Farmer Preferences for Attributes of Conservation Agriculture in Eastern Uganda

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Abstract: Conservation agriculture has many potential benefits for small farmers. This study seeks to estimate the value that farmers in eastern Uganda place on some these benefits. Data from a choice experiment study are analyzed with a mixed logit model to determine farmers' willingness to pay for increases in maize yield, reductions in erosion, and reductions in land preparation labor requirements. It finds that farmers have a statistically significant willingness to pay for increases in yield and reductions in erosion, but not for reductions in planting labor. In addition, farmers in Kapchorwa district value erosion control and labor reductions more and price increases less than in Tororo district, while women care more about price increases than men do.

Dedication

This thesis is dedicated to my parents.

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Chapter I. Introduction

I.1. Sustainability and the Potential Role for Conservation Agriculture

For over 10,000 years, humans have practiced agriculture. While this development has allowed populations to soar, its impact on the Earth itself has not always been positive, often resulting in a variety of environmental consequences such as soil erosion and loss of fertility. It can appear at times that human societies are destined to conflict with their environments and that economic development necessarily leads to destruction of the Earth's resources. However, researchers, producers, and consumers around the world are working together to avoid this conflict.

Before knowing how to fix the Earth's problems, it is necessary to understand in more detail what they are. It is estimated that each year, the world loses an average of .38 millimeters of topsoil, and that this is expected to grow in the coming decades (Yang et al., 2003). Soil erosion is a particular problem on smallholder farms in developing countries, as these farms are often on marginal, low-productivity land (Pimentel, 2006). Soil erosion increases water and nutrient runoff and decreases the water-holding capacity of the soil, which decreases productivity (Pimentel, 2006). Although soil erosion occurs naturally, human activity exacerbates the problem. Yang et al. (2003) estimate that 60% of the Earth's soil erosion is due to human activity, and that soil erosion will increase by 14% in the next one hundred years due to both climate change and increased land use.

Soil fertility is partly determined by soil organic matter. Organic matter consists of plant residues, living microbial biomass, active organic matter known as detritus, and inactive organic matter known as humus. Healthy, productive soil is typically between three to six percent organic matter. (Cornell University Cooperative Extension, 2008). The breakdown of organic matter releases phosphorus and other nutrients into the soil. The humus is primarily responsible for soil structure, soil tilth, and cation exchange capacity. When soil is tilled, organic matter is exposed to the air and decomposes rapidly, making the soil less productive and vulnerable to erosion (Ohio State University Extension.) Thus, human activity, particularly agriculture, is responsible for at least some of the loss of global soil fertility.

Human- induced climate change is a relatively new environmental phenomenon. While the Earth's climate has always fluctuated, its rate of change in recent decades has alarmed scientists around the globe. Carbon and other greenhouse gasses act as heat traps that affect the transfer of energy in the atmosphere. As humans today burn fossil fuels to heat their homes, run their factories, and drive their cars (among other activities), this releases greenhouse gasses into the atmosphere. Atmospheric carbon is increasing by a rate of 4 billion mt per year, and this increase is coming from fossil fuel, biotic, and soil pools. The Earth's temperature has increased since 1880, with the warmest 10 years occurring in the last 12 years, and the number of extreme weather events has increased, as well. Because of the Earth's warming, global sea levels have risen 6.7 inches in the last 100 years as ice sheets and glaciers melt (NASA).

Agriculture both affects and is affected by climate change. Industrial agriculture burns fossil fuels in a variety of ways, from the manufacture of fertilizers to the operation of tractors. Even traditional agriculture releases carbon into the atmosphere. Carbon makes up approximately 57% of organic soil matter (Ohio State University Extension), and most soils have a maximum sink capacity of 20 to 50 million mt per hectare (IFPRI, 2009). When the land is tilled, some of this carbon is transferred from the soil to the air. This transfer of carbon to the atmosphere exacerbates climate change and leads to a decrease in soil fertility. In turn, climate change is affecting agriculture throughout the world by increasing extreme weather events, decreasing rainfall in many places, and reducing the availability of surface water. This can leave farmers more vulnerable to drought and displacement.

Fortunately, there are ways to manage agriculture so as to minimize or even reverse its negative effects. Proper farming techniques can increase levels of organic matter to 60-70% of their natural levels (Ohio State University Extension). Some of these management techniques include reduced tillage, rotation of crops with perennial grasses or legumes, and the establishment of legume cover crops. These techniques are part of a management approach known as conservation agriculture. According to the FAO (2014), conservation agriculture is "an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment." Reduced tillage lowers erosion and mineralization rates, rotation reduces erosion and builds up organic soil matter from the decomposition of roots, and legume cover crops provide nitrogen to the soil, an important factor in the decomposition of organic matter (Cornell University Cooperative Extension, 2008). Conservation agriculture provides ways to increase positive eco-system services that agriculture can provide. In addition to food, fiber, and fuel, agriculture delivers many of these services, such as water filtration. Just as agriculture can be managed in such a way to increase yields of food, it can be managed in ways that increase eco-system services (Swinton et al., 2007). Many such services, including soil conservation, are non-market services, meaning farmers cannot sell them directly to make a profit, although they may increase short or long term productivity.

There is another potential benefit to conservation agriculture, one that helps farmers far less directly. This benefit is that of carbon sequestration. Just as certain management practices can decrease carbon levels in the soil, others can increase them, as well. Carbon sequestration is “the process by which atmospheric carbon dioxide is taken up trees, grasses, and other plants through photosynthesis and stored as carbon in biomass…and soils” (USDA, 2007). Plants around the globe photosynthesize approximately 120 billion mt of atmospheric carbon per year. Fossil fuel emissions and land use conversion emit approximately 9.6 to 10.8 billion mt per year. According to IFPRI (2009), if approximately 8% of photosynthesized carbon could be retained within the ground, this could entirely offset the amount being emitted by human uses.

Conservation agriculture may be able to increase carbon soil sequestration by maintaining a positive balance between carbon inputs (from photosynthesis and application of manure) and outputs (from erosion and degradation) into the soil. Conservation agricultural techniques have the potential to increase soil carbon rates from 100kg/ha per year in warm, dry regions to 1,500 kg/ha per year in colder or temperate regions. Worldwide, cropland soils could sequester .4 billion to 1.2 billion mt of carbon per year (IFPRI, 2009).

Carbon sequestration in agricultural lands has more potential on degraded land or land farmed using extractive practices for long periods. Essentially, the more carbon that soil has lost, the higher the amount that can be added back into it. The regions of the world that have lost the most soil carbon include Sub-Saharan Africa, South and Central Asia, the Caribbean, Central America, and the Andean regions (IFPRI, 2009). IFPRI (2009) calls soil carbon sequestration a “win-win” strategy that can mitigate climate change, improve the environment, increase agricultural productivity, and enhance food security. While IFPRI appears optimistic about this possibility, recent evidence suggests there is not much of a sequestration advantage to conservation agriculture (Stevenson et al., 2014), but research continues to be conducted on this matter.

Conservation agriculture therefore has the potential to provide significant benefits to both farmers and the world. In addition to increasing fertility, reducing erosion, and sequestering carbon, conservation agriculture can reduce fuel and labor requirements for farmers, improve water infiltration and retention, making land more resilient to floods, droughts, and extreme weather variability, reducing hypoxia in nearby coastal ecosystems, and increased soil biodiversity (FAO, 2014). Regardless of carbon sequestration ability, conservation agriculture could still have a role in mitigating climate change for many of the world's farmers through other ecosystem service provision.

Unfortunately, there are many reasons why farmers may not want or be able to adopt conservation agriculture techniques. One compelling reason is that even scientists are uncertain about their impacts. In addition, although conservation agriculture may improve the environment and potentially help farmers in the long run, many farmers cannot bear the risk of decreased yields in the short run. Because many of the ecosystem services provided by conservation agriculture are nonmarket services, it is unclear if or by how much farmers value them.

Farmers living in poverty may be particularly unable to afford the risk and short-term losses of conservation agriculture. They may, however, be the ones with the most to lose if their land becomes degraded. For these reasons, scientists and economists are researching how conservation agriculture affects soil fertility and farmer livelihoods, respectively. The Sustainable Agriculture and Natural Resource Management Innovation Lab (SANREM IL) employs development economists and natural resource scientists around the globe "to increase smallholders' agricultural productivity and food security through improved cropping systems that contribute to and take advantage of improved soil quality and fertility" (SANREM IL). SANREM's focus is on small farms in developing countries, which could have great potential and need for the benefits of conservation agriculture.

One of the countries in which the SANREM IL operates is Uganda. Specifically, SANREM works in the districts of Tororo and Kapchorwa. Tororo is a hot, dry, flat district about a four hour drive from Kampala, the nation's capital, while Kapchorwa is a cooler, mountainous district about five hours from Kampala. Both districts are characterized by a rural, agricultural population growing both for home consumption and for sale in the marketplace. Farmers in these regions, particularly in Kapchorwa, as soil erosion is generally highest in mountainous regions, have a high potential to benefit from conservation agriculture. Extension workers funded by SANREM are currently informing farmers of the benefits of conservation agriculture and instructing them on its methods. According to the 2011 SANREM Annual Report, researchers have found that soil disturbance is a factor of traditional farming methods in East Africa and that conservation was a new concept to most farmers participating in the project.

I.2. Problem Statement

Conservation agriculture may provide many benefits in the long and short run to farmers. However, the value of many of these services is not directly measurable through markets. If international organizations and governments wish to increase the adoption of conservation techniques, they must first determine how farmers value the services these provide. Non-market goods and services are difficult to place a value on, because there are no prices for them. Economists have developed a number of tools to overcome this problem, which all require more effort than simply observing a market price.

Policy makers who wish to promote conservation agriculture would benefit from knowing how much, if at all, farmers value the non-market goods and services that conservation agriculture provides. By estimating the premium farmers will pay for an agricultural technique that, for instance, decreases soil erosion, it will provide information on the likelihood that they will adopt. If policy makers choose to implement carbon contracts or some other payment-for-environmental-services scheme, it will help to determine how high payment levels will need to be.

This knowledge can also help extension workers to know how to market conservation agriculture and how to develop new methods of conservation agriculture in which local farmers will be interested. While the basic methods of conservation agriculture always include minimum tillage, maintaining consistent ground cover, and rotating crops, there is some flexibility in how these are done. For example, in Tororo, farmers and extension workers have found that using mucuna, a leguminous plant not typically eaten due to its need to first be processed, as a cover crop is a better way for farmers to maintain ground cover than to retain crop fodder on their fields, as neighbors will often collect the fodder from surrounding fields for use in cooking. Extension workers need conservation agriculture methods compatible with local conditions and preferences.

I.3. Objectives

This paper will use a choice experiment survey to estimate how farmers in Tororo and Kapchorwa districts in Uganda value different potential attributes of conservation agriculture.

The main objectives of this study are as follows:

1. To estimate Ugandan farmers' willingness to pay for increases in maize yield, measured in 100KG bags. Although yield increases are a market good, it will be helpful to know if farmers value them at the market rate or at some higher or lower rate.
2. To estimate willingness to pay for a fifty percent decrease in erosion, and an "almost total" decrease in erosion.
3. To estimate Ugandan farmers' willingness to pay for a decrease of land preparation labor.
4. To determine if preferences vary randomly and/or by socioeconomic and farming characteristics such as location, gender, and education level.

I.4. Hypotheses

1. Farmers will have a positive willingness to pay for increases in yield.
2. Farmers will have a positive willingness to pay for a decrease in soil erosion.
3. Farmers will have a positive willingness to pay for a decrease in land preparation labor requirements, as this will give farmers more free time for leisure and/or other farming or wage-earning tasks.
4. Farmers in Kapchorwa will place a greater value on decreases in erosion than Tororo farmers because Kapchorwa is a more mountainous region and erosion is generally a larger problem in mountainous regions compared to flat regions. Farmers who have practiced methods of conservation agriculture in the past will value erosion control more highly than those who have not. Men and women will have the same preferences.

I.4. Procedures and Data

This study uses data from a choice experiment survey administered to farmers in Tororo and Kapchorwa districts in Uganda in the summer of 2013 to determine farmer preferences for different attributes of conservation agriculture. While the precise outcomes of conservation agriculture are as of yet unknown, this study provides important information as to the likelihood that farmers may be to adopt, given different outcomes.

I.5. Organization of Thesis

This thesis is organized into six chapters. Chapter two provides background information about Uganda and a literature review of studies regarding conservation agriculture outcomes, barriers to adoption of conservation agriculture, and prior choice experiment studies done to estimate farmer preferences. Chapter three outlines survey development and data collection procedures. Chapter four describes the econometric models used to estimate the data. Finally, chapter five gives the results of the models and chapter six concludes with recommendations for extension workers and suggestions for further research.

Chapter II: Background and Literature Review

II.1. Uganda Background

Prior to British colonization during the 19th century, the area that is now Uganda was made up of different tribes, the largest being the Baganda. Geographic boundaries were made when the British created the Uganda Protectorate, which existed from 1894-1962. In 1962, the country won its independence, which was followed by decades of dictatorial rule. Most of the country has been relatively stable since the late 1980's, though there has been continued violence in the northern parts of the country.

Today, there are over thirty ethnic groups living in Uganda. The official language is English, though local languages are still dominant throughout most of the country. Staple foods vary somewhat by tribe and include matoke, made from a variety of banana, posho, made from cornmeal, and kalo, a sticky bread made from millet and cassava flour. About 12% of the population is Muslim, 41% Catholic, 42% Protestant, 3.1% other, and .9% none. Uganda is the 37th most populated country in the world, with about 35 million people in 2009. The capital city is Kampala, home to 1.54 million people (CIA, 2013). As of 2012, 84% of the population lived in a rural area (World Bank, 2013).

