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Are consumers willing to pay for conservation agriculture? The case of white maize in the Democratic Republic of the Congo

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Abstract

Throughout the low-income world, agricultural producers have a motivation to slash-and-burn rainforests as they cannot afford inorganic fertilizers. Farmers in the Democratic Republic of the Congo (DRC), who are predominantly women, are often forced to walk long distances to cultivate more productive lands, when fertility near their villages is reduced. On their way and while working away from home, women become targets for rape. Adopting conservation agriculture (CA) could help mitigate deforestation and potentially create a safer environment for women. Limited knowledge about the benefits of CA across countries in Sub-Saharan Africa (SSA) has hindered its adoption. Taking these impediments into account, we estimate if consumers in the DRC are willing to pay (WTP) a premium for CA, using maize flour as the medium. By means of a double-bounded dichotomous choice valuation method, 600 consumers in Bukavu, DRC, were surveyed about their willingness-to-pay for CA-produced maize. Our study finds that only those consumers who identify themselves as farmers are WTP a premium. This study indicates that if CA adoption is to spread in the DRC, it will likely need to happen via increased yields or reduced costs before the farm gate and not premiums after the farm gate.

KEYWORDS
conservation agriculture; deforestation, the Democratic Republic of the Congo; rural women; willingness-to-pay

1 | INTRODUCTION

Deforestation has been detrimental to accelerating global climate change (Bala et al., 2007; Fearnside, 2000; Intergovernmental Panel on Climate Change (IPCC), 2013). Annually, a forested area the size of Austria is lost due to deforestation globally (Seymour & Busch, 2016). In the Democratic Republic of the Congo (DRC), which accounts for 62% of the Congo Basin rainforest (approximately 167 million hectares), the deforestation rate doubled between 1990 and 2005 (Tchatchou et al., 2015). The expansion of small-scale forest clearing in search of fertile agricultural land is among the largest deforestation drivers in the DRC (Turubanova et al., 2018; Tyukavina et al., 2018). Agricultural producers often have to slash and burn old-growth rainforests, as they cannot afford or find inorganic fertilizers. Once they harvest the cost of organic fertilizer from one area, they search for alternative productive land, often at the expense of rainforests (Cannon, 2018).

Farmers' safety, especially women, is an additional concern in the agricultural sector in rural DRC (Mulimbi et al., 2019). Safety, or the lack of it, is associated with social strife, civil conflicts, and political instability underway since the 1990s (World Food Programme (WFP), 2020). As a consequence of this destabilization, one out of six people living in extreme poverty in SSA resides in the DRC, despite the country's immense endowments in natural resources (World Bank, 2018). Millions of Congolese women have encountered rape or sexual violence due to these civil conflicts, which have resulted in massive population displacements, as people have migrated for safety and fertile agricultural land (Peterman et al., 2011). DRC farmers, who are predominantly women (58%) (Ministère du Plan et Suivi de la Mise en Oeuvre de la Révolution de la Modernité et al., 2014) are often forced to walk long distances to cultivate more productive lands, when agricultural fertility is reduced near their home villages (Mulimbi et al., 2019). This is not only at a considerable cost to opportunities and development, but it also cuts into productive work hours. Moreover, as women walk long distances to work, they become a target for sexual violence and rape. These social and environmental issues are likely to escalate in the DRC due to a growing population, continued regional conflicts, increased demand for food, and the pressure on natural resources. As the population expands and arable land becomes scarcer across the majority of low-income countries (LICs), including the DRC, an increased number of farmers may choose to slash and burn fragile rainforest lands in search of more fertile ground (Sunderlin et al., 2005).

The adoption of conservation agriculture (CA) can mitigate deforestation (environmental benefits) and potentially create a safer working environment for rural women in the DRC (social benefits). If female producers were to adopt CA (such as in white maize production), it would reduce the longer distance they have to travel to tend to their crops, potentially reducing deforestation (land expansion) and improving the safety of female producers who have fallen victim to sexual violence as they travel to far away fields.

In this study, we are using the definition of CA provided by the Food and Agriculture Organization of the United Nations (FAO): "a farming system that promotes a permanent soil cover, minimum soil disturbance (i.e., no-tillage), and diversification of plant species that enhances soil quality and promotes soil health (Food and Agriculture Organization of the United Nations (FAO), 2019; Mkomwa et al., 2017; Pisante et al., 2015). Such soil improvements induce increased crop yields (Ares et al., 2015) and make CA an economically viable alternative to slash-and-burn agriculture in forested areas such as the DRC (Legoupil et al., 2015). As farmers in the DRC harvest the nutrients from a cleared forest floor, they practice slash-and-burn agriculture to harvest new organic income. The problem is that they have to move further away from their villages each year. A substitute to slash-and-burn such as CA can accommodate these farmers' old farmlands and prevent them from walking further away to establish new farmlands in the forest.

Previous research (Angelsen, 2009; Landers et al., 2006; Rudel et al., 2009) has shown how CA can reduce deforestation, which sustains old-growth forests.

However, knowledge amongst agricultural producers across SSA countries, including the DRC, about the benefits of CA, which include reduced tillage and production costs, improved soil quality, better crop water balance, the potential for enhanced yield, and potential for reduced yield variability, is limited, hindering CA's widespread adoption (Wall, 2007; Wall et al., 2014). The lack of information on CA throughout farming communities combined with a poor understanding of its principles, limited access to inputs and crop residues, and resistance to change impedes large-scale CA adoption (Bunderson et al., 2017). Agricultural producers in the DRC often have multiple objectives, hence a need for a multi-disciplinary approach, but they rarely have access to people and information, such as best management practices for CA, that can help them work out appropriate solutions. CA production has a learning curve, as it requires new management skills and can result in reduced yields if not conducted under best management practices, thus making knowledge of its implementation crucial (Knowler & Bradshaw, 2007; Rusinamhodzi et al., 2011). Given that the poor agricultural extension service plagues most SSA countries, alternative avenues need to be explored to increase CA adoption.

This paper examines whether CA adoption by rural producers could be driven by consumers' willingness to pay (WTP) a premium for goods produced with CA. We test the effect of different types of information related to CA benefits in the DRC on consumers' WTP a premium for a product (in our study, white maize flour) produced under CA. The information sets are related to CA environmental (potential reduced deforestation) and social (potential reduced violence against women as they are not forced to walk long distances to cultivate new ground) benefits. If CA principles were applied in cultivating white maize, the large amount of cultivated land used for its production could have considerable social and environmental impacts. Given the challenge of obtaining reliable data in the DRC (Thontwa et al., 2017), little research has been conducted to assess sustainable agricultural technologies' demand amongst consumers. To date, no study has explored whether DRC's consumers would be willing to pay (WTP) to reduce socio-environmental concerns (farmers' safety and deforestation). The existing literature on WTP for CA is either producer- or policy-focused (Amusa et al., 2015; Asrat et al., 2004; Baffoe et al., 2021; Johnston & Duke, 2007), leaving a large gap with consumer situations.

Given the impediments to CA adoption across the DRC, this study seeks to estimate if urban consumers in the DRC are WTP for white maize flour produced sustainably by means of CA. White maize flour is a staple in this part of the DRC, and our study focuses on the WTP for CA through an explanation of its social and environmental benefits, only using white maize flour as our testable medium. While the majority of LICs and the DRC consumers simply concentrate on price minimization for their dietary needs, many Congolese are aware of rural sexual violence and deforestation due to years of civil unrest and evident widespread deforestation. Thus, this study aims to be the first to estimate if consumers in the DRC are WTP a premium for CA-produced agricultural goods in an effort to help alleviate deforestation and violence against women using white maize flour as our medium. The results of this study are important as they provide valuable information to the DRC government, commodity producers, agricultural scientists, policymakers, and non-governmental organizations (NGOs) about the potential for consumers to pull (via demand) the adoption of CA via premiums instead of policies and extension programs that try to push (via supply) its adoption. If it is found that consumers are WTP a premium for CA-produced goods, producers should be more likely to adopt CA, which ultimately has the potential to reduce violence against rural women and deforestation. Furthermore, this study is unique within existing literature, because it addresses the consumer demand side of CA. After all, while CA has been proven to provide environmental benefits in a meta-analysis of 933 locations across 16 different countries in SSA, the average yield was only found to be 3.7% higher for six major crop species and 4.0% for maize under CA, compared to conventional agricultural (including slash and burn) practices (Corbeels et al., 2020). Thus, studies such as this, which analyze consumer demand for CA, could be pivotal for providing information, such as estimated premiums associated with CA, for its widespread adoption across SSA.

