
# Farmers' preferences to cultivate threatened crop varieties: Evidence from Peru

by Inès Martina, Liesbet Vrankena, and Roberto Ugás

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**Abstract**

Addressing the problem of the underutilization of genetic diversity is of utmost importance, not only for biodiversity conservation, but also to ensure and improve the sustainability of the livelihoods of smallholder farmers in the long run. *In situ* conservation depends on the active participation of farmers and requires to understand their (un)willingness to cultivate these local and threatened crops. In this study, a discrete choice experiment is used to analyse Peruvian farmers' willingness to cultivate the Mochero chili pepper in the department of La Libertad and an investigation of the factors that determine the producers' preferences is performed. Results indicate that the farmers are willing to cultivate the Mochero chili pepper, preferably on smaller land shares and that they furthermore value higher yield levels, local, national and international market access and higher sales prices. Moreover, the study identifies the existence of heterogeneity in farmers' overall willingness and preferences. Results from the latent class approach identify two classes of farmers, respectively more and less willing to cultivate the Mochero chili pepper. The results demonstrate the existence of potential to enhance the native chili pepper diversity in Peru, given that the required incentives for local production are in place.

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Throughout the twenty-first century, agriculture is likely to remain the most important driver of biodiversity loss[1,2]. To meet the dietary needs and preferences of a growing world population, further expansion of agriculture through extensification and intensification will be required[3,4]. In terms of agricultural biodiversity, the expansion of modern agriculture has been accompanied by an increased homogeneity in global production systems and global food supplies[5]. Additionally, as a result of several interrelated agronomic and genetic factors, economic circumstances and historical, social and cultural determinants, the shift from traditional and subsistence to modern and commercial farming contributes to the underutilization of genetic diversity when farmers replace a diverse set of local varieties and landraces with monocultures of modern varieties[6–10]. Underutilization threatens the genetic resource base and contributes to genetic erosion in local production systems, being especially a concern when knowledge about traditional varieties disappears[6,7,10].

Maintaining genetic diversity in local production systems is an important strategy to safeguard sustainable and resilient livelihoods, to ensure food security, to increase and diversify sources of income of local communities and to reduce risk from weather, pests and diseases and market fluctuations[6,11]. These widely acknowledged benefits of agricultural diversity and the concern over the loss of it have led to the creation of complementary *ex situ* and *in situ* conservation approaches[12–14]. Since the turn of the century, promoting *in situ* or on-farm management of genetic diversity has increasingly become a crucial element of conservation strategies[6].

The goal of *in situ* or on-farm conservation is to encourage farmers to continue growing and managing local and threatened crop varieties and landraces[13]. This conservation strategy depends on the active participation of farmers and requires to understand their (un)willingness to cultivate these local and threatened crops[10,13]. To the extent that the private value of genetic diversity to farmers is lower than the optimal public value to society, farmers may not conserve the optimal amount of diversity[10,15]. Farmers might thus need to receive public support for on-farm conservation through appropriate interventions[10,15]. Which interventions are appropriate depends on whether the constraints faced by farmers to continue growing threatened crop varieties are demand or supply driven[10]. The purpose of demand driven interventions is to create incentives for production by increasing the value of underutilized crops to farmers, which can be achieved with market-based as well as nonmarket-based approaches[10,13], whereas the purpose of supply driven interventions is to decrease the costs and transaction costs of accessing these varieties and information about their characteristics[10].

de Janvry & Sadoulet (2019) describe two complementary approaches to create incentives for production. The first approach intends to remove specific constraints to adoption. Reviews of adoption processes by farmers have often focused on agricultural innovations and technology[17–20]. However, according to Bjarklev et al. (2019), the adoption process is also relevant to underutilized crops; several constraints exist that influence their (re)adoption. Specific constraints in an adoption process for a smallholder farmer typically relate to risk and insurance, difficulties in accessing credit and savings, the unavailability of information and restricted market access due to high transaction costs arising from inadequate infrastructure[16]. An approach that intends to remove these constraints may nonetheless be hampered due to heterogeneity in farmers' circumstances, objectives and capacity and due to its aim of achieving a predetermined solution to adoption[16].

The second approach is to create incentives for production through the development of markets, which requires the exploration of strategies to promote inclusive value chain development to meet well identified consumer demand[16]. Establishing value chains for underutilized species and improving the linkages of producers to the market creates opportunities for the conservation of biodiversity while simultaneously enhancing the livelihoods of farmers and contributing to rural development and poverty alleviation[16,21–24]. Positive welfare effects from value chain participation are expected to arise from increased productivity, a higher income, market access, lower transaction costs, economies of scale and the reduction of risk and uncertainty through the availability of information and the provision of credit, insurance, agricultural inputs and technical services[22,24,25]. However, up to now, the potential of value chain development for underutilized species has not been fully exploited due to lacking knowledge on the potential value of these crops, inadequate policies and programs and trade and regulatory barriers[26,27]. Nevertheless, value chain development increasingly receives attention due to changing consumer preferences and increased consumer demand for added value and differentiated products, induced by globalization and socio-economic changes[7,23]. This phenomenon gives rise to the development of markets niches[7,23] and to tailor-made marketing approaches[26] that allow for price differentiation[7,11,14,28,29]. This requires that farmers have the capacity to reflect on and satisfy consumer demand and that complementary interventions related to information and communication, technology and trade and regulatory barriers are in place to fulfil the requirements at other stages in the value chain, these being indispensable to ensure the sustainability of production [23,26].

One example of a threatened and underutilized variety is the Mochero chili pepper (Capsicum *chinense* Jacq.)[30,31]. Traditionally, the genus *Capsicum* originated in the arid regions of the

Andes[28] and is native to tropical America[32]. As a consequence of Peru's natural advantages for the adaptation of these local varieties to different environments, Peru is an important centre of diversification and currently the country with the largest cultivated *Capsicum* diversity in the world[28,33,34]. Addressing the problem of the underutilization of native chili pepper diversity is of utmost importance, not only for biodiversity conservation and to avoid the process of genetic erosion, but also to explore opportunities to ensure and improve the sustainability and the viability of the livelihoods of rural smallholder farmers growing threatened *Capsicum* varieties as a means to poverty alleviation and rural development[28]. As such, studying farmers' preferences for growing the Mochero chili pepper can provide useful insights for other regions where local varieties are under threat of extinction.

