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An Economic Valuation of Biodiversity: Measuring Willingness-to-Pay for Quinoa Conservation in Peru

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Abstract: Peru is facing increasing homogenization of traditional crops as a result of international market pressures. Destruction of the genetic resource base creates vulnerability to disease, climate, and pest shocks which threaten food security and the economic future of Peru's agricultural sector. This paper aims to determine whether informational priming on the non-market value of national identity is sufficient to change the willingness to pay for agro biodiversity programs among the Peruvian general population in both urban and rural areas. A choice set willingness to pay experiment combined with choice rankings and randomized priming measures how much individuals are willing to contribute to conservation programs, whether national identity is a factor which affects the amount they are willing to pay, and which factors of conservation they prefer. By offering an opportunity to donate a part of participation payments to a conservation group, the experiment also examines whether hypothetical stated preference measures of the non-use value of an environmental public good are incentive compatible.
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1. Introduction

The world currently faces a number of threats to global food security, including population growth, climate change, and increased vulnerability to production shocks caused by mono cropping. Furthermore, climate change is changing the conditions under which current crops can be grown. It's estimated that almost one billion hectares around the world are vulnerable to creeping salinization and acidification of both water and soil (Hasegawa 2013). Climate change is also expected to change the nature of precipitation in many areas, resulting in rainfall that occurs with less frequency but higher intensity, often separated by long periods of drought (Zeglin et al. 2013). The agricultural sector will require new and different approaches to adapt to these changing conditions.

One of the most effective protections against agricultural production shocks is a diverse genetic base for food crops (Brock and Xepapadeas 2003). Quinoa in particular is notable due to both the size of its gene pool and the seemingly strategic manner in which varieties have adapted to both incredibly harsh and different conditions such as frost (Jacobsen et al. 2005), salinity Hariadi et al. 2011), and drought (Pulvento et al. 2010). Many of these adaptive varieties are grown at limited scale by local farmers in remote parts of the Andean regions of countries such as Peru and Bolivia (Ruiz et al. 2014). Peru is currently the world's largest producer of quinoa, accounting for approximately 60% of global production in 2014 (FAOSTAT 2016).

However, production of these shock-resistant species is currently at risk due to commercial quinoa's increasing homogeneity (Fuentes et al. 2012). Commercialized varieties comprise approximately 20 of the roughly 3,000 total quinoa species (FAO 2015; Bioversity International). This degradation to the underlying genetic base is caused primarily by two factors: First and foremost, quinoa has exploded in popularity throughout the developed world over the last decade. Peru alone has experienced a 167% increase in yield from 2008 to 2014 (FAO - FAOSTAT 2018). Increased international demand for quinoa creates a price premium on homogenous varieties grown for export. Second, Peru's industrialization increases migration from rural to urban areas, further adding to demand for quinoa (Bazile et al. 2011). When combined with higher returns to large landowners, this results in the migration of many smaller farmers who traditionally cultivated adaptive varieties.

Reduced crop variation leads to greater vulnerability of production systems to shocks. Biodiversity in staple crops is necessary for breeding programs which seek to improve yields, account for uncertainty in weather and disease conditions, and enable adaptation to different growing conditions (e.g. different altitudes, irrigation systems, etc.) (Jacobsen and Mujica 2002). It is therefore crucial to maintain a socially optimal level of genetic diversity. However, funds with which to do so are often limited, particularly in developing countries. In order to efficiently allocate funds towards conservation, it is important to measure properly the economic value of this resource.

The purpose of this research is to estimate the total economic value (TEV) of quinoa biodiversity in Peru.

This study ultimately explores three main research questions: (1) What is the total economic value of quinoa agrobiodiversity? (2) Which attributes of biodiversity programs increase public support the most? (3) Can informational priming increase consumer valuation and/or attribute preference?

We attempt to answer these questions using a consumer choice experiment which estimates willingness to pay (WTP) values for hypothetical biodiversity programs.
Our findings will be used to orient overall conservation policy and support the design of cost-effective conservation initiatives for both our partner organization (Bioversity International), and any other bodies who seek to promote efforts to preserve genetic diversity.

We find that WTP values for components of the total economic value of quinoa biodiversity are significant and positive. Preservation of cultural traditions and practices is the most influential attribute, suggesting that the largest component of TEV is generated by non-use cultural value. Both priming treatments fail to have any significant impact on price sensitivity. Our robustness check also finds evidence of consumer heterogeneity in preferences.

The rest of this paper is organized as follows: Section 2 briefly summarizes the relevant background literature for this study. Section 3 details the sampling methodology and data collected. Section 4 describes the econometric specification used. Section 5 summarizes the analysis of our primary findings and robustness check. Section 6 highlights some challenges faced in this area of research, and section 8 concludes.

2. Literature Review

In examining the current state of knowledge on the subject, there are three important areas of background literature. In section 2.1 we summarize the body of work surrounding the economic value of biodiversity and general natural resource valuation. Section 2.2 focuses on contingent valuation and consumer choice experiments more generally. In section 2.3, we examine papers which contribute to the specific methodology of our research design, and whether priming is an effective tool for influencing consumer choices. Finally, section 2.4 briefly describes this study's contributions to the literature at large.

2.1 Natural Resource Valuation and Total Economic Value (TEV)

The first question that should be asked when studying biodiversity is whether it has economic value that needs conserved at all. Brock and Xepapadeas (2003) argue that biodiversity is traditionally praised without measurable merit. Rather than accepting it as something inherently good or virtuous, in any economic model biodiversity needs to create or enhance some kind of value. They create a simplified model in which the optimum steady state proportions of 2 crop varieties on a fixed plot of land can be calculated. The authors find that these optimizations are characterized by the existence (of lack of) property rights to the gene pool. Social optimums include crop diversity as a means of minimizing the value lost to continually evolving pests. Private optimums, however, generally result in mono-cropping. Individual farmers often make decisions based on private costs and benefits, growing whichever varieties add the most value to their land. However, as the market pushes farmers towards crops of a single species (or other singular trait such as color or grain size), vulnerability to shocks on a system-wide scale increase. There are three simple takeaways from this research: First, genetic diversity in crops reduces pest effectiveness, increasing overall yields. In this manner agrobiodiversity an insurance mechanism, in which the vulnerability to any one pest is spread among various species of a crop. Second, human work in the GMO sector is not a perfect substitute for naturally occurring diversity, as it incentivizes cultivation of fewer varieties. The authors argue that while artificial use of GMO sounds appealing, it greatly increases vulnerability to pest shocks, as it only takes one unforeseen pest evolution to wipe out an entire mono-crop. Third, and most importantly, the social optimum levels of diversity depend on full property rights over the gene pool, suggesting that agro biodiversity is susceptible to the tragedy of the commons (Hardin 1968).

Pearce and Moran (1994) reinforce this notion that genetic diversity in crops functions like a public good. Their work argues that the degradation of natural resources to satisfy economic activities with lower values is evidence that, "[genetic] conservation generates economic values that are not captured in the marketplace" (122). The authors claim that this market failure is a result of the public goods nature of biodiversity, in which individual actors have little incentive to protect genetic variation. Gowdy (1997) supports this claim, arguing that the economic value of biodiversity is essentially zero due lack of a formalized marketplace.

Evenson and Santaniello (1998) explore the difficulties in identifying the contributions of any one particular local breed or variety of crop in improving the species as a whole, as the genetic traits are not formally traded in markets. This research reinforces the need for a diverse gene pool, as it is almost impossible to distinguish those breeds, which will make a difference in adapting to future shocks (which are inherently unpredictable).