2 | SMALL-SCALE AGRICULTURE IN THE DRC

2.1 | Female agricultural workers in the DRC

While women are the backbone of the agricultural workforce in the DRC, representing 60% of agricultural labor and 73% of the farmers, and producing 80% of food crops for household consumption, they are the most vulnerable members in the agriculture sector (UNDP, 2021; International Monetary Fund (IMF), 2013; USAID, 2014; World Bank, 2018). According to the Demographic and Health Survey (DHS) (MPSMRM et al., 2014), agriculture has been the primary occupation for 58% of all DRC women. This occupation rate increases to 66% for women between 45 and 49 years old with more than five children and 77% for women in rural settings (MPSMRM et al., 2014). According to the United Nations Entity for Gender Equality and the Empowerment of Women (UN Women, 2016), despite their high representation in agriculture, DRC women are discriminated against within the sector when it comes to access to arable land, financing, and technologies. Less than 10% of women are landowners; only 2% of women have access to credit from financial institutions, and because of this, 42% of women take loans from family and friends at exorbitant interest rates (UN WOMEN, 2016). Women in agriculture in the DRC are victims of both economic and civil inequality.

DRC women are also among the primary victims of the country's socio-political instability (Ministère de l'Agriculture et du Développement Rural (MINAGRI), 2010). According to Herderschee et al. (2011), the government efforts to reduce inequality, exacerbated by civil conflicts and their consequences, are still not leveling the playing field. Women face many types of discrimination, exploitation, and exclusion in their communities throughout the DRC (USAID, 2014). In particular, rural women in the DRC are more disadvantaged than their male counterparts and exposed to higher levels of poverty, food insecurity, and sexual violence. Sexual and gender-based violence (GBV) has turned into a wider social disease, representing a significant barrier to women's full engagement in social and economic life (World Bank, 2018). Millions of DRC women have faced sexual violence (Peterman et al., 2011). According to Fourati et al. (2021), sexual violence experienced by rural women is a "weapon of war" used by armed groups and, in the case of the DRC, it is mainly associated with the presence of artisanal mining activities. Regardless of these high levels of vulnerability, the DRC still does not have a national social protection mechanism to assist its most impoverished and vulnerable communities (World Bank, 2018).

2.2 | Slash-and-burn practice in the DRC

Slash-and-burn agriculture is a farming practice that is still widely implemented in the DRC agroecological zones today. The increase in the use of the slash-and-burn method is one of the primary current and future threats to the Central African rainforest (Torbay & Vantomme, 2017). It used to be a sustainable practice, with farmlands being left fallow while soil fertility was restored after the cropping cycle. Beyond a certain threshold, however, the forest no longer has time to regenerate between cropping cycles (Torbay & Vantomme, 2017). A study by Nsombo et al. (2016) has shown that in the DRC the yield increases through slash-and-burn agriculture do not last, as soil organic matter drastically decreases over the next cropping cycle, making this practice unsustainable from food security and environmental standpoints.

The rural population in the DRC conducts slash-and-burn agriculture to address their subsistence or financial needs (Ministère de l'Environement Conservation de la Nature et Tourisme (MECNT), 2012). Slash-and-burn is an activity that has been necessary due to a challenging economic environment and a weak institutional framework, interfacing with political decisions, civil wars, poor governance, crisis, unemployment, and poverty (MECNT, 2012). Subsistence agriculture is a primary livelihood for DRC rural citizens, even though between 1960 and 2006, productivity decreased by 60% due to political instability and farmers abandoning production because of civil strife (IMF, 2013). Additionally, the decline of the agriculture extension system throughout the country hampered the

dissemination of best management practices, leading to reduced agricultural productivity, decreased earnings, and increased food insecurity (World Bank, 2013). In 2009 in the province of Maniema, in the Eastern DRC, it was reported that women were at increased risk of sexual violence due to employing slash-and-burn as a farming practice, as it continuously forces them to work farther away from their homes (Catholic Relief Services (CRS), 2009).

2.3 | Consumers' WTP for maize in Sub-Saharan Africa

Maize-WTP studies in SSA have traditionally gravitated around the six central themes of biofortification, genetic modification, food preparation, seed system security, tolerance to weather shocks, and aflatoxin. Consumers' WTP for biofortified maize has been studied extensively in SSA (Banerji et al., 2018; Diro et al., 2016; Hamukwala et al., 2019). For example, Meenakshi et al. (2012) investigated the impact of nutrition information on WTP for biofortified-provitamin-A orange maize in rural Zambia. Their results suggested that orange maize (traditionally used for livestock feed) could compete with white maize (traditionally used for human consumption). It was established that rural Zambian consumers would be WTP a 19% premium over non-fortified maize, when they learned about orange maize from community leaders at home, and a 23% premium when they heard about orange maize from the radio outside their homes. Simelane et al. (2016) examined the use of genetically modified (GM) maize in eSwatini, where GM maize is currently outlawed for production. Their results indicate that Emaswati consumers require an 8% discount for GM maize compared to non-GM maize due to health and ethical concerns. A study in Kenya (Kimenju & De Groote, 2008) found that urban consumers in Nairobi were WTP a 13.8% premium for GM maize foods mainly due to trust in their government's ability to control and regulate the food industry.

2.4 | CA-produced maize in the DRC

CA maize in the DRC is unique in that it is a staple crop that could both have the environmental benefits (slowing deforestation) and social benefits (potentially lowering violence against women). Thus, this study sets out to estimate if consumers in the DRC, who typically focus on price minimization, would be WTP a premium for CA-produced maize.

The survey for this study was conducted in the city of Bukavu in the DRC. Bukavu, the South Kivu province's capital, is a large city of 1,078,002 people (United Nations Department of Economic and Social Affairs (UNDESA), 2019) located in the eastern part of the country. Maize, specifically maize flour, was chosen for this study, as it is the most traded and consumed cereal and ranks second only to cassava as a staple crop in the DRC (Famine Early Warning Systems Network (FEWS NET), 2015). Maize is the most widely-produced cereal in the DRC (Institut National de la Statistique (INS), 2017). CAID, FAO and WEP (2018) report that, on average, 55% of locally harvested maize is consumed on site, and 45% taken to the market, making maize not only an important crop economically, but a crop that most consumers are familiar with through purchasing. In 2018, South Kivu province was ranked second for DRC maize production (CAID, FAO, & WEP, 2018).

3 | EXPERIMENTAL DESIGN

An electronic survey questionnaire was designed using *Qualtrics* survey software and uploaded to tablets to be used by four surveyors in the summer of 2019. The survey was created to estimate the WTP of consumers in the DRC for white maize flour produced with CA. The survey consisted of three sections. The first section provided participants with an overview of the survey and CA. In the second section, participants were randomly assigned to a treatment group. They were then familiarized with a "cheap talk" script before answering the double-bounded dichotomous

choice valuation questions (Cummings & Taylor, 1999) to reduce potential hypothetical bias (Carlsson et al., 2005; Silva et al., 2011), given the stated preference nature of the study. The cheap talk script asked participants to behave as if they were actually shopping in a white maize flour market, making the decisions that best met their white maize flour needs. The third section contained a series of questions collecting demographic and socio-environmental views.

The WTP analysis in this study was conducted by using a double-bounded dichotomous choice (DBDC) contingent valuation and is consistent with the work of Hanemann et al. (1991), who provided empirical evidence of the increased statistical efficiency of this approach. Similarly described by Holmquist et al. (2012), McLeod and Bergland (1999), and Patterson (1993), in a study applying the DBDC model, two prices are revealed to each subject. The second price option level is contingent upon the first price choice response, which is randomly chosen from a set of prices for each subject. When the subject's answer is "yes," meaning that they are WTP the amount of the initial price (B_i), they are presented with a second higher price (B_h). As a matter of choice, if the subject's answer is "no," meaning that they are not WTP the initial price amount, they are presented with a second lower bid (B_l).