II.1.2 Climate

Uganda is located on the equator, and thus has a tropical climate, though some areas are cooler due to high elevation. Average temperature in the coolest, mountainous regions, is 20 degrees Celsius and in the warmest region, 25 degrees Celsius. The country has two rainy seasons, one from October to December and one from March to May. Mean average temperatures have increased 1.3 degrees Celsius since 1968, with the number of hot days increasing and the number of cold days decreasing (Lizcano et al., 2008).

II.1.3 Development

In 2012, the United Nations Development Program (UNDP) gave Uganda a Human Development Index (HDI) of .456, ranking it the 161st most developed country in the world out of 186 countries (UNDP, 2013). Health indicators are particularly bad. It has the world's 22nd highest infant mortality rate and the 37th highest maternal mortality rate. It has the 10th highest prevalancy of HIV/AIDS, the 8th highest total number of individuals living with HIV/AIDS, and an appallingly low life expectancy of 55.38 years, ranking it 208th out of the 223 countries counted by the CIA (CIA, 2013).

The country is also very young and is growing rapidly. It has the 3rd highest birthrate in the world and the 5th highest population growth rate. Nearly 50% of the country's population is under 15 years old, and the median age is 15.5 years (CIA, 2013).

The people of Uganda have low incomes contributing to high rates of poverty. The poverty headcount ratio of people living under $1.25 a day in 2009 was 38%; for $2.00 a day it was 64.7%. The poverty headcount at the national poverty line was 24.4% in 2009, which was down from 38.8% in 2002 (World Bank, 2013).

II.1.4 Economy

The total GDP (purchasing power parity) of Uganda in 2012 was $50.27 billion. Purchasing power parity takes into consideration different costs of goods and services in different countries. It has the 206th highest GDP (purchasing power parity) per capita, at $1,400 (CIA, 2013). Its currency is the Ugandan Shilling, which has an inflation rate of 14% (CIA, 2013). At the time of data collection, summer 2013, the official exchange rate was approximately one US dollar to 2,500 shillings. Agriculture makes up 24.4% of the GDP, manufacturing is 26.5%, and services is 49.3%. In 2012, the industrial growth rate was 3% (CIA, 2013). Its main agricultural products in order of production quantity are plantains, cassava, maize, sweet potatoes, fresh milk, beans, coffee, beef and pork (FAO, 2013). Its biggest industries are sugar, brewing, tobacco, cotton textiles, cement, and steel production (CIA, 2013).

Uganda's exports were worth $2.804 billion in 2012 and its imports were worth $5.187 billion. Its main exports are coffee, fish and fish products, tea, cotton, flowers, horticultural products, and gold. Its biggest export partners are Kenya (12.8%), Rwanda (10.7%), UAE (9.9%), Democratic Republic of the Congo, Netherlands, Germany, and Italy (CIA, 2013). Its biggest imports are capital equipment, vehicles, petroleum, medical supplies, and cereals, and it imports mainly from Kenya (16.6%), UAE (14.5%), China (12.3%), India (11.3%), and South Africa (4.2%) (CIA, 2013).

Uganda has a labor force of 16.49 million people. Of these, 82% work in agriculture, 5% in industry, and 13% in services (CIA, 2013).

II.1.5 Agriculture

Given its share of the labor force and GDP, the agriculture sector is crucial to Uganda. About 70% of its land is agricultural land. Cereal yields, in kg/hectare, are 2,029, which is roughly the same as the total average for all "low income" countries (2,034), though much higher than Sub-Saharan Africa as a whole (1,361) and less than half of that of "high income" countries (4,645) (World Bank, 2013). In 2009, fertilizer consumption was 2.08 kg/hectare of arable land, compared to 11.48 in all of Sub-Saharan Africa and 21.56 in all low income countries (World Bank, 2013).

The Uganda Ministry of Agriculture, Animal Industry, and Fisheries Agricultural Census of 2008/2009 reports that 19.3 million people live in agricultural households, which make up 3.94 million agricultural households in the country. Of these, .91 million household members are a member of a farmers group, .68 million households have been visited by an extension worker, and .38 million households had accessed credit (fewer than 10%). As for technology use, .03 million households used irrigation, 3.4 million used hoes, .03 million used tractors, and 3.3 million used local seeds (Uganda Ministry of Agriculture, Animal Industry, and Fisheries, 2011). These statistics paint a picture of a traditional, low-input agricultural sector.

Growth in the agricultural sector in recent decades has been primarily due to increased area under cultivation, rather than increased productivity per unit of land. Input use is low overall, though higher for households with lower amounts of land per household member (IFPRI, 2008). Production is dominated by subsistence. About one quarter of households sell less than 4% of their produce on the market, and one quarter sell more than 50% on the market, with the rest falling in the middle (World Bank, 2011).

II.1.6 Soil Loss and Infertility

Soil erosion and loss of fertility are major problems throughout much of Sub-Saharan Africa, although a wide range of estimates of their extent can be found in the literature. Areas with high population density and relatively fertile soils, as in Uganda, are experiencing particularly high rates of degradation, especially on lands farmed by the poor (Nkonya et al., 2008). Nkonya et al. (2008) surveyed and measured nutrient inflows and outflows in farm plots throughout Uganda. Most plots had a net outflow of resources. The average nutrient depletion of nitrogen, phosphorus and potassium, combined, across all regions was 179 kg/ha/year. They then used an Economic Nutrient Depletion Ratio (ENDR) model to estimate the economic loss of this nutrient depletion. ENDR measures the share of farm income that would be required to purchase the nutrients that were lost. The farm shares range from one third of annual income for northern farmers to 11% of income for farmers in the Mt. Elgon region. They find that the average depletion rate across nutrients is 1.2% per year in the top 20 centimeters of soil.

Lufafa et al. (2003) use a GIS-based Universal Soil Loss model to predict rates of soil erosion in the Lake Victorian basin of 93 t $ha^{-1} year^{-1}$ for annual cropland. They find, unsurprisingly, that erosion was highest on slopes, followed by summits, and lowest in valleys.

II.2 Overview of Relevant Literature

A number of recent studies have examined the need for new, more sustainable agricultural technologies in Sub-Saharan Africa and other developing countries, and many others have attempted to determine whether conservation agriculture could be one of these technologies.

While agriculture is clearly an important sector in African economies, productivity rates have lagged those in other parts of the world, and the continent suffers from low soil fertility and soil nutrient depletion (Yu and Nin-Pratt, 2011). Mineral fertilizer is 2-6 times more expensive in Sub Saharan Africa than it is in Europe, North America, or Asia, and Africans as a whole are not replenishing nutrients with fertilizer or manure. Low-tech “knowledge intensive” technologies, such as agro-forestry may be more efficient and appropriate in Africa than Green Revolution technologies (Sanchez, 2002). Conservation agriculture qualifies as a knowledge intensive technology, but before pursuing it there needs to be proof that it can improve outcomes for farmers in developing countries. Fortunately, a number of studies have examined the issue.

II.2.1. Effectiveness of Conservation Agriculture and Other Sustainable Methods in Developing Countries

Researchers in the Philippines conducted a study comparing soil quality under different farming practices. They took soil samples from study plots that were farmed using different management techniques at different depths over time. They found that soil in plots under conservation agriculture had a significantly higher residual moisture content than did the conventionally farmed plots. Of all CAPS treatments, fallowing resulted in the highest residual moisture content (Ella et al., 2012).

The University of Zimbabwe conducted a similar study that examined the impacts of conservation agriculture on soil organic carbon (SOC) and maize yields. They compared soil types that they categorized as “conventional tillage”, “undisturbed or natural”, and “conservation agriculture,” of which there were three different types, and found organic carbon levels to be highest in the undisturbed or natural soil (1.85%) and lowest in the conventional tillage soil (.46%). They found that, within the conservation agriculture categories, maize yield was correlated with soil organic carbon. They conclude that long term use of conservation agriculture can improve maize yield and that this is due to an improvement in organic carbon matter (Gotosa et al., 2011).

A study in Mozambique found that conservation agriculture using a maize-sunflower-bean rotation had a higher rate of water infiltration than other conservation techniques and conventionally tilled plots. However, they did not find any significant difference in maize yield or in soil parameters (organic matter, nitrogen and phosphorus levels) between the conservation and conventional plots (Famba et al., 2011).

Brunner et al. (2008) studied farmer perceptions of soil quality and effects of management practices on soil loss in Uganda. Their study area was the village of Magada, located in south east Uganda, near Lake Victoria. They used the Water Erosion Production Project (WEPP) model to estimate what effects different land management methods had on soil conditions. They examined different tillage options on seven representative types of land: summit, upper shoulder, lower shoulder, upper backslope, lower backslope, footslope, and valley. The tillage options were traditional tillage (the researchers in this study called it "conservation tillage," but it does not indicate reduced tillage but rather hand-hoe ploughing typically practiced), residue management, in which crop residue is put on or left in the field, and contour farming, which involves ploughing parallel to the contour lines of the slope, and mechanized tillage. They found that soils tended to be of higher fertility and suffered less from soil erosion at the summit and valley sites as compared with sites at higher slope gradients. The researchers found differences in soil loss for different management systems. Soil loss under traditional tillage ranged from 1.5 to 9 t ha^{-1}, while under high tech tillage by chisel plough it ranged from 10.1 to 112.8 t ha^{-1}. While high-tech tillage was not practiced by the farmers, this clearly shows that type of tillage has an impact on soil erosion. On average, annual soil losses were 2 t ha^{-1} for conventional tillage, .3 t ha^{-1} with residue management, 1.9 t ha^{-1} with contouring, and 46.7 t ha^{-1} with high-tech tillage. Variances changed by slope gradient, with steeper slopes seeing a higher different between conventional tillage and residue management.

Despite these findings, some researchers are skeptical of the effects of conservation agriculture. Giller et al. (2009) point out that much of the most convincing research on conservation agriculture has been undertaken in the US, where farmers typically have access to and apply herbicides and fertilizers. They note that without these, conservation agriculture may increase weeding labor requirements. In addition, there has been little adoption within Sub-Saharan Africa. Ultimately, they call for more research focused specifically on conservation agriculture within Africa.

Recently, the Journal of Agriculture, Ecosystems and Environment published an issue focusing on conservation agriculture in developing countries. An editorial article in the issue written by James R. Stevenson et al. (2014) discusses the main findings of the issue, and explains the "Nebraska Declaration" for conservation agriculture. The authors conclude that given the evidence, yield increases under conservation agriculture are uncertain, and more likely to occur after a few years of implementation than immediately. In addition, although initially there was enthusiasm about the potential of conservation agriculture leading to greater soil carbon sequestration, recent research that uses improved analytical methods has not found this to be the case. Carbon contracts therefore are unlikely to be implemented, though payment for other "public good" type ecosystem services may be possible. In particular, conservation agriculture does appear to lead to less soil erosion and greater water infiltration. The Nebraska Declaration calls for more research on the effects of conservation agriculture and on barriers to adoption.

II.2.2. Barriers to Adoption and How to Overcome Them

There could exist barriers to farmers adopting conservation agriculture. Farmers may not know how conventional methods mine soil fertility, or they may rationally choose to degrade their soil, unable to sacrifice short-term yields for long-term viability.

II.2.2.a. Payment for Environmental Services Contracts

Payments for environmental services contracts could be a way for policy makers to overcome these barriers to adoption. These work by paying farmers to adopt a practice that has public good environmental benefits. They reduce the pressure for new farming methods to be profitable in the short-run, creating incentives for farmers to adopt and reap long term benefits. They could be extremely beneficial for farmers in developing countries. One type of contract that has emerged in North America and Europe is carbon contracts (Young, 2003). Antle et al. (2007) found that carbon contracts could be very helpful to farmers in developing countries. With carbon prices above $50 per MgC, adopting terracing and agroforestry (two types of farming practices that have the potential to increase soil carbon sequestration) could raise per capita incomes by 15% on steep farms and reduce poverty by 9% in the Peruvian Andes. As stated above, recent evidence does not suggest there is greater carbon sequestration under conservation agriculture than under conventional farming methods. Payment contracts for other environmental services, such as erosion control, could still be possibilities. Unfortunately, there are several challenges to implementing these contracts, including potentially high administrative and enforcement costs.

II.2.3. Farmer Willingness to Adopt

If farmers are willing to adopt conservation agriculture on their own, however, payment for environmental services contracts and other incentive programs do not need to be implemented. There is hope in Uganda and other developing countries that this could be the case.

Prior research demonstrates that most farmers in developing countries are aware of soil fertility and erosion problems and are willing to devote resources to dealing with these problems. In a workshop of farmers in eastern Uganda, Brunner et al. (2008) found that the farmers were able to identify strong indicators of erosion, such as erosion rills, although not weaker signs, such as root exposure. A 2004 study by Asrat et al. found that, out of 100 farmers sampled in Ethiopia, 30 stated that they were willing to contribute money for soil conservation practices and 60 stated they were willing to contribute labor to participate in soil conservation practices. The education level of the household head, the farmer's perception of soil erosion hazard, awareness of soil conservation techniques, and attitude towards soil conservation were all positively correlated with willingness to pay at a 10% significance level (Asrat et al., 2004). Birungi and Hassan (2007) report that, of a sample of farmers from several districts in Uganda, 27.9% use traditional methods of enhancing soil fertility such as fallowing, and 47.8% of farmers report observing nutrient problems. They found that the use of inorganic fertilizer and the practice of fallowing increase the probability of having fertile soils, though the impact of inorganic fertilizer was not statistically significant. Higher rates of education and the availability of non-farm income increase the probability of a farmer reporting no erosion and decrease the probability of reporting mild and severe erosion.

Duncan Knowler and Ben Bradsaw have conducted a review of recent literature regarding the adoption of conservation agriculture and found that there are few variables that explain adoption across the board. There are many variables that significantly explain adoption in at least one study, including awareness of erosion, concern for environmental threats, soil erosion rate, prices of inputs and outputs, and income. Some variables, such as level of education and steepness of slopes, are found significant in several but not all studies. Some variables, such as age and farm size, are found positively correlated to adoption in some studies but negatively correlated in others. Given the lack of consistency, Knowler and Bradshaw conclude that promotion of conservation should be tailored to individual locations rather than people who fit a certain profile (Knowler and Bradshaw et al., 2007).