In order to increase the cultivation of the threatened Mochero chili pepper by Peruvian smallholder farmers in the department of La Libertad, it is necessary to acquire insights on the preferences and constraints faced in cultivation. This study investigates farmers' willingness to cultivate this underutilized native chili pepper variety using a discrete choice experiment and aims to identify and improve the understanding of the factors that shape this willingness in order to allow for more purposely targeted agricultural extension activities. As far as the literature is concerned, several empirical studies have used a discrete choice experiment to elicit farmers' preferences for production practices[35], crop variety traits[36–38], technology adoption[39] and biodiversity and conservation practices[40–42]. The literature on adoption processes has mainly focused on logit and probit models for dichotomous adoption decisions and on tobit models to also account for the intensity of adoption[17]. To our knowledge, no previous research has been conducted to analyse farmers' willingness to cultivate an underutilized and endangered native chili pepper variety in Peru using a discrete choice experiment. The paper is structured as follows: the introduction is followed by the second section describing the methodology; the third section presents the results and is followed by a discussion of the results in the fourth section; finally, the fifth section provides a conclusion and policy implications.

## B METHODOLOGY

### STUDY AREA

The study area of the research project is part of the department of La Libertad, situated along the north-eastern coast of Peru. The capital city is Trujillo and the department is further divided into twelve provinces and eighty-tree districts. 80% of the area of La Libertad is part of the Andean mountain range, but it is also composed of rainforest and coastal area[43]. The research was conducted in the coastal area, which has a semitropical or, according to the Köppen climate classification, a hot desert climate (BWh), with an average temperature of 18°C and no more than 50 mm precipitation annually[43,44]. As a consequence of this arid climate, irrigation is required for the cultivation of chili peppers[45]. The special project Chavimochic, implemented in the provinces of Ascope, Trujillo and Virú, aims to provide irrigation for 160,000 ha in the valleys of the rivers Chao, Virú, Moche and Chicama, using the hydrological potential of the river Santa[46]. The study area of the research includes the valleys of these four rivers and is displayed in Figure 1.

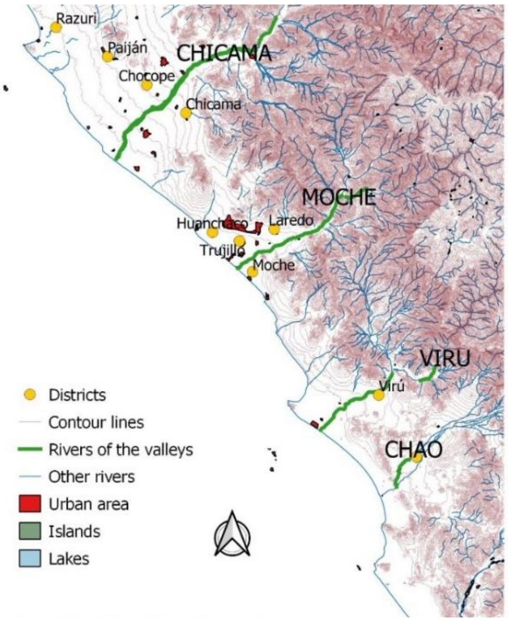


*Figure 1: Study area with the indication of the four valleys and the districts*

According to MINAGRI[1], in 2018, chili pepper production in La Libertad amounted to 1,653 tons and was seeded on 176 ha, corresponding to respectively 11.2% and 4.5% of national total[47]. The average chili pepper yield was 23,120 kg/ha; the highest yield in Peru[47,48]. In the coastal area of La Libertad, mainly the ají [2] Amarillo and Escabeche, varieties of *C. baccatum*, and the ají Mochero, Panca and Limo, varieties of *C. chinense,* are cultivated[49]. As suggested by its name, the Mochero chili pepper traditionally belongs to the valley of the river Moche[50]. This variety has a very low diversity, is almost exclusively restricted to the region of Moche[45] and is considered an underutilized native chili pepper[31]. The medium sized Mochero chili pepper is the fruit of a productive plant and is characterised by an intense yellow colour, obtained through seed selection by farmers. Because of its characteristic citric aroma, it is an indispensable ingredient in traditional food preparation[33,45].

[1] Ministerio de Agricultura y Riego (Ministry of Agriculture and Irrigation)
[2] *C. annuum, C. frutescens, C. chinense* and *C. baccatum* are named 'ajíes'[28] in Spanish.

DISCRETE CHOICE EXPERIMENT

*Theoretical framework*

A discrete choice experiment (DCE) is a stated preference method in which individuals' discrete choice behaviour is used to reveal their preferences for hypothetical alternatives based on the assumption of utility-maximisation[51–53]. The theory behind the DCE was founded on the combination of two important economic theories: random utility theory and the economic theory of value. Random utility theory (RUT) was elaborated in economics by McFadden (1974) and structurally formalized by Manski (1977) and assumes that the latent utility consists of a systematic and a random component[52]. The economic theory of value was developed by Lancaster (1966) and states that utility is derived from the characteristics of the goods instead of from the goods themselves. Most DCEs have been applied in health care[57,58], in transportation economics[59,60], in environmental economics[60,61] and in marketing[60].

Following Kjær (2005) and by Amaya-amaya et al. (2008), total latent utility associated with individual n choosing alternative i from choice set $C_n$ can be expressed as follows:

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

where $U_{in}$ is the latent, unobservable utility for alternative i; $V_{in}$ the systematic, observable component of utility and $\varepsilon_{in}$ the random, unobservable component of utility[57].

When assuming a linear additive utility function[57], i.e. $V_{in} = \beta_n x_{in}$, the systematic component of utility for alternative i can be specified as a linear function of the attributes of the alternatives[51,61,62]. Estimation of the model parameters allows to estimate the weight of the different attributes in the observable component of utility of a specific alternative and to determine the preferences of individuals for the different attributes[60]. Incorporating a continuous monetary attribute in the model allows to obtain marginal willingness-to-pay

(WTP) estimates for each of the attributes[57] as the ratio of the coefficient of a certain attribute to the coefficient of the monetary variable[63] and provides an estimate of the marginal rate of substitution between a certain attribute and the monetary attribute[51].

$$WTP = \frac{\beta_{attribute}}{\beta_{income}} \tag{2}$$

*Discrete choice modelling*

Discrete choice modelling involves the specification of a probabilistic model for the observed choices as a function of the parameters[60]; statistical estimation of discrete choice models is performed using maximum likelihood estimation (MLE)[60] with software package Stata[64]. To assess farmers' willingness to cultivate the threatened Mochero chili pepper, we estimate the generalized multinomial logit model (G-MNL). Heterogeneity in farmers' willingness can arise both from differences in the deterministic utility component, resulting in preference or taste heterogeneity, as from differences in the random utility component, resulting in scale heterogeneity[65,66].

To obtain a model that can be identified, the scale factor is typically normalized to unity, as is the case in the conditional logit and the mixed logit model; however, by doing so, the mean of the systematic component and the variance of the random component are confounded and cannot be estimated independently, potentially causing biased parameter estimates[65,66]. The computation of marginal rates of substitution eliminates the effect of the scale on the parameter estimates and can be used as a strategy to avoid biased estimates[66]. This also applies to WTP calculation, where the observed heterogeneity is by definition explained by preference heterogeneity as potential scale heterogeneity is eliminated by the division of the coefficient estimates[67]. Another strategy consists of the use of scale-adjusted models to estimate both the mean and the variance heterogeneity[66]. One of such approaches, described by Fiebig et al. (2010), is the estimation of the generalized multinomial logit model (G-MNL), combining the scaled multinomial logit model (S-MNL), where $\beta_n = \sigma_n\beta$ and the mixed logit model (MXL), where $\beta_n = \beta + \theta_n$.

