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ABSTRACT

A large proportion of the original potato genetic resources are in the hands of Andean farmers who have been selecting and reproducing landraces or native cultivars for generations. Previous research has shown that those farmers have been able to manage the introduction of new varieties while maintaining diversity of native materials. However, adoption of improved varieties may lead to a reduction in the use of native potatoes cultivars, a result that is know as the displacement hypothesis. Native potato cultivars are not only important for farmers who grow them but are a key resource of breeding programs as well. Understanding farmers' preferences for the different types of varieties is a critical issue to develop policies to prevent loss of native cultivars and to assess the trade-off with the adoption of improved varieties.

The present study applied choice experiments to determine the value of native potato cultivar attributes to Andean farmers and the trade-offs with attributes related to improved varieties. The study was carried out in two sites located in two contrasting regions of Peru: in the Province of Huancayo, in the Junín region, with presumed lower levels of landrace diversity and better access to central markets (including the main market of Lima), and in the Province of Paucartambo, in the Cusco region, with higher levels of landrace diversity and with lower access to markets. Measures of the level of diversity of native cultivars and improved varieties were taken using different techniques. Four different attributes were selected for the choice experiments: number of native cultivars, area under native cultivars, yield and price of improved varieties. Near 200 interviews were conducted between March and May of 2010.

The results show that diversity, yield and price are the attributes with more value to farmers in both locations, an indication that farmers in the two study sites are weighing them equally when deciding about crop structure, and that expected and previous differences in behavior between both sites have been reduced. Slight differences in favor of diversity and area under native potato cultivars in the Paucartambo site confirm that the number of native potatoes cultivars is still an important factor contributing to crop structure decisions and that farmers are willing to give up area planted with native cultivars more than reducing the number of native cultivars they grow, confirming part of the argument underlying the displacement hypotheses.

The revealed preference analysis confirmed the *finding* in the choice experiment with respect to native cultivars. The total diversity of morphologically distinct cultivars, particularly native-floury cultivars, is higher in Huancayo compared to Paucartambo. Indeed this research shows that there is no evidence to suggest a direct irreversible displacement of diverse native by improved cultivars.

1. INTRODUCTION

1.1. Background

CIP has worked with the national agricultural research systems to introduce new varieties to farmers in the Andes, the center of biodiversity for the potato. Releases of CIP related materials began in the 1980s. In Peru, the country selected for the study, about 80,000 has of potato are planted mostly in the highlands, has CIP provenance. These potatoes provide benefits in terms of earlier maturity, reduction in pesticide use and higher market value. However, Andean potato producers also conserve, manage, multiply and use a wide diversity of landraces known as native potatoes. It has been hypothesized that the adoption of CIP related varieties has led to a reduction in the use of native potatoes cultivars, although so far no clear evidence is available (Bamberg and del Rio, 2007). In general, it appears to be the case that at higher altitudes in the Andes native potatoes predominate and some studies indicate that 40% of the potato production are over 3800 m. , whilst at lower altitudes most potatoes are now of improved varieties. Since adoption of improved varieties in Peru began around 1952 and CIP related varieties were only released in 1986 after there had been substantial varietal displacement by improved varieties from other sources (e.g. the national breeding program), the net contribution of CIP to biodiversity loss remains to be determined. Besides the broader issue of genetic diversity loss or "genetic erosion", this loss of local biodiversity is normally considered an "off-site" type of environmental impact, and therefore seen as an externality. There could be several sources of negative externality:

- Native potatoes have cultural and sentimental value to highland populations, e.g., by having multiple colors, textures and as gifts (Zimmerer, 1991).
- Native potatoes contribute to enhanced nutritional status and increase household food security.
- Native potatoes could contribute to local adaptation strategies in the face of climate change such as different resistances to biotic and abiotic stress.
- In situ loss of biodiversity can also affect the ability of potato crop improvement programs to access desired genetic variability in the long-run.
- Crop population structure, rather than diversity of native varieties, could be affected, meaning that the same number of native varieties is grown in a reduced area with higher concentration of modern varieties, increasing the risk of future genetic losses (Brush, 1992).