Adoption rates of conservation agriculture will depend both on how conservation agriculture performs in different localities and on how farmers value its benefits. More research is needed on both fronts. SANREM IL is an interdisciplinary research program funded by the

United States Agency for International Development (USAID). Some of its many goals are to increase income generation of farmers in developing countries, to improve soil quality, and to promote sustainable development. The program consists of four cross-cutting research activities (CCRA's), which are Soil Quality and Carbon Sequestration, Economic and Impact Analysis, Gendered Knowledge, and Technology Networks for Conservation Agriculture. SANREM currently operates in thirteen countries throughout Africa, Latin America, and Asia. It seeks to fill in the blanks of research in conservation agriculture; namely, how will conservation agriculture techniques change soil quality and yields, and ultimately how will they impact farmers' lives.

One project funded by SANREM was Agricultural Actors, Networks and Mindsets: Discovering the predisposition for CAPS in the Mt Elgon region of Uganda and Kenya by Moore et al. (2012). Researchers sampled 395 households in Uganda and Kenya to determine farmers' attitudes toward different farming practices, and if contact with an extension agent had an impact on attitudes. They found that the vast majority of farmers agreed with the statement "rotating crops is best practice." Of farmers with extension agent contact, 27.1% agreed with the statement "one should maintain a permanent cover crop," compared to 24.3% of farmers without extension contact, though this difference was not statistically significant. By contrast, 73% of service sector/community agents agreed with this statement, which was significantly different than the farmers' responses. These levels of agreement were much lower within Kapchorwa district, though; only 17.5% of farmers without contact and 20% with contact agreed, compared to 73.7% of service sector/community agents. In Tororo, the values were 29.6% for farmers without contact, 20.5% for farmers with contact, and 80.0% for service sector/community agents. For the statement "tillage causes land degradation," 48.4% of farmers with extension contact, 39.2%

of farmers without extension contact, and 62.2% of service sector/community agents agreed, though there were no statistically significant differences in these levels. Of the four districts surveyed (Tororo and Kapchorwa, and two sectors in Kenya), farmers in Kapchorwa exhibited the highest level of agreement with this statement; 50.9% of farmers without contact and 62.5% with contact agreed that tillage causes land degradation. By comparison, 31.5% of farmers without contact and 46.2% of farmers with contact agreed with the statement. Kapchorwa farmers' responses to this question were significantly different from the responses of the other districts.

II.2.4. Choice Experiments on Farmer Preferences

This study uses a choice experiment to evaluate farmer's willingness to pay for different attributes of conservation agriculture. The data are analyzed with a mixed logit model. A choice experiment is a type of discrete choice model in which respondents give preferences for different choices that contain varying levels of attributes. This paper will give more detail on choice experiments and logit models in chapters three and four.

Many other studies in recent years have used the choice experiment format and different types of logit models to examine preferences for ecosystem services in both developed and developing countries. Birol and Das (2012) find that citizens of Chandernagore, India have a positive and significant willingness to pay for improved wastewater quality. Garcia-Llorente et al. (2012) use a multinomial logit and a mixed logit model to examine preferences for land-use options in the Nacimiento watershed in Spain. Agimass and Mekonnen (2011) studied willingness to pay for fisheries management in Ethiopia and found that Ethiopian fishermen have a positive willingness to pay for management improvements. Kragt and Bennett (2011) examine community preferences for natural resource management in Tasmania. Like this study, Kragt and

Bennett use a mixed logit model with interaction terms to analyze how socio-economic variables influence preferences for different attributes. Otieno et al. (2011) use a choice experiment to examine preferences of cattle farmers for different types of disease-free zones in Kenya.

This study adds to the array of choice experiment studies conducted in recent years on valuation of agricultural nonmarket services, with a focus on conservation agriculture in Uganda.

Chapter III. Survey Development and Data Collection

III.1. Explanation of Choice Experiment Format

This study uses a choice experiment to elicit farmers' valuation of yield increases of maize, decreases in soil erosion, and decreases in days spent doing land preparation. A choice experiment is a type of discrete choice model in which respondents are asked to choose between different alternatives that contain differing levels of different attributes. In discrete choice models, the set of alternatives, or the choice set, must be mutually exclusive and exhaustive. The number of alternatives must also be finite (Train, 2003). By asking a series of such questions, it is possible to determine how each individual attribute impacts the likelihood that the respondent will make a particular choice.

III.2. Survey Development

A choice experiment survey requires attributes and levels of attributes that are relevant and realistic. The initial stages of survey development therefore consisted of research on possible outcomes of conservation agriculture. A list of potential attributes was created, including yield increase, cost increase, the inability for farmers to feed crop fodder to livestock, a change of labor requirements for weeding, and a change of labor requirements for land preparation. Upon arrival in Uganda, the survey was discussed with students at Makerere University in Kampala and employees of the NGO, Appropriate Technology (AT) Uganda, which helps farmers in Tororo and Kapchorwa district to adopt sustainable agricultural techniques, including conservation agriculture. The organization operates a test farm and works with farmer collaborators to test the effectiveness of conservation agriculture in the region, and receives funding from SANREM. These discussions helped refine the wording of the survey and the levels of the attributes.

Pilot testing occurred in early June, 2013 in Tororo district with farmers who were known to AT Uganda staff. Farmers explained that in Tororo, crop fodder is so often taken by neighbors or consumed by their neighbors' livestock that the prospect of not being able to use it would not be an important factor in decision making. That attribute was thus removed from the survey. Farmers and AT Uganda staff suggested erosion control as an attribute to replace crop fodder. As some farmers seemed to have difficulty understanding the choice experiment due to the large number of attributes, the questions were simplified by eliminating the weeding labor attribute. That attribute had a low value placed on it during the pilot testing.

Attribute levels were determined with the help of Makerere students and AT Uganda staff. Originally, the researcher wanted them to be based upon percentage reductions, but there was concern that farmers would have difficulty understanding this concept. Instead, concrete levels were identified with the primary goals of being easy to understand and meaningful to farmers. Final attribute levels are summarized in table 1. "Current" levels of all attributes represent the farmer's typical or status-quo level.

Table 1: Choice Experiment Attribute Levels

Attribute	Level	Value
Yield	**0**	Current Yield
	1	Current Yield Plus 100KG
	2	Current Yield Plus 200KG
Soil Erosion	**0**	Current Erosion
	1	Current Erosion Decreased by Half
	2	Current Erosion Decreased Almost Totally
Land Preparation Labor	**0**	Current Land Preparation Labor
	1	Current Land Preparation Labor Minus Two Days
	2	Current Land Preparation Labor Minus Four Days
Input Costs	**0**	Current Input Costs
	1	Current Input Costs Plus 30,000 Ush
	2	Current Input Costs Plus 60,000 Ush
	3	Current Input Costs Plus 90,000 Ush

Because some of the farmers were illiterate, the choice experiment contained pictures to the greatest extent possible. Yield attributes were depicted with one large picture of a bag, which stated "Current Yield," with one or two smaller bags, with "100 KG" written on them, as appropriate. Land Preparation was depicted with a picture of a woman hoeing a field, which represented the current land preparation labor, with "- 2 Days" or "- 4 Days" written in a box set into the picture. Input costs were depicted with a rectangle that said "Current Costs," and smaller rectangles that had "30,000 Shillings" written on them. Current erosion was a picture of a field that had soil running off of it, with six arrows pointing down, representing erosion. For half erosion, the number of arrows was decreased to three, and for near total erosion, it was reduced to one arrow. This was the most difficult attribute to depict, and was developed with the help of farmers during the pilot testing phase. Attribute pictures can be seen in Figures 1-4.

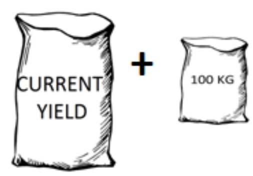
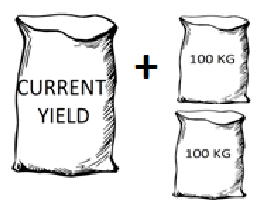
Yield Attribute	**Picture**
Current Yield	
Current Yield Plus One 100 KG Bag	
Current Yield Plus Two 100 KG Bags	

Figure 1: Yield Attributes

Soil Erosion Attribute	**Picture**
Current Level of Soil Erosion	

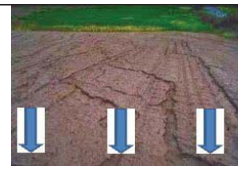
Half Decrease from Current Level of Soil Erosion	
Almost Total Decrease from Current Level of Soil Erosion	

Figure 2: Erosion Attributes

Photo from http://forages.oregonstate.edu/nfgc/eo/onlineforagecurriculum/instructormaterials/availabletopics/environmentalissues/erosion. Found 2013. Used under fair use.

Land Preparation Attribute	Picture
Current Land Preparation Labor Requirement	
Current Land Preparation Labor Requirement Minus Two Days	
Current Land Preparation Labor Requirement Minus Four Days	

Figure 3: Land Preparation Labor Attributes

Photo from http://rainerfellows.org/author/3owl/page/2/. Found 2013. Used under fair use.

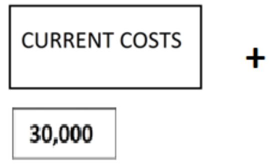
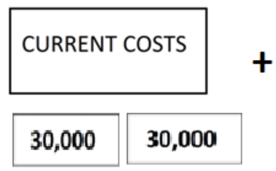
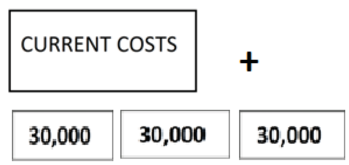
Input Cost Attribute	**Picture**
Current Input Costs	
Current Input Costs Plus 30,000 Ush	
Current Input Costs Plus 60,000 Ush	
Current Input Costs Plus 90,000 Ush	

Figure 4: Input Cost Attribute

Farmers were each given three choice sets to answer in addition to an example question that tested their understanding of the experiment. Each choice set included three options: Option A, Option B, and Option C. Option A always represented a “no change” scenario; it contained the levels of Current Yield, Current Erosion, Current Land Preparation Labor, and Current Costs. This gave farmers the option to choose their current situation over either of the choice combinations in Options B and C, which varied between choice sets to contain different levels of the attributes. Choice experiments often include a “no choice” option in order to not force respondents to choose either of the given choice combinations. Option A in this survey served that purpose.

The example question was structured identically to the regular choice sets, but had a dominant choice. A dominant choice is one that has universally "better" attribute levels. For this study, Option C was a dominant choice in the example question. If a farmer did not choose Option C, it was clear that they did not understand the question. Their surveys were therefore discarded. Figure 5 shows the example question.

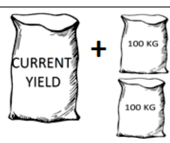
	EXAMPLE QUESTION			
	YIELD	EROSION	LAND PREPARATION LABOR	INPUT COSTS
OPTION A				CURRENT COSTS
OPTION B				CURRENT COSTS + 30,000 30,000
OPTION C				CURRENT COSTS

Figure 5: Choice Experiment Example Question

Photos from http://forages.oregonstate.edu/nfgc/eo/onlineforagecurriculum/instructormaterials/availabletopics/environmentalissues/erosion and http://rainerfellows.org/author/3owl/page/2/. Found 2013. Used under fair use.

III.3. Experimental Design

Once attributes and attribute levels were determined, the software Ngene (Choicemetrics pty ltd, 2012) was used to determine an efficient survey design (Ngene Manual, 2012). Ngene runs iterations of possible choice sets in an attempt to minimize error of the design. For this survey, Ngene was run according to D-efficiency, which minimizes d-error, or the determinant of the covariance matrix. This gives the percentage of optimality of the design (Ngene Manual, 2012). In addition, Ngene ensured that there were no dominant alternatives in the final design. A respondent's answer to this choice set with a dominant choice gives no information as to how the respondent is making his or her choice. Essentially, by using Ngene, it is more likely that respondent answers to all of the questions will provide enough information to estimate which attributes the respondents care most about.

Efficient designs aim to reduce standard errors in parameter estimates from choice experiment data. In situations when it is possible to make estimates of what the parameter estimators might be, even just what the signs will be, efficient designs are best (Ngene Manual, 2012). In this study, data from the pilot study was evaluated using a conditional logit model. The parameter estimates from this model were used as priors in the Ngene script to generate choice sets for the study. Ngene generated twenty-four choice sets, which were broken into eight blocks, or groups, so that each farmer had three choice sets to answer.

III.4. Survey Structure

The survey began with a short introduction explaining the purpose of the study, an estimate of how long it would take (one hour), and questions asking if the farmer was willing to participate, and if he/she made farming decisions for the household. If he/she did not make farming decisions, enumerators asked to speak to someone in the household who did. Following the introduction, the survey consisted of three major parts: a demographic survey, a game that measured farmers' attitudes toward risk, and finally the choice experiment section. The data collected from the risk part of the survey, however, will be used in a separate study. Thus, while risk may be an important factor in farmers' decisions in changing farming practices, it was not examined in this study.

The demographic portion of the survey collected information from the farmers such as household size, whether or not they are currently using conservation agriculture, and whether or not they view soil erosion as a problem on their land.

III.5. Data Collection

Surveys were administered in Tororo and Kapchorwa districts from June 12, 2013 through June 27, 2013. Two hundred farmers from each district were interviewed[11].