According to Fiebig et al. (2010), the general expression for the G-MNL model is given by:

$$\beta_n = \sigma_n\beta + \gamma\theta_n + (1-\gamma)\sigma_n\theta_n \quad (3)$$

The parameters $\sigma_n$ and $\theta_n$ are used to model scale heterogeneity and preference heterogeneity respectively; $\sigma_n$ is assumed to follow a log-normal distribution with mean one and standard deviation τ. The parameter γ is used to model how the variance of the preference heterogeneity depends on the scale heterogeneity[65]. When $\gamma = 1$, the resulting model is the G-MNL I model, where $\beta_n = \sigma_n\beta + \theta_n$; the variance of the preference heterogeneity does not depend on the scale heterogeneity. When $\gamma = 0$ , the resulting model is the G-MNL II model, where $\beta_n = \sigma_n(\beta + \theta_n)$; the variance of the preference heterogeneity is proportional to the scale heterogeneity[65].

To understand the factors that shape the farmers' willingness to cultivate the threatened Mochero chili pepper and to identify their different socio-economic profiles, we estimate the latent class (LC) model by using the expectation-maximization (EM) algorithm[68–70]. This model recognizes discrete classes of individuals with similar utility functions[51] and is based on drawing parameters from a density function with finite support and thus with a discrete number of parameter values[60,71,72]. Latent or unobserved variables indicate to which class individuals can be assigned and may be associated with observed socio-economic characteristics of the individuals[34].

*Design of the discrete choice experiment*

The design of a DCE consists of different steps. Firstly, the process of attribute selection, often described as a two-stage process, includes an initial conceptual attribute development and a subsequent refinement of the intended meaning of the attributes, involving the determination of relevant attribute levels[73]. Relevant attributes regarding the willingness of farmers to cultivate the threatened Mochero chili pepper were obtained through a literature review and brainstorming sessions on crop characteristics, use of inputs, the environment of the farm, harvest characteristics, the value chain and the market[35–42,74–77] and qualitative approaches such as expert consultation at the UNALM[3] and two focus group discussions (FGDs). FGDs were conducted following the methodological framework proposed by Jeanloz et al. (2016) with researchers at the UNALM and a group of five farmers cultivating the ají Mochero in the valley of Moche and belonging to the producer association 'Asociación Renacimiento Campiñero de Moche'. The six identified attributes, descriptions and levels are displayed in Table 1. Farmers are expected to prefer to allocate a smaller share of land to the cultivation of the Mochero chili pepper; a good adaptability to the local growth conditions in order to use less agricultural inputs to cope with environmental stress factors; higher yield levels; stable yields so as to obtain a more stable income and to use less agricultural inputs to cope with pests and diseases; local, national or international market access and higher sales prices.

Secondly, choice sets were constructed by grouping the attributes and attribute-levels into combinations that form mutually exclusive hypothetical alternatives[51,61]. The creation of choice sets was based on an appropriate experimental design strategy and was performed

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using software package Ngene[79]; a Bayesian D-efficient design was generated (Table A.1). Every choice task consisted of three alternatives; two alternative scenarios and an opt-out alternative. To be able to assess the willingness of farmers to cultivate the ají Mochero, the opt-out alternative in this study represented the scenario in which the farmer chose not to cultivate this chili pepper variety. To account for the opt-out alternative and the associated differences in utility between the alternatives[57], an alternative specific constant (ASC) was included in the model. The ASC was coded zero for the opt-out alternative and one for the two other alternatives, thus representing the general willingness to cultivate the Mochero chili pepper. Sixteen choice tasks were created in two blocks; every respondent was given eight choice tasks.

*Table 1: Identified attributes and their respective descriptions and levels*

| Attribute | Description | Levels | Type |
|---|---|---|---|
| **Share of ají Mochero** | Share of the agricultural land used for the cultivation of the Mochero chili pepper. | 10 %<br>40 %<br>70 % | Continuous |
| **Adaptability to growth conditions** | Whether or not the Mochero chili pepper has a good adaptability to local growth conditions, influenced by environmental stress factors. | Adapted<br>Not adapted | Categorical |
| **Yield** | Average production of the Mochero chili pepper harvested per ha (ton/ha). | 2 ton/ha<br>4 ton/ha<br>6 ton/ha | Continuous |
| **Yield stability** | Whether or not the Mochero chili pepper gives a stable yield year after year, influenced by pests and diseases. | Stable<br>Variable | Categorical |
| **Market access** | Whether or not the farmer has access to a market for selling his produce of Mochero chili pepper and to which type of market. | No access<br>Local market<br>National market<br>International market | Categorical |
| **Price** | The average price the farmer obtains for selling 1kg of the Mochero chili pepper. | 1 PEN<br>6 PEN<br>11 PEN<br>16 PEN | Continuous |

Note: Categorical attributes were effects-type coded.

### HOUSEHOLD SURVEY AND SOCIO-ECONOMIC VARIABLES

The second part of the survey consisted of a questionnaire regarding the socio-economic characteristics of the producers and their households, their farming practices and financial situation. This information allows to identify whether a different socio-economic profile influences the willingness to cultivate the Mochero chili pepper. It thus allows the detection of potential factors that determine or explain preference heterogeneity among the sample[57].

In the abundant literature on adoption behaviour, several factors are suggested to affect an adoption process by influencing the farmers' perceptions, uncertainty and attitudes[19]. The questionnaire was developed based on the review of theoretical and empirical studies of adoption behaviour by Feder et al. (1985) and by Feder & Umali (1993) and on the framework presented by Abadi Ghadim & Pannel (1999), which considers an adoption decision as a dynamic, multi-stage process based on the acquisition of information and learning-by-doing. Factors potentially influencing an adoption process include farm size, being related to the amount of fixed costs an adoption decision brings about[17,18]; the physical environment of the farm, including soil fertility and access to water[18]; human capital, covering skills, health, education level and labour availability[18,19]; wealth, credit constraints, savings and off-farm income[17,18]; land tenure or ownership, influencing the incentives to invest [17,18]; access to inputs, technology and infrastructure[17]; risk aversion, positively correlated with age of the farmer and negatively with wealth and the ability to invest[18,19] and uncertainty, which can be reduced with the acquisition of information through media or extension services and with the development of skills through previous experience with adoption processes[18,19]. These potential factors were complemented by considering the livelihood assets and the factors associated with the five components of available capital in the sustainable livelihoods approach[30,80–82].