Previous measures of natural resource value often sum only direct-use values, resulting in errors due to the rival nature of many resources (Gowdy 1997). Plottu and Plottu (2007) argue that a multidimensional framework is needed to derive the value of any natural resource in order to be inclusive of both use and non-use values. The theory of Total Economic Value provides a structure through which different types of benefits to society, both direct and indirect, can be aggregated in order to construct a comprehensive valuation. Any all-encompassing measure of an environmental asset's value must include both use (actual and option) and non-use (existence, altruistic, and bequest) values (OECD 2006). Many of agrobiodiversity's benefits fall under non-use values, which is the value of an asset that one does not directly consume (e.g. although one might consume quinoa, they do not consume genetic diversity directly). Non-use values can only be obtained through hypothetical stated preference techniques, which are used in this study. Using this valuation technique, agrobiodiversity does have a measurable value, although it is not tangible and therefore not measurable through standard market observation (Nunes 2001).

It should be noted that stated preference survey methods measure subjective values, not intrinsic ones. It's therefore possible that the human value of genetic diversity is much smaller than it's intrinsic value due to lack of information or perception (Mitchell & Carson 1989). This creates two potential sources of bias that must be accounted for in experimental design. The first of these is that human subjects have difficulty contextualizing the scale of natural resources in a quantitative way. Perhaps the most notable example is an experiment conducted in the aftermath of the Exxon-Valdez oil spill in which participants willingness to pay to save either 2,000, 20,000, or 200,000 birds was measured. The study found no difference between the WTP values for each group, suggesting the number of birds made little difference (Carson et al. 2003). It's suggested that the subjects reacted to the emotional trigger of that particular situation (a bird covered in oil) more-so than any quantitative signal (Kahneman 2011). The second source of bias comes from the demographic traits of those surveyed when conducting valuations. An ideal study would survey the entire world's population to generate a total economic value, but of course this is impossible. WTP for natural resources may therefore depend on the sampling population used in the study. There is some limited evidence to suggest that those who face increased exposure to and/or impact from environmental degradation have higher marginal WTP for natural resource conservation (Karapetyan & d'Adda 2014). However, the general consensus is that resource valuation correlates more strongly with education and income (Greenstone & Jack 2015).

2.2 Contingent Valuation

Contingent valuation (CV) refers to an economic technique which utilizes survey data to conduct a valuation of a good or service. The use of surveys makes CV experiments extremely flexible since it does not require observation of a real market (Carson et al. 2001). This makes it an important tool for valuation of natural resources and public goods, for which no formal marketplace often exists. It has become the most common tool for biodiversity valuation due its ability to estimate TEV by soliciting WTP values for different attributes by which biodiversity is defined (Zander et al. 2013). Use of CV to measure TEV of biodiversity is further supported by Atkinson et al. (2012), who provide a comprehensive summary of economic valuation methods used in ecosystem valuation. They note that species conservation and non-use values generally fall under the purview of stated preference methodologies, due to lack of observable markets and lack of direct interaction between consumer and the good whose value is being measured.

Stated preference experiments, in which subjects are asked directly for their valuation, have come under scrutiny due to concern over hypothetical bias. Hypothetical bias is defined as the difference between the valuation provided via stated preference and the actual valuation in an observable market scenario. Hypothetical bias generally results in overstated WTP values, especially when the good involved is either new, or tied to some kind of virtuous trait (Houseman 2012). It's reasonable to believe that environmental conservation falls under this category, and that therefore WTP values may not necessarily reflect market outcomes exactly. Murphy et al. (2005) conduct a meta-analysis of 28 stated preference choice experiments. They estimate a hypothetical bias of approximately 35%, and confirm that hypothetical bias skews upwards. However, they find that choice-based stated preference experiments can reduce the level of hypothetical bias significantly. While comparative choice experiments don't eliminate bias entirely, they do provide a more sophisticated alternative to simple stated preference experiments. The use of contextual decision-making with comparable alternatives more closely (although not perfectly) mimics the quasi-market observable outcomes found in revealed preference experiments. Hanemann (1994) further argues that despite imperfections, results from contingent valuation of natural resources are compatible with economic theory. He notes, "Even without a market, there still exists a latent demand curve for non market goods; contingent valuation represents a way to tease this out" (19). His work finds that questionnaire design plays a fundamental role in the reliability of such experiments.

One questionnaire adaptation which improves the accuracy of contingent valuation is the use of attributes to represent a hypothetical good. Presenting subjects with a bundle of attributes, each of which has a limited number of varying levels eliminates several of the critiques to natural resource valuation so far presented in the literature. First, they allow us to estimate the TEV of a resource through use of attributes specifically designed to represent different value categories. This is particularly convenient because there is some research which suggests attributes must be highly differentiable to avoid consumer fatigue (Gao & Schroeder, 2009). Attributes allow for easy comparisons in terms of order and magnitude to compensate for lack of precise empirical estimates (Zander, 2010; Drucker et. al., 2013). Finally, it allows for sophisticated choice experiments in which consumers are choosing between different hypothetical goods that are comparable across based on the attributes used (Bleimer et al. 2009).

2.3 Willingness-to-Pay and Priming

Consumer choice experiments which utilize hypothetical goods of varying attributes to elicit stated preferences can be found across a wide range of products.

Some notable examples include utility services (Hensher et al. 2005; Goett et al. 2000; Longo et al. 2008), coffee (De Pelsmacker et al. 2005), and cars (Hildrue et al. 2011).

Much of our experimental design is based on previous work by Bioversity International. A study by Drucker et al. (2013) measures willingness and extent of participation in hypothetical genetic conservation programs for Italian cattle.

Given the experimental nature of our study design (which is expanded upon in Section 3.2), it was decided to include a randomized priming treatment. Priming is defined as the introduction of stimuli before an experiment is conducted in order to elicit an emotional response, establish context, or change a subjects' frame of reference. Priming stimuli can come in the form of additional information, questions, or narratives (Weingarten et al. 2006). Some common examples include There is little consensus over which forms of priming are more effective, and what the duration is of any particular kind (Tulving et al. 1982). One common critique of priming asserts that publication bias results in numerous case studies which show priming to be effective, without any real underlying theory on its true effectiveness, nor any best practices for its use (Bower 2012).

However, there are case studies showing that informational priming increases WTP in some contexts for both direct and non-direct use products. Banerji et al. (2016) finds that nutritional information significantly increases WTP for vitamin-fortified millet in India. Fox, Hayes, & Shogren (2002) find Chinese consumers willing to pay less for pork products when information about harmless irradiation is presented. These two findings suggest that the effects of priming on WTP can move in both directions, depending on the subject's perception of the information included. Bergstrom, Stoll & Randall (1990) provide an invaluable example of priming as it relates to natural resource valuation: Their study finds significant increases in WTP for American wetlands when subjects were reminded how different program attributes related to desirable consumption services.

2.4 Contributions

This study doesn't necessarily expand upon any of the methodologies described above. However, it does contribute to the literature in its unique context. To out knowledge this will be the first case of a contingent valuation study that focuses on one particular agricultural crop across multiple varieties. This stands out from previous studies, which generally attempt to measure WTP for entire ecosystems. The use of priming in a developing context is also novel, as many of the case studies in which priming is found successful are conducted in developing countries. There is speculation as to how much the priming methods found effective thus far are dependent on cultural context.

3. Data and Experiment

3.1 Sampling Methodology

The desired population of interest is for this study is the general adult population of Peru. This population was selected as the issues of crop vulnerability effect the entire country, and the scale of conservation programs also often require funding at a level only made possible by nationwide investment (Drucker 2001).