III.5.1 Study Area

III.5.1.1. Tororo District

Tororo District is located in southeastern Uganda, about 200 km east of Kampala. The district is flat and common crops are maize, cassava, bananas, and groundnuts. Farmers have two planting seasons per year. Common livestock are pigs, chickens, goats, and cows. It has a population of approximately 463,600, of which 63,225 live in urban areas. Sixty three percent of the

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[1] Although 400 farmers were surveyed between the two districts, incomplete surveys and surveys of farmers who did not grow maize were not included in the analysis. This is because the choice experiment was based on maize, and farmers who do not grow maize may not be able to properly think about maize growing decisions hypothetically. It is important that they do not simply substitute another crop in their decision-making process, as different crops will have different values; for instance, how a farmers values a 100 kg increase in maize yield could be vastly different from a 100 kg increase in potato yield.

population has access to safe water (Directorate of Water Development, Ministry of Water and Environment, 2010). Total annual rainfall in Tororo district is between 1,130 and 1,720 mm, which is bimodal and peaks in May and October. Annual temperatures range from 16 degrees Celsius to 28 degrees Celsius (Action for Development, 2005).

III.5.1.2. Kapchorwa District

Kapchorwa District is located in eastern Uganda, about 270 km northeast of Kampala. The district is mountainous and the most common crops are maize, bananas, coffee, potatoes, and barley. As the elevation rises, potatoes and barley are more common. Farmers in this district have one planting season per year. Common livestock are donkeys, chicken, and goats. It has a population of approximately 199,200, of which 12,200 are urban and 60% has access to safe water (Directorate of Water Development, Ministry of Water and Environment, 2010). Annual average rainfall varies from less than 1,000 mm in the north to 2,000 mm on the high slops of Mt. Elgon. Rainfall is heaviest from April to October. Annual average temperature is over 20 degrees Celsius in the north and slightly less in the south. Loss of soil fertility is severe on the slopes of Mt. Elgon. Although the soils here are classified as "low erodibility," farming on steep slopes and lack of conservation measures are causing severe erosion. Parish workshops of farmers in 1999 and 2004 identified loss of land productivity as the greatest problem facing agriculture in the region, and identified poor farming methods as a primary cause of the loss (Kapchorwa District Production and Environment Planning Committee, 2004).

III.5.1. Household Selection Process

The survey was first administered in Tororo District in the sub-counties of Molo and Kisoko, and then in Kapchorwa in the sub-counties of Kapchesombe and Kwosir. These sub-counties were selected because they are representative of the population in their respective districts. In each of the four sub-counties selected, ten villages were randomly selected for survey enumeration, and in each village, ten households were randomly selected. Lists of villages were provided to the researchers by the local sub-county administrative offices and lists of households were provided by local village leaders.

Three extra names were randomized for each village, so that if one of the farmers was not home or had died, he or she could be replaced. If the individual farmer whose name had been randomized was not available but his or her spouse was available, enumerators were instructed to interview the spouse.

III.6. Survey Enumeration

Ten enumerators who spoke English as well as the local language were trained and hired for administering the survey in Tororo. Once Tororo was completed, ten more enumerators who spoke both English and the local language were hired in Kapchorwa. The use of local enumerators was crucial, as most farmers in Tororo and nearly all farmers in Kapchorwa spoke no or limited English. Enumerators were hired by AT Uganda and trained by the researchers. Many of them had done data collection in the past.

Because choice experiments require a thorough understanding by respondents, and the researchers had to rely on others to do enumeration, all attempts were made to ensure that farmers made informed choices during the survey. Enumerators participated in a day-long training session which included supervised practicing of all survey sections. The example question was used as a check on understanding. If the farmer did not choose Option C (the dominant alternative), enumerators re-explained the experiment and asked the farmer to choose again. In a few cases, the farmer was unable to grasp either the concept or the hypothetical nature of the experiment, and these surveys were not included in data analysis. Enumerators were also required to ask farmers why they made each choice, to ensure that the farmer was not choosing randomly and understood each attribute. Although it was not possible to supervise every survey that was administered, three supervisors rotated in supervising enumerators one at a time to ensure that the enumerators were following each step of the survey correctly and taking their time in explaining the choice experiment section to the farmers.

Chapter IV: Methods

IV.1. Random Utility Theory

This study uses a choice experiment to determine farmers' valuations of yield increases, planting labor requirement decreases, erosion control, and input cost increases. Choice experiments are a type of discrete choice modeling. Discrete choice modeling is theoretically based upon Random Utility Theory (McFadden, 1974) and on Lancaster's theory of characteristics (Lancaster, 1966). According to Lancaster, it is not goods themselves but the attributes or characteristics of goods that provide people with utility. For example, when looking at consumer demand for cars, it is not the car itself that people are demanding, but the car's ability to provide transportation, its level of comfort, its power as a status symbol, etc.

IV.2. Farmer Utility Function

This study examines the utility that farmers derive from different attributes of farming method outcomes. Without including interaction terms, the farmer utility function is (see table 1 for definitions):

$$V_A = ASC + \beta_1(additionalyield) + \beta_2(half) + \beta_3(total) + \beta_4(labordecrease) + \beta_5(price) \quad (1)$$

Table 2: Model Variables

Variable Name	Definition/concept
ASC (Alternative Specific Constant)	Constant term estimated as a part of conditional and mixed logit models.
additionalyield	Additional 100KG bags of maize.
currenterosion	Current level of soil erosion
half	A decrease in soil erosion by 50%
total	An almost total decrease in soil erosion
labordecrease	Decrease in labor requirements
price	An increase in input prices. Can take on values of 9; 30,000; 60,000; or 90,000

The Alternative Specific Constant (ASC) acts as a constant variable and is estimated in conditional and mixed logit modeling. It controls for unobservables in the model. In the context of choice experiments, the ASC captures the difference in utility between the status quo and non-status quo options. For this project, the ASC was set to one if the respondent chose choice option B or C, and set to zero if the respondent chose A. If respondents made their choices based only on the attributes of the experiment, the ASC variable should not be statistically significant. If it is statistically significant, it means that the respondents had a systematic preference for choosing a non-status quo option. This would indicate that they were bringing to the experiment preferences for some things other than the four attributes.

Additionalyield and *labordecrease* were coded as continuous variables while *half* and *total* were coded using effects coding, which is recommended by Bech and Gyrd-Hanson (2005) when there is a status quo option in the choice experiment.

IV.3. Systematic Preference Heterogeneity

This study is also interested in the existence of systematic (as opposed to random) preference heterogeneity. In particular, this study examines how gender, farmer location, prior farming practices, age and education level affect how a farmer values erosion control. It is hypothesized that farmers who live in Kapchorwa will value decreases in erosion more highly than farmers in Tororo because Kapchorwa is a more mountainous district and therefore is more vulnerable to soil erosion. It is also hypothesized that farmers who have practiced conservation agriculture methods in the past will place a higher value on decreases in soil erosion. In order to measure how demographic variables might influence preferences, interaction terms must be added to the model. Dummy variables for district and whether or not the farmer has practiced minimum tillage, cover crops, and crop rotation are thus interacted with the choice variables.

After including interaction terms, the utility function becomes (see table 3 for definitions):

$$Va = ASC + \beta_1(\text{additionalyield}) + \beta_2(\text{currenterosion}) + \beta_3(\text{labordecrease}) + \beta_4(\text{price}) + \beta_5(\text{kapASC}) + \beta_6(\text{kapyield}) + \beta_7(\text{kaphalf}) + \beta_8(\text{kaptotal}) + \beta_9(\text{kaplabordecrease}) + \beta_{10}(\text{kapprice}) + \beta_{11}(\text{mintilASC}) + \beta_{12}(\text{mintiltotal}) + \beta_{13}(\text{coverASC}) + \beta_{14}(\text{covertotal}) + \beta_{15}(\text{rotateASC}) + +\beta_{16}(\text{rotatetotal}) + \beta_{17}(\text{genderASC}) + \beta_{18}(\text{genderyield}) + \beta_{19}(\text{genderhalf}) + \beta_{20}(\text{gendertotal}) + \beta_{21}(\text{genderlabor}) + \beta_{22}(\text{genderprice}) + \beta_{23}(\text{educationASC}) + \beta_{24}(\text{educationtotal}) + \beta_{25}(\text{ageASC}) + \beta_{26}(\text{educationprice}) + \beta_{27}(\text{ageprice}) \quad (2)$$

Table 3: Interaction Variables

Variable Name	Definition
kapASC	Interaction term between the respondent living in Kapchorwa and the ASC variable
kaphalf	Interaction term between the respondent living in Kapchorwa and the half variable
kaptotal	Interaction term between the respondent living in Kapchorwa and the total variable
kapyield	Interaction term between the respondent living in Kapchorwa and the additionalyield variable
kaplabor	Interaction term between the respondent living in Kapchorwa and the labordecrease variable
kapprice	Interaction term between the respondent living in Kapchorwa and the price variable
genderASC	Interaction term between the respondent being male and the ASC variable
genderyield	Interaction term between the respondent being male and the additionalyield variable
genderlabor	Interaction term between the respondent being male and the labordecrease variable
genderhalf	Interaction term between the respondent being male and the half variable
gendertotal	Interaction term between the respondent being male and the total variable
genderprice	Interaction term between the respondent being male and the price variable
mintilASC	Interaction term between having ever practiced minimum tillage and the ASC variable
mintiltotal	Interaction term between having ever practiced minimum tillage and the total variable
coverASC	Interaction term between having ever practiced using cover crops and the ASC variable
covertotal	Interaction term between having ever practiced using cover crops and the total variable
rotateASC	Interaction term between having ever practiced using cover crops and the ASC variable
rotatetotal	Interaction term between having ever practiced crop rotation and the total variable
educationASC	Interaction term between years of education and the ASC variable
educationtotal	Interaction term between years of education and the total variable
ageASC	Interaction term between age and the ASC variable
educationprice	Interaction term between years of education and the pricevariable
ageprice	Interaction term between age and the price variable

IV.4. Random Utility Model Estimation

Discrete choice models use random utility theory to estimate the probability that an alternative is chosen. This probability depends on the attributes of the alternative, competing options, and characteristics of each individual. The utility an individual obtains from object j can be shown:

$$U_j = V_{j+} e_j \qquad (3)$$

U_j is the total latent, unobserved, utility obtained for the individual from object j. V_j is a vector of attributes that object j contains. These attributes can be observed and measured by the researcher, so they make up the systematic component of utility. e_j is a random error component that contains unobserved factors that influence utility. It takes into account that different individuals have difference preference strengths for different attributes (Train, 2003) Logit models assume that e_j is logistically distributed and is independently and identically distributed (iid) extreme value. This means that the error term of each alternative is independent of the error terms of all other alternatives and that each error term is identically distributed.

Adamowicz et al. (1998) outline how choice experiments relate to utility theory. Utility theory predicts that each individual will maximize her utility. When applied to consumer choice, this prediction means that a consumer will choose object j when the utility she gets from j is higher than the utility she obtains from other choices. When compared to a different object choice, i, this means that she will choose option j over i when

$$U_j > U_i \, \forall \, j \neq i \qquad (4)$$

Or

$$V_j + e_j > V_i + e_i \quad \forall j \neq i \tag{5}$$

The probability of choosing object j is the following

$$prob\,\{j\ chosen\} = prob\left\{V_j + e_j > V_i + e_i \ \ \forall j \in C\right\} \tag{6}$$

Where C is the set of all possible alternatives.

It is important to note that in random utility models, the overall level of utility is irrelevant. It is only differences in utility between the available alternatives that matter (Train, 2003).

IV.5. Conditional Logit Model

In the choice experiment, the V_j contains attributes of the situation and there are three alternatives (A, B, and status quo or none of the above). Assuming iid error distributions and independence between choice scenarios and individuals, the probability of choosing alternative A becomes

$$Prob\{A\} = \frac{e^{sV_A}}{\sum_{j \in C} e^{sV_j}} \quad (7)$$

Where s is a scale parameter, usually assumed to be 1 (Adamowicz et al., 1998).

In plain English, equation 5 states that the probability of choosing object A equals the ratio of e raised to the utility of A to e raised to the utility of all choices (utility here including only the deterministic components). This is how the conditional logit model estimates how different attributes, which make up V, influence the probability of an item being chosen. The first model estimated is a conditional logit model. This model is relatively simple to estimate and it is often used in choice modeling because it models decision making as a function of the characteristics of alternatives (Hoffman and Duncan, 1988). A major drawback of the conditional logit model is that it assumes homogeneous preferences, or no random preference variation among different respondents. It also assumes Independence of Irrelevant Alternatives (IIA), which means that the probably that a respondent will choose A over B will not change if a third option, C, is introduced. These are not always realistic assumptions of how people make decisions. For this reason, a mixed logit model is also estimated.

IV.6. Mixed Logit Model

The mixed logit model, also known as the random parameter logit model, has a more flexible functional form than other logit models. It allows for heterogeneous preferences, or random taste variation. Variables can be specified as having either fixed or random coefficients, and random coefficients allow for preference heterogeneity. It also allows for unrestricted substitution patterns, relaxing the IIA assumption, and correlation between unobserved factors over time (Train, 2003). The mixed logit model also accounts for the panel nature of choice data because it includes an individual specific error term that is correlated across the choices made by a particular individual (Bateman et al., 2008). In a mixed logit model, the probabilities are the "integrals of standard logit probabilities over a density of parameters" (Train, 2003). The probability that person n will choose object A can be expressed:

$$P_{nA} = \int L_{nA}(\beta) f(\beta) d\beta \tag{8}$$

where *Lni* (*β*) is the standard logit probability evaluated at parameters β, and conditional on β:

$$L_{ni}(\beta) = \frac{e^{V_n(\beta)}}{\sum_{j=1}^{J} e^{V_n(\beta)}} \tag{9}$$

If utility is linear in β, then the mixed logit takes the form:

$$P_{ni} = \int \frac{e^{\beta' x_{nA}}}{\sum_j e^{\beta' x_{nj}}} f(\beta) d\beta \tag{10}$$

This is a weighted average of the logit formula evaluated at β's, and is not conditional on β. The weights are given by the density function f(β) (Train, 2003).