The subsequent questions attempting to elicit upper or lower bounds of the WTP lead to four possible outcomes: (i) both answers are" no," meaning a participant's WTP is lower than B_l; (ii) a" no "followed by a" yes," meaning a participant's WTP is lower than B_i but greater than or equal to the accepted B_l amount; (iii) a" yes "followed by a" no "meaning the participant's WTP is greater than or equal to B_i but lower than the rejected B_h amount, and (iv) both answers are "yes," meaning a participant's WTP is greater than or equal to B_h. By denoting the WTP for individual i as WTP_i, we describe the following discrete outcomes in the bidding procedure:

$$y_i = \begin{cases} 1 & if\ WTP_i < B_l\ (no,\ no) \quad (1a) \\ 2 & if B_l \le WTP_i < B_i\ (no,\ yes) \quad (1b) \\ 3 & if\ B_i \le WTP_i < B_h\ (yes,\ no) \quad (1c) \\ 4 & if\ WTP_i \ge B_h\ (yes,\ yes) \quad (1d) \end{cases}$$

In a WTP analysis related to a commodity's characteristics, the objective is to examine the maximum an individual consumer would pay for the commodity in question and how the commodity's properties influence this amount. The contingent valuation (CV) methodology is commonly used to estimate WTP.

Accordingly, based on Carson and Hanemann (2005), the response probabilities for the outcomes in the set of equations (1) will be given by:

$$\Pr(no, no) = \Pr\left(B_l > WTP_i^*\right) = G_{WTP}(B_l), \quad (2a)$$

$$\Pr(no, yes) = \Pr\left(B_i > WTP_i^* \ge B_l\right) = G_{WTP}(B_i) - G_{WTP}(B_l), \quad (2b)$$

$$\Pr(yes, no) = \Pr\left(B_l \ge WTP_i^* \ge B_l\right) = G_{WTP}(B_h) - G_{WTP}(B_i), \quad (2c)$$

$$Placeholder\ Text\Pr(yes, yes) = \Pr\left(B_h \le WTP_i^*\right) = 1 - G_{WTP}(B_h) \quad (2d)$$

where G_{WTP} is the WTP cumulative distribution function.

The DBDC design generates interval-censored data on WTP. Following several applications of DBDC (Basu, 2013; Lang, 2010; Nosratnejad et al., 2014), the interval regression method is used in this study. As the latent value of WTP could be effectively observed by analyzing respondents' statements, and there is a probability that the latent value is located within an interval, interval regression is a suitable method for assessing consumers' WTP for white maize flour (Alberini, 1995; Cameron, 1991). Basu (2013) argues that other discrete choice models such as

ordered logit or ordered probit models, even though appropriate, could rank the WTP as an ordinal model and ignore the boundary point values.

The participants' WTP for white maize flour produced under CA is then determined in the linear form of its function as follows:

$$WTP_i^* = \alpha + \tau \cdot W_i + \beta' X_i + \varepsilon_i \quad (3)$$

where WTP_i^* is the subject *i*'s unobserved true WTP, *W* is the treatment indicator, *X* the vector of covariates associated with participant *i*, α, τ and β are the coefficients representing the parameters to be estimated, and ε denotes the error term following a normal distribution with mean 0 and variance σ^2. Here, the vector *X* covariates include gender, age, education, household size, and being-a-farmer. These covariates help to test the internal validity of the WTP (Alberini et al., 2005). This study extended the specification in equation (3), allowing for the following specification (equation 4) with a set of interactions to check for potential heterogeneity (Barrett & Carter, 2010).

$$WTP_i^* = \alpha + \tau \cdot W_i + \beta' X_i + \gamma' X_i \cdot W_i + \varepsilon_i \quad (4)$$

where γ is the coefficient estimated for the interaction term. Groups' WTP variation can be found in a study involving people's environmental attitudes, and accounting for unobservable heterogeneity leads to better model fit (Aldrich et al., 2007). Moreover, field experiments in developing nations have established that individuals' subjective perceptions of new markets and technologies are heterogeneous.

Given that initial, lower, and upper bounds are used to figure different bids within the sample of respondents, the likelihood function for the interval regression model takes the form (Bettin & Lucchetti, 2012; Lu & Shon, 2012):

$$L = \sum_i \left[\Phi\left(\frac{U_i - \beta' x_i}{\sigma} \right) - \Phi\left(\frac{V_i - \beta' x_i}{\sigma} \right) \right] \quad (5)$$

where U_i and V_i are respectively the upper bound and lower bound of the interval in which WTP_i^* falls and ϕ is a standard normal cumulative distribution function. Notice that, as illustrated in Table 1, for respondents who gave two "yes" responses, U_i is infinity, and for respondents who gave two "no" responses, V_i is negative infinity (Alberini & Cooper, 2000).

A between-subject design was used by randomly assigning respondents to either a control group or one of the three informational treatments. Participants randomly assigned to the control group were simply shown a picture of a one-kg package of white maize flour commonly purchased throughout eastern DRC. There was no brand name or identification on the package itself to mitigate consumer preference for branding.

Participants in the first information group, that is, the United Nations' FAO-Definition (treatment 1), had the FAO's definition of CA in addition to a picture of a one-kg package of white maize flour. Participants in treatment 1 (*Def*) were given the following information:

> According to the United Nations, Conservation Agriculture (CA) is a farming system that promotes the maintenance of a permanent soil cover, minimum soil disturbance (i.e., no-tillage), and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contributes to increased water and nutrient use efficiency and to improved and sustained crop production.

Participants in treatment 1 were told that the one-kg package of white maize flour was produced following the FAO guidelines on CA as described above.

TABLE 1 Bounded prices for 1 kg of white maize flour (in CDF)

Prices		Responses			
Starting (B_i)	**Bounded**	**Yes – Yes**	**Yes – No**	**No – Yes**	**No – No**
1100	Lower (B_l)	1300	1100	900	–
	Higher (B_h)	–	1300	1100	900
1300	Lower (B_l)	1500	1300	1100	–
	Higher (B_h)	–	1500	1300	1100
1500	Lower (B_l)	1700	1500	1300	–
	Higher (B_h)	–	1700	1500	1300
1700	Lower (B_l)	1900	1700	1500	–
	Higher (B_h)	–	1900	1700	1500
1900	Lower (B_l)	2100	1900	1700	–
	Higher (B_h)	–	2100	1900	1700

Note: 1 US Dollar (USD) = 1646 Congolese Franc (CDF) at the time of the field survey in Bukavu, DRC (Banque Centrale du Congo (BCC), 2019).

Participants in treatment 2, which included information about social benefits of CA (*Soc*), received the FAO's definition of CA plus a short paragraph stating how CA could help to reduce female farmers' burdens, vulnerability, and risk of violence in rural areas, helping farmers, especially women, to save more time and energy. In addition to a picture of a one-kg package of white maize flour, participants in treatment 2 were provided with the following information:

> In the Maniema province of DRC, CA has been applied through farming practices involving crop rotation, no-tillage, and mulching. CA has the potential to reduce or will reduce farmers' workload burdens and vulnerability in the DRC. CA allows females to farm closer to their homes, which can (or has been shown to) reduce the incidence of harassment and risk of violent assaults (Mulimbi et al., 2019). Further, CA has the potential to save time and energy as labor requirements decrease (Catholic Relief Services (CRS), 2015).

Participants in the treatment 3, which included information about environmental benefits of CA (*Env*), received the FAO definition of CA plus a short paragraph stating how CA could improve soil quality and help to reduce deforestation. In addition to a picture of a one-kg package of white maize flour, participants received the following statement envisaged in the environmental aspect of CA:

> In the Maniema province, CA has been applied through farming practices involving crop rotation, no-tillage (or at least minimum tillage), and mulching. CA can enhance soil quality and has the potential to reduce deforestation in the DRC (CRS, 2015). In 2017, the DRC lost 1.46 million ha of forest cover through deforestation (Weisse & Goldman, 2018).

The second section of the survey questionnaire incorporated the double-bounded dichotomous choice (DBDC) contingent valuation (CV). The CV method was used to determine consumers' WTP for white maize flour produced under CA. The DBDC can mimic the reality of urban open markets in the DRC, where customers are exposed to multiple prices and attributes for the same commodity (Alberini & Cooper, 2000). The DBDC approximates how consumers make choices in a market as they choose whether they want to buy or not (Loomis, 2011). DBDC requires little explanation, as respondents are asked to state their purchasing preference in an environment where prices have

been predetermined (Durand-Morat et al., 2016). Other methods also use predetermined prices. See, for example, Domonko et al. (2018), who used both a DBDC as well as a choice experiment. We chose the DBDC due to its ease of explanation in a market setting.

In an attempt to mitigate potential hypothetical bias, this study integrated a cheap talk script into the second section of the survey questionnaire and administered it prior to the DBDC. A similar technique has been used in Aprile et al. (2012), Van Loo et al. (2011), Sanjuán et al. (2012), and Lee et al. (2015).