### Sampling method and data collection

Data was collected between the 16th of September and the 12th of October 2019. Due to the unavailability of a sampling frame or the lack of information about the number, distribution and proportion of farmers producing chili peppers in the area where the irrigation project Chavimochic is implemented, the producers were selected in the four valleys on the basis of whether they were available and willing to participate in the project. As a result of this convenience sampling technique, the obtained statistical results may not be representative of the whole region under the Chavimochic project; a drawback is that the surveyed farmers all were, at least to some extent, interested in the cultivation of chili peppers.

The mode used for data collection was a face-to-face interview, consisting of three parts: the DCE, follow-up questions related to attribute non-attendance (ANA) and the household questionnaire. During the implementation of the DCE, the purpose was clearly explained in the introduction and all attributes and levels were thoroughly described to the respondents. To avoid the occurrence of bias caused by an order effect, the choice tasks were presented in a random order to every respondent[57,62]. In addition, the possibility of the occurrence of hypothetical bias[83,84] was taken into account and mediated by introducing a cheap talk script[84].

## C Results

### Descriptive statistics

Table 2 represents summary statistics of all socio-economic variables of the sampled population. All respondents were farmers, but 7.5% did not consider agriculture to be their principal economic activity. On average, the interviewed farmer was 52 years old and disposed of 27 years of agricultural experience. Respectively 90% and 48% of the farmers had current or previous experience with chili pepper cultivation and with the ají Mochero in particular. More than 60% of these farmers completed secondary education. Households cultivated on average 7.57 ha of land, which by more than 85% of the farmers was considered to be of at least average soil fertility. In about two-fifths of the cases the land was owned. Most respondents indicated to dispose of an average standard of living. However, for almost a quarter of the households, monthly income amounted to less than 500 Peruvian soles. More than 70% of the households used credit and 50% had at least one off-farm wage employed household member. In general, the family labour force was little and most farmers relied more on contracted labour force, especially in times of higher labour requirements. Related to the cultivation of the land and the use of inputs, three-quarters of the farmers relied on the river as water source and 43% belonged to the irrigation commission. Organic fertilizer was applied by almost 90% of the respondents. Inorganic fertilizer and pesticides were used by almost all interviewed farmers. A little more than half of the farmers received capacity building and technical assistance. Considering the fact that on average, the principal market for their produce was located 40 km away from their fields, more than three-quarters of the respondents sold their produce to an intermediary, almost half of the respondents in a local market or to a wholesaler and about one-third directly to the final consumer.

*Table 2: Socio-economic characteristics of the full sample (N=120)*

| | | Full sample | |
|---|---|---|---|
| | | Mean | Standard deviation |
| **Age of the household head** | | 52.23 | 10.90 |
| **Secondary education completed** | | 0.61 | 0.49 |
| **Experience** | Agricultural experience (years) | 27.48 | 14.20 |
| | Experience with Mochero | 0.48 | 0.50 |
| | Experience with chili peppers | 0.90 | 0.30 |
| **Cultivated area (ha)** | | 7.57 | 9.31 |
| **Labour availability/ha** | Family labour/ha | 0.69 | 1.11 |
| | Contracted labour/ha | 1.14 | 1.29 |
| **Number of crops** | | 2.45 | 1.31 |
| **Tropical livestock units** [a] | | 3.04 | 6.41 |
| **Soil fertility** [b] | | 0.56 | 0.21 |
| **Water source** | River | 0.75 | 0.43 |
| | Well | 0.23 | 0.42 |
| | Reservoir | 0.02 | 0.13 |
| **Tenure** | Completely owned | 0.38 | 0.49 |
| **Wealth** | Standard of living [b, c] | 0.54 | 0.11 |
| | Income < 500 PEN/month [d] | 0.24 | 0.43 |
| | Income > 1500 PEN/month [d] | 0.28 | 0.45 |
| | Use of credit | 0.72 | 0.45 |
| | Off-farm employed inhabitants (number) | 0.93 | 1.17 |
| **Input use** | Organic fertilizer | 0.88 | 0.33 |
| | Inorganic fertilizer | 0.98 | 0.13 |
| | Pesticides | 0.98 | 0.16 |
| **Market** | Distance to the market (km) | 41.31 | 88.48 |
| | Final consumer | 0.36 | 0.48 |
| | Local market | 0.45 | 0.50 |
| | Intermediary | 0.78 | 0.42 |
| | Wholesaler | 0.48 | 0.50 |
| **Information** | Technical assistance | 0.54 | 0.50 |
| | Capacity building | 0.52 | 0.50 |
| **Membership** | Irrigation commission | 0.43 | 0.50 |

Note: [a] One cow equals 1 livestock unit, one pig 0.40, one goat/sheep 0.20, one chicken/turkey/duck/rabbit 0.05 and one guinea pig 0.005 [39]. [b] These variables were measured on a Likert-type scale and based on respondents' self-assessment. When calculating the mean, 0 corresponds to an answer in the lowest category and 1 to an answer in the highest. [c] The variable standard of living includes the evaluation of the respondent on the aspects of housing, alimentation, education, employment, recreation and health of the family. [d] Monthly income includes both on-farm and off-farm activities.

## ECONOMETRIC ANALYSIS

Table 3 represents the estimation results of the mean and the standard deviation of the coefficients for the generalized multinomial logit models (G-MNL I and G-MNL II). In both models, the parameter estimate for the ASC is positive and significant, suggesting that the farmers, overall, are willing to cultivate the threatened Mochero chili pepper. The same applies to the coefficients of the yield, price, and all types of market access, indicating that farmers prefer and thus derive utility from these attributes; they prefer higher yield levels, higher prices and local, national and international market access over the reference category of no market access. On the other hand, the coefficient for the share of ají Mochero is negative and significant, indicating a dislike for this attribute. Although in general, the farmers are willing to cultivate the Mochero chili pepper, they preferably devote only a small share of their land to this threatened variety; the larger the share of their land cultivated with this crop, the lower their utility. Other parameter estimates are not significant, indicating that farmers do not derive utility nor disutility from these attributes; in other words, farmers are indifferent to these attributes when choosing a certain alternative. Considering the standard deviation of the coefficients, estimates for the ASC, the share of land allocated to the ají Mochero, the adaptability to growth conditions and international market access are significantly different from zero, indicating preference heterogeneity for these attributes. None of the G-MNL models provide evidence for the presence of scale heterogeneity in the data, as the estimate for $\tau$ is insignificant. The additional information provided by the G-MNL II model, where the individual-specific standard deviations are scaled with an individual-specific scale factor, leads to an improvement in model fit, observed from the higher log likelihood and the lower Akaike's information criterion (AIC), Bayesian information criterion (BIC) and consistent Akaike's information criterion (CAIC).