IV.7. Willingness to Pay

Mean willingness to pay can be evaluated from the coefficients of the conditional and mixed logit model. A common method for estimating WTP is to divide the attribute coefficient by the price coefficient. For the conditional logit model and the mixed logit model, when price is specified as fixed and other variables are specified either as fixed or random with normal distributions, WTP can be conducted in this manner.

$$WTP_{Attribute} = \beta_{Attribute}/\beta_{Price} \quad (11)$$

Standard errors and confidence intervals for the WTP estimates were evaluated using the Krinsky-Robbs method, which is one of a few legitimate methods for doing so (Hole, 2007a).

Chapter V: Results

V.1 Individual and Household Demographic Characteristics

Table 4: Descriptive Statistics

Demographic Characteristic	Total Sample	Tororo	Kapchorwa	P-value
Gender	Male 47.2%	47.79%	46.67%	.5501
Location	Tororo 47%			
	Molo 26.65 %			
	Kisoko 20.35 %			
	Kapchorwa 53%			
	Kwosir 29.13 %			
	Kapchesombe 23.86 %			
Age (Years)	Mean 42.43 (15.15)	45.09 (15.52)	40.09 (14.41)	0.0000
Education (Years)	Mean 5.83 (3.934)	4.98(3.86)	6.68 (3.82)	0.0000
Farming Experience (Years)	Mean 24.1 (15.94)	29.19 (17.08)	19.60 (13.33)	0.0000
Household Members	Mean 7.3 (3.16)	7.24 (3.11)	7.22 (3.12)	0.8678
Household Members who work on farm	Mean 4.17 (2.37)	4.12 (2.31)	4.21 (2.41)	0.3086
Children under 13 years of age	Mean 2.87 (1.83)	3.06 (1.94)	2.70 (1.71)	0.0000

Table gives the mean and standard deviation (in parentheses) for each variable for the total sample, and for Tororo and Kapchorwa districts. The p-values are for the test that the values in Tororo and Kapchorwa are equal.

Table 4 gives descriptive statistics of the farmers interviewed and their households. The average farmer in 42.43 years old, has 5.83 years of education. 24.1 years of farming experience, with 7.3 household members. Some variables have statistically significant differences between districts. Residents of Kapchorwa are, on average, significantly younger and better educated than those of Tororo. They also have less farming experience and fewer children, which is to be expected because they are younger, on average.

Table 5: Farm Characteristic and Farming Practice Descriptive Statistics

Farm Characteristic/ Farming Practices	**Total Sample**	**Tororo**	**Kapchorwa**	**P-value**
Acres farmed this season	2.72 (2.80)	2.78 (1.75)	2.67 (3.48)	0.3545
Acres owned this season	2.26 (2.23)	2.49 (1.71)	2.05 (2.59)	0.0000
Percentage of families growing:				
Maize	100%	100%	100%	N/A
Beans	60.74%	71.87%	50.88%	0.0000
Vegetables	51.27%	53.85%	50.88%	0.1100
Cassava	48.55%	96.04%	6.43%	0.0000
Fruits	50.01%	55.82%	45.03%	0.0000
Groundnuts	39.88%	84.84%	0%	0.0000
Potatoes	40.60%	.66%	76%	0.0000
Have you ever used/practiced ______ in the past? (% responded yes)				
Reduced tillage	24.84%	16.26%	32.54%	0.0000
Cover crops	67.56%	60.66%	73.68%	0.0000
Crop Rotation	86.59%	92.09%	81.66%	0.0000
Do you currently use/practice ______? (% responded yes)				
Reduced tillage	22.21%	11.87%	31.55%	0.0000
Cover crops	63.73%	55.09%	71.35%	0.0000
Crop Rotation	84.56%	89.31%	80.29%	0.0000
Do you view erosion as a problem on your field?	93.49%	90.11%	96.49%	0.0000
Are you doing anything to control erosion?	85.30%	85.40%	85.21%	0.8852

Table gives the mean and standard deviation (in parentheses) for each variable for the total sample, and for Tororo and Kapchorwa districts. The p-values are for the test that the values in Tororo and Kapchorwa are equal.

Table 5 gives statistics on the households' farming practice. There are also differences in farming practices between the two districts. Though they are farming the same amount of land this season, farmers in Tororo own about .5 acres more than farmers in Tororo, indicating that more land is rented in Kapchorwa. Twice as many farmers in Kapchorwa have practiced minimum tillage than those in Tororo, and over twice as many are practicing it this season. Thirteen percent more farmers in Kapchorwa have used a cover crop than in Tororo, and over 15% more are using one this season. Crop rotation, on the other hand, is more popular in Tororo. Farmers in Kapchorwa are also more likely to view erosion as a problem on their field, but farmers in both districts are equally likely to have done something to control erosion. Although this was not a question on the survey, discussions with farmers during pilot testing and data collection indicate that common erosion control techniques are planting grasses and digging trenches along the borders of fields to ease the loss of soil.

Crops grown also vary by district. Cassava, groundnuts, and fruit are more common in Tororo while irish potatoes are more common in Kapchorwa. Other crops common in Kapchorwa were coffee, barley, and wheat.

A further breakdown by county reveals some differences. Tables 6 and 7 report the variables that vary by subcounty in each district.

Table 6: Variables that Vary by Subcounty, Tororo

Demographic Characteristic	Molo	Kisoko	P-value
Education (Years)	5.22 (4.18)	5.73 (3.71)	0.0192
Farming Experience (Years)	28.36 (17.21)	30.27 (16.86)	0.0407
Acre	2.95 (1.62)	2.56 (1.88)	0.0001
Children < 13	2.88 (1.69)	3.30 (2.21)	0.0001
Have you ever practiced cover cropping?	65.12%	54.82%	0.0001
Are you currently practicing reduced tillage?	13.95%	9.14%	0.0064
Are you currentlyusing a cover crop?	58.82%	50.25%	0.0016
Are you currently practicing crop rotation?	91.67%	86.29%	0.0015

Table gives the mean and standard deviation (in parentheses) for variables that vary by subcounty for Molo and Kisoko. The p-values are for the test that the values the two subcounties equal.

Farmers in Molo, on average, have less education and farming experience, more land, and fewer children than those in Kisoko. They are also more likely to have tried all of the CA practices and more likely to be currently practicing reduced tillage.

Table 7: Variables that Vary by Subcounty, Kapchorwa

Demographic Characteristic	Kwosir	Kapchesombe	P-value
Age	38.83 (13.91)	41.64 (14.87)	0.0001
Education (Years)	5.84 (3.98)	6.59 (3.65)	0.0001
Farming Experience (Years)	18.17 (12.16)	21.34 (14.44)	0.0000
Acre	2.96 (3.60)	2.35 (3.29)	0.0006
Own	2.30 (2.99)	1.75 (1.96)	0.0000
Children <13	2.96 (1.90)	2.39 (1.39)	0.0000
Have you ever practiced crop rotation?	78.49%	85.53%	0.0004
Are you currently using a cover crop?	69.15%	74.03%	0.0353
Are you currently practicing crop rotation?	75.92%	85.53%	0.0000

Table gives the mean and standard deviation (in parentheses) for variables that vary by subcounty for Kwosir and Kapchesombe. The p-values are for the test that the values the two subcounties equal.

Farmers in Kwosir, on average, are younger, less educated, and have less farming experience, though they have more children and more land that they own and are farming this season than farmers in Kapchesombe. Kwosir farmers are less likely to have practiced crop rotation and to be currently using a cover crop or practicing crop rotation.

V.4. Conditional Logit Results

The initial conditional logit estimates found the ASC to be statistically significant at a 5% level, suggesting that farmers had a bias toward choosing the non-status-quo option regardless of the attributes presented (table 8). The variable *labordecrease* was significant at a

5% level. The variables *additionalyield*, *half*, *total*, and *price* were all significant at a 1% level. *Total* had the highest coefficient, followed by *ASC*, *additionalyield*, *half*, *labordecrease*, and finally, *price*.

Table 8: Conditional Logit Results

Conditional Logit Results	
Log Likelihood	-505.90916
Prob> chi2	0.000
Pseudo R2	.5243

Choice	**Coef.**	**Std. Err.**	**z**	**P > |z|**
ASC**	.962084	.3914618	2.46	0.014
additionalyield***	.5524878	.0835944	6.61	0.000
half ***	.244549	.0752856	3.25	0.000
total ***	1.270757	.0849406	14.96	0.000
labordecrease**	.1132927	.0466388	2.43	0.015
price *	-9.93e-06	3.04e-06	-3.27	0.001

The results from table 8 were used to compute the willingness to pay for the different conservation agriculture outcomes. All estimates of willingness to pay are statistically significant at a 5% level. The WTP for total erosion decrease is the largest, at Ush 127,968, or approximately $49. This was followed by additional yield at Ush 55,636 ($21), half erosion decrease at 24,617 ($9.50), and finally labordecrease at Ush 11,408 ($4.50).

Willingness to pay values and 95% confidence intervals are given in table 9 below. P-values are not calculated for these, simply the means and upper and lower bounds of the confidence intervals. All willingness to pay confidence intervals in this study are 95% confidence intervals. Confidence intervals estimated using the Krinsky-Robb method were done so using 15,000 simulation draws.

The IIA assumption was tested using a hausman test (Hausman and McFadden, 1984) and it was found that the assumption does not hold for this choice experiment. This indicates that the mixed logit model, which relaxes this assumption, is a more appropriate model.

Table 9: Willingness to Pay Estimates from Conditional Logit Model (in Ush, rounded to the nearest Ush)

	additionalyield	**half ***	**total ***	**labordecrease***
WTP	55,637	24,617	127,968	11,409
Lower Level	27,655	8,009	77,834	1,651
Upper Level	156,682	73,397	313,692	43,572

*= Significant at a 5% level

Conditional logit models were also used to assess differences amongst respondents for each enumerator. Conditional rather than mixed models were used for this purpose because conditional logit models have much shorter run-times. Enumerator-attribute interaction terms were included and it was found that no enumerator was systematically different from the sample coefficient means. Separate conditional logit models were also run for each enumerator. No coefficient for any enumerator model had an unexpected sign that was statistically significant. Two enumerators had very high standard errors with p-values close to one for all coefficients, which could indicate that they had not truthfully recorded correct responses, and three enumerator models would not converge. Taking these enumerators out of the final model changed wtp estimates only slightly. All model results given within the body of this paper were estimated using all enumerator responses.

V.5. Mixed Logit Results

The mixed logit model allows preferences to vary randomly for the attributes. To determine if there is preference heterogeneity, a lagrange multiplier test can be run on the conditional logit model, but it is easier and preferred to simply run a mixed logit to assess which variables, if any, have random coefficients (Hensher and Greene, 2003). Mixed logit models can be specified in a number of different ways, as different coefficients can be specified as fixed or random, and random coefficients can be given normal or lognormal distributions. The first mixed logit model was run with *price* fixed and all other variables as random with normal distributions. *Price* was initially fixed because when price is fixed and all other variables have a normal distribution, willingness to pay can be calculated using STATA's wtp command. [2]

All variables in this model are significant at the 5% level with the exception of *labordecrease*, which is significant at only 10% (table 9). In addition, they are all positive with the exception of price. In the mixed logit results, the ASC is statistically significant at the 5% level and positive. This indicates that farmers had a preference for choosing a non-status quo option other than the attributes included in the experiment. Mixed logit results also indicate whether or not each variable exhibits preference heterogeneity, depending on whether the variable has statistically significant standard deviations. Here, *half* and *labordecrease* do not have significant standard deviations, while *total* and *additionalyield* do. The fact that there is preference heterogeneity for some variables demonstrates that holding these coefficients fixed is not correct, and that therefore the mixed logit is more appropriate than the conditional logit.

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[2] The mixed logit models were estimated by simulated maximum likelihood with 1,000 Halton draws using the STATA mixlogit package developed by Arne Risa Hole (Hole, 2007b).

Table 10: Mixed Logit Model 1 Results

Mixed Logit Model 1 Results				
Log Likelihood	-465.51693			
Prob> chi2	0.000			
Pseudo R2	.07984086			
Choice	**Coef.**	**Std. Err.**	**z**	**P > |z|**
Mean				
ASC	2.984479	1.236767	2.41	0.016
additionalyield	.8242864	.1517334	5.43	0.000
half	.3797642	.11032	3.44	0.001
total	2.066139	.2219086	9.31	0.000
labordecrease	.1203984	.0717164	1.68	0.093
price	-.0000148	4.69e-06	-3.16	0.002
SD				
ASC	2.364859	.8540019	2.77	0.006
additionalyield	.7921258	.2114278	3.75	0.000
half	-.005345	.1956255	-0.03	0.978
total	1.382825	.2213965	6.25	0.000
labordecrease	.0265177	.1527894	0.17	0.862

Willingness to pay estimates are derived from the results shown in table 10 are shown in table 11. They represent willingness to pay for farm outcomes in the current season. All are significant at a 5% level except for *labordecrease*. Overall, they are similar to those of the conditional logit model except that *labordecrease* is no longer significant.

Table 11: Willingness to Pay Results from Mixed Logit Model 1 (in Ush, rounded to the nearest Ush)

	additionalyield*	**half ***	**total ***	**labordecrease**
WTP	55,584	25,609	139,325	8,119
LL	25,896	9,109	83,075	-1,012
UL	165,046	77,535	349,039	37,333

* = Significant at a 5% level

Mixed logit models with price specified as random with a lognormal distribution were also run, and wtp estimates were calculated. Price was specified to have a lognormal distribution for reasons explained in Appendix E, and also because the model would not converge if it had a normal distribution, which is the default in STATA. The price coefficient was found to have a statistically significant standard deviation, indicating that it does exhibit preference heterogeneity. Additionally, the psuedo-R^2 measure of goodness of fit is higher and the log likelihood value lower in absolute terms for the model with a random price coefficient. Output for this model can be seen in Appendix E. For the purposes of calculating willingness to pay, however, price was left specified as fixed. Revelt and Train (2000) recommend simply using a fixed price coefficient for ease of evaluating wtp estimates, to help model stability, and to avoid the problem of having to choose a distribution for the price coefficient. Sillano and de Dios Ortúzar (2005) point out that because fixed coefficients tend to smaller than random coefficients, fixing the price coefficient can result in a smaller wtp denominator, thereby inflating estimates. In the models here however, the coefficients on price when it is fixed vs. when it is allowed to be random are very similar. In addition, willingness to pay estimates from this model were nearly identical to those from the model with fixed price (comparisons are given in Table E.4 in Appendix E). Results therefore do not appear to be sensitive to different specifications of variables, which is encouraging, as correctly specifying distributions and variables as fixed or random is one of the biggest challenges of mixed logit modeling (Carson and Czajkowski, 2013). This lends more confidence to the results presented. Results from the model with a random price coefficient are presented in Table E.1 in Appendix E.