Given the difficulty involved with obtaining a perfectly representative sample of an entire country, the scope of the study was limited to the cities of Lima, Cusco, and Puno. These cities were selected for two reasons: First, their combined populations comprise roughly 43% of Peruvians (CIA 2016). Second, their geographic locations are at different areas along the quinoa supply chain. This reduces any potential bias generated by surveying those closest to quinoa production (e.g. respondents in Puno). In Cusco and Puno, surveys were split between both urban and rural districts. Surveys in Lima were conducted in urban districts only, due both to the city's size and overwhelmingly urban population relative to Cusco and Puno. Table 1 provides a breakdown of the sampling plan by City, and rural/urban area.

Subjects were selected via convenience sampling. Enumerators were instructed to visit central, communal areas such as town squares, bus stations, and markets in order to recruit participants. Generally convenience sample poses a major risk of selection bias and unbalanced samples. However, given the experimental design and randomized treatment, we don't anticipate any major issues arising from demographic imbalances (although the extent to which the sample matches the actual demographics of Peru may impact the external validity of our findings). Subjects were not compensated for their participation, eliminating any selection bias related to financial incentives.

3.2 Survey Design

This study utilizes a choice experiment similar to that developed as part of previous research by Bioversity International, and published under Zander et al. (2013). This previous work studies the valuation of endangered cattle varieties in Italy, thus certain modifications have been made to adjust for the different context.

Data collected from each individual includes the following: Awareness / experience with different varieties of quinoa, prior history regarding donation behaviors (e.g. whether the subject has made prior donations, in what form, what amount, and to what kinds of causes), basic demographic information (e.g. gender, age, occupation, income, education, household composition, and a series of socio-economic indicators (e.g. ownership of certain indicator assets such as a mobile phone or car, construction quality of residence, type of cooking fuel, access to clean water, electricity, internet, etc.). Some basic information regarding the importance of biodiversity and its impact on Peru is also included. A copy of the full questionnaire used can be found in Appendix XX.

Our survey contains two experimental components: A randomly assigned priming treatment, followed by a consumer choice WTP experiment in which the subject chooses between sets of hypothetical conservation programs.

Systematic random sampling is used to assign each subject to one of three priming groups: treatment 1 (national identity priming), treatment 2 (food security priming), or control (no priming). The national identity priming contains a series of historical facts which detail quinoa's native history to Peru, and attempts by Spanish colonizers to eradicate the crop upon their arrival in the 16th century. This stimulus was selected in the belief that involving cultural nationalism will increase valuation of native crops. The food security priming utilizes a series of questions regarding personal food security. This stimulus was selected in the belief that fear over sensitivity to food shocks may increase valuation of biodiversity, given its role as an informal insurance mechanism as discussed in Section 2.1. The language used for each priming treatment can be found in Appendix XX. These priming treatments were designed in consultation with Bioversity International (BI) and the International Potato Center (CIP). Given the notable lack of literature regarding priming's effect on non-direct use goods, any significant effect on WTP as a result of either priming treatment would be considered a major contribution to the literature.

3.3 Structure of the Choice Experiment

Hypothetical conservation programs are used to simulate an artificial market for quinoa biodiversity. Each program is presented as a bundle of five different attributes, with varying levels for each attribute. The attributes used are as follows: Preservation of the Andean landscape, risk of production loss, % of quinoa varieties existing in 50 years, maintenance of cultural traditions, and cost, represented by a one-time hypothetical donation. In order to measure the TEV of quinoa biodiversity, each attribute is designed to capture a different use or non-use value of genetic diversity. The use of attributes is important for three additional reasons: First, it allows for identification of different stakeholders within the population, as biodiversity does not always have a universally recognized definition. Second, it allows for specific targeting of conservation programs depending on which attributes are valued most by those stakeholders. Finally, narrowly defined attribute levels enable consumers to make more accurate choices when compared to quantitative estimates, as discussed in Section 2.1. The attributes, levels, and TEV indicators used for this study are listed in Table 2, and were determined in consultation with Peruvian agricultural experts from BI and CIP.

Each participant is presented with a, "block", of 8, "choice cards", each of which contains 3 hypothetical conservation programs. For each card, one card at a time, the subject selects the program from each card that he/she would prefer compared to the other two choices. The third program for each card is the, "Status Quo" – a program which contains the lowest possible value for each attribute. The Status Quo option is present as the third program on all cards for all subjects. The first two programs for each card contain randomly assigned attribute levels. The number of attributes and levels used allows for 3,401 unique combinations for programs 1 and 2. However, time, budget, and personnel limitations necessitate that only a sub-sample of 128 unique programs are used, following an orthogonal design created by Willy Pradel of CIP. These 128 unique programs are divided amongst 8 separate blocks, each of which contains 8 cards. The block of cards used for each survey are randomly distributed throughout the sample to ensure the program attribute levels are appropriately orthogonal. Thus, there are 64 unique choice cards, split into 8 blocks of 8 cards. Subjects have a ~⅛ chance of their survey using any particular block of cards. This random distribution of blocks/cards/programs minimizes any systematic bias arising from any individual choice set.

This design was pretested by Bioversity and CIP before primary data collection occurred. Figure 1 features a sample choice card for reference.

4. Econometric Model

4.1. Analyzing Program Choice

As discussed in section 3.3, Participants are presented with 8 sets (cards) of 3 programs, and choosing one program per card. Although only one of three programs is chosen per card, the participant also expresses preferences through their omission of the 2 non-chosen programs. As a result, each choice card can be modeled as 3 inter-dependent decisions. We record this using a binary choice variable for each program presented to each subject. This generates 24 observations per individual (8 cards x 3 programs per card). In addition to the binary choice variable, each observation contains the program attribute levels, along with all choice-invariant demographic information for each subject. This form of data collection (one observation per choice) is referred to as, "long form". This is because each choice is recorded within a separate observation instead of a separate variable. One benefit to choice experiments using long form data is increased sample size and power, although one must be aware of potential correlation between choices made by a single individual. Our goal is to exploit variation within the program attribute levels to derive estimates for how much each attribute determines whether a particular program is chosen or not.

4.1.1 Logistic Regression & Choice Experiments

Most discreet choice experiments use some version of the logit model to interpret binary choice data. This can be explained in part by the limitations of the standard linear probability model (OLS). However, where logit falls short is its ability to restrict choices to specific individuals. In our case the basic logit model aggregates all choices made throughout the entire sample when estimating the effect of each attribute. In doing so, it fails to take into account that each set of 24 choices is restricted to one individual.

4.1.2 Conditional Logit (CL)

Conditional logistic regression differs from the basic logistic regression in that observations can be grouped by matched cases such as subject id (Hosmer et al. 2013). Likelihood estimates are then calculated relative to each group. Conditional logit regression has also been referred to as, "fixed-effects logit for panel data" (Chamberlain 1980). Although conditional logit can group choices by individual, it has no way of taking into account that choices are presented in sets of 3. Rather, conditional logit treats the decision-making progress like the subject makes 24 simultaneous choices. A model is needed that can account for the separation of programs into cards for each individual.

We utilize an alternative-specific conditional logit (ASCL) model to derive willingness to pay from the attribute values of the programs selected (or not selected) by the subjects in our sample. Once these values have been calculated, a two-sided t-test is used to determine whether the average values for willingness to pay are different with statistical significance between those who received the priming treatment and those who did not.