Trade-off between gains from planting improved varieties and these negative externalities needs to be analyzed to inform researchers and decision makers on the ultimate impact of research activities. If it turns out there are negative externalities which are not outweighed by the benefits of growing improved potatoes it could be appropriate to consider compensatory measures. More often, economic assessments have not differentiated between the estimation of benefits from plant breeding and the benefits of conserving biodiversity (Rubenstein et al., 2005). In economic terms, this implies

differentiating between the direct use of genetic resources (to produce more efficient varieties) and their option value, leaving future generations to reap the benefits those genetic resources might produce. Earlier attempts have estimated the value of accessing additional genetic resources for ex situ conservation (i.e., genebanks). For example, the value of 1,000 additional rice accessions was estimated at $325 million (Evenson and Gollin, 1997). However, in situ conservation of potato genetic resources, both landraces and wild relatives, have additional value to potato farmers related to the different sources raised above, and these should be included to give a more comprehensive estimation of the net benefits of using genetic resources. Estimating these types of benefits, more related to their option value, broadens the scope of previous studies which only valued genetic resources for their direct use. To illustrate the point, Rubenstein et al. state that "many scientists…have raised concerns about the continued availability of sufficient genetic resources for future plant breeding efforts. Furthermore, both the scientific and economic literature agrees that the measurement of genetic diversity is complex".
The study looks at the possible negative externalities through biodiversity loss from the adoption of improved varieties of CIP origin in the Andes, and the tradeoffs which exist with improved productivity, reduced pesticide use, and recovery of lost native cultivars, with the objective of estimating monetary measures of non-market benefits and costs. There have been significant efforts in attempting to value the conservation and use of genetic resources of major crops such as wheat, rice and maize. Genetic resources are the major input for breeding programs to produce improved varieties, the core mandate of most CGIAR Centers and at the heart of the strategy of the Green Revolution. However, much less has been done in terms of valuing biodiversity and very little progress has been made in valuing genetic erosion or crop displacement (Rubenstein et al., 2005). A large proportion of the original potato genetic resources are in the hands of farmers who have been selecting and reproducing landraces or native varieties for generations. Research has shown that Andean farmers have been able to manage the introduction of new varieties while maintaining diversity of native materials (Brush, 1995). This adds another level of complexity to the measurement issue but opens up the possibility of rebuilding the story of potential genetic erosion with the farmers. With that respect, the study intends to update previous work by Brush et al. (1992) in two contrasting locations. The objective is to determine by using panel data whether native variety displacement has followed the same pattern outlined by the authors between the two regions and update information on trends of adoption of improved and native varieties in each location and by altitude zone (table 1).

Table 1: Adoption of improved and traditional (native) varieties in Peru (% of total area planted to potatoes).

	Paucartambo Valley			Tulumayo Valley		
Variety	High zone	Middle zone	Low zone	High zone	Middle zone	Low zone
Improved	28	67	15	23	59	18
Traditional	98	2	0	89	11	0
Percentage of area planted to improved varieties	11.7			45.1		

Source: Based on Brush et al., 1992.

Work conducted in the Mantaro Valley (Province of Junín, Peru) in the late 70s and early 80s found as many as 30 native cultivars on a single farm, with a mean of 14 cultivars per farm and more than 75 different native cultivars grown in the surveyed farms (Carney, 1980). The studies also hypothesized that loss of on farm diversity had already occurred, since many farmers recalled scores of varieties that were no longer being planted. Most farmers had also increased planting of improved varieties for commercial purpose. This type of study provides benchmark evidence of biodiversity loss in the Andean regions. Other areas such as the Vilcanota Valley near the city of Cuzco are also a source of native potato diversity where losses were reported in the early 80s (Brush et al., 1980). Surveys conducted in 1997 and 2007 by CIP show mixed results relative to area and number of native varieties. While aggregate national area cultivated under native potatoes in Peru, Bolivia and Ecuador has remained fairly stable, the number of native varieties grown has increased in Peru. These results are tentative but nevertheless fuel the debate about the contribution of varietal release to the conservation of genetic resources.