Table 4 shows the results of the WTP calculation for the G-MNL II model in preference space, allowing to gain insight into the extent to which the farmers value certain attributes related to the cultivation of the Mochero chili pepper. The magnitude of the estimates of WTP indicates the amount of money the individuals are willing to pay or to forego from their income for a one unit change in that respective attribute, compared to the base-level. In this context, the positive WTP values represent the farmers' willingness to forgo some income and thus accept a lower sales price for a certain attribute, while negative values indicate farmers need to receive a higher sales price to accept the attribute[85]. The positive estimate of WTP for the ASC, amounting to 40.03 PEN, represents the amount of money the farmers are willing to pay, or willing to forego from their income, to cultivate the ají Mochero. As far as the other attributes are concerned, the positive value for the estimates of WTP for the yield and all types of market access reflects the fact that farmers are willing to a pay and thus accept a lower minimum sales price, being an indication of attributes that are preferred over the reference category. A negative value indicates a less preferred attribute because it reflects the fact that farmers are only willing to accept a higher minimum sales price; this is the case for the share of land allocated to the ají Mochero. For one kg of Mochero chili pepper, the farmers need to receive 0.70 PEN extra to cultivate a 10% larger land share with this variety, they are willing to receive on average 1.35 PEN/kg less for a one ton/ha yield increase, 5.90 PEN/kg less for local, 9.30 PEN/kg less for national and 14.98 PEN/kg less for international market access. Given that the sales price for one kg of this chili pepper variety was estimated 1-16 PEN, these WTP estimates seem rather high. They nevertheless allow to rank the attributes and suggest that, in the decision to cultivate the ají Mochero, farmers mostly value international market access. They regard this 1.6 times more important than national market access, 2.5 times more important than local market access, 11.1 times more important than a one ton/ha yield increase and 21.5 times more important than cultivating a 10% smaller land share.

*Table 3: Generalized multinomial logit model estimates for the full sample*

| | G-MNL I | | G-MNL II | |
|---|---|---|---|---|
| | Coefficient (Standard error) | | Coefficient (Standard error) | |
| **Mean** | | | | |
| ASC[e] | 2.991 | *** | 2.941 | *** |
| | (0.686) | | (0.674) | |
| Share of ají Mochero | -0.050 | * | -0.051 | * |
| | (0.025) | | (0.026) | |
| Adaptability to growth conditions[a] | 0.163 | | 0.173 | |
| | (0.090) | | (0.091) | |
| Yield | 0.094 | *** | 0.099 | *** |
| | (0.028) | | (0.029) | |
| Yield stability[b] | 0.075 | | 0.069 | |
| | (0.100) | | (0.102) | |
| Market access (local)[c] | 0.423 | ** | 0.433 | ** |
| | (0.139) | | (0.143) | |
| Market access (national)[c] | 0.667 | *** | 0.683 | *** |
| | (0.154) | | (0.164) | |
| Market access (international)[c] | 1.076 | *** | 1.101 | *** |
| | (0.173) | | (0.184) | |
| Price[d] | 0.073 | *** | 0.074 | *** |
| | (0.010) | | (0.010) | |
| **Standard deviation** | | | | |
| ASC | 2.048 | *** | 1.997 | *** |
| | (0.545) | | (0.565) | |
| Share of ají Mochero | 0.200 | *** | 0.210 | *** |
| | (0.031) | | (0.036) | |
| Adaptability to growth conditions | 0.397 | * | 0.414 | ** |
| | (0.154) | | (0.157) | |
| Yield | 0.090 | | 0.076 | |
| | (0.052) | | (0.053) | |
| Yield stability | 0.119 | | 0.150 | |
| | (0.246) | | (0.190) | |
| Market access (local) | -0.033 | | -0.060 | |
| | (0.324) | | (0.324) | |
| Market access (national) | -0.355 | | -0.376 | |
| | (0.266) | | (0.256) | |
| Market access (international) | 0.840 | *** | 0.808 | *** |
| | (0.210) | | (0.215) | |
| tau | 0.219 | | 0.290 | |
| _cons | (0.173) | | (0.228) | |
| Number of individuals | 120 | | 120 | |
| Log likelihood | -684.84 | | -684.73 | |
| df | 18 | | 18 | |
| AIC | 1405.68 | | 1405.46 | |
| BIC [f] | 1493.28 | | 1493.06 | |
| CAIC [f] | 1511.28 | | 1511.06 | |

Note: Categorical attributes were dummy coded. For the interpretation of the ASC, effects-type coding was used to exclude the possibility of the dummy variable trap (Table A.2). [a] Reference category is bad adaptability. [b] Reference category is variable yield. [c] Reference category is no market access. [d] Assumed fixed instead of random. [e] Assumed fixed instead of scaled. An ASC that is fixed among the individuals allows to obtain a better model fit (Fiebig et al., 2010). Significance at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. [f] To calculate BIC and CAIC, the number of cases was used (N=960).

*Table 4: Willingness to pay, estimates for the G-MNL II model in preference space*

| | Full sample | | |
|---|---|---|---|
| | WTP | | Standard error |
| ASC | 40.027 | *** | 11.045 |
| Share of ají Mochero | -0.698 | * | 0.351 |
| Adaptability to growth conditions[a] | 2.350 | | 1.285 |
| Yield | 1.350 | *** | 0.401 |
| Yield stability[b] | 0.935 | | 1.379 |
| Market access (local)[c] | 5.896 | ** | 2.065 |
| Market access (national)[c] | 9.298 | *** | 2.366 |
| Market access (international)[c] | 14.979 | *** | 2.860 |

Note: Categorical attributes were dummy coded. [a] Reference category is bad adaptability. [b] Reference category is variable yield. [c] Reference category is no market access. WTP in Peruvian soles (PEN). Significance at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

## *Latent class model*

With the EM algorithm, the optimal number of latent classes was determined based on minimizing the CAIC and BIC (Table A.3); both criteria were minimized for a total of two classes. Respondents were assigned to the class that provides the highest probability of membership[68]; 93 individuals more likely belong to the first class and 27 individuals more likely to the second class. Table 5 represents the coefficients estimated for the LC model. For respondents belonging to the first class, parameter estimates for all types of market access and the price are positive and significant, indicating class-specific preferences for these attributes. For respondents belonging to the second class, parameter estimates for the yield, international market access and the price are positive and significant, whereas coefficients for the share of ají Mochero and for yield stability are negative and significant, indicating a class-specific dislike for these attributes. For both classes, the parameter estimate for the ASC is positive and significant, indicating that both classes of farmers are willing to cultivate the Mochero chili pepper.