4.1.3 Alternative-Specific Conditional Logit (ASCL)

The alternative-specific conditional logit regression tweaks the regular conditional logit slightly by allowing for specified alternatives to each program. Thus, decisions are made not only based on the attributes of a specific alternative, but also based on the attributes of alternate possibilities not chosen. It takes a form very similar to the regular logit function, but with the inclusion of an additional coefficients to account for case-invariant demographic traits. Its functional form is as follows:

$$p(y_i = j) = \frac{e^{f(x,w,z)}}{\sum_{j=1}^{J} e^{f(x,w,z)}}$$

The probability of individual (i) choosing alternative (j) takes the standard logit functional model, but with vectors w and z. The specifics of this functional form are discussed in greater depth in Section 4.1.4, as ASCL is very specific to alternative-specific mixed logit.

4.1.4 Alternative-Specific Mixed Logit (ASML)

The alternative-specific mixed logit model serves two primary purposes for this study. First, it serves as a robustness check to test whether we see similar findings when using a different econometric specification. However, it also allows us to expand on one major weakness of the alternative-specific conditional logit model: lack of variation in consumer preferences. As discussed in Section 4, ASCL makes the unrealistic assumption that preferences are identical across all respondents.

ASCL regression is based off of 3 equations, which are:

1. $U_{ia}=x_{ia}\beta_i+w_{ia}\alpha+z_i\delta_a+\epsilon_{ia}$
2. $P_{ia}=\int P_{ia}(\beta)f(\beta)d\beta$
3. $P_{ia}(\beta)=\frac{e^{x_{ia}\beta_i+w_{ia}\alpha+z_i\delta_a}}{\sum_{a=1}^{A}e^{x_{ia}\beta_i+w_{ia}\alpha+z_i\delta_a}}$

Equation 1 describes the utility (U) that an individual (i) receives from an alternative (a). β_i are random coefficients that vary from subject to subject, and α is a set of fixed coefficients. x_{ia} and w_{ia} are vectors of alternate-specific variables – in this case the attribute levels of both program/alternative a as well as the attribute values of the two other alternates presented on the card. δ_a are fixed, alternative-specific parameters on z_i, which is a vector of case-specific variables – in this case demographic traits. ε_{ia} is a random error term.

Equation 2 integrates the probability that individual (i) chooses alternative (a) over the entire distribution of randomly distributed coefficients β_i. Equation 3 states that the probability (P) that an individual (i) chooses alternative (a) as a function of their individual preferences (β) is represented by the logistical function evaluated at parameters β. In theory it's quite similar to a standard logit equation, but incorporates heterogeneous preferences through a randomly distributed coefficient.

4.2 Willingness-to-Pay

To calculate willingness-to-pay (WTP) from conditional and/or mixed logit coefficients, we use an extremely simple trick pioneered by Vermuelen et al. (2008). The authors suggest that willingness-to-pay is synonymous with the marginal rate of substitution (MRS) between a product and money. The logit coefficients we estimate are synonymous with marginal utility for increasing levels of a particular attribute. We will also estimate a cost coefficient that serves as a proxy for price sensitivity. Thus, we can calculate the MRS and thus WTP using the following formula (4).

$$WTP_{\text{attribute}}=-\frac{\beta_{\text{attribute}}}{\beta_{\text{cost}}}$$

5. Results

5.1 Summary Statistics

Given the nature of convenience sampling, obtaining a truly random and balanced sample is extremely difficult to achieve as data is collected rapidly via different enumerators concurrently. Our primary concerns are ensuring that priming treatments are balanced across cities, and that demographic traits are (roughly) balanced across treatment groups.

Table 3 shows a breakdown of the sample by treatment group and city. We find the treatment groups to be roughly even across all three cities. This is consistent with expectations, as treatment group was randomized using systematic random sampling as mentioned in Section 3.1. This was accomplished by physically arranging surveys in a repeating pattern by treatment prior to distribution to enumerators.

Table 4 provides the average values for some key demographic variables (gender, age, education level, and income level) by priming treatment group. To ensure there are no significant demographic differences between the treatment groups, a series of t-tests are run for each of the means in Table 4 between each unique treatment group pair (control vs. national identity priming, control vs. food security priming, and national identity priming vs. food security priming). The t-values from these tests are displayed in Table 5. The only difference of note is that of age between the control group and the national identity group. The national identity group being ~3 years younger than both the control and food security groups (although the difference between the two priming groups is just barely not significant, with a t-stat of -1.88). The difference is significant at the 5% level, however we are currently unable to make an argument for this difference having any meaningful effect on our findings, especially given the relatively large standard deviations for age across all three groups. It should also be noted that running twelve t-tests without multiple hypothesis testing (which we were advised is generally not used for sample balance tests) can increase the chance of a type one error.

It is important to note that Income is measured using a series of ranges, and education using highest level of schooling completed. The use of, "bucket values" for these traits can present a challenge, as their mean values don't necessarily correspond directly to a quantitative value. In the interest of transparency, distributions of income ranges are shown in Table 6 and education levels in Table 7. From these tables we confirm that all education groups between primary and university are represented adequately across the treatment groups. Additionally, while the vast majority of respondents (~97%) report income within the lowest three brackets (monthly income of ~$0-$120, ~$121-$250, and ~$251-$606), all three groups are well represented across all treatment groups.

Due to the exploratory nature of this research, we are not attempting to balance test our sample with the Peruvian population at this time. Issues of representativeness are gaining traction as a major fumbling block for many microeconomic case studies (Niehaus 2018). However, doing so in developing contexts such as Peru is difficult due to two primary factors. First, there is high variance in the urban/rural population distribution, making the general population difficult to model due to extreme standard of living differences. The second is a lack of accurate and consistent data sources containing demographic data at any unit of observation small enough to be useful (Bioversity), The priority of this study is to test the validity of the experimental design. We make no claims of accurate representativeness outside of the sample that was gathered.

5.2 Choice Experiment Results

The choice experiment data is interpreted through an alternative-specific conditional logit regression, the results of which are presented in Table 8. This represents the most important findings of the paper.

In column (1), the dependent variable is, "Choose" - which refers to the binary choice variable for any one program discussed in Section 4.1. Coefficients for each of the 5 attributes are estimated, with clustered (at the card level) standard errors in parenthesis . Given that conditional logit is a likelihood estimator, attribute coefficients can be interpreted in the following (simplified) way: "All else equal, a one-unit increase in the attribute level increases the probability of a program being selected by the value of the coefficient." One might also interpret the coefficients as the marginal utility provided by a one-unit increase in that attribute (again, all else equal). The marginal utility interpretation allows us to answer research question (2) (Which attributes of biodiversity programs increase public support the most?). We simply rank the attributes by their coefficients to determine which have the biggest impact on program choice. Maintenance of cultural practices and traditions holds the highest value, followed by % of varieties existing in 50 years, then risk of production loss, and finally preservation of the Andean landscape. All 5 attribute coefficients are significant at the 1% level. This is consistent with the literature, and implies that participants are making rational choices (Zander). Non-significant attribute coefficients might suggest that subjects select programs with no regard to the programs attribute levels. The Landscape, Production, Variety, and Culture coefficients are all positive, while the Cost coefficient is negative. This is also consistent with the literature and reaffirms rational consumer habits (especially the negative response to increasing Cost).

In addition to the 5 program attributes, we also estimate two interaction terms comprised of the cost attribute multiplied by a treatment dummy for each of the two priming treatment groups. The cost coefficient alone estimates price sensitivity for the entire sample, irrespective of treatment group. Estimation of these interaction terms provides the difference between the cost coefficients in the control and treatment groups. For example, a Cost*Identity coefficient of 0.03 suggests that the national identity priming treatment group had an estimated cost coefficient of -0.014 + 0.03 = -0.011. Positive coefficients on the interactions for both treatment groups suggest that priming did decrease price sensitivity (and thus increase WTP, to be discussed in the next section). However, these values are not statistically significant at even the 10% level. This suggests that the priming treatments used in the study did not have any significant impact on consumer valuation.