1.2. Potato Improvement Impact Pathway Analysis

Compared to native varieties, varieties developed from CIP material offer increased levels of resistance to diseases (late blight and viruses) as a primary source of benefits, and also gains in yield potential and earliness. CIP established a program to breed varieties especially suitable for developing countries in 1973. This used the diverse target environments for growing potato in Peru, where experimental stations were being set up. Two years later a breeding strategy to develop four different breeding populations had been defined, with multiple breeding targets including screening of germplasm for resistance to cyst nematodes, Phoma blight (Phytophthora erythroseptica), Erwinia, viruses (PLRV, PVX and PVY), as well as the characterization of selected germplasm for protein and frost tolerance. Priorities and importance of different traits have changed and evolved to respond to new challenges and demands to overcome constraints on priority eco-regions and also due to the lack of clear progress in producing research results for some traits of interest (e.g., resistance to bacterial wilt). Since 1995 CIP's breeding strategy is defined by the existence of two breeding populations with a primary trait for resistance each: the Virus Resistance Population for the Lowland Sub-tropics and the Late Blight resistant population with resistance to late blight as primary trait.

The first modern potato variety (Renacimiento) was released in Peru in 1952. This was followed by a considerable increase in the area under modern varieties. While native varieties are still sought for home consumption and grown by small-farm and subsistence oriented households, varieties bred by the public sector have become increasingly popular in market-oriented regions. Farmers have been active in selecting the most popular high-yielding and late blight resistant varieties.

The first CIP-related variety Perricholi, with late blight resistance, was released in 1986, considerably after the wide diffusion of modern varieties had already occurred. The evaluation of original CIP germplasm (in the form of advanced clones) by national breeding programs intensified as farmers involvement in the process was facilitated by greater seed availability. Farmer field trials were established and farmers received half of the output as compensation for their involvement and resources used. As soon as the advantages of the new varieties were clear to farmers, rapid diffusion of the new varieties occurred through the informal seed system (Fonseca et al., 1996). CIP varieties became more successful and began occupying larger areas which are maintained even the sources of benefit were not always those which had been projected initially. For instance, Canchan-INIA, initially selected for its late blight resistance, remained popular for its earliness and market acceptance even after the disease resistance broke down.

In Peru, which has the greatest biodiversity of cultivated potato species, by 2007 CIP derived varieties occupied about 30 percent of the 260,000 hectares planted with potatoes, with only one variety (Canchan-INIA) grown in more than 57,000 hectares. At the same time, the area planted with native varieties in Latin America slightly increased to 126,000 hectares and in Peru it represented in 2007 around one quarter of the total area planted with potatoes (Thiele et al., 2008).

As CIP breeding program has achieved success in developing germplasm which was later adopted by farmers, the question arises as to whether this has contributed to the reduction in diversity of native varieties or the new varieties simply displaced older improved varieties or occupied new areas. Farmers may choose to reduce the resources (land, labor) devoted to planting native varieties in favor of market-oriented varieties which provide much needed cash. Even if area under native potatoes is not reduced, a growing commercial area reduces the availability of resources for growing native potato from mostly resource-poor farmers, which might amongst other things affect yields.

1.3. Study hypotheses and justification

A set of linked hypotheses of impacts on biodiversity can be formulated:

1. Improved varieties displaced native varieties in terms of cropped area. Some studies have confirmed this at some elevations (Brush et al., 1992).
2. Improved varieties led to an absolute loss in amount of biodiversity (reduction in numbers of landraces).
3. CIP varieties displaced native varieties in terms of cropped area. Certainly true at some elevations.
4. CIP varieties led to an absolute loss in amount of biodiversity (reduction in numbers of landraces).