Socio-economic variables were compared among the classes with the unpaired t-test, allowing to potentially relate class-specific preference heterogeneity to the observed characteristics and are represented in Table 6. The only significant differences between the two classes are observed for overall agricultural experience, shorter for the first class; family labour force per ha, higher for the first class; and the type of water source, water from the river rather than from a well for the first class. None of the other variables significantly differ among the classes, also resulting from the large standard deviations. However, although not statistically significant, some other general differences between the classes in terms of livelihood assets can be observed. As far as human capital is concerned, individuals belonging to the first class are more likely to have completed at least secondary education and to have had some previous experience with the cultivation of the Mochero chili pepper. Considering natural capital, these farmers tend to have a smaller cultivated area, but more fertile soils. As far as financial capital and wealth is concerned, farmers in the first class are more likely to have more off-farm employed household members, to use less credit and to rent their land. Considering physical capital, these individuals tend to own less tropical livestock units. They furthermore tend to live closer to the nearest market where their produce is sold and to rely more on local markets, wholesalers and final consumers to sell their produce. Finally, as far as social capital is concerned, they are less likely to belong to the irrigation commission and less often receive technical assistance or capacity building.

*Table 5: Latent class model estimates for the full sample divided into two classes*

| | Class 1 | | Class 2 | |
|---|---|---|---|---|
| | Coefficient (Standard error) | | Coefficient (Standard error) | |
| ASC | 2.874 | *** | 1.020 | * |
| | (0.638) | | (0.500) | |
| Share of ají Mochero | 0.023 | | -0.297 | *** |
| | (0.023) | | (0.062) | |
| Adaptability to growth conditions[a] | 0.113 | | 0.267 | |
| | (0.092) | | (0.225) | |
| Yield | 0.044 | | 0.212 | ** |
| | (0.029) | | (0.073) | |
| Yield stability[b] | 0.165 | | -0.505 | * |
| | (0.091) | | (0.230) | |
| Market access (local)[c] | 0.410 | * | 0.576 | |
| | (0.165) | | (0.385) | |
| Market access (national)[c] | 0.719 | *** | 0.073 | |
| | (0.178) | | (0.393) | |
| Market access (international)[c] | 0.856 | *** | 1.020 | * |
| | (0.149) | | (0.402) | |
| Price | 0.070 | *** | 0.046 | * |
| | (0.011) | | (0.024) | |
| Share1 | 1.062 | ** | 1.062 | ** |
| _cons | (0.399) | | (0.399) | |
| Number of individuals | 93 | | 27 | |
| Log likelihood | -689.63 | | -689.63 | |

Note: Categorical attributes were dummy coded. [a] Reference category is bad adaptability. [b] Reference category is variable yield. [c] Reference category is no market access. Significance at $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

*Table 6: Socio-economic characteristics of Class 1 (N=93) and Class 2 (N=27)*

| | | Class 1 | | Class 2 | | |
|---|---|---|---|---|---|---|
| | | Mean | Standard deviation | Mean | Standard deviation | |
| **Age of the household head** | | 51.82 | 11.15 | 53.67 | 10.05 | |
| **Secondary education completed** | | 0.62 | 0.49 | 0.56 | 0.51 | |
| **Experience** | Agricultural experience (years) | 26.43 | 14.67 | 31.07 | 12.02 | * |
| | Experience with Mochero | 0.51 | 0.50 | 0.41 | 0.50 | |
| | Experience with chili peppers | 0.90 | 0.30 | 0.89 | 0.32 | |
| **Cultivated area (ha)** | | 7.29 | 8.44 | 8.56 | 11.96 | |
| **Labour availability/ha** | Family labour/ha | 0.77 | 1.23 | 0.44 | 0.34 | ** |
| | Contracted labour/ha | 1.18 | 1.29 | 1.00 | 1.31 | |
| **Number of crops** | | 2.41 | 1.32 | 2.59 | 1.28 | |
| **Tropical livestock units** | | 2.94 | 6.18 | 3.40 | 7.27 | |
| **Soil fertility** | | 0.58 | 0.20 | 0.50 | 0.22 | |
| **Water source** | River | 0.80 | 0.41 | 0.59 | 0.50 | * |
| | Well | 0.19 | 0.40 | 0.37 | 0.49 | * |
| | Reservoir | 0.01 | 0.10 | 0.04 | 0.19 | |
| **Tenure** | Completely owned | 0.37 | 0.48 | 0.44 | 0.51 | |
| **Wealth** | Standard of living | 0.55 | 0.10 | 0.54 | 0.11 | |
| | Income < 500 PEN/month | 0.25 | 0.43 | 0.22 | 0.42 | |
| | Income > 1500 PEN/month | 0.28 | 0.45 | 0.26 | 0.45 | |
| | Use of credit | 0.70 | 0.46 | 0.78 | 0.42 | |
| | Off-farm employed inhabitants (number) | 0.97 | 1.24 | 0.81 | 0.96 | |
| **Input use** | Organic fertilizer | 0.87 | 0.34 | 0.89 | 0.32 | |
| | Inorganic fertilizer | 0.99 | 0.10 | 0.96 | 0.19 | |
| | Pesticides | 0.98 | 0.15 | 0.96 | 0.19 | |
| **Market** | Distance to the market (km) | 38.33 | 80.65 | 51.57 | 112.58 | |
| | Final consumer | 0.38 | 0.49 | 0.30 | 0.47 | |
| | Local market | 0.47 | 0.50 | 0.37 | 0.49 | |
| | Intermediary | 0.78 | 0.41 | 0.74 | 0.45 | |
| | Wholesaler | 0.52 | 0.50 | 0.37 | 0.49 | |
| **Information** | Technical assistance | 0.51 | 0.50 | 0.67 | 0.48 | |
| | Capacity building | 0.49 | 0.50 | 0.59 | 0.50 | |
| **Membership** | Irrigation commission | 0.40 | 0.49 | 0.56 | 0.51 | |

Note: Unpaired t- test used to test for differences between Class 1 and Class 2. Significance at $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

### PREFERENCES FOR MOCHERO CHILI PEPPER CULTIVATION

Estimation of the G-MNL models identified the existence of significant heterogeneity in farmers' willingness and preferences and demonstrated that this is better explained by heterogeneity in preferences rather than by heterogeneity in scale. Overall, the farmers are willing to cultivate the Mochero chili pepper, also reflected in the farmers' willingness to forego 40 PEN from their income in order to do so. However, this is phenomenon is not observed in reality; currently none of the interviewed farmers is cultivating the underutilized pepper variety. Possible explanations are the following: although farmers derive utility from growing the Mochero chili pepper, cultivation comes at a certain cost; this cost probably exceeding their willingness to pay. Furthermore, farmers are confronted with specific constraints in the adoption process of this variety. Besides that, a hypothetical bias, causing the overall willingness to cultivate the ají Mochero to be estimated stronger than in case of a real commitment, needs to be considered[84,86]. Despite this overall willingness, the general observation of the farmers' preference to allocate smaller land shares to the threatened crop may be related to farmer risk aversion[18,19]. The result that higher yield levels are considered more important than yield stability is contradictory to what most other studies considering the preferences of risk averse farmers observe[39]. This observation may however be context specific; since yield stability is mainly influenced by the occurrence of pests and diseases, the possible production shock can be addressed with the use of pesticides, to which 97.5% of all interviewed farmers had access. Moreover, the adaptability to local growth conditions does not appear to contribute to the utility of the farmers. Adaptability is mainly influenced by environmental stress factors such as poor soils and droughts; a good adaptability requires lower input use[36]. The indifference to adaptability most likely results from the fact that less than 15% of all farmers indicated to have poor soils, that more than respectively 87% and 98% of all farmers uses organic or inorganic fertilizer and that they all have access to irrigation technology. The high values of WTP for market access indicate that the farmers are willing to substitute a guaranteed market access for a higher income and this trade-off applies in particular to guaranteed international market access. This is also reflected in the highly significant preferences for market access, especially at international level, highlighting the importance of creating market niches at international level[7,23,31,33,34]. However Leakey et al. (2005) notice that market specialisation at international level exposes smallholder farmers to price fluctuations on the world market and undermines their ability to compete with larger companies; they advocate the importance of establishing local market niches.