V.5.1. Interaction Terms

The mixed logit model was also estimated with interaction terms included. The purpose of including interaction terms is to see if any demographic or farming characteristic variable influences how farmers make decisions. Several interaction terms were included in the conditional logit models, and definitions can be seen in Table 3. District was interacted with half, total, yield, and price. Gender was interacted with ASC, half, total, labordecrease and price. It was hypothesized that men and women may make decisions differently in regards to choosing new farming practices, and in particular the value they place on labor savings, as woman in developing countries often do a large portion of farm labor. Education was interacted with ASC, price and total, with the thought that more educated people may be more willing to change from their status quo and to realize the benefit of erosion control while possibly being wealthier and thus being less sensitive to price. Age was interacted with ASC with the thought that older individuals may be less likely to make a change from their status quo and price. Lastly, the three farming practice variables (whether the farmer has ever practiced minimum tillage, cover crops, or crop rotation) were interacted with ASC and total. It was hypothesized that farmers who have tried these practices in the past may care relatively more about erosion or be more likely to diverge from their status quo.

Table 12: Mixed Logit with Interaction Terms Results

Mixed Logit with Interaction Terms Results				
Log Likelihood	-416.7495		N= 2796	
Prob> chi2	0.000			
Pseudo R^2	.0634381			
Choice	**Coef.**	**Std. Err.**	**z**	**P > |z|**
ASC	2.921036	2.109204	1.38	0.166
additionalyield	1.038352	.2390282	4.34	0.000
half	.370404	.1817548	2.04	0.042
total	1.495895	.4729463	3.16	0.002
labordecrease	-.1133792	.118011	-0.96	0.337
price	-.0000494	.0000162	-3.05	0.002
kapASC	-.2756169	1.376027	-0.20	0.841
kapyield	-.3304615	.2855681	-1.16	0.247
kaplabor	.267637	.1557175	1.72	0.086
kaphalf	.1879331	.2225982	0.84	0.399
kaptotal	.8829989	.3140814	2.81	0.005
kapprice	.00002	9.98e-06	2.00	0.045
mintilASC	1.947829	1.486609	1.31	0.190
mintiltotal	.2699629	.3297364	0.82	0.413
coverASC	1.334089	.7712883	1.73	0.084
covertotal	.1360318	.2836207	0.48	0.631
rotateASC	.4477901	1.087405	0.41	0.680
rotatetotal	-.0496669	.4070886	-0.12	0.903
genderASC	-1.402533	1.294103	-1.08	0.278
genderyield	.0280651	.2885142	.10	.923
genderhalf	-.0997554	.2223192	-0.45	0.654
gendertotal	-.2517827	.3005299	-0.84	0.402
genderlabor	.2389335	.1569995	1.52	0.128
genderprice	.0000287	.0000104	2.76	0.006
educationASC	-.0600653	.1134235	-0.53	0.596
educationtotal	.0385003	.0345271	1.12	0.265
ageASC	-.0200733	.0282386	-0.71	0.477
educationprice	-6.25e-07	1.03e-06	-0.61	0.543
ageprice	3.24e-07	2.51e-07	1.29	0.197
childtotal	.0265008	.0708225	0.37	0.708

SD				
ASC	1.793992	.8718672	2.06	0.040
additionalyield	.7636841	.2458459	3.11	0.002
half	.0107302	.242401	0.04	0.965
total	1.296152	.2346621	5.52	0.000
labordecrease	.0016025	.1880155	.01	.993

The only significant interactions terms at a 5% level are *kaptotal*, *kapprice*, and *genderprice*. *Kaplabor* and *CoverASC* are significant at a 10% level.

Chapter VI. Conclusions and Implications

VI.1. Coefficients and WTP

The attribute variables were statistically significant at 1 or 5% in all models run with the exception of *labordecrease*, which was significant at at least 10% in all models except for the model with interaction terms. This implies that erosion control, yield increases, and labor savings could all serve as incentives for farmers to adopt conservation agriculture.

Farmers in Tororo and Kapchorwa district have, on average, a positive and significant willingness to pay for increases in yield, as well as half and total reductions in erosion in the current season. This is encouraging for policy makers who wish to promote conservation agriculture practices. If results indicate that conservation agriculture has a positive impact on erosion control or yield, farmers may pay a premium to adopt the practices. Labor savings may serve as less of an incentive for farmers to adopt a new practice.

VI.2. ASC

The significant ASC coefficient on the conditional and mixed logit model suggests that farmers were biased toward choosing a non-status quo option while completing the choice experiment. There is something about switching from their current farming outcomes that appeals to farmers, aside from the attributes in the experiment. This could be encouraging for the spread of conservation agriculture, as it indicates that farmers are at least hypothetically interested in trying something new that will lead to different outcomes. However, when interaction terms are included in the model, the ASC is no longer significant.

VI.3. Preference Heterogeneity

Results indicate significant preference heterogeneity amongst respondents, both randomly and systematically. Random taste variation exists in the region for *total* erosion decrease, *additionalyield*, *price*, and *ASC*. Policy makers and extension workers should thus not expect all farmers to value these attributes of farming practices, and to expect some farmers to be more willing to adopt a new farming practice than others.

Taste variation varied by farmer traits, as well. Results indicate that farmers who live in Kapchorwa care relatively more about decreasing erosion and planting labor requirements and less about price increases than those who live in Tororo, as the coefficients on *kaptotal, kaplabor,* and *kapprice* were significant. This is an important result, as it indicates to both policy makers and extension workers that, if conservation agriculture decreases erosion, reduces labor requirements, or increases costs, farmers in Kapchorwa may be more likely to adopt than farmers in Tororo. This indicates that policy makers in other regions, as well, may wish to focus conservation agriculture promotion in mountainous areas. In addition, farmers who have used a cover crop in the past may be more likely to choose a new farming option compared to farmers who have not, though this was significant only at 15%. This implies that extension workers may wish to target their efforts in promoting conservation agriculture at farmers who have already tried cover cropping. Lastly, women care relatively more about price increases than do men. This indicates that women make more budget-conscious farming decisions.

Preferences of farmers of different education levels, age, and most prior farming practices do not vary systematically, indicating that these groups make farming decisions in similar ways.

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VI.5. Implications

If conservation agriculture within Tororo and Kapchorwa districts decreases erosion and/or increases yield, then the results indicate that farmers may be interested in the practices, though actual adoption will depend on many factors not included in this study, such as risk preferences. The logit model results suggest that all else equal, farmers will be more interested in a practice that decreases erosion, increases yield, or possibly that decreases labor requirements. The willingness to pay estimates indicate that farmers may even be willing to pay more in input costs to achieve these outputs.

If conservation agriculture decreases erosion and/or sequesters carbon into the soil, policy makers may have an incentive to promote its practices to obtain these environmental services. Farmers only have an incentive to adopt, however, if they benefit directly. If policy makers choose to offer a payment-for-environmental-services scheme, they would be able to offset the payment amounts by any perceived benefit of the farmers. The results of this choice experiment survey indicate that farmers perceive the environmental service of erosion control as a benefit.

VI.6. Suggestions for Future Research

Further research on the effects of conservation agriculture in the region is needed. This is ongoing by SANREM. As of early 2014, some data has been compiled regarding the comparisons of outcome of farmer practice vs. minimum and no till treatments in farmer test plots. From six test farm observations in Tororo and Kapchorwa each, minimum till practices achieved a higher average bean yield than either no till or farmer practice. Maize yield averages were highest for conventional practices in both districts in the farmer practice plots, however. More data and further research are planned for the future. As researchers become more aware about the specific benefits that conservation agriculture can provide, another choice experiment survey could be conducted in the future to reflect this updated information.

References

Zorya, S., Kshirsagar, V., Gautam, M., Odwongo, W., Verbeek, J., Sebudde, R., 2012. Agriculture for Inclusive Growth in Uganda. Inclusive growth policy note 2. The World Bank, Washington, D.C.

Choicemetrics pty ltd. 2012. *Ngene 1.1.1*.

Climate Change: How Do We Know? Earth Science Communication Team at NASA's Jet Propulsion Laboratory/ California Institute of Technology, Ponoma, CA. http://climate.nasa.gov/evidence.

Soil Organic Matter, 2008. Agronomy Fact Sheet Series Fact Sheet 41. Cornell University Cooperative Extension, Ithaca, NY. http://nmsp.cals.cornell.edu/publications/factsheets/factsheet41.pdf

Gender Budget Analysis of Tororo District, Mulanda, and Nawanjofu Subcounties 2003/2004, 2005. Action for Development, Kampala, Uganda.

Human Development Report, 2013. United Nations Development Programme, New York, NY.

FAOSTAT, 2013. edited by Food and Agricultural Association, Rome, Italy.

Conservation Agriculture, updated 2014. Food and Agricultural Association, Rome, Italy. www.fao.org/ag/ca.

Kapchorwa, 2010. Ministry of Water & Environment Directorate of Water Development, Kampala, Uganda.

Kapchorwa District State of the Environment Report 2004, 2004. Kapchorwa District Production and Environment Planning Committee.

Statistical Abstract 2011, 2011. Republic of Uganda Ministry of Agriculture, Animal Industry and Fisheries, Kampala, Uganda.

Tororo, 2010. Ministry of Water and Environment Directorate of Water Development, Kampala, Uganda.

Soil Carbon Sequestration in Conservation Agriculture, 2008. Food and Agricultural Organization, Rome, Italy.

Sustainable Agriculture, Definitions and Terms, revised 2007. United States Department of Agriculture, Washington, D.C.

World Bank Open Data, 2013. edited by The World Bank Group, Washington, D.C.

The World Factbook, 2013. edited by Central Intelligence Agency, Washington, D.C.

Adamowicz, W., P. Boxall, M. Williams, Louviere, J., 1998. Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. American Journal of Agricultural Economics 80(1), 64-75.

Agimass, F., Mekonnen, A., 2011. Low-Income Fishermen's Willingness-to-Pay for Fisheries and Watershed Management: An Application of Choice Experiment to Lake Tana, Ethiopia. Ecological Economics 71, 162-70.

Antle, J.M., Diagana, B., 2003. Creating Incentives for the Adoption of Sustainable Agricultural Practices in Developing Countries: The Role of Soil Carbon Sequestration. Agricultural and Applied Economics Association Annual Meeting, Montreal, Quebec.

Antle, J.M., Stoorvogel, J.J., Valdivia, R.O., 2007. Assessing the Economic Impacts of Agricultural Carbon Sequestration: Terraces and Agrofrestry in the Peruvian Andes. Agriculture, Ecosystems & Environment 122 (4), 435-45.

Asrat, P., Belay, K., Hamito, D., 2004. Determinants of Farmers' Willingness to Pay for Soil Conservation Practices in the Southeastern Highlands of Ethiopia. Land Degradation and Development 15, 423-438.

Bateman, I.J., Carson, R.T., Day, B., Dupont, D., Louviere, J.J., Morimoto, S., Scarpa, R., Wang, P., 2008. Choice Set Awareness and Ordering Effects in Discrete Choice Experiments. CSERGE Working Paper EDM 08-01.IIED, London, UK.

Bech, M., Gyrd-Hanson, D., 2005. Effects coding in discrete choice experiments. Health Econ 14(10), 1079-83

Bingxin, Y., Nin-Pratt, A, 2011. Agricultural Productivity and Policies in Sub-Saharan Africa. IFPRI Discussion Paper 01150. International Food Policy Research Institute, Washington, D.C.

Birol, E., Das, S., 2012. Valuing the Environment in Developing Countries: Modeling the Impact of Distrust in Public Authorities' Ability to Deliver Public Services on the Citizens' Willingness to Pay for Improved Environmental Quality. Urban Water Journal 9, 249-58.

Birungi, P.B., Hassan, R.M., 2007. Impact of Alternative Land Management Options on Soil Fertility and Erosion in Uganda. Agrekon 46 (3).

Brunner, A.C., Park, S.J., Ruecker, G.R., Vlek, P.L.G., 2008. Erosion Modelling Approach to Simulate the Effect of Land Management Options on Soil Loss by Considering Catenary Soil Development and Farmers Perception. Land Degradation & Development 19, 623-35.

Carson, R. and M. Chajkowski. A New Baseline Model for Estimating Willingness to Pay from Discrete Choice Models. Paper presented at the International Choice Modelling Conference, Sydney, June 2013.

Daly, A., Hess, S.,Train, K., 2012. Assuring finite moments for willingness to pay in random coefficient models. Transportation, Springer 39(1), 19-31.

Ella, V. B., Reyes, M., Mercado, Jr, A., 2012. Soil Quality Monitoring and Evaluation under Conventional Plow-Based and Conservation Agriculture Production Systems in Southern Philippines. Paper presented at International Conference of Agricultural Engineering, Valencia, Spain.

Famba, S. I., Loiskandl, W., Thierfelder C., Wall, P., 2011. Conservation Agriculture for Increasing Maize Yield in Vulnerable Production Systems in Central Mozambique. African Crop Science Conference Proceedings 10, 255-62.

G. Lizcano, C. McSweeney, New, M., 2008. UNDP Climate Change Country Profile, Uganda. United Nations Development Programme, New York, NY.

Garcia-Llorente, M., Martin-Lopez, B., Nunes, P., Castro, A., Montes, C., 2012. A Choice Experiment Study for Land-Use Scenarios in Semi-Arid Watershed Environments. Journal of Arid Environments 87, 219-30.