Alternative-specific conditional logit allows for the specification of a baseline alternative. Following the literature, we choose the status quo option as the baseline due to it's presence on every choice card. Columns (2) and (3) estimate the effect of four subject-invariant demographic traits on selection of either Program 1 or Program 2 relative to the base alternative ("Status Quo"). Of the four traits, only education is significant - at the 1% level for both Programs. This implies that those with higher levels of education are more likely to select a non-status-quo option. This finding is consistent with the literature. Notable, however, is the lack of significance for the income coefficients. The literature suggests that marginal WTP for natural resource conservation increases with both education and income (Greenstone & Jack 2015). It is possible that the lack of significance may be a result of a lack of variation among subject incomes, due to limited number of income, "buckets" used in the survey. Nonetheless, this discrepancy suggests the need for further study. Age and gender are also both lacking in statistically significant effect, however there is no pre-determined consensus in the literature that these traits correlate highly with increasing resource valuation (if at all).

It is possible that there may be attribute-specific effects related to demographic traits. This could be tested by including interaction terms in the regression. However, we are not exploring that area of interest at this time. It would also require meticulous multiple hypothesis testing due to the large number of parameters being added to the regression.

5.3 Willingness-to-Pay

As discussed in Section 4.2, willingness-to-pay is defined in this context as the marginal rate of substitution between the attribute level and program cost. We can derive WTP values for each attribute by dividing its coefficient by the cost coefficient. We re-run our regress for each treatment group separately (motivated primarily by its simplicity. Despite sacrificing some degrees of freedom, long form data provides enough observations to split up the data set without sacrificing much accuracy). The attributes from each regression are used to generate MRS/WTP values for each attribute in each treatment sample - including the whole sample as its own group for comparison purposes. WTP values by attribute and treatment are shown graphically in Figure 2. This graph provides three important, central findings for our study.

First, we can answer part of research question (1) (What is the total economic value of quinoa agrobiodiversity?). We find that individual attribute values are significant and non-zero. The attributes selected represent different values associated with biodiversity in accordance with the TEV literature. An important policy implication arises from this finding - strategies for funding conservation of biodiversity could be identified based on the *relative* values of individual TEV components (which are synonymous with the attribute WTP values). It should be noted that the absolute WTP values used here are subject to debate over their validity. This is because the individual values can vary wildly depending on the system used to code attribute levels. In our study, for example, attribute levels are coded as {0,1,2} (see Table 2 for more detail). However, price is coded linearly. This results in small cost coefficient values relative to the other attribute values, which in turn drives WTP values up.

Second, we provide further support to the preference rankings found in Section 5.2. More the marginal utilities (attribute coefficient values) and MRS (WTP values) allow us to rank the attributes in order of how much they influence consumer choice. Furthermore, breaking down treatment group WTP by attribute shows that the ranked preferences are consistent across all treatment groups, although the size of the values vary from group to group. Most notable is the national identity group, in which the cultural attribute commands a higher value (42.6) over the next preferred attribute (variety, 26.91) than any other treatment/attribute pair. This might suggest that while national identity priming did not shift consumer price sensitivity significantly, it could have influenced the premium of it's related trait (culture) relative to that of the other program attributes. A follow-up study might estimate additional treatment-attribute parameters to test whether priming treatments influence specific attributes (although once again, this would require careful planning, including pre-declaring list of parameters and incorporation of rigorous multiple-hypothesis testing).

5.4 Robustness Check

Estimations from the ASML regression are found in Table 9. Upon first glance, it appears very similar to our initial findings. Our attribute coefficients are all still significant with the correct signs, reaffirming that our subjects were rational consumers. Our marginal utility rankings are also the same, suggesting that we were able to accurately rank attribute preferences among our sample. Furthermore, treatment/cost interactions are still insignificant, which also supports our claims that priming had no significant effect on price sensitivity. Finally, education remains the only subject-invariant demographic trait to significantly correlate with non-status-quo choices. As a robustness check, the ASML model successfully replicates all of our earlier findings.

The ASML model also adds an entirely new estimation - standard deviations for each of the attribute coefficients. Whereas the ASCL model provides only point estimates for attributes, our robustness check includes a measure of how marginal utility for each attribute is distributed throughout the (estimated) population. Significant coefficients in column (2) suggest heterogenous preferences across the population, which is both consistent with the literature and a major weakness of our primary econometric specification. However, ASML is unable to converge on coefficient estimates for individual treatment groups - likely due to small sample size as ASML burns through greater degrees of freedom. It is therefore unable to generate WTP values. For this reason, ASCL remains our primary econometric tool.

6. Challenges

There are four main challenges that exist with this body of work which are crucial to understand for any who may wish to either conduct similar research, or continue the work included in this paper. It's not always common for authors to be open about challenges to their work, but economic models often teach us as much by their shortcomings as by their merits.

The first challenge is representativeness. There is a distinct trade-off between represented samples and cheap and/or easily collected data. In this case, putting the choice experiment methodology through its paces was prioritized over obtaining a perfectly representative sample of Peru. While it might limit this study's policy influence in the short-run, refining and improving upon the toolkit of natural resource valuation

The second challenge is perhaps less of a challenge and more of a curiosity and/or opportunity for a future consistency check. The attribute preference rankings derived from the ASCL and ASML regressions are identical to the order the attributes are presented on the choice card (running from right to left, with cost on the far right). I suspect it's possible that consumers looked at price first, and were then swayed most by the attributes closest to price. This could possibly occur due to decision fatigue, disinterest, or confusion with regard to the survey instrument. I emphatically recommend that anyone performing a similar consumer choice experiment randomize the order in which attributes appear on choice cards if possible.

The third challenge arises from limitations in the priming literature. The priming literature tends to be strongly influenced by publication bias – with lots of studies finding (often interesting and peculiar) results, but with little theory to support *why* subjects acted the way they did. As a result, it is difficult to create sophisticated priming techniques from scratch, as there are few resources on what makes an effective stimuli (other than confirmation bias).

The final challenge is one of measurement. There is a consensus amongst supporters of contingent valuation that sophisticated consumer choice experiments help to mitigate hypothetical bias. However, without a real market it is near impossible to confirm what actual level of bias exists for any one particular study. Ecological pragmatists are generally un-phased by this, however limited ability to answer the hypothetical bias question often limits buy-in from empirical purists.

All of these challenges have been addressed throughout the paper, and all findings are tempered by the specific challenges they rub up against. It is my recommendation that these fundamental challenges points be considered starting points in future studies of natural resource valuation.

7. Conclusion

This study presents results of a consumer choice experiment designed to measure the total economic value of quinoa biodiversity among the general population of Peru. Hypothetical conservation programs are presented as bundles of attributes designed to represent different non-use values. An alternative-specific conditional logit regression exploits variation in attribute levels to generate marginal utility coefficients and WTP values for each attribute, both of which were significant at the 1% level of significance. The magnitudes of these values can be compared to rank the order in which attributes influence participant decision-making. Preservation of cultural traditions and practices is the most influential attribute, suggesting that the largest component of TEV for quinoa biodiversity is non-use cultural value. The choice experiment also featured two randomly assigned priming treatments: One focused on inflating national identity, and the other aimed to establish doubt regarding food security. However, neither treatment had a significant impact on price sensitivity. An alternative-specific mixed logit regression suggests that the paper's findings are robust, and also provides evidence for heterogeneity of preferences across the population. The findings of this study, particularly the attribute rankings, represent a valuable tool in guiding conservation policy with maximum buy-in from the public.