### FACTORS INFLUENCING MOCHERO CHILI PEPPER CULTIVATION

The inclusion of interaction terms between the attributes and certain socio-economic variables in the choice models did not result in additional insights. Therefore, the study used the latent class approach to explain preference heterogeneity among the farmers. Assuming that farmers within each class have homogeneous preferences for Mochero chili pepper cultivation indicates that, on average, both classes of farmers dispose of an overall willingness to cultivate the ají Mochero, but this willingness is stronger in the first class than in the second class; besides, they are willing to do so for different reasons. Farmers belonging to the former class are indifferent to what share of land to allocate to this variety, to the yield level and the stability of the yield and mostly value local, national and international market access and higher prices. Farmers belonging to the latter class are indifferent to local and national market access, but significantly derive utility from smaller shares of land under Mochero cultivation, higher but variable yields, international market access and higher prices. Their preference for variable rather than stable yields possibly results from a misunderstanding of the meaning of the attribute, in the sense that they interpreted a variable yield as a yield spread throughout the year and therefore considered it beneficial. As such, the farmers in the first class, with a strong willingness for cultivation, exhibit stronger preferences for marketability and prices rather than production-related attributes. Farmers in the second class, with a weaker willingness for cultivation and a strong reluctance to allocate a large share of land to this pepper variety, demonstrate stronger preferences for production-related attributes rather than marketability, except at international level. In a study on farmers' preferences for crop variety traits, performed by Asrat et al. (2010), the different level of importance attached to either price-related attributes or production-related attributes was also observed when distinguishing between latent classes. The price-related attributes are found to be more important for farmers belonging to the first class, corresponding to the farmers with better market access[37], who tend to live closer to the principal market where their produce is sold and to rely more often on local markets, wholesalers and final consumers; indeed market access is believed to be positively related to the adoption decision[88]. The production-related attributes, on the other hand, are found to be more important for farmers belonging to the second class, potentially explained by the fact that these farmers tend to rely more on agriculture and less on off-farm activities for their livelihood[36]. Based on these preferences, the former class of farmers can be thought of as less risk averse and more market-oriented, whereas the opposite applies to the latter class of farmers. In the abundant literature on adoption processes, risk preferences and risk perception have often been considered important factors influencing an adoption decision[7,19]. The distinction made between the two types of farmers in terms of their risk attitude was justified based on the general observation that farmer risk aversion negatively influences adoption[19] and logically results from the fact that a higher level of risk aversion relates to the reluctance to adopt a crop variety on large scale or a larger land share[18,19].

The latent class approach furthermore allows to investigate underlying socio-economic factors related to the observed discrete heterogeneity in preferences. The farmers that can be thought of as less risk averse tend to be, although not statistically significant, more educated and to have had previous experience growing the ají Mochero. A higher education level and previous experience reduce risk aversion[89], facilitate the adoption process[18] and increase the likelihood of growing the Mochero pepper[19,90,91]. These factors increase the ability of individuals to acquire information on cultivation practices[88,90], the conservation of biodiversity in general[92] and to develop required skills[18,19]. However, the fact that education was not found to be significantly different between the classes may result from the fact that it can be considered a proxy for the opportunity cost of labour investment or for the willingness to experiment[93]. Disposing of more overall experience in agriculture, which is the case for the second class of farmers, can increase the opportunity cost from not continuing to grow the crops typically cultivated and can impede the adoption process[19]. The adoption of the Mochero chili pepper by more risk averse farmers can be stimulated by providing more information, for example on yields and technical knowledge, through agricultural extension activities[18,19,90], which may substitute for a lower education level[18]. This creates important opportunities as the second class of farmers highly values yield levels and tends to receive more capacity building and technical assistance.

The farmers that were classified as less risk averse and more market-oriented tend to have more household members with an off-farm employment, although not statistically significant.

An off-farm income or the availability of cash, credit and wealth in general reduce risk aversion[19,37,89] and increase the likelihood of cultivating a crop[18] as financial constraints incurred with the adoption process are reduced[19]. Asrat et al. (2010) also find that farmers who have less off-farm employed household members rely more on their agricultural produce and tend to be more risk averse in the choice of which crops to cultivate[37]; a description that more closely corresponds to the profile of the second class of farmers. The same is observed by Pattanayak et al. (2003); producers mainly relying on farming as principal source of income may be reluctant to invest in an unknown crop. However, relying more on off-farm income can sometimes also impede adoption because of a lack of interest in experimenting with other farming practices[93]. Empirical evidence on the influence of credit is mixed[18]. Lacking cash or credit does not necessarily prevent adoption, especially for innovations that involve small fixed costs. Indeed, fFor individuals who are already involved in agriculture, the adoption of another crop does not require to make large investments or to incur significant fixed costs[19]. Furthermore, the likelihood to adopt is positively associated with larger labour forces[18,19,93], more fertile soils and water availability through better irrigation quality[17,18,93]. Such is indeed rather the case for the first class of farmers as they have a larger family labour force/ha and use the river as water source. However, the importance of reliable water availability and irrigation creates opportunities for the adoption of this variety in the second class of farmers as they more often tend to belong to the irrigation commission.

## E CONCLUSION AND POLICY IMPLICATIONS

Given the growing concern over the process of genetic erosion caused by the underutilization of biodiversity, conservation efforts and use of genetic resources are indispensable to ensure the sustainability of the livelihoods of current and future generations all around the world[7].

However, the absence of incentives to maintain local production limits the realization of these efforts; *in situ* conservation requires public support through appropriate interventions[10]. Understanding the constraints faced by smallholder farmers and their preferences for cultivation is of fundamental importance to develop policies or interventions aiming at biodiversity conservation and at increasing the sustainability of smallholder farming systems growing threatened *Capsicum* varieties as a means to enhance rural development. Under the circumstances, this study created insights into the preferences of producers and farming households. To assess Peruvian farmers' willingness to cultivate the threatened and underutilized Mochero chili pepper, a discrete choice experiment was conducted with smallholder farmers in La Libertad. The study also encompassed an investigation of the factors that determine the farmers' preferences in order to identify the socio-economic profiles corresponding to farmers more or less willing to grow this endangered chili pepper variety.