In the DBDC, each subject was asked if he/she would be WTP a randomized price (Table 1) for white maize flour. Then, a follow-up bid was offered, which was lower if participants answered "No" to the starting bid and higher if they answered "Yes" (Patterson, 1993). The prices for white maize flour used in the DBDC were built around the average market price for 1 kg of flour in Bukavu at the time of the survey, which was 1500 Congolese Francs (CDF) (about USD 0.91) (Cellule d'Analyses des Indicateurs de Développement (CAID), 2018). Prices were increased and decreased by 200 CDF twice over. The resulting options provided five starting prices (1100 CDF, 1300 CDF, 1500 CDF, 1700 CDF, and 1900 CDF), with the starting bid price randomized for each participant. Table 1 illustrates the configuration of bounded prices based on bid responses.

Surveyors recruited participants from six different local open markets in Bukavu, DRC. Participants were recruited using convenience sampling within each market. Although convenience sampling has limitations, selecting consumers who were actively shopping for food justified it. This survey was not a random sample, however. Since most markets would have typical representatives of the Bukavu larger population, anyone could be selected. The authors recognize the limitations of convenience sampling but given the difficulty of recruiting a randomized representative sample in a LIC, they implemented the method. Convenience samples can provide useful information regarding preliminary trends for novel studies such as this one. The team of four surveyors recruited 638 participants over 4 weeks in June 2019. After cleaning incomplete and survey pretest responses, the analysis dataset included 599 participants. Participation in the survey was voluntary, and, in the beginning, the instructions clearly stated that there was no compensation. Participants were informed about the study's implications, and their consent to participate was collected. In order to participate, individuals were required to be at least 18 years old and consume white maize flour at least once per week. Participants were randomly assigned to treatment groups that varied depending upon the type of information provided about CA following introductory survey instructions. The survey was designed to collect quantitative responses elicited from the DBDC and qualitative responses (converted to quantitative responses through the use of binary or other numeric scalings) elicited from questions regarding demographic and occupational data, as well as questions about deforestation, and the role of women in agriculture.

This study explains the participants' WTP using the randomly assigned informational treatments, integrates a series of independent demographics as covariates and runs group analysis. The demographic variables are listed in Table 2. The inclusion of covariates in WTP analysis meets policymakers' frequent need to know potential WTP differences in the targeted population (Carson & Hanemann, 2005).

This study used the *Survival* package (Therneau, 2015; Therneau & Grambsch, 2013) in R Studio (R version 3.5.1) to perform the interval regression modeling with robust error estimation.

4 | RESULTS AND DISCUSSION

Approximately half of the respondents were between 25 and 34 years old, and 41% were 35 years and above, while 12% were under 25 years old. This sample selection process is consistent with the country's last Demographic Health Survey, indicating that in 2013 the large majority of DRC's urban population was 25 and older (MPSMRM et al., 2014). Our sample consisted of 75% female respondents. This unbalanced gender figure makes intuitive sense in the DRC, since women conduct the majority of food shopping. Among the respondents, 11% stated their primary occupation to be farming. Agriculture is the activity of 70.7% of women and 45.6% of men in South Kivu province (MPSMRM et al., 2014), and it is possible to find urban citizens who are still farming occasionally in rural areas.

TABLE 2 Characteristics of study participants

Explanatory variables	Description	Hypothesized signs for WTP
College	Participant has a university education, = 1 if Yes, = 0 if No	+
Woman	Female participant, = 1 if Yes, = 0 if No	+
Male	Male participant, = 1 if Yes, = 0 if No	+/−
Farmer	Involved in farming, = 1 if Yes, = 0 if No	+
Non-Farmer	Not involved in farming, = 1 if Yes, = 0 if No	+/−
Household size	Household size = total number of family members living in the participant's home	+/−
Age	Participant's age groups: <25 years, 25–34 years, and 35 years and more	+/−

TABLE 3 Descriptive statistics aggregated by treatment

Variable	Categories	Control	*Def* treatment 1	*Env* treatment 2	*Soc* treatment 3	Full sample
College[a]	% of Yes	21.7%	24.7%	27.2%	22.3%	24%
Woman[a]	% of Yes	78.3%	73.5%	77.6%	69.6%	75%
Farmer[a]	% of Yes	8.0%	11.4%	10.2%	14.9%	11%
Household size[b]	Average	7.0	6.7	6.9	6.6	6.8
Age[a]	Between 25–34	47.1%	49.4%	46.9%	46.6%	47%
	35 and over	37.0%	42.2%	42.9%	40.5%	41%
	Less than 25	15.9%	8.4%	10.2%	12.8%	12%
Observations		138	166	147	148	599

Note: Chi-square test reported no statistical difference for this variable across treatments ($p > .1$). Analysis of variance reported no statistical difference across treatments ($p > .1$).

Additionally, 24% of respondents had a college degree. Table 3 describes the sample's characteristics in numbers and disaggregates for each of the study treatments. Table 3 illustrates that the four treatment groups were similar in demographic characteristics. The chi-square test and analysis of variance yielded no statistical difference amongst participants across the four experimental groups ($p > .10$) in Table 3.

Figure 1 shows the responses to the DBDC model. The majority of respondents chose the initial higher price in each of the treatments (CA definition, environmental benefits, and social benefits). Further, after being presented with a higher price in the follow-up question, more than half of the sample continued to choose the higher price for the white maize flour produced with CA. These results would seem to imply that consumers are open to the idea of CA.

A series of questions asked at the end of each survey found the following: 24% of participants had already heard about CA, 86% are aware of deforestation in the DRC, 94% are aware of violence against rural women in the DRC, and 72% are aware of the contribution of women to agricultural labor. These results would seem to indicate that maize consumers in Bukavu were at least aware of the social (females in agriculture and violence against women) and environmental (deforestation) issues in the DRC.

Table 4 reports the results of nine interval regression models, starting with estimating consumers' WTP on the full sample in the first column (Model 1), followed by subsets of the full sample by gender and occupation. The estimations reported in Table 4 focus on the informational treatments (*Def*, *Soc*, *Env*, and the control). Model 1 was estimated on the full study sample and yielded non-significant treatment effects ($p > .1$), as shown in Table 4. Thus, there was no significant effect of any information set on WTP from a WTP standpoint. Models 2 to 9 in Table 4

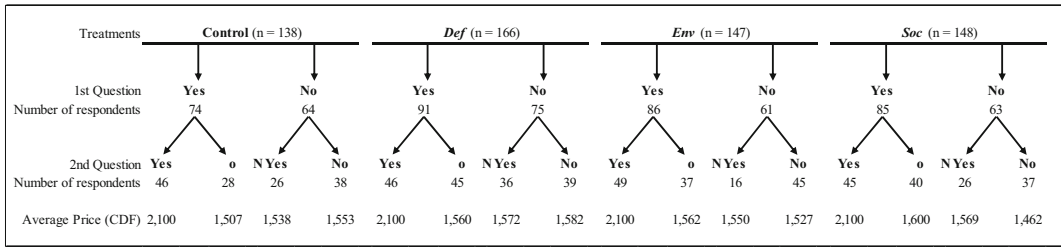

FIGURE 1 Responses to double-bounded dichotomous-choice contingent valuations

examine subsets of the data: *farmers*, non-*farmers*, *female*, *male*, *female farmers*, male *farmers*, female non-*farmers*, and male non-*farmers*, respectively.

Looking at individual subsets, Model 2 (those participants who identified as farmers) in Table 4 suggests that when provided information about the social benefits of CA (*Soc*, *treatment 2*), a participant who self-identified as a farmer is WTP 206 CDF ($p < .05$) more for CA-produced white maize flour compared to farmers who received no information about CA. This result suggests that farmers are WTP a 15.3% premium for CA-produced white maize flour when exposed to CA's social benefits.[1] Similar to the Chen et al. (2019) study, we report actual WTP (in Congolese Francs) for each treatment and subgroup in Table A3. These findings indicate that the issue of rural women's safety raised by this study appears to be something that farmers are WTP to mitigate. Even though 94% of those surveyed said they were aware of the issue, it is prioritized only by farmers. Urban white maize consumers, most of whom are not farmers, are not WTP a premium regardless of the amount of information provided, as Model 3 (non-farmers) in Table 4 indicates".