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APPENDIX A: Tables & Figures

Table 1. Sampling Plan by City and Urban/Rural Split

	Cusco	**Puno**	**Lima**	**Total**
Urban	120	100	200	420
Rural	120	100	0	220
Total	240	200	200	**640**

Table 2. Attributes and Levels Used in the Choice Experiment

Attribute	TEV Component	Levels	Levels (coding)
Preservation of the Andean landscape	Indirect use value (landscape)	3	Increase (0), Maintain (1), Decrease(2)
Risk of production loss	Non-use value (production)	3	Low (0), Medium (1), High (2)
% of quinoa species existing in 50 years	Existence value	3	10% (0), 50% (1), 90% (2)
Maintenance of cultural traditions	Non-use value (cultural)	2	No (0), Yes (1)
One-off hypothetical contribution (PEN)		7	0, 2, 5, 10, 25, 50, 100 (linear coding)

Figure 1. Sample Choice Card

				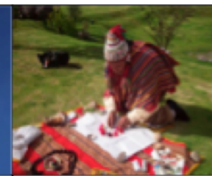	S/.
	Conservation of the Andean Landscape	**Risk of Production Loss**	**% of Quinoa Varieties in Existence in 50 Years**	**Maintenance of Traditional Knowledge and Cultural Practices**	**Cost**
Program 1	Stable	Medium	10%	✖	100
Program 2	↓	Low	50%	✔	5
Status Quo	↓	High	10%	✖	0

Table 3. Sample Split Across Treatments and Cities

	Lima	**Puno**	**Cusco**	**Total**
Control	67	64	31	162
National Identity	66	67	31	164
Food Security	67	69	29	165
Total	200	200	91	491

Table 4. Demographic Train Means by Treatment Group

Treatment	**N**	**Female**	**Age**	**Education**	**Income**
Control	162	0.47 (0.50)	40.57 (14.35)	2.34 (1.07)	1.87 (1.27)
National Identity	164	0.48 (0.50)	37.53 (12.83)	2.31 (1.02)	1.71 (1.15)
Food Security	165	0.48 (0.50)	40.34 (14.03)	2.29 (1.11)	1.62 (1.23)
Total	491	0.48 (0.50)	39.48 (13.82)	2.31 (1.07)	1.73 (1.22)

(Standard deviations in parentheses)

Table 5. Summary Statistic Balance Test T-Values

	Control vs. National Identity	Control vs. Food Security	National Identity vs. Food Security
Gender	t = -0.28	t = -0.28	t = 0.00
Age	t = 2.01	t = 0.15	t = -1.88
Education	t = 0.28	t = 0.18	t = -0.09
Earnings	t = 1.18	t = 1.74	t = 0.62

Table 6. Income Category by Treatment Group

Treatment	0 - 400	401 - 850	851 - 2000	2,001 - 5,000	5,001 - 10,000	10,000+
Control	35	73	21	2	0	1
National Identity	33	68	22	3	0	0
Food Security	38	55	25	4	0	0
Total	106	196	68	9	0	1

Table 7. Highest Level of Education by Treatment Group

Treatment	Primary	Secondary	Technical	University	Masters	PhD
Control	36	49	55	17	1	0
National Identity	39	50	52	19	1	0
Food Security	33	50	56	14	2	0
Total	108	149	163	50	4	0

Table 8 Alternative-Specific Conditional Logit Model with Program Attributes and Base Program Status Quo

VARIABLES	(1) Choose	(2) Program 1	(3) Program 2
Landscape	0.167***		
	(0.031)		
Production	0.240***		
	(0.028)		
Variety	0.296***		
	(0.028)		
Culture	0.380***		
	(0.043)		
Cost	-0.014***		
	(0.002)		
Cost*FoodSec	0.002		
	(0.003)		
Cost*Identity	0.003		
	(0.003)		
Age		0.004	0.003
		(0.009)	(0.009)
Gender		0.102	0.151
		(0.238)	(0.235)
Income		0.016	0.092
		(0.138)	(0.139)
Education		0.487***	0.503***
		(0.138)	(0.138)
Constant		-0.361	-0.618
		(0.536)	(0.526)
Observations	11,064	11,064	11,064

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 2.

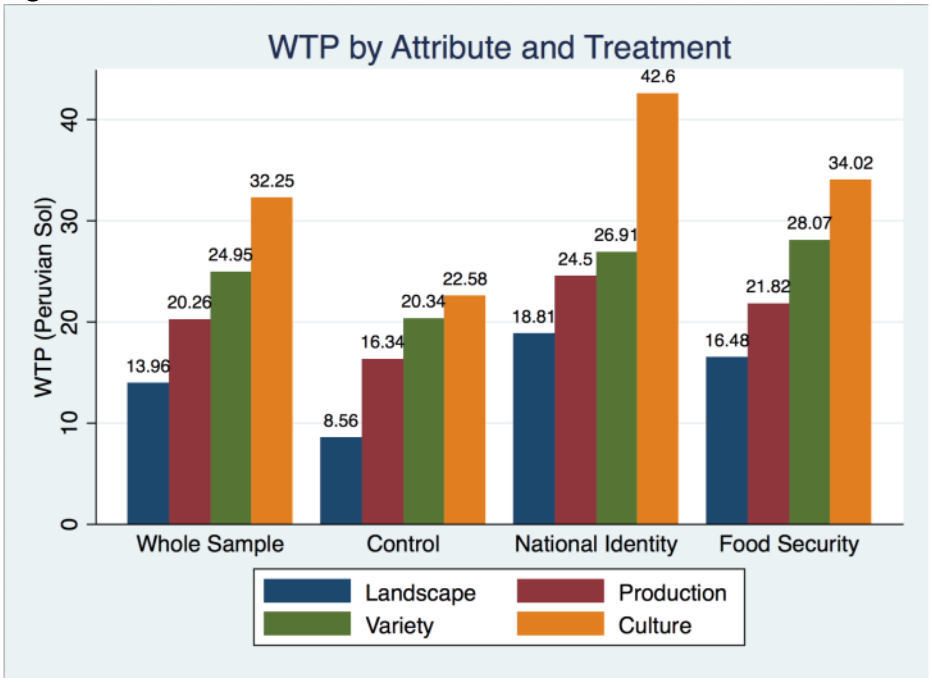
WTP by Attribute and Treatment
WTP (Peruvian Sol)
0
10
20
30
40
13.96
20.26
24.95
32.25
8.56
16.34
20.34
22.58
18.81
24.5
26.91
42.6
16.48
21.82
28.07
34.02
Whole Sample
Control
National Identity
Food Security
Landscape
Production
Variety
Culture

Table 9 Alternative-Specific Mixed Logit Model

	(1) Choose	(2) SD	(3) Program 1	(4) Program 2
Landscape	0.322***	0.499**		
	(0.095)	(0.241)		
Production	0.430***	0.654***		
	(0.105)	(0.249)		
Variety	0.567***	0.731***		
	(0.137)	(0.272)		
Culture	0.651***	0.979		
	(0.143)	(0.991)		
Cost	-0.038***	0.049***		
	(0.009)	(0.009)		
Cost*FoodSec	0.004	0.019		
	(0.008)	(0.014)		
Cost*Identity	0.003	0.038**		
	(0.009)	(0.016)		
Age			0.000	-0.000
			(0.013)	(0.012)
Female			0.190	0.264
			(0.340)	(0.341)
Income			-0.046	0.104
			(0.173)	(0.170)
Education			0.645***	0.673***
			(0.211)	(0.213)
Constant			-0.233	-0.645
			(0.796)	(0.806)
Observations	11,061	11,061	11,061	11,061