This study has important policy implications. Firstly, the overall willingness of farmers to cultivate the ají Mochero demonstrates the existence of potential to enhance the native chili pepper diversity in Peru, given that the required incentives for production are in place. The paramount importance farmers attached to market access suggests that these incentives for local production will have to be created through the development of market niches at local, national, but mainly at international level[7,23,31,33,34], which requires the exploration of strategies to promote inclusive value chain development to meet well identified consumer demand[16], to enhance the functioning of the value chain at the stages of production, storage, processing, trade and retail[26] as well as to create consumer awareness[9]. Secondly, the observed heterogeneity in preferences may hamper approaches that intend to remove specific constraints to adoption[16]. Therefore, policy incentives to increase farmers' willingness to cultivate the Mochero chili pepper and to address the constraints they face in production need to be targeted purposely at each class of farmers in order to enhance their effectiveness. This implies that future agricultural extension activities should primarily be targeted at the more risk averse farmers as they exhibit a lower willingness to adopt the threatened variety. Agricultural extension services can stimulate adoption by providing information on cultivation practices and by allowing the development of skills; both expected to reduce risk aversion[18,19,90].

Despite the demonstration of the validity of the discrete choice experiment as a method to elicit preferences to cultivate the threatened Mochero chili pepper, the research also has some important limitations. Firstly, the sample size in the case study may be too small to extrapolate the results and conclusions to the whole region under the Chavimochic project. Secondly, the fact that the sample was not obtained through random sampling but instead through convenience sampling may imply that the results overestimate the readiness to cultivate the Mochero chili pepper and are therefore possibly not representative of the whole population of farmers in the region. Thirdly, although a cheap talk script was introduced as a way to limit hypothetical bias, it is possible that the overall willingness to cultivate the Mochero chili pepper was estimated stronger than would be the case if the farmers had to make a real commitment. Fourthly, the latent class approach did not account for heterogeneity in scale; further research could include the scale-adjusted latent class model in the analysis. Fifthly, describing the profiles of farmers in terms of their risk attitude and using this distinction to develop and implement more targeted policy incentives may be more relevant to the early stages of the adoption process[17]. However, to contribute to poverty alleviation, the diffusion of these adoptions in commercialization is also important[17] and may require a different targeting of policy incentives. Finally, this research contributes to only one of the objectives of the Vliruos JOINT initiative project. Consequently, the results of this study need to be integrated with research related to consumer preferences, agronomy, food composition and gastronomy to achieve the ultimate goal of the project in order to allow for more informed policy design.

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*Table A.1: Bayesian design with prior means and prior variances*

| Attribute | Levels | Prior mean | Prior variance |
|---|---|---|---|
| Share of ají Mochero | 10%<br>40%<br>70% | -0.01 | 0.1 |
| Adaptability to growth conditions | Not adapted | 0 | / |
| | Adapted | 0.01 | 0.1 |
| Yield | 2 ton/ha<br>4 ton/ha<br>6 ton/ha | 0.01 | 0.1 |
| Yield stability | Variable | 0 | / |
| | Stable | 0.01 | 0.1 |
| Market access | No access | 0 | / |
| | Local market access | 0.01 | 0.1 |
| | National market access | 0.02 | 0.1 |
| | International market access | 0.03 | 0.1 |
| Price | 1 PEN<br>6 PEN<br>11 PEN<br>16 PEN | 0.01 | 0.1 |

*Table A.2: Effects-type coded generalized multinomial logit model estimates for the full sample*

| | G-MNL I | | G-MNL II | |
|---|---|---|---|---|
| | Coefficient (Standard error) | | Coefficient (Standard error) | |
| **Mean** | | | | |
| ASC[e] | 1.424 | *** | 1.435 | *** |
| | (0.312) | | (0.315) | |
| Share of ají Mochero | -0.048 | * | -0.052 | * |
| | (0.024) | | (0.026) | |
| Adaptability to growth conditions[a] | 0.081 | | 0.086 | |
| | (0.044) | | (0.045) | |
| Yield | 0.091 | *** | 0.095 | *** |
| | (0.028) | | (0.029) | |
| Yield stability[b] | 0.032 | | 0.028 | |
| | (0.048) | | (0.050) | |
| Market access (local)[c] | -0.090 | | -0.099 | |
| | (0.086) | | (0.090) | |
| Market access (national)[c] | 0.143 | | 0.156 | |
| | (0.088) | | (0.093) | |
| Market access (international)[c] | 0.486 | *** | 0.498 | *** |
| | (0.096) | | (0.102) | |
| Price[d] | 0.072 | *** | 0.072 | *** |
| | (0.010) | | (0.010) | |
| **Standard deviation** | | | | |
| ASC | 0.914 | *** | 0.934 | *** |
| | (0.248) | | (0.271) | |
| Share of ají Mochero | 0.188 | *** | 0.201 | *** |
| | (0.031) | | (0.038) | |
| Adaptability to growth conditions | 0.186 | * | 0.204 | * |
| | (0.081) | | (0.080) | |
| Yield | 0.081 | | 0.073 | |
| | (0.053) | | (0.056) | |
| Yield stability | 0.062 | | 0.087 | |
| | (0.126) | | (0.096) | |
| Market access (local) | 0.048 | | 0.024 | |
| | (0.180) | | (0.201) | |
| Market access (national) | -0.178 | | -0.216 | |
| | (0.188) | | (0.157) | |
| Market access (international) | 0.411 | ** | 0.391 | ** |
| | (0.128) | | (0.140) | |
| tau | 0.156 | | 0.316 | |
| _cons | (0.201) | | (0.286) | |
| Number of individuals | 120 | | 120 | |
| Log likelihood | -687.37 | | -687.08 | |
| df | 18 | | 18 | |

Note: Categorical attributes were effects-type coded. [a] Reference category is bad adaptability. [b] Reference category is variable yield. [c] Reference category is no market access. [d] Assumed fixed instead of random. [e] Assumed fixed instead of scaled. Significance at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

*Table A.3: Comparison of the selection criteria for the different number of latent classes*

| **Number of classes** | **Log likelihood** | **Number of parameters** | **CAIC** | **BIC** |
|---|---|---|---|---|
| 2 | - 689.63 | 19 | 1,489.22 | 1,470.22 |
| 3 | - 678.96 | 29 | 1,525.76 | 1,496.76 |
| 4 | - 666.73 | 39 | 1,559.17 | 1,520.17 |
| 5 | - 659.66 | 49 | 1,602.90 | 1,553.90 |