These hypotheses need to be addressed at different levels of scale. There may be biodiversity loss at the plot and community level but not at the landscape level, representing a mosaic pattern of conservation. Since the importance of the value of native landraces is also attached to the number and area they represent in each location, there was a need to accurately represent the actual diversity level in each of the selected locations of the study.

The rationality of attempting to value the native potatoes attributes by farmers is because we want to know how much biodiversity is worth to farmers (use value), which of the attributes (area or number of varieties) they value the most, and how much they are willing to trade-off biodiversity for accepting new improved varieties. We tested these hypotheses by using the choice experiment and checking their consistency with the revealed preferences

The policy relevance of the study is to give scientific evidence of current trends in biodiversity conservation and farmers preferences to develop policies and shape research programs that ultimately help in both promoting technology adoption and economic growth while avoiding irreversible damage to the social and environmental settings responsible for conserving potato biodiversity in the fragile systems of the Andes.

1.4. Methods

The study consisted in the use of two methodologies:

1. A survey of the current status of the biodiversity that consisted in questionnaires about potato diversity, land plot using GPS to have a more accurate data and potato sampling at planting time to have a better identification of varieties.
2. The choice experiment exercise that due to logistical issues had to be modified to be adapted to the situation encountered in the communities.

Details of the methodologies and approaches are described in sections 3 and 4.

The biodiversity survey took place between September and November 2009 in Huancayo and Paucartambo province almost simultaneously. 104 surveys, workshops, plot mapping and sampling of cultivars were collected in Huancayo, and 98 in Paucatambo.

Qualified enumerators were trained on how to conduct choice experiments surveys.
The choice experiment questionnaire was administered during March 2010 in the Huancayo province, and final data collected represent 102 surveys in 4 different communities. For the Paucartambo province, the choice experiment survey was translated into local dialect (Quechua) and enumerators were selected to comply with the additional requirement of being Quechua speaking. The

Photo 1. . Qualified enumerators were trained on how to conduct choice experiments surveys, Cusco, Peru, 2009

questionnaire was administered between April and May 2010 and final data is from 93 respondents in three different communities.

1.5. Area of the study

The study was conducted in two contrasting highland locations in Peru, one in the Huancayo Province in the region of Junín with expected lower levels of biodiversity, and another near the city of Cuzco (Paucartambo Province), with presumably higher levels of biodiversity. Both locations are known for including communities that grow native potatoes and offer sufficient heterogeneity to see whether there is a distinct behavior from farmers located in different geographic regions (i.e., altitude levels and distance to major administrative cities). CIP scientists in the Genetic Resources Division have expertise to determine for each region whether different names for varieties in fact represent different germplasm. For some of those locations, previous evidence of diversity of native varieties in the fields exists.

1.5.1. Cusco: Challabamba district, Paucartambo province

The Paucartambo province is located east to Cusco city in the slopes of the Eastern Andes at 3200-4000 m. of altitude and have access to different agroecological zones. This is an Quechua speaker agricultural area where potato is cultivated by tradition. This area is recognized as a “potato diversity hotspot” where it is found more than 250 different native potato varieties, especially in the upper lands over 3500 m. of altitude. This area is historically known as the origin of the potato 70 centuries ago. David Spooner, researcher from the U.S. Department of Agriculture, presented a study about the origin of the potato and after studying DNA of more that 200 varieties, he determined that the origin is located between Cusco and Puno region, exactly in this geographical area.

Photo 2. Landscape in Cochacochayoc, Paucartambo, Cusco, 2009

This area is still relatively unexposed to formal dissemination of improved potato varieties, but the national agricultural research institute, together with CIP worked with them to test new potato varieties with resistance to late blight as they were experienced severe attacks from this disease as temperature is increasing. Communal permission was needed to conduct the research. First, letters were sent to the head of the communities involved in the study through our local partners and then a visit to give a presentation to the community of the project, introducing the enumerators, and pre-testing the instruments were applied.