Table 4 also estimates how male and female *farmers* differ when valuing CA. Model 6 (female farmers) in Table 4 suggests that providing the technical definition of CA (*Def*, *treatment 1*) and the information about the social benefits of CA (*Soc*, *treatment 2*) to female farmers increases their WTP for CA-produced maize flour. The premiums estimated for each *Def* (232 CDF) and *Soc* (382 CDF) are statistically significant ($p > .05$) within each subgroup. Hence, these results suggest that female farmers are WTP a 30.7% premium for CA-produced white maize flour when provided the information about CA's social benefits and an 18.7% premium when informed about CA's FAO definition. These findings are intuitive, as female farmers, who compose the largest percentage of agricultural workers, are able to gain the most social benefits through CA adoption. Interestingly, there was no significance ($p > .1$) for CA's environmental benefit amongst female farmers. The seemingly odd results of Model 7 (male farmers) in Table 4 suggest that providing information on CA's environmental benefits (*Env*) to male farmers negatively affects their WTP for CA-produced maize flour. This obtuse outcome is likely the result of a small subset of the total sample identifying as male farmers. The subsets of male farmers have only three such individuals in the control group, seven in the *Def* group, eight in the *Soc* group, and five in the *Env* group, and thus, the results need to be interpreted with caution. Alternative specifications were estimated and presented in Table A1, with similar effects to those found in Table 4, which contains our preferred models.

Given the number of sub-sample analyses presented in Table 4, this study's approach accounted for multiple hypothesis testing issues usually illustrated through a higher chance for false positives (Type I error). Specifically, a *p*-value adjustment was performed on our model specification in Table 4 using the Benjamini – Hochberg (BH) procedure. The results of *p*-value adjustments for the informational treatment *Soc* in Model 6 and *Env* in Model 7 did not change their statistical significance under the BH method, while Soc in Model 2 statistical significance moved to the 10% level (Table A2). However, alternative adjustments using Bonferroni and Benjamini – Yekutieli (BY) methods were consistent with BH for the first two models, while the latter became insignificant (Table A2).

Taken together, the findings in Table 4 suggest the following. First, CA matters to only participants who identify as farmers and only with specific information sets (*Soc* and *Def*). White maize flour consumers who self-identified as farmers are WTP a premium for CA-produced maize when provided with information about CA's social benefits

TABLE 4 Interval regression modeling results

	Dependent variable								
	WTP								
	All	Occupation		Gender		Occupation by Gender			
	(1)	Farmer (2)	Non-Farmer (3)	Female (4)	Male (5)	Female farmers (6)	Male farmers (7)	Female non-farmers (8)	Male non-farmers (9)
Def (*treatment 1*)	13.490	159.111	1.694	−11.389	89.969	231.970**	−46.323	−29.950	108.630
	(35.648)	(96.650)	(37.182)	(39.698)	(79.839)	(114.283)	(86.624)	(40.159)	(88.907)
Env (*treatment 2*)	7.923	−6.328	11.756	−17.552	99.071	93.290	−270.846***	−27.286	157.767
	(40.831)	(121.019)	(42.031)	(43.905)	(100.139)	(164.135)	(86.578)	(43.835)	(110.508)
Soc (*treatment 3*)	−0.836	206.060**	−21.578	−8.206	27.569	381.785***	−185.555	−47.227	61.659
	(40.390)	(103.643)	(42.809)	(45.207)	(87.991)	(119.278)	(125.863)	(47.320)	(96.872)
Constant	1546.637***	1352.603***	1564.876***	1556.645***	1514.218***	1243.092***	1615.779***	1583.608***	1500.571***
	(28.327)	(70.689)	(29.525)	(30.455)	(67.232)	(74.730)	(18.434)	(30.720)	(74.894)
Observations	599	67	532	447	152	44	23	403	129
Log Likelihood	−679.511	−76.484	−597.327	−488.238	−188.997	−50.542	−22.559	−430.297	−163.196
chi^2 (df = 3)	0.200	5.270	0.726	0.174	1.896	7.580*	3.151	1.140	2.851

Note: Model (1) is the pooled Model using the whole data sample, while Models (2) to (9) are based on sub-samples. *p < .1; **p < .05; ***p < .01.

(reduced sexual violence against women). Second, female farmers were estimated to pay a premium when informed about CA's definition and CA's social benefits but not when informed about the CA's environmental benefits. Third, CA's social aspect (reducing sexual violence against women) appears to be more of a WTP driver for consumers than CA's environmental benefits (reducing deforestation). Finally, non-farmers appear to be indifferent regarding the WTP associated with CA's benefits, regardless of the information they have been provided with.

5 | CONCLUSION

CA could help alleviate deforestation, a major environmental threat in the DRC, through increased soil health of existing agricultural land, reducing the need for slash and burn. Further, CA has the potential to lower violence against women as there would be a reduced need to farm further away from home, if existing agricultural lands were more fertile. While the overwhelming majority of the participants in this study thought deforestation was an important issue in the DRC (86%) and that women in agriculture were at greater risk of assault than those in urban areas (94%), this a priori knowledge did little in the way of eliciting premiums for CA and its potential to reduce both risks. This study's key finding seems to confirm that most consumers in LICs are likely more concerned with the price of a commodity rather than attributes associated with its production. However, our study is unique, with an additional key finding, revealing that while people condemn both violence against women in rural areas and deforestation, as issues plaguing the DRC, they still are not WTP a premium to eradicate these problems.

The only premiums found for CA maize were for participants who presented themselves as farmers. There are two likely explanations for this finding. First, it is possible that farmers wanted to highlight that CA should be worth a premium. This scenario is unlikely, though, as the only information which elicited a premium was the social aspect (reducing violence against women). If farmers were simply trying to highlight that CA should garner a premium regardless, we should have found significance for CA attributes. Most likely, those who identified themselves as agricultural producers (specifically female farmers) were intimately aware of the dangers that farming far from home poses and thus saw the social value associated with CA. Interestingly, no subgroups of participants who would be WTP a premium for CA and its potential ability to reduce deforestation were found. Even those participants who were given the environmental information set (of which 83% recognized deforestation to be an issue in the DRC) were not WTP a premium for CA. One caveat about the results of this study is that they are drawn from a relatively small sample size that used convenience sampling. Future research on WTP for CA in the DRC should focus on a more robust sampling technique that ensures a representative sample which could mitigate the unbalanced and small sample size of subsets present in this study.

While our results indicate that agricultural producers are WTP a premium for CA to reduce the potential violence against female agricultural workers, they are the least likely (albeit for semi-subsistence farmers) group to be market consumers for agricultural goods produced with CA. This study suggests that if such groups as NGOs, universities, local and federal governments wanted to increase CA adoption in the DRC, it will likely need to come via increased yields or reduced costs before the farm gate, and not premiums thereafter. Crop yields are problematic, as in their meta-analysis of CA in SSA, Corbeels et al. (2020) concluded that the practice of CA is not a technology that allows smallholder farmers to overcome low crop productivity and food insecurity in the short term. Such a conclusion (Corbeels et al., 2020), coupled with the lack of WTP, would indicate that policy should be focused on increasing funding to enhance CA productivity, making it more profitable and thus resulting in higher adoption for agricultural producers. Further, this study's results can signal to stakeholders that if the global community is serious about mitigating climate change and preserving rainforests, it may choose to fund the reduction of deforestation in LICs, since their citizens are often more worried about short-run issues, such as food security. This study shows that consumers in the DRC are informed about deforestation and violence against women and believe that these issues pose a threat, but they do not want to pay to reduce it. The international community can use this study to help reduce, and ideally eliminate, violence against women and deforestation by informing global stakeholders that they need to play a role, rather than look exclusively for domestic solutions to international problems.

This study has highlighted that urban consumers in Bukavu, the DRC, are not likely to pay a premium for agricultural goods produced with CA, although they can internalize the benefits it would bring. This research is the first attempt at eliciting consumer demand for agricultural commodities produced under CA in the DRC. Given the sample size (both in observations and geographical distribution), additional research is needed to draw large-scale policy conclusions for the DRC in its entirety. Future research needs to focus on the potential supply-side benefits of CA agriculture in the DRC. The potential economic benefits of CA adoption need to be identified, explaining how these benefits can offset any increased costs. Further research needs to be conducted with female agricultural producers in the DRC and assess what, if any, barriers to the adoption of CA exist. Future surveys should focus on relevant farm, institutional and locational characteristics. Issues like deforestation and sexual violence against women are complex, and a single solution, such as CA, is unlikely to alleviate them. If research showed that producers can increase profitability through CA adoption, it could be a tool that has the positive externality of reducing two of the most crucial problems in the DRC today.