Giller, K.E., Witter, E., Corbeels, M., Tittonell, P., 2009. Conservation agriculture and smallholder farming in Africa: the heretics' view. Field Crops Research 114 (1), 23-34.

Gotosa, T., Mvumi, B.M., Nyagumbo, I., Norton A.J., Chikukura, L., 2011. Long Term Effects of Conservation Agriculture on Soil Organic Carbon and Maize Yield in Zimbabwe. African Crop Science Conference Proceedings 10, 509-14.

Hausman, J.A., McFadden, R.L., 1984. Specification tests for the multinomial logit model. Econometrica 52, 1219-1240.

Lancaster, K.J., 1966. A new approach to consumer theory, Journal of Political Economy 74.

Lal, R., 2009. Agriculture and Climate Change: An Agenda for Negotiations in Copenhagen. The potential for soil carbon sequestration. International Food Policy Research Institute, Washington, D.C.

Hensher, D.A., Greene, W.H., 2003. The Mixed Logit Model: The State of Practice. Transportation 30, 133-176.

Hoffman, S.D., Duncan, J.D., 1988. Multinomial and Conditional Logit Discrete-Choice Models in Demography."Demography 25 (3).

Hole, A., 2007(a). Fixing mixed logit models by using simulated maximum likelihood. The Stata Journal 7 (3), 388-401

Hole, A., 2007(b). A comparison of approaches to estimating confidence intervals for willingness to pay measures. Health Economics 16 (8), 827-840.

Knowler, D., Bradshaw, B., 2007. Farmers' Adoption of Conservation Agriculture: A Review and Synthesis of Recent Research. Food Policy 32, 25-48.

Kragt, M.E., Bennet, J.W., 2011. Using Choice Experiments to Value Catchment and Estuary Health in Tasmania with Individual Preference Heterogeneity. Australian Journal of Agricultural and Resource Economics 55, 159-79.

Krinsky, I., Robb, A.L., 1986. On Approximating the Statistical Properties of Elasticities. The Review of Economics and Statistics 68 (4) 715-19.

Kyomugisha, E., 2008. Land Tenure and Agricultural Productivity in Uganda. International Food Policy Research Institute, Washington, D.C.

Lufafa, A., Tenywa, M.M., Isabirye, M., Majaliwa, M.J.G., Woomer, P.L., 2003. Prediction of Soil Erosion in a Lake Victoria Basin Catchment Using a Gis-Based Universal Soil Loss Model. Agricultural Systems 76 (3), 883-94.

McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In P. Zarembka (Ed.), Frontiers in Econometrics 1, 105-142. Academic Press, Waltham, MA.

Moore, K., Lamb, J., Laker-Ojok, R., Nyachwo, J.,Ngosia Sikuku, D., Ashilenj, D.S., Juma Mukhwanaand, E., Bashasha, B., Norton, J., 2012. Agricultural Actors, Networks and Mind-sets: Discovering the predisposition for CAPS in the Mt Elgon region of Uganda and Kenya. SANREM CRSP Working Paper 03-12.

Nkonya, E., Pender, J., Kaizzi, K.C., Kato, E., Mugarura S., Ssali, H., Muwonge, J., 2008. Linkages between Land Management, Land Degradation, and Poverty in Sub-Saharan Africa the Case of Uganda. International Food Policy Research Institute, Washington, D.C.

Otieno, D., Ruto, E., Hubbard, L., 2011. Cattle Farmers' Preferences for Disease-Free Zones in Kenya: An Application of the Choice Experiment Model. Journal of Agricultural Economics 62, 207-24.

Pimentel, D., 2006. Soil Erosion: A Food and Environmental Threat. Environment, Development and Sustainability 8, 119–137.

Revelt D., Train K. E., 2000. Customer-specific taste parameters and mixed logit: Households' Choice of Electricity Supplier. Economics Working Papers E00-274, Department of Economics, University of California at Berkeley, CA.

Sillano, M. Ortúzar, J.D., 2005. Willingness-to-pay estimates with mixed logit models: some new evidence. Environment and Planning A 37, 525-550.

Sanchez, P.A., 2002. Soil Fertility and Hunger in Africa. Science, 2019-20.

Stevenson, J.R., Serraj, R., Cassman, K.G., 2014. Evaluating conservation agriculture for small-scale farmers in Sub-Saharan Africa and South Asia. Agriculture, Ecosystems and Environment 187, 1-10.

Sundermeier, A., Reeder, R., Lal, R. Soil Carbon Sequestration – Fundamentals. The Ohio State University Extension. Extension Fact Sheet http://ohioline.osu.edu/aex-fact/pdf/0510.pdf

Swinton, S., Lupi, F., Robertson, G.P., Hamilton, S.K., 2007. Ecosystem services and agriculture; Cultivating agricultural ecosystems for diverse benefits. Ecological Economics 64, 245-252.

Train, K. 2003. Discrete choice methods with simulation. Cambridge University Press, Cambridge, England.

Yang, D., Kanae, S., Oki, T., Koike, T., Musiake, K., 2003. Global potential soil erosion with reference to land use and climate changes. Hydrological Processes 17, 2913–2928.

Young, L.M., 2003. Soil Carbon Sequestration in Agriculture: The US Policy Context. Montana State University Extension Service, Bozeman, MT.

Yu, B., Nin-Pratt, A., 2011. Agricultural productivity and policies in Sub-Saharan African. IFPRI discussion papers 1150. International Food Policy Research Institute, Washington, D.C.

Appendices

Appendix A: Ngene Script

Software: Ngene Version 1.1.1 (Choicemetrics pty ltd)
Prior values obtained from pilot testing in Tororo district in June 2013

```
Design
;alts = A*, B*, C
;rows = 24
;block = 8
;alg = swap (stop=noimprov(80 secs))
;eff = (mnl,d)
;model:
U(A) = NextSeasonYield.dummy[.69|.32]*Yield[2, 1, 0] + Erosion.Dummy[.38|.35]*ErosionLevel[2, 1,
0] +
PlantingLabor.dummy[(u, 0, .04)|(u, 0, .02)]*Planting[4, 2, 0] +
Cost[-.5]*Dollar[30, 60, 90, 0]  /

U(B) =  NextSeasonYield*Yield + Erosion.Dummy*ErosionLevel + PlantingLabor*Planting +
Cost*Dollar  $
```

Appendix B: Choice Sets

Table B. 1

Choice 1	**A**	**B**	**C**	**Choice 13**	**A**	**B**	**C**
Yield	Current	Plus 2 Bags	Current	**Yield**	Current	Current	Plus 2 Bags
Erosion	Current	Near Total Decrease	Current	**Erosion**	Current	Half Decrease	Near Total Decrease
Land Prep Labor	Current	Minus 2 Days	Minus 4 Days	**Land Prep Labor**	Current	Minus 4 Days	Current
Input Costs	Current	Plus 30,000 Ush	Plus 90,000 Ush	**Input Costs**	Current	Current	Plus 30,000 Ush
Choice 2	**A**	**B**	**C**	**Choice 14**	**A**	**B**	**C**
Yield	Current	Current	Plus 2 Bags	**Yield**	Current	Plus 2 Bags	Current
Erosion	Current	Near Total Decrease	Current	**Erosion**	Current	Current	Near Total Decrease
Land Prep Labor	Current	Current	Minus 4 Days	**Land Prep Labor**	Current	Minus 4 Days	Minus 2 Days
Input Costs	Current	Plus 90,000 Ush	Plus 30,000 Ush	**Input Costs**	Current	Current	Current
Choice 3	**A**	**B**	**C**	**Choice 15**	**A**	**B**	**C**
Yield	Current	Current	Plus 1 Bag	**Yield**	Current	Plus One Bag	Current
Erosion	Current	Near Total Decrease	Current	**Erosion**	Current	Current	Half Decrease
Land Prep Labor	Current	Current	Minus 2 Days	**Land Prep Labor**	Current	Minus 2 Days	Minus 4 Days
Input Costs	Current	Plus 90,000 Ush	Plus 30,000 Ush	**Input Costs**	Current	Plus 60,000 Ush	Plus 60,000 Ush
Choice 4	**A**	**B**	**C**	**Choice 16**	**A**	**B**	**C**
Yield	Current	Plus 2 Bags	Plus 1 Bag	**Yield**	Current	Current	Plus 2 Bags
Erosion	Current	Half Decrease	Current	**Erosion**	Current	Current	Near Total Decrease
Land Prep Labor	Current	Minus 2 Days	Minus 4 Days	**Land Prep Labor**	Current	Minus 4 Days	Current
Input Costs	Current	Plus 60,000 Ush	Plus 90,000 Ush	**Input Costs**	Current	Plus 90,000 Ush	Plus 60,000 Ush
Choice 5	**A**	**B**	**C**	**Choice 17**	**A**	**B**	**C**
Yield	Current	Plus 2 Bags	Plus 1 Bag	**Yield**	Current	Plus 1 Bag	Current
Erosion	Current	Half Decrease	Current	**Erosion**	Current	Near Total Decrease	Half Decrease
Land Prep Labor	Current	Minus 4 Days	Minus 2 Days	**Land Prep Labor**	Current	Current	Minus 2 Days
Input Costs	Current	Plus 30,000 Ush	Current	**Input Costs**	Current	Current	Current
Choice 6	**A**	**B**	**C**	**Choice 18**	**A**	**B**	**C**
Yield	Current	Current	Plus 1 Bag	**Yield**	Current	Current	Plus 1 Bag
Erosion	Current	Current	Half Decrease	**Erosion**	Current	Near Total Decrease	Half Decrease
Land Prep Labor	Current	Minus 2 Days	Current	**Land Prep Labor**	Current	Minus 2 Days	Current
Input Costs	Current	Plus 90,000 Ush	Plus 60,000 Ush	**Input Costs**	Current	Plus 60,000 Ush	Plus 60,000 Ush
Choice 7	**A**	**B**	**C**	**Choice 19**	**A**	**B**	**C**
Yield	Current	Plus 1 Bag	Plus 2 Bags	**Yield**	Current	Plus 2 Bags	Current
Erosion	Current	Half Decrease	Near Total Decrease	**Erosion**	Current	Near Total Decrease	Current
Land Prep Labor	Current	Minus 2 Days	Minus 4 Days	**Land Prep Labor**	Current	Current	Minus 2 Days
Input Costs	Current	Current	Plus 30,000 Ush	**Input Costs**	Current	Plus 30,000 Ush	Plus 90,000 Ush
Choice 8	**A**	**B**	**C**	**Choice 20**	**A**	**B**	**C**
Yield	Current	Plus 2 Bags	Plus 1 Bag	**Yield**	Current	Plus 2 Bags	Plus 1 Bag
Erosion	Current	Half Decrease	Current	**Erosion**	Current	Half Decrease	Near Total Decrease
Land Prep Labor	Current	Current	Minus 4 Days	**Land Prep Labor**	Current	Current	Minus 4 Days
Input Costs	Current	Plus 60,000 Ush	Plus 60,000 Ush	**Input Costs**	Current	Plus 60,000 Ush	Current

Choice 9	A	B	C
Yield	Current	Plus 1 Bag	Current
Erosion	Current	Current	Near Total Decrease
Land Prep Labor	Current	Current	Minus 4 Days
Input Costs	Current	Plus 90,000 Ush	Plus 30,000 Ush

Choice 10	A	B	C
Yield	Current	Plus 1 Bag	Plus 2 Bags
Erosion	Current	Near Total Decrease	Half Decrease
Land Prep Labor	Current	Minus 2 days	Current
Input Costs	Current	Plus 30,000 Ush	Plus 90,000 Ush

Choice 11	A	B	C
Yield	Current	Current	Plus 2 Bags
Erosion	Current	Current	Half Decrease
Land Prep Labor	Current	Minus 4 Days	Minus 2 Days
Input Costs	Current	Plus 90,000 Ush	Plus 30,000 Ush

Choice 12	A	B	C
Yield	Current	Plus 1 Bag	Current
Erosion	Current	Half Decrease	Near Total Decrease
Land Prep Labor	Current	Minus 4 Days	Minus 2 Days
Input Costs	Current	Plus 30,000 Ush	Plus 90,000 Ush

Choice 21	A	B	C
Yield	Current	Plus 2 Bags	Plus 1 Bag
Erosion	Current	Current	Half Decrease
Planting Labor	Current	Minus 2 Days	Current
Input Costs	Current	Plus 60,000 Ush	Plus 60,000 Ush

Choice 22	A	B	C
Yield	Current	Plus 1 Bag	Plus 2 Bags
Erosion	Current	Half Decrease	Current
Land Prep Labor	Current	Current	Minus 2 Days
Input Costs	Current	Current	Current

Choice 23	A	B	C
Yield	Current	Current	Plus 2 Bags
Erosion	Current	Near Total Decrease	Half Decrease
Land Prep Labor	Current	Minus 4 Days	Current
Input Costs	Current	Current	Current

Choice 24	A	B	C
Yield	Current	Plus 1 Bag	Current
Erosion	Current	Current	Half Decrease
Land Prep Labor	Current	Minus 4 Days	Current
Input Costs	Current	Plus 30,000 Ush	Plus 90,000 Ush

Appendix C: Data Screening Process

400 people took the survey

18 respondents did not choose C on the example question

59 of the remaining surveys did not grow maize

There were 323 usable surveys

Appendix D: Stata Code

Effects Coding for Categorical Variables

```
replace total=-1 if ceros==1

replace half=-1 if ceros==1
```

Source: (Bech, Gyrd-Hanson , 2005)

Conditional Logit STATA Code

```
ssc install wtp

global kr "15000"

 gen ASC = b|c

clogit choice ASC additionalyield half total labordecrease price, group (number)

wtp price ASC additionalyield half total labordecrease, krinsky reps(15000) level(95)
```

Mixed Logit STATA Code (with fixed price)

```
ssc install mixlogit

ssc install wtp

gen ASC = b|c

mixlogit choice price, ASC additionalyield half total labordecrease group(number) id(rid) nrep (1000)

wtp price ASC additionalyield half total labordecrease, krinsky reps(15000) level(95)
```

Appendix E: Results

Table E. 1: Mixed Logit Model 2 Results

Mixed Logit Model 2 Results				
Log Likelihood	-448.55782			
Prob> chi2	0.000			
Pseudo R2	.11336292			
Choice	**Coef.**	**Std. Err.**	**z**	**P > |z|**
Mean				
ASC	2.858839	1.887024	1.51	0.130
additionalyield	.9651308	.1563582	6.17	0.000
half	.3920688	.1124662	3.49	0.000
total	2.10019	.2269455	9.25	0.000
labordecrease	.1854604	.0719056	2.58	0.010
nprice	-12.80795	1.254788	-10.21	0.000
SD				
ASC	-1.196935	1.80909	-0.66	0.508
additionalyield	.7132022	.2367923	3.01	0.003
total	1.200407	.2189251	5.48	0.000
nprice	2.16008	.8861309	2.44	0.015

Price is specified as random and given a lognormal distribution[3]. *Nprice* is the negative of the price variable.