Photo 3. Informing community about the study and asking formal permission to start the work, Cusco, Peru, 2009

1.5.2. Junín: Quilcas district, Huancayo province

The district of Quilcas is located in the left margin of the Mantaro River in the province of Huancayo, department of Junín in Central Peruvian Andes. It is surrounded by the mountains Huamaje, Huara cocha, and Chochín and the hillsides of Putaja and Tihuas. Quilcas is crossed by the Highway that connects the Capital Lima with the cities in the Central Andes, and therefore information flow is higher and new potato varieties reached this place since the release of the first improved varieties “Renacimiento” in the fifthties.

The district has an extension of 167.98 squared km and an altitude between 3,275 m (lowlands) and los 4,800 m in the highlands. Its climate is cold template. The district has the following neighborhood towns of Colpar, Ñahuinpuquio and Rangra, as well as Llacta, Patac, Luco, Uniumarca, Pachas Cucho and Manco Culí . The main economic activity is the agricultural production in small scale and under variable and complex ecological and climatic conditions where production of different crops and varieties minimizes climatic hazards.

Quilcas is located in the lowlands of the valley. District authorities have rights on the community resources located in the neighborhood towns of the district and about the decisions on how to manage the resources. The importance of that community resource driven decision is weakening through the years but it still exists at least in a proportion of the population. Being a community member or "comunero" means that they have the obligation of participation in communal labor for the benefit of the community and has the right to work a communal plot for grazing and crop cultivation usually from 3700 m or higher.

Photo 4. Landscape of Quilca,, Peru, 2010

The NGO Yanapai have been working in potatoes for many years in Quilca in participatory breeding and dissemination of improved potatoes as well as conservation and marketing of native potatoes. The selected communities for the study were Colpar, Llacta and Rangra in Quilcas district, and Casacancha in the Ingenio district but very close to Quilcas district border.

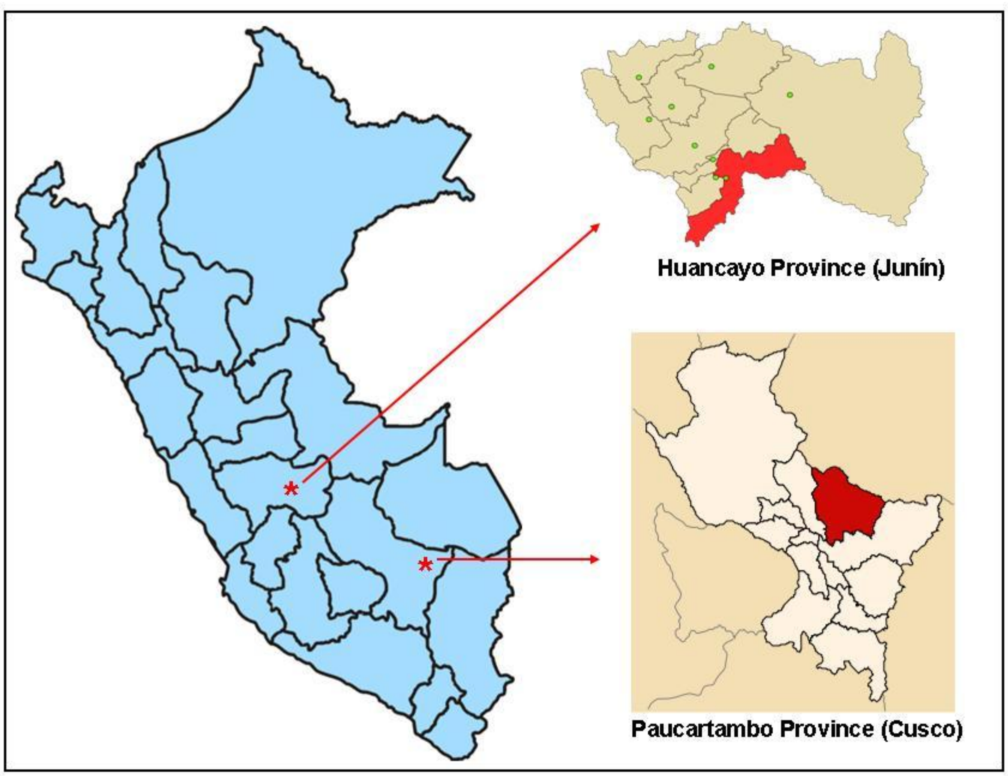

Figure 1: Map of selected study sites.