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ENDNOTE

[1] Given the small sample size for some subsets, a Minimum Detectable Effects (MDE) test was conducted for each subset. Specifically, we acknowledge that the small size of our subsamples of farmers, female farmers, and male farmers for our results in columns (2), (6), and (7) in Table 4, could lead to Type II errors. These MDEs were calculated conservatively, based on the sample size of the control group and the smallest of the treated groups for each subsample. Our calculation assumed 80% power for a 90% confidence interval, using a one-sided hypothesis test with an unbalanced proportion of treated and control groups. The results were 202.14 CDF, 220.14 CDF, and 53.9 CDF, respectively, for farmers, female farmers, and male farmers subgroups. As percentages of control group WTPs, these ex-post calculations suggest that these samples were not designed to detect impacts of less than 14.9%, 17.7%, and 3% of the farmers', female farmers', and male farmers' WTP, respectively.

REFERENCES

Alberini, A. (1995). Optimal designs for discrete choice contingent valuation surveys: Single-bound, double-bound, and bivariate models. *Journal of Environmental Economics and Management*, *28*(3), 287–306.

Alberini, A., & Cooper, J. (2000). Applications of the contingent valuation method in developing countries. A survey. In *FAO economic and social development paper* (Vol. 146, p. 63). Food and Agriculture Organization (FAO). https://www.cabdirect.org/cabdirect/abstract/20013037756

Alberini, A., Rosato, P., Longo, A., & Zanatta, V. (2005). Information and willingness to pay in a contingent valuation study: The value of S. Erasmo in the lagoon of Venice. *Journal of Environmental Planning and Management*, *48*(2), 155–175.

Aldrich, G. A., Grimsrud, K. M., Thacher, J. A., & Kotchen, M. J. (2007). Relating environmental attitudes and contingent values: How robust are methods for identifying preference heterogeneity? *Environmental and Resource Economics*, *37*(4), 757–775.

Amusa, T. A., Enete, A. A., & Okon, U. E. (2015). Willingness-to-pay for agronomic soil conservation practices among crop-based farmers in Ekiti state, Nigeria. *Trends in Agricultural Economics*, *8*(1), 1–12.

Angelsen, A. (2009). *Realising REDD+: National Strategy and policy options*. CIFOR.

Aprile, M. C., Caputo, V., & Nayga, R. M., Jr. (2012). Consumers' valuation of food quality labels: The case of the European geographic indication and organic farming labels. *International Journal of Consumer Studies*, *36*(2), 158–165.

Ares, A., Thierfelder, C., Reyes, M., Eash, N. S., & Himmelstein, J. (2015). Global perspectives on conservation agriculture for small households. In C. Chan & J. Fantle-Lepczyk (Eds.), *Conservation agriculture in subsistence farming: Case studies from south. Asia and beyond* (pp. 22–54). CABI Publishing.

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 & Development*, *15*(4), 423–438.

Baffoe, J. D., Mizunoya, T., & Yabar, H. (2021). Determinants of Rice Farmers' willingness to pay for conservation and sustainable use of swampy wetlands in Ghana's northern and Ashanti regions. *Agriculture*, *11*(6), 507.

Bala, G., Caldeira, K., Wickett, M., Phillips, T. J., Lobell, D. B., Delire, C., & Mirin, A. (2007). Combined climate and carbon-cycle effects of large-scale deforestation. *Proceedings of the National Academy of Sciences*, *104*(16), 6550–6555.

Banerji, A., Chowdhury, S., De Groote, H., Meenakshi, J. V., Haleegoah, J., & Ewool, M. (2018). Eliciting willingness-to-pay through multiple experimental procedures: Evidence from lab-in-the-field in rural Ghana. *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie*, *66*(2), 231–254.

Banque Centrale du Congo (BCC). (2019). *Bulletin Mensuel d'Informations Statistiques - Juillet 2019*. https://www.bcc.cd/bcc/publications-redirect/bulletin_de_statistiques?page=1

Barrett, C. B., & Carter, M. R. (2010). The power and pitfalls of experiments in development economics: Some non-random reflections. *Applied Economic Perspectives and Policy*, *32*(4), 515–548.

Basu, R. (2013). Willingness-to-pay to prevent Alzheimer's disease: A contingent valuation approach. *International Journal of Health Care Finance and Economics*, *13*(3–4), 233–245.

Bettin, G., & Lucchetti, R. (2012). Interval regression models with endogenous explanatory variables. *Empirical Economics*, *43*(2), 475–498. https://doi.org/10.1007/s00181-011-0493-9

Bunderson, W. T., Jere, Z. D., Thierfelder, C., Gama, M., Mwale, B. M., Ng'oma, S. W. D., Museka, R. M., Paul, J. M., Mbale, B., Mkandawire, O., & Tembo, P. (2017). Implementing the principles of conservation agriculture in Malawi: Crop yields and factors affecting adoption. In A. H. Kassam, S. Mkomwa, & T. Friedrich (Eds.), *Conservation agriculture for Africa: Building resilient farming systems in a changing climate* (pp. 75–99). CABI Publishing.

CAID, FAO & WEP. (2018). *Sécurité alimentaire, niveau de production agricole et Animale, Évaluation de la Campagne Agricole 2017–2018 et Bilan Alimentaire du Pays*. https://reliefweb.int/sites/reliefweb.int/files/resources/WFP-0000098937.pdf

Cameron, T. A. (1991). Interval estimates of non-market resource values from referendum contingent valuation surveys. *Land Economics*, *67*(4), 413–421.

Cannon, J. C. (2018). DR Congo–Maps tease apart complex relationship between agriculture and deforestation in DRC Title. Mongabay Series: Global Forest Reporting Network (Global Forests). https://news.mongabay.com/2018/02/maps-tease-apart-complex-relationship-between-agriculture-and-deforestation-in-drc/

Carlsson, F., Frykblom, P., & Lagerkvist, C. J. (2005). Using cheap talk as a test of validity in choice experiments. *Economics Letters*, *89*(2), 147–152. https://doi.org/10.1016/j.econlet.2005.03.010

Carson, R., & Hanemann, M. (2005). Contingent valuation. In K. G. Mäler & J. R. Vincent (Eds.), *Handbook of environmental economics, volume 2: Valuation of environmental changes* (Vol. 2, pp. 821–936). Elsevier B.V. https://doi.org/10.1016/S1574-0099(05)02017-6

Catholic Relief Services (CRS). (2009). *Kulima Pasipo Kutipula Udongo: Improving agricultural productivity through No-tillage agriculture in Maniema Province, Democratic Republic of the Congo*. Catholic Relief Services - DRC.

Catholic Relief Services (CRS). (2015). *No-tillage agriculture in Kailo, Kasongo and Kabambare territories of Maniema - Ex post evaluation report*.

Cellule d'Analyses des Indicateurs de Développement (CAID). (2018). *Surveillance des Prix des Produits Alimentaires de Base - mKengela*.

Chen, K.-J., Marsh, T. L., Tozer, P. R., & Galinato, S. P. (2019). Biotechnology to sustainability: Consumer preferences for food products grown on biodegradable mulches. *Food Research International*, *116*, 200–210. https://doi.org/10.1016/j.foodres.2018.08.013

Corbeels, M., Naudin, K., Whitbread, A. M., Kühne, R., & Letourmy, P. (2020). Limits of conservation agriculture to overcome low crop yields in sub-Saharan Africa. *Nature Food*, *1*(7), 447–454.

Cummings, R. G., & Taylor, L. O. (1999). Unbiased value estimates for environmental goods: A cheap talk design for the contingent valuation method. *American Economic Review*, *89*(3), 649–665.

Diro, S., De Groote, H., & Gunarata, N. (2016). Effect of nutritional information and sensory quality on the willingness to pay for quality protein maize-results of a field experiment in Jimma zone, Ethiopia. In *Transforming Smallholder Agriculture in Africa: The Role of Policy and Governance* African Association of Agricultural Economists (AAAE): Fifth International Conference, September 23-26, 2016; Addis Ababa, Ethiopia. semanticscholar.org

Domonko, E. S., McFadden, B. R., Mishili, F. J., Mullally, C., & Farnsworth, D. (2018). Consumer risk perception of vitamin a deficiency and acceptance of biofortified rice in the Morogoro region of Tanzania. *African Journal of Agricultural and Resource Economics*, *13*, 1–14.

Durand-Morat, A., Wailes, E. J., & Nayga, R. M., Jr. (2016). Challenges of conducting contingent valuation studies in developing countries. *American Journal of Agricultural Economics*, *98*(2), 597–609.