[3] A lognormal distribution will force the coefficient to be positive. Carson and Czajkowski (2013) show that without assuming that the denominator will be positive, WTP standard errors will equal infinity. By assuming that the cost coefficient is positive, this problem can be overcome. Furthermore, this assumption is consistent with economic theory and is true empirically, i.e. it is reasonable to assume that price will have a negative effect on every individual's utility, and therefore the negative of the price coefficient will be positive (Carson and Czajkowski, 2013). Daly et al. (2012) also explain that the distribution of the cost coefficient, because it is in the denominator of the WTP estimate, plays a large role in the distribution of WTP. In fact, depending on the distribution of the cost coefficient, the distribution of WTP may not even have finite moments. They list the lognormal distribution as one that will lead to finite moments in the distribution. STATA allows coefficients to have a normal or lognormal distribution. The model would not converge if price had a normal distribution.

Table E. 2: Mixed Logit Model 3 Results

Mixed Logit Model 3 Results				
Log Likelihood	-465.53692			
Prob> chi2	0.000			
Pseudo R2	-			
Choice	**Coef.**	**Std. Err.**	**z**	**P > |z|**
Mean				
ASC	2.75711	1.059211	2.60	0.009
additionalyield	.8339106	.1543107	5.40	0.000
half	.3830481	.1111736	3.45	0.001
total	2.081192	.2272456	9.16	0.000
labordecrease	.1215656	.0718507	1.69	0.091
nprice	-11.11001	.3156711	-35.19	0.000
Mean_price	-.000015	4.73e-06	-3.16	0.002
SD				
ASC	-2.193995	.7084395	-3.10	0.002
additionalyield	.8202087	.2108155	3.89	0.000
total	1.392841	.225325	6.18	0.000
npice	0	(omitted)		

Same as above model, SD of price is constrained to zero.[4]

[4] The standard deviation of the price coefficient is fixed at zero when evaluating willingness to pay to prevent the possibility of having to divide by zero when calculating the asymptotic variance of the wtp estimates. This step is recommended by Carson and Czajkowski (2013).

Table E. 3: WTP Results from Model 3

	additionalyield	half	total	labordecrease
WTP	55,736	25,601	139,100	8,125
LL	10,998	2,570	53,333	-4,863
UL	100,474	48,633	224,866	21,113

WTP estimates and confidence intervals, krinsky reps (15000) level(95) for Mixed Logit Model[5]

Table E. 4: Comparison of WTP Estimates

Attribute	Conditional	Mixed 1	Mixed 3
Additionalyield	55,637*	55,584*	55,736*
Half	24,617 *	25,606*	25,602*
Total	127,968 *	139,325*	139,100*
labordecrease	11,409 *	8,119	8,125

Mixed 1: Price is fixed. All other variables are random with normal distributions.

Mixed 3: Half and labor are fixed. Price is random and has a lognormal distribution and other variables are random with normal distributions. Standard deviation of price is constrained to zero for better estimation of willingness to pay.

[5] When price has a lognormal distribution, mean wtp is calculated by:

$$WTP_{Attribute} = \beta_{Attribute}/\exp(\beta_{\mathrm{Price}}) \quad (12)$$

Appendix F : Survey

Respondent ID: ______________________

District : __________________Sub County:_______________ Village:_________________

Name of Interviewers: ___________________________ Date: ____________

Gender of respondent: **Male** **Female**

Hello, my name is _________, and this is ______________ and __________. We are conducting research for the SANREM Project, which has many institutions involved, including Makerere University, Appropriate Technology, and universities in the United States. We would like to ask you questions about your household farming decisions. Would you be willing to participate in this survey? Participation in this survey is voluntary and the answers that you provide will be anonymous and confidential.

This survey will take about 1 hour. Do you agree to participate in this survey? **YES** **NO**

1) Do you make farming decisions for your household? **YES** **NO**
    - ***(If there is no person to make farming decision go on to the next farm)***
2) What is your age?______
3) How many years of school have you completed? ________
4) How many people in total are in your household?_______
5) How many people in your household work on your farm?_______
6) How many people in your household are under 13 years old?__________
7) How many years have you worked on a farm? ________
8) How many acres are you farming this season? __________
9) Of these acres that you are farming this season, how many acres do you own? ____________
10) Do you borrow money to buy inputs for your farm? **YES** **NO**

    If yes, what type? Mark all that apply.

- Banks
- Get money from family and/or friends
- SACCO/Group Savings Schemes
- Other _____

11) In this season was more than half of your land preparation done by hired labor? **YES NO**

12) In this season was more than half of your weeding done by hired labor? **YES NO**

13) Do you have any nonfarm source of income? **YES NO**

    - If yes is it greater than your farm income? **YES NO**

14) How many of each of the following animal do you own?

Type	Cattle	Goat	Donkey	Sheep	Oxen	Pig
# Head						

15) In the last five years, how many complete crop failures have you had? (Circle the correct answer)

0 1 2 3 4 5 6 7

16) How did you cope with these crop failures? Mark all that apply.

    - Spent savings
    - Sold assets
    - Reduced consumption
    - Bank Loan
    - Got help from family and/or friends
    - Other ________________________

17) In the last five years, how many times have you tried something new on your farm that you considered to be successful? For example, a new crop variety, a new fertilizer, a new piece of equipment. ____________________

18) In the last five years, how many times have you tried something new on your farm that did not meet your expectations? For example, a new crop variety, a new fertilizer, a new piece of equipment.

____

19) Which of these crops did you plant on your farm this season? Circle all that apply.

MAIZE BEANS CASSAVA GROUNDNUTS IRISH POTATOES

SWEET POTATOES VEGETABLES FRUIT

20) Have you ever practiced minimum tillage? **YES NO**

- If yes, do you still practice minimum tillage? **YES NO**

21) Have you ever grown a cover crop? **YES NO**

- If yes, do you still grow a cover crop? **YES NO**

22) Have you ever practiced crop rotations? **YES NO**

- If yes, do you still practice crop rotations? **YES NO**

23) Do you view soil erosion as a problem on your land? **YES NO**

24) Are you doing something to manage erosion? **YES NO**

25) Type of roof on house:

THATCHED TIN IRON SHEET TILE OTHER_________

26) Type of floor in house:

MUD FLOOR	**CEMENT**	**TILE**	**OTHER__________**

27) Number of rooms in house: _________

CONSERVATION AGRICULTURE CHOICE EXPERIMENT – INTRODUCTION

In this part of the survey we would like you to answer questions that tell us why farmers choose particular production practices, including those related to Conservation Agriculture. Conservation Agriculture is a method of farming that minimizes soil tillage while providing permanent soil cover. When you practice Conservation Agriculture, you rotate crops, minimize tillage, and do not let your soil remain bare.

Conservation agriculture has the potential to increase yields and decrease labor required to produce crops. However, it can also increase input costs. While practicing Conservation Agriculture, farmers usually keep all crop residues in the field and do not feed them to their animals. The purpose of this is to decrease soil erosion and water loss and increase soil fertility.

I am now going to explain the attributes to you and show you all of their possible levels.

[ENUMERATOR- Pull out LEVELS CARD]

The first attribute is:

1. **Yield Increase**. Conservation Agriculture could increase your yields. The yield attribute will reflect the amount that your total yields will change.

These are the possible yield attributes:

1. When you see this level, it means that your yield will not change from your normal yield amount this season.

2. When you see this level, it means that you will grow 100 KG of maize in addition to what you normally grow this season.

3. When you see this level, it means that you will grow 200 KG in addition to what you normally grow this season.

Do you have any questions about the yield attribute?

The second attribute is:

2. **Change in Planting Labor requirements.** An outcome of Conservation Agriculture practices is the potential to reduce the demand for labor during planting. This labor attribute will indicate how much your planting labor will decrease.

These are the possible planting labor levels:

1. When you see this level, it means that you will have to use as much labor as you normally do to plant in a season.

2. When you see this level, it means that you will be able to spend two fewer days this season planting.

3. When you see this level, it means that you will be able to spend one fewer day this season planting.

Do you have any questions about this attribute?

The third attribute is

3. **Change in Weeding Labor requirements.** Using Conservation Agriculture could increase or decrease your need for weeding labor. This weeding labor attribute will indicate how much your weeding labor will change.

These are the possible levels of this attribute:

1. When you see this level, it means that you will have to weed as much as you normally would in a season.

2. When you see this level, it means that you can spend two fewer days weeding this season than you normally would.

3. When you see this level, it means that you must spend two more days weeding this season than you normally would.

Do you have any questions about this attribute?

The fourth attribute is:

4. **Animal Feed.** Conservation Agriculture usually implies leaving any crop residue on the field. This effect on feed indicates whether or not you can feed the crop residue to your livestock or sell it. If the option says "No," then you must leave your crop residue on your field. If it says "Yes," then you can feed the crop residue to your animals or sell it.

This attribute has only two levels.

1. When you see this picture, it means that you can feed your crop residue to your livestock or use it in whichever way you prefer.

2. When you see this picture it means that you must leave your crop residue on your field so you cannot feed your crop residue to your livestock or use it in any way.

Do you have any questions about this attribute?

The last attribute is:

5. **Production Costs.** When implementing CA practices, you might incur additional expenses for inputs. These expenses could be an extra cost for seed to be used for a cover crop, new equipment, or other inputs. This attribute will tell you how much your input costs have increased.

1. When you see this level, it means your costs will not change from what they currently are each season.
2. When you see this level, it means that your costs will be 30,000 more than what they usually are in a season.
3. When you see this level, it means that your costs will be 60,000 USh more than what they usually are in a season.
4. When you see this level, it means that your costs will be 90,000 USh more than what they usually are in a season.

Do you have any questions about this attribute?

Now, I am going to show you cards that have three different options on them. This is what the cards will look like.

[ENUMERATOR- Pull out the BLANK CHOICE CARD]

Option A represents your current farming practices. Yield in Option A is your current maize yield, whatever that is. Land Preparation Labor is the amount of time it takes you to prepare your land for planting maize. Weeding labor is the amount of time it takes you to weed your maize. Animal Fodder shows that you can feed your fodder to your animals, if you choose to do so. Costs represent your current costs. All of the levels of Option A will be the same on every card.

The other two options, Option B and Option C, show changes from your current situation. These will show you different levels of the five attributes that I just showed to you. Assume that these are the management options available to you, and that you are certain that the effects shown will be the outcomes. After I read the levels to you and you have a chance to look at the card, I will ask you to choose which option you prefer. If you do not like either of these options, and you prefer your current farming practices, then you should choose Option A.

Are you ready for me to show you an example choice card? We will go through this one together and I can answer any questions that you have.

***[ENUMERATOR- Take out EXAMPLE CHOICE CARD and go through the attribute levels with the participant. Allow them to examine the card. Ask them which one they would pick and why. This card will have an obvious choice (Option C), so if they choose Option A or Option B, assume that they have not understood the task. If they have chosen Option C and can explain why, then continue. If they choose Option A or Option B and/or cannot explain why they have made a particular choice, help them with the thought process of making a choice.]**

Now that we have gone through an example question, I will give you choices for you to answer on your own. I will read the options to you and you can also look at the card, as well. When you have decided which option you prefer, tell me and I will mark it down for you.

This survey is hypothetical, but please answer the questions as if you were actually making choices in real life. Your answers to this survey will help researchers understand if farmers would be willing to adopt conservation agricultural techniques given their effects.

Do you have any questions? Are you ready to continue?

[ENUMERATOR- if the person has no questions and appears to have understood the example, then pull out the three choice experiment question cards. Read the first card to the respondent while allowing them to view the card at the same time, beginning with the attributes of Option A, then the attributes of Option B, and then read them Option C. Point to the appropriate box as you are reading it. Repeat if necessary. Allow them to examine the choice card for a few minutes if they wish. When they make a choice, check off the appropriate box on the choice card, and then continue with the remaining questions in the same way.]

Ending

Thank you so much for your participation in our survey. The information you have provided will help researchers understand how farmers make decisions regarding farming practices. Do you have any questions for us before we leave?

(For the pilot) Do you feel that everything in this survey was explained to you fully? Was there anything you did not understand? Do you have any suggestions about how we could make this survey better?

Appendix G: International Review Board (IRB) Approval Letter

VirginiaTech

Office of Research Compliance
Institutational Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	June 11, 2013
TO:	George W Norton, Kate Alyse Vaiknoras, Barry Weixler-Landis
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE:	Survey for Uganda under SANREM
IRB NUMBER:	**13-531**

Effective June 11, 2013, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Exempt, under 45 CFR 46.110 category(ies) 2**
Protocol Approval Date:	**June 6, 2013**
Protocol Expiration Date:	**N/A**
Continuing Review Due Date*:	**N/A**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?
06/06/2013	05001607	US Agency International Development	Not required (Exempt approval)

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.