1.6. General characteristics of households in study sites

The characteristics of the households and respondents (table 2) show that for both locations average age of the household head and household size are similar. Livestock composition in Paucartambo reflects that farmers in this site have larger livestock assets than those in Huancayo, particularly regarding the number of cows and bulls and those animals are usually a financial resource when emergency expenses comes. The higher number of female respondent in Quilcas is explained by the fact that off-farm income is more important in this place and usually men are working in the nearby city: Huancayo. In both cases, livestock provide basic needs such as milk and are also a potential cash source to address temporary liquidity constraints.

Table 2: Households' and respondents' characteristics in study sites

	Huancayo (Junín) N= 102	Paucartambo (Cusco) N= 93
	Mean (s.d.)	
Age of household respondent	43 (14)	42 (14)
Female respondents	53.9%	16.1%
Education of household head in years	5.5	3.2
Number of household members	4.5 (1.9)	4.6 (2.0)
Number of cows and bulls	1.54 (1.74)	5.63 (5.88)
Number of sheep	23.25 (29.25)	15.67 (24.51)
Number of Andean camelids	10.12 (16.89)	11.60 (17.27)
Number of Guinean pigs	6.28 (6.51)	9.57 (7.89)

The measures and mapping of diversity produced detailed maps at the community level and for each of both sites, showing the location of each of the plots grown by the sampled households and for each community. An example of the maps generated by the work of sampling plots in the Paucartambo Province is presented in figure 2.

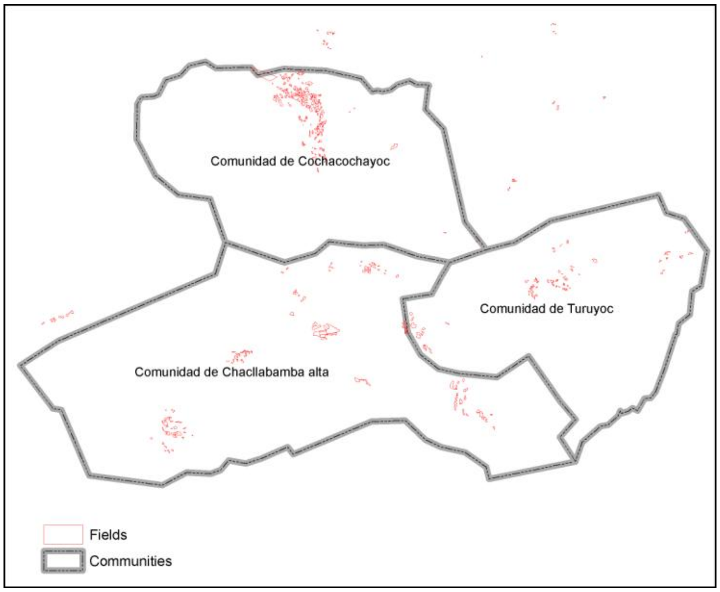

Figure 2: location of potato plots in Paucartambo, Peru, 2010.

More detailed mapping shows area under different types of potato cultivars (bitter, floury and improved) for each plot in one of the Communities in the Paucartambo province (figure 3). Similar maps were produced for each of the communities in each site.