Famine Early Warning Systems Network (FEWS NET). (2015). *DRC Staple Food Market Fundamentals*. https://fews.net/sites/default/files/documents/reports/DRC_MarketFundamentals_20160111_508Compliant.pdf

Fearnside, P. M. (2000). Global warming and tropical land-use change: Greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation. *Climatic Change*, *46*(1–2), 115–158.

Food and Agriculture Organization of the United Nations (FAO). (2019). *Conservation Agriculture | Food and Agriculture Organization of the United Nations*. http://www.fao.org/conservation-agriculture/en/

Fourati, M., Girard, V., & Laurent-Lucchetti, J. (2021). *Sexual violence as a weapon of war*. Universidade Nova de Lisboa, Faculdade de Economia, NOVAFRICA.

Hamukwala, P., Oparinde, A., Binswanger-Mkhize, H. P., & Kirsten, J. (2019). Design factors influencing willingness-to-pay estimates in the Becker-DeGroot-Marschak (BDM) mechanism and the non-hypothetical choice experiment: A case of biofortified maize in Zambia. *Journal of Agricultural Economics*, *70*(1), 81–100.

Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics*, *73*(4), 1255–1263. https://doi.org/10.2307/1242453

Herderschee, J., Kaiser, K.-A., & Samba, D. M. (2011). *Resilience of an African giant: Boosting growth and development in the Democratic Republic of Congo*. The World Bank.

Holmquist, C., McCluskey, J., & Ross, C. (2012). Consumer preferences and willingness to pay for oak attributes in Washington chardonnays. *American Journal of Agricultural Economics*, *94*(2), 556–561.

Institut National de la Statistique (INS). (2017). *Annuaire Statistique 2015*. http://ins-rdc.org/wp-content/uploads/2019/03/Annuaire-statistique-2015.pdf

Intergovernmental Panel on Climate Change (IPCC) (2013). In T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P. M. Midgley (Eds.), *Climate change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change* (Vol. 1535). Cambridge University Press.

International Monetary Fund (IMF). (2013). *Democratic Republic of the Congo: Poverty reduction strategy paper*. IMF. https://www.imf.org/en/Publications/CR/Issues/2016/12/31/Democratic-Republic-of-the-Congo-Poverty-Reduction-Strategy-Paper-40814

Johnston, R. J., & Duke, J. M. (2007). Willingness to pay for agricultural land preservation and policy process attributes: Does the method matter? *American Journal of Agricultural Economics*, *89*(4), 1098–1115.

Kimenju, S. C., & De Groote, H. (2008). Consumer willingness to pay for genetically modified food in Kenya. *Agricultural Economics*, *38*(1), 35–46.

Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy*, *32*(1), 25–48. https://doi.org/10.1016/j.foodpol.2006.01.003

Landers, J. N., de Freitas, P. L., & Boddey, R. M. (2006). Potential for mitigation of deforestation and negative off-farm impacts with conservation agriculture: Employing zero tillage farming in the Brazilian Cerrado. In *Savannas and dry forests: Linking people with nature* (pp. 241–266). Routledge.

Lang, H. (2010). Willingness to pay for lung cancer treatment. *Value in Health*, *13*(6), 743–749.

Lee, S. H., Lee, J. Y., Han, D. B., & Nayga, R. M., Jr. (2015). Are Korean consumers willing to pay a tax for a mandatory BSE testing programme? *Applied Economics*, *47*(13), 1286–1297.

Legoupil, J.-C., Lienhard, P., & Khamhoung, A. (2015). Conservation agriculture in Southeast Asia. In M. Farooq & K. H. M. Siddique (Eds.), *Conservation agriculture* (pp. 285–310). Springer.

Loomis, J. (2011). What's to know about hypothetical bias in stated preference valuation studies? *Journal of Economic Surveys*, *25*(2), 363–370.

Lu, J.-L., & Shon, Z. Y. (2012). Exploring airline passengers' willingness to pay for carbon offsets. *Transportation Research Part D: Transport and Environment*, *17*(2), 124–128.

McLeod, D. M., & Bergland, O. (1999). Willingness-to-pay estimates using the double-bounded dichotomous-choice contingent valuation format: A test for validity and precision in a Bayesian framework. *Land Economics*, *75*, 115–125.

Meenakshi, J. V., Banerji, A., Manyong, V., Tomlins, K., Mittal, N., & Hamukwala, P. (2012). Using a discrete choice experiment to elicit the demand for a nutritious food: Willingness-to-pay for orange maize in rural Zambia. *Journal of Health Economics*, *31*(1), 62–71.

Ministère de l'Agriculture et du Développement Rural (MINAGRI). (2010). *Programme National de Securite Alimentaire*. Ministère de l'Agriculture et du Développement Rural.

Ministère de l'Environement Conservation de la Nature et Tourisme (MECNT). (2012). *Synthèse des études sur les causes de la déforestation et de la dégradation des forêts en République Démocratique du Congo*. https://www.unredd.net/index.php?option=com_docman&Itemid=134&view=download&alias=9159-synthese-des-etudes-sur-les-causes-de-la-deforestation-et-de-la-degradation-des-forets-en-republique-democratique-du-congo-9159&category_slug=studies-publications-and-o

Ministère du Plan et Suivi de la Mise en Oeuvre de la Révolution de la Modernité (MPSMRM), Ministère de la Santé Publique (MSP), & ICF International. (2014). *République Démocratique du Congo Enquête Démographique et de Santé (EDS-RDC) 2013–2014. MPSMRM, MSP, and ICF International Rockville, MD*. https://catalog.ihsn.org/index.php/catalog/5256/related_citations

Mkomwa, S., Kassam, A. H., Friedrich, T., & Shula, R. K. (2017). Conservation agriculture in Africa: An overview. In A. H. Kassam, S. Mkomwa, & T. Friedrich (Eds.), *Conservation agriculture for Africa. Building resilient farming Systems in a Changing Climate* (pp. 1–9). CABI Publishing.

Mulimbi, W., Nalley, L., Dixon, B., Snell, H., & Huang, Q. (2019). Factors influencing adoption of conservation agriculture in The Democratic Republic of the Congo. *Journal of Agricultural and Applied Economics*, *51*(4), 622–645.

Nosratnejad, S., Rashidian, A., Mehrara, M., Sari, A. A., Mahdavi, G., & Moeini, M. (2014). Willingness to pay for social health insurance in Iran. *Global Journal of Health Science*, *6*(5), 154–163.

Nsombo, B. M., Lumbuenamo, R. S., Lejoly, J., Aloni, J. K., & Mafuka, P. M. M. (2016). Caractéristiques des sols sous savane et sous forêt naturelle sur le plateau des Batéké en République démocratique du Congo. *Tropicultura*, *1*, 87–97.

Patterson, D. (1993). *An extended model for double bounded dichotomous choice data*. Western North American Region of The International Biometric Society (WNAR) Meeting.

Peterman, A., Palermo, T., & Bredenkamp, C. (2011). Estimates and determinants of sexual violence against women in the Democratic Republic of Congo. *American Journal of Public Health*, *101*(6), 1060–1067.

Pisante, M., Stagnari, F., Acutis, M., Bindi, M., Brilli, L., Di Stefano, V., & Carozzi, M. (2015). Conservation agriculture and climate change. In M. Farooq & K. H. M. Siddique (Eds.), *Conservation agriculture* (pp. 579–620). Springer.

Rudel, T. K., Defries, R., Asner, G. P., & Laurance, W. F. (2009). Changing drivers of deforestation and new opportunities for conservation. *Conservation Biology*, *23*(6), 1396–1405.

Rusinamhodzi, L., Corbeels, M., Van Wijk, M. T., Rufino, M. C., Nyamangara, J., & Giller, K. E. (2011). A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions. *Agronomy for Sustainable Development*, *31*(4), 657–673.

Sanjuán, A. I., Resano, H., Zeballos, G., Sans, P., Panella-Riera, N., Campo, M. M., Khliji, S., Guerrero, A., Oliver, M. A., & Sañudo, C. (2012). Consumers' willingness to pay for beef direct sales. A regional comparison across the Pyrenees. *Appetite*, *58*(3), 1118–1127.

Seymour, F., & Busch, J. (2016). *Why forests? Why now?: The science, economics, and politics of tropical forests and climate change*. Brookings Institution Press.

