputs Across Multiple Plots	4.172	.8675	4.462	.6077
Planting Decisions are Always Based off of Current Market Prices	1.778	1.0180	1.436	.6484
Timely Weeding is Important to a Successful Harvest	4.353	.7010	4.336	.6415
Crops Should Only be Grown for Sale	1.291	.5423	1.361	.5783
Crop Residues Should Only be Fed to Livestock and Poultry	3.414	1.3518	3.765	1.2934
Tillage Causes Land Degradation	3.293	1.1943	3.118	1.2900
One Should Always Strive to Grow the Most on One's Land	4.707	.4758	4.739	.4408
Staple Crop Should be Planted Every	4.684	.4670	4.588	.5882
Crop Rotation is Best Practice	4.250	.7086	4.319	.6369
Land Preparation for Crop Production Begins with Plowing	3.205	1.1784	3.581	1.0524
Earning Off-Farm Income is More Important than a Large Harvest	1.470	.7260	1.479	.9553

Table 15: Item Means and Standard Deviations by Agroecology in Lesotho

	Lesotho Lowlands		Lesotho Foothills		Lesotho Highlands	
	Mean	SD	Mean	SD	Mean	SD
Land is One's Heritage to be Preserved for Future Generations	4.979	.2041	5.000	0.0000	4.988	.1567
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	4.292	1.3911	4.154	1.4904	4.227	1.5287
Engage in Multiple Activities	4.563	1.1681	4.744	.9563	4.644	1.1093
Farm Income Should Always be Reinvested to Grow the Business	4.708	1.0044	4.718	.9758	4.620	1.1451
Maintain Permanent Vegetative Cover	4.688	.9326	4.538	1.1324	4.337	1.3709
It is Better to Grow Staples Within the Household or Community than Purchase Them	4.792	.8934	4.731	.9925	4.632	1.1598
Applying Chemical Pesticides is Always Necessary	4.625	1.0588	4.731	.9662	4.693	.9834
Farm Production Feeds Family	4.854	.7252	4.872	.6693	4.755	.9368
Inorganic Fertilizer is Best to Improve Soil Quality	4.396	1.3336	4.603	1.1454	4.558	1.1764
Spread Crops and Inputs Across Multiple Plots	4.688	1.0189	4.705	1.0362	4.460	1.3158
Planting Decisions are Always Based off of Current Market Prices	3.229	1.9000	3.269	1.9155	2.988	1.9309
Timely Weeding is Important to a Successful Harvest	4.958	.4082	4.974	.3203	4.951	.4417
Crops Should Only be Grown for Sale	1.979	1.6669	2.013	1.6924	1.724	1.4878
Crop Residues Should Only be Fed to Livestock and Poultry	2.479	1.7946	2.667	1.8849	2.914	1.8902
Tillage Causes Land Degradation	3.917	1.6135	3.346	1.8479	2.890	1.8359
One Should Always Strive to Grow the Most on One's Land	3.854	1.7591	3.564	1.8428	4.055	1.6676
Staple Crop Should be Planted Every	4.688	1.0594	4.833	.7856	4.644	1.1314
Crop Rotation is Best Practice	4.979	.2041	4.718	.9214	4.644	1.0164
Land Preparation for Crop Production Begins with Plowing	3.333	1.8955	3.500	1.8682	4.006	1.6832
Earning Off-Farm Income is More Important than a Large Harvest	2.208	1.6791	2.359	1.7596	2.497	1.8100

Note: Lesotho scores were originally "1" disagree "2" neutral "3" agree but were changed to "1" disagree "3" neutral "5" agree to mirror scores of Kenya, Uganda, and Mali. Comparisons should be made with caution as these are more extreme scores missing the somewhat categories that a "2" and "4" generate.

Table 16: Item Means and Standard Deviations by Agroecology in Kenya & Uganda

	KU High Production		KU Low Production	
	Mean	SD	Mean	SD
Land is One's Heritage to be Preserved for Future Generations	4.733	.6522	4.237	1.1405
Farm Labor Should be Replaced by More Efficient Herbicides and Machinery	3.307	1.3595	3.467	1.0692
Engage in Multiple Activities	4.385	.7798	4.353	.6501
Farm Income Should Always be Reinvested to Grow the Business	4.176	.7984	4.018	.8398
Maintain Permanent Vegetative Cover	3.075	1.1730	2.693	1.0264
It is Better to Grow Staples Within the Household or Community than Purchase Them	4.574	.6548	4.108	1.0756
Applying Chemical Pesticides is Always Necessary	3.190	1.3701	3.455	1.0738
Farm Production Feeds Family	4.439	.7724	4.188	.9914
Inorganic Fertilizer is Best to Improve Soil Quality	2.872	1.3315	3.329	1.2780
Spread Crops and Inputs Across Multiple Plots	3.391	1.2754	3.892	.7787
Planting Decisions are Always Based off of Current Market Prices	3.455	1.3599	2.841	1.2431
Timely Weeding is Important to a Successful Harvest	4.352	1.0258	4.563	.8750
Crops Should Only be Grown for Sale	2.097	1.1228	1.679	1.0359
Crop Residues Should Only be Fed to Livestock and Poultry	2.948	1.2130	2.267	1.0426
Tillage Causes Land Degradation	3.529	1.2724	3.063	1.0535
One Should Always Strive to Grow the Most on One's Land	3.734	1.2050	3.451	1.2904
Staple Crop Should be Planted Every	3.949	1.0628	4.030	1.0674
Crop Rotation is Best Practice	4.580	.6364	4.488	.6961
Land Preparation for Crop Production Begins with Plowing	4.239	.7170	3.822	1.1107
Earning Off-Farm Income is More Important than a Large Harvest	2.671	1.2157	2.388	1.3094