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX B: ATTRIBUTE DESCRIPTIONS

	Attribute	Options	Description
	Conservation of the Andean landscape	Increase / Decrease / Stable	Maintaining different varieties of quinoa can be very important for landscape maintenance. A lack of biodiversity can negatively impact ecological processes and aesthetic values.
	Risk of production loss	Low / Medium / High	A lack of biodiversity increases crop vulnerability to extreme events, such as hail, pests, disease, etc. This can negatively impact regional food security. Funding would increase incentives to plant more native ecotypes on farms to offset cost of lower market returns.
	% of existing quinoa varieties existing in 50 years	10% / 50% / 90%	Market pressures for certain kinds of quinoa have meant a more precarious existence for varieties without market value. Funding would provide access to seeds, seed sharing programs, and storage in gene banks. Maintaining at least a "safe" minimum population of quinoa varieties in their traditional environment will greatly reduce the possibility that they might one day become extinct and no longer be available to future generations.
	Maintenance of traditional knowledge and cultural practices	Yes / No	Biodiversity is an important Peruvian cultural asset. Different varieties of quinoa are often associated with local cultural events. For example, misa quinoa is used for pago de la tierra ceremonies.
	Program Cost	0 / 2 / 5 / 10/ 25 / 50 / 100 (soles)	Each program has an associated cost that reflects the cost of management. These costs represent a one-time individual donation.

APPENDIX C: FULL QUESTIONNAIRE

1. **ADMINISTRATIVE (1 of 12):** Please fill out the following information before beginning

1.1	Enumerator name		
1.2	Date		
1.3	Time		
1.4	Region		
1.5	District		
1.6	Location/Cluster		
1.7	Consent information was read to participant	☐ Yes	☐ No, discontinue survey

SURVEY CODE:

CONSENT INFORMATION:
Hello, I am conducting research on behalf of graduate students from the University of San Francisco. The aim of this 20 minute study is to measure how people value traditional varieties of quinoa. Your participation is voluntary and has no negative consequences. All answers will be anonymous and confidential.

2. **ELIGIBILITY (2 of 12):** Please ask participant the following

2.1	Are you a resident of Peru?	☐ Yes	☐ No, discontinue survey
2.2	Are you over the age of 18?	☐ Yes	☐ No, discontinue survey

3. **QUINOA INFORMATION (3 of 12):** Please ask participant the following and read the options:

3.1	Which of the following varieties of quinoa have you seen in real life? Check all that apply. ***If [None] is selected, skip to Section 4***	☐ Pink	☐ Grey	☐ Brown	☐ White	☐ Red	☐ Yellow	☐ Black	☐ Other:_______	☐ None
3.2	Which of the following varieties of quinoa have you consumed? Check all that apply. ***If [None] is selected, skip to Section 4***	☐ Pink	☐ Grey	☐ Brown	☐ White	☐ Red	☐ Yellow	☐ Black	☐ Other:_______	☐ None
3.3	How often do you consumer the following varieties each month:	Pink: ____	Grey ____	Brown ____	White ____	Red ____	Yellow ____	Black ____	Other:_______	

4. **DONATION INFORMATION (4 of 12):** Please ask the participant the following and read the options:

4.1	Have you donated to a person, organization, or cause in the past two years? **If [No], skip to Section 5**	☐ Yes	☐ No
4.2	What types of causes did you donate to? **Check all that apply.**	☐ Health ☐ Political ☐ Environmental ☐ Social justice	☐ Religious ☐ Economic ☐ Natural disaster ☐ Other:____________
4.3	What did you donate? Check all that apply. **If [Money] was not selected, skip to section 5**	☐ Labor/Time (volunteer) ☐ Money	☐ In-kind (clothes, supplies, etc.) ☐ Food

			☐ Other:______________
4.4	On average, how much do you donate per organization/cause/person in soles:	☐ 0.10 to 0.90 ☐ 1 to 3 ☐ 3.10 to 10 ☐ 10.10 to 20	☐ 20.10 to 50 ☐ 50.10 to 100 ☐ 100.10 to 500 ☐ 500.10 to 2000 ☐ more than 2000
4.5	On average, how many organizations/people/causes do you support with money per year.	☐ 1 to 3 ☐ 4 to 7	☐ 8 to 10 ☐ more than 10

5. **AGROBIODIVERSITY INFORMATION (5 of 12)**: Please read excerpt to participant and fill out 5.1. Ask the participant 5.2

AGROBIODIVERSITY:
What is agrobiodiversity: Agrobiodiversity refers to "the different types and varieties of crops that make up our food systems".

Why is it important? An important example of agro biodiversity is the thousands of traditions varieties of quinoa, each adapted to slightly different conditions and needs. This diversity is an important form of insurance against environmental risks, pests, and other threats that might negatively impact any particular variety.

What is the current status/threat? As quinoa has taken off as an export crop, the market favors a few large-seeded, "white" varieties, leading farmers to concentrate on these varieties and neglect man of the others. As a result, many of the traditional varieties are disappearing, and with them the ability for quinoa to adapt to different conditions.

5.1	***For enumerator:*** Background information on agrobiodiversity was read	☐ Yes	☐ No
5.2	***For participant:*** Have you previously heard about conservation and agrobiodiversity?	☐ Yes	☐ No

6. **CHOICE EXPERIMENT DIRECTIONS (6 of 12)**: Please read the following to the participant. Then show the participant the example with description.

CHOICE SET DIRECTIONS:
You will be shown several of cards, each of which includes multiple conservation programs from which to choose. Each program has an associated cost that reflects the management costs. These costs represent a one-time donation. For each card, select the program that you would support given the associated costs.

Please consider the following when choosing a program from each card:
- Bringing about good conservation outcomes costs money;
- Quinoa varieties are not the only crop that may require further funding;
- There are other good causes that you may wish to support;
- You may have limited income and need to consider this cost in light of your other expenses.

6.1	Choice experiment directions were read to participant	☐ Yes	☐ No

6.2	Choice set example shown to participant	☐ Yes	☐ No

7. **PRIMING**

7.1	**For enumerator:** Select survey type. **If [Control], skip to section 8.**	☐ Food security treatment	☐ Identity treatment	☐ Control
7.2	**For enumerator:** Appropriate information was read or asked to participant	☐ Yes	☐ No	

NATIONAL IDENTITY PRIMING: to be read/asked if this treatment is randomly picked

1. Peru is one of the most important centres of crop diversity and domestication in the world. This diversity has a value that goes beyond Peruvian borders. Agricultural biodiversity is the basis of human survival and well-being – and through maintenance of biodiversity, Peruvians are protectors of the entire human race.
2. Quinoa originated in the mountains of Peru, and has been important to Andean cultures for over 5,000 years. For the Inca, one of the most powerful civilizations on the American continent, quinoa was an important staple crop and was considered. They called it, the mother of all grains, or chisaya mama. The legend states that the Incan emperor would ceremoniously plant the first quinoa seeds every year. It remains a prominent food source for their indigenous descendants, the Quechua and Aymara people.
3. Like many of the ancient grains, quinoa slipped into obscurity in 1532 with the arrival of the Spanish. Explorer Francisco Pizarro, in his resolve to destroy Incan culture, had quinoa fields destroyed. Thanks to the diversity of quinoa species, some varieties were able to survive high in the mountains. This allowed for quinoas reintroduction to the modern world. Now, we can benefit from the mother grain that our Incan predecessors left behind.
4. Maintaining traditional varieties of quinoa is important to maintain Peru's culture. Biodivesity is a Peruvian cultural asset just like languages, archeology, or food.