Silva, A., Nayga, R. M., Jr., Campbell, B. L., & Park, J. L. (2011). Revisiting cheap talk with new evidence from a field experiment. *Journal of Agricultural and Resource Economics*, *36*(2), 280–291.

Simelane, M. M., Masuku, M. B., Rugambisa, J. I., & Earnshaw, D. M. (2016). Analysis of consumer willingness to pay for genetically modified maize food in Swaziland. *International Journal of Sustainable Agricultural Research*, *3*(1), 19–28.

Sunderlin, W. D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L., & Wunder, S. (2005). Livelihoods, forests, and conservation in developing countries: An overview. *World Development*, *33*(9), 1383–1402.

Tchatchou, B., Sonwa, D. J., Ifo, S., & Tiani, A. M. (2015). Deforestation and forest degradation in the Congo Basin: State of knowledge, current causes and perspectives (No. 144; Occasional Paper). CIFOR.

Therneau, T. M. (2015). *A package for survival analysis in S*. Mayo Clinic. www.mayo.edu

Therneau, T. M., & Grambsch, P. M. (2013). *Modeling survival data: Extending the cox model*. Springer Science & Business Media.

Thontwa, S. K., De Herdt, T., Marivoet, W., & Ulimwengu, J. (2017). National datasets on livelihoods in the DRC: Precisely wrong or vaguely right? IOB Working Papers, 2017.12.

Torbay, M., & Vantomme, P. (2017). Background. In Food and Agriculture Organization of the United Nations (FAO) (Ed.), *Living in and from the forests of Central Africa* (pp. 3–8). FAO.

Turubanova, S., Potapov, P. V., Tyukavina, A., & Hansen, M. C. (2018). Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia. *Environmental Research Letters*, *13*(7), 74028.

Tyukavina, A., Hansen, M. C., Potapov, P., Parker, D., Okpa, C., Stehman, S. V., Kommareddy, I., & Turubanova, S. (2018). Congo Basin forest loss dominated by increasing smallholder clearing. *Science Advances*, *4*(11), eaat2993.

U.S. Agency for International Development (USAID). (2014). *Country development cooperation strategy (CDCS) 2014–2019: Democratic Republic of the Congo*. USAID.

UN WOMEN. (2016). *Empowering women through climate-smart agriculture in the DRC*. UN Women Africa News. https://africa.unwomen.org/en/news-and-events/stories/2016/11/empowering-women-through-climate-smart-agriculture-in-the-drc

United Nations Department of Economic and Social Affairs (UNDESA). (2019). *World Economic Situation And Prospects: October 2019 Briefing, No. 131 | Monthly Briefing*. https://www.un.org/development/desa/dpad/publication/world-economic-situation-and-prospects-october-2019-briefing-no-131/

Van Loo, E. J., Caputo, V., Nayga, R. M., Jr., Meullenet, J.-F., & Ricke, S. C. (2011). Consumers' willingness to pay for organic chicken breast: Evidence from choice experiment. *Food Quality and Preference*, *22*(7), 603–613.

Wall, P. C. (2007). Tailoring conservation agriculture to the needs of small farmers in developing countries: An analysis of issues. *Journal of Crop Improvement*, *19*(1–2), 137–155.

Wall, P. C., Thierfelder, C., Ngwira, A., Govaerts, B., Nyagumbo, I., & Baudron, F. (2014). Conservation agriculture in eastern and southern Africa. In R. A. Jat, K. L. Sahrawat, & A. H. Kassam (Eds.), *Conservation agriculture: Global prospects and challenges* (pp. 263–292). CABI.

Weisse, M., & Goldman, L. (2018). 2017 was the second-worst year on record for tropical tree cover loss. *Global Forest Watch*. https://blog.globalforestwatch.org/data-and-research/2017-was-the-second-worst-year-on-record-for-tropical-tree-cover-loss/

World Bank. (2013). *Congo, Democratic Republic of - country assistance strategy for the period FY13 - FY16 (English)*. World Bank.

World Bank. (2018). Democratic Republic of Congo systematic country diagnostic: Policy priorities for poverty reduction and shared prosperity in a post-conflict country and fragile state. *World Bank - Africa Region*. http://hdl.handle.net/10986/30057

World Food Programme (WFP). (2020). *Evaluation of Democratic Republic of the Congo interim country strategic plan 2018–2020*. WFP Office of Evaluation. https://www.wfp.org/publications/democratic-republic-congo-interim-country-strategic-plan-evaluation-2018-2020

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APPENDIX A

TABLE A1 WTP analysis involving treatments, covariates, and gender subgroups samples

	Dependent variable				
	WTP				
	(1)	(1a)	(1b)	(1c)	(1d)
Def	13.490	16.227	−0.004	−39.832	120.781
	(35.648)	(35.777)	(37.901)	(40.012)	(90.492)
Env	7.923	8.816	9.351	−40.644	170.372
	(40.831)	(40.391)	(42.241)	(43.670)	(106.759)
Soc	−0.836	3.341	−25.120	−54.736	70.478
	(40.390)	(40.515)	(43.276)	(47.142)	(95.594)
College	–	−43.034	−43.813	−33.450	−57.420
		(37.640)	(37.325)	(48.586)	(61.411)
Woman	–	−34.876	−36.327	–	–
		(32.972)	(32.834)		
Farmer	–	−108.390**	−237.990***	−372.631***	110.528
		(43.462)	(73.202)	(73.787)	(95.698)
Household size	–	5.599	5.435	4.241	6.281
		(4.837)	(4.816)	(5.569)	(9.134)
Age ≥ 35	–	38.591	40.628	49.449	25.259
		(28.753)	(28.645)	(31.020)	(63.421)
Age < 25	–	−4.447	−0.234	−39.539	20.659
		(41.088)	(41.082)	(48.451)	(78.617)
Farmer x Def	–	–	171.728*	282.373**	−130.955
			(101.063)	(116.698)	(140.174)
Farmer x Env	–	–	9.457	147.846	−382.797**
			(126.340)	(159.760)	(168.055)
Farmer x Soc	–	–	246.578**	443.741***	−226.931
			(108.289)	(116.175)	(182.090)
Constant	1546.637***	1539.883***	1552.058***	1554.580***	1459.805***
	(28.327)	(60.002)	(60.270)	(49.661)	(117.320)
Observations	599	599	599	447	152
Log Likelihood	−679.511	−673.346	−670.231	−477.615	−185.966
Chi^2	0.200	12.529	18.760*	21.420**	7.957
	(df = 3)	(df = 9)	(df = 12)	(df = 11)	(df = 11)

Note: *$p < .1$; **$p < .05$; ***$p < .01$.

TABLE A2 Multiple treatments evaluation outcomes

Subgroups	Informational treatments	*p*-value	Adjusted *p*-values		
			Bonferroni	BY	BH
All	*Def*	.705	1	1	0.983
(Model 1)	*Env*	.846	1	1	0.983
	Soc	.983	1	1	0.983
Farmers	*Def*	.1	0.499	0.285	0.125
(Model 2)	*Env*	.958	1	1	0.958
	Soc	.047**	0.234	0.178	0.078*
Female farmers	*Def*	.042**	0.212	0.121	0.053*
(Model 6)	*Env*	.57	1	1	0.57
	Soc	.001***	0.007***	0.005***	0.002***
Male Farmers	*Def*	.593	1	1	0.593
(Model 7)	*Env*	.002***	0.009***	0.007***	0.003***
	Soc	.14	0.702	0.401	0.176

Abbreviations: BH, Benjamini – Hochberg method; BY, Benjamini – Yekutieli method.
Note: *$p < .1$; **$p < .05$; ***$p < .01$.

TABLE A3 Estimated WTP per respondents' subgroups and treatment groups (in Congolese francs)

Subgroup	Control	*Def* treatment 1	*Env* treatment 2	*Soc* treatment 3
Pooled data	1546.6	1560.0	1554.6	1545.8
Farmer	1352.6	1511.7	1346.3	1558.7**
Non-farmer	1564.9	1566.6	1576.6	1543.3
Female	1556.6	1545.3	1539.1	1548.4
Male	1514.2	1604.2	1613.3	1541.8
Female farmers	1243.1	1475.1**	1336.4	1624.9***
Male farmers	1615.8	1569.5	1344.9***	1430.2
Female non-farmers	1583.6	1553.7	1556.3	1536.4
Male non-farmers	1500.6	1609.2	1658.4	1562.2

Note: Estimates derived from interval regression results in Table 4. *$p < .1$; **$p < .05$; ***$p < .01$.