FOOD SECURITY PRIMING: to be read/asked if this treatment is randomly picked

Currently, the global population relies on 15 crops for 90% of all calories. By 2050, the agricultural industry will need to support 9 billion individuals and increase food production by 70 percent according to the Food and Agricultural Organization. Food security can be defined as: "when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life"

7.2.1	Think about your current food situation. On a scale from 0 to 10, how food insecure do you feel today? 0 = completely food insecure, 10= completely food secure. **If any number other than 10 was selected, skip to 7.2.3.**	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10

7.2.2	What would make you feel more food secure?					
7.2.3	How vulnerable are you to experiencing food insecurity (not enough savings, unstable job, living in area without access to food)	☐ Very insecure	☐ Somewhat insecure	☐ Neutral	☐ Somewhat secure	☐ Very secure
7.2.4	Think about your current food needs. How important is it to you to have food security now?	☐ Very unimportant	☐ Somewhat unimportant	☐ Indifferent	☐ Somewhat important	☐ Very important
7.2.5	Think about your future food needs. How important is it to you to have food security in 50 years?	☐ Very unimportant	☐ Somewhat unimportant	☐ Indifferent	☐ Somewhat important	☐ Very important
7.2.6	Think about your children and loved ones. How important is it to you to have food security now?	☐ Very unimportant	☐ Somewhat unimportant	☐ Indifferent	☐ Somewhat important	☐ Very important
7.2.7	Think about your children and/or loved ones. How important is it to you to have food security in 50 years?	☐ Very unimportant	☐ Somewhat unimportant	☐ Indifferent	☐ Somewhat important	☐ Very important
7.2.8	What if you lost your job tomorrow. How likely is it that you would remain food secure for month?	☐ Very unlikely	☐ Somewhat unlikely	☐ Neutral	☐ Somewhat likely	☐ Very likely
7.2.9	What is disease destroyed this agriculture, How likely is it that you would remain food secure for month?	☐ Very unlikely	☐ Somewhat unlikely	☐ Neutral	☐ Somewhat likely	☐ Very likely

8. **CHOICE SET:** Show the participant the randomly chosen block and their choices.

8.1	**For enumerator:** Which block was chosen?	☐ A	☐ B	☐ C	☐ D	☐ E	☐ F	☐ G	☐ H
8.2	**For enumerator:** Card 1: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				
8.3	**For enumerator**: Card 2: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				
8.4	**For enumerator:** Card 3: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				
8.5	**For enumerator:** Card 4: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				
8.6	**For enumerator:** Card 4: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				
8.7	**For enumerator:** Card 4: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				
8.8	**For enumerator**: Card 4: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				
8.9	**For enumerator:** Card 4: Which program was chosen?		☐ Program 1	☐ Program 2	☐ Status Quo				

9. **FOLLOW UP**

9.1	What is the largest amount you would be willing to donate one time to a conservation program?	___________ soles

9.2	How confident are you that you would actually make a donation if presented with the opportunity?	☐ 0%	☐ 10%	☐ 20%	☐ 30%	☐ 40%	☐ 50%	☐ 60%	☐ 70%	☐ 80%	☐ 90%	☐ 100%

9.3	Rank the following attributes**: 4 = most important, 1 = least important**	☐ Conservation of Andean Landscape	☐ Risk of production loss	☐ % of quinoa varieties existing in 50 years	☐ Maintenance of traditional knowledge and cultural practices

Enumerator to read: "Thinking about the information presented earlier about agrobiodiversity and quinoa, please indicate your response to the following statements:"

9.4	I understood the information in the questionnaire	☐ Strongly agree	☐ Agree	☐ Neither agree nor disagree	☐ Disagree	☐ Strongly disagree
9.5	I needed more information than was provided	☐ Strongly agree	☐ Agree	☐ Neither agree nor disagree	☐ Disagree	☐ Strongly disagree
9.6	I found the choice questions difficult to understand	☐ Strongly agree	☐ Agree	☐ Neither agree nor disagree	☐ Disagree	☐ Strongly disagree

9.7	Which **one** option of the following motivated your conservation decision the most?	☐ The cost of the conservation program	☐ Concerns about the environment	☐ Concerns about food security	☐ Concerns about loss of identity

9.8	What is your weekly food expenditure?	____________________ soles	
9.9	What are the primary staples in your diet? **List top three.**		
9.10	Who prepares the food in your house?	☐ Me	☐ Other: ________________
9.11	Who purchases the food in your house?	☐ Me	☐ Other: ________________

10. **DEMOGRAPHIC**

10.1	Gender;	☐ Male	☐ Female
10.2	How old are you?	☐ Years	☐ No Answer

10.3	In which region do you reside?	☐ Here	☐ Other: ____________
10.4	In which district do you reside?	☐ Here	☐ Other: ____________
10.5	In which community do you live?	☐ Here	☐ Other: ____________

10.6	How long have you lived at your current residence?	_________ years

10.7	What is the highest level of education you have attained or are in the process of attaining:	☐ Primary	☐ Secondary	☐ Technical	☐ University	☐ Master's	☐ Doctorate	☐ Other: ________

10.8	What is your marital status?	☐ Single	☐ Married	☐ Cohabitating	☐ Widowed	☐ Divorced

10.9	Do you have children? **If [No] skip to 10.11**	☐ Yes	☐ No
10.10	How many children do you have?	____________________ children	

10.11	What is your household size?	Adults: ___________	Children (<18 years): ___________	Total:_____________

10.12	What is your main profession?	Agriculture	Wage labor	Entrepreneur	Government	Student	Full-time parent	Unemployed	Other

10.13	Please approximate your total monthly income:	☐ 0-300 soles	☐ 301-600 soles	☐ 601-900 soles	☐ 901 – 1200 soles	☐ 1201 – 1500 soles	☐ 1501 – 1800 soles
		☐ 1801 – 2100 soles	☐ 2101 – 2400 soles	☐ 2401 – 2700 soles	☐ 2701 – 3000 soles	☐ 3000 – 3500 soles	☐ 3500+ soles

10.14	Do you consider yourself a member of a community of indigenous peoples? If no, skip to 10.16	☐ Yes	☐ No

10.15	Which of the following communities do you consider yourself a part of:	☐ Quechua	☐ Aimara	☐ Other

10.16	Which of the following languages can you converse in:	☐ Spanish	☐ Quechua	☐ Aimara	☐ Ashaninka	☐ English	☐ Other native	☐ Other foreign

10.17	Which language do you speak the most in your household?	

11. **SOCIO-ECONOMIC**
12. **PAYOUT**

13. **CONSENT AND CONCLUSION (12 of 12):** Please read the Statement of Consent and Conclusion to the participant. Please ask the participant to sign an "X."

STATEMENT OF CONSENT:
I heard the consent form for the project Agrobiodiversity in Peru conducted by students of the University of San Francisco. The nature, demands, risks, and benefits of the project were explained to me. I am aware that I had the opportunity to ask questions about this research. I understand that I may withdraw my consent and discontinue my participation at any time without penalty or loss of benefits to which I am otherwise entitled. If I have any questions about this study, I understand I can contact Dr. Elizabeth Katz by email at egkatz@usfca.edu. If I have any questions about my rights as a participant, I understand I may contact the University of San Francisco IRB at IRBPHS@usfca.edu.

Participant place "X" below:

____

12.1	**For enumerator:** Consent form was read to participant	☐ Yes	☐ No
12.2	**For enumerator:** Participant marked an X	☐ Yes	☐ No

CONCLUDING REMARKS:
Thank you so much for helping us to gather this important research. The information this survey gathers is important in guiding conservation policies which help to protect Peru's environmental assets. Have a wonderful day.