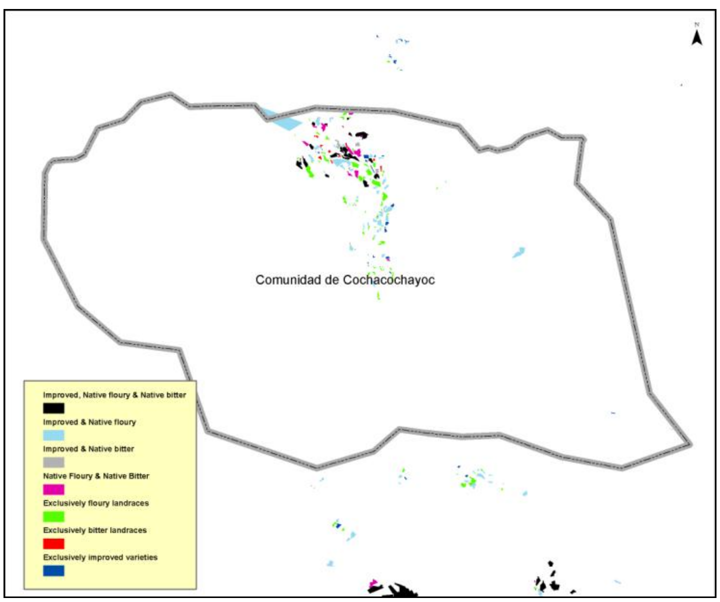

Figure 3: distribution of different types of potato cultivars in Cochacochayoc community, Paucartambo, Peru, 2010.

These basic maps together with the dynamics over time are a useful visual aid to look at changes in area (and also altitudinal level) under different potato cultivars. More detailed household level information was processed for average plot size cultivated under each type of potato cultivars. With this information we were able to estimate area under each type of cultivar in each community and each site, which were compared to previous information to draw conclusions of the dynamics of improved and native potato cultivars over time.

2. MEASURING DIVERSITY IN THE FIELD

2.1. Literature review on biodiversity measures

Several measures of landrace and cultivar diversity were estimated using different techniques. These measures are based on some definitions which are worth discussing. Introduce the different concepts.

2.1.1. Agrobiodiversity

- From an agroecological perspective it is a sub-set of general biodiversity; it includes all forms of life directly relevant to agriculture: crops and livestock, but also organisms such as soil fauna, weeds, pests and predators, pollinators, etc.
- From a biosystematics perspective it represents a system of classification, with emergent properties, of cultivated or domesticated plants: a. genetic diversity (alleles), b. cultivar diversity (traditional and improved varieties), c. species diversity (botanical species), and d. agroecological diversity (species patterning within the agricultural landscape).
- It is generally accepted that the cultivated potato in Peru is represented by: a. high levels of genetic diversity, b. 2,800 to 3,000 native cultivars in Peru (=landraces or traditional varieties) & < 100 improved cultivars, c. 7 species (S. stenotomum subsp. stenotomum, S. stenotomum subsp. goniocalyx, S. phureja, S. ajanhuiri, S. chaucha, S. juzepczukii, S. tuberosum subsp. tuberosum, S. tuberosum subsp. andigenum, S. curtilobum), d. numerous agroecological production zones based on biophysical and crop management factors.
- Andean farmers generally use the cultivar ("variedad") as a communicable unit to identify diversity within the cultivated potato. They often differentiate so-called cultivar categories: native-floury cultivars ("papa nativa harinosa"), native-bitter cultivars ("papa nativa-amarga"), improved cultivars ("papa mejorada").

2.1.2. Species displacement

Displacement within a specific time-scale of a (wild or domesticated) species by another in terms of area under cultivation (e.g. barley by potato).

2.1.3. Cultivar displacement

Displacement within a specific time-scale of one cultivar category or specific cultivar by another in terms of area under cultivation (e.g. native-floury cultivars by improved cultivars).

2.1.4. Species loss

The loss of a species from a (socioeconomically or geographically) predefined conservation area (e.g. household, community or province).

2.1.5. Cultivar loss

The loss of one or more cultivars from a (socioeconomically or geographically) predefined conservation area (e.g. household, community or province).

2.1.6. Genetic loss

The loss of one or more alleles from a (socioeconomically or geographically) predefined conservation area (e.g. household, community or province).

2.1.7. Genetic erosion

The compounding of the three losses above

2.2. Methods for measuring cultivar diversity

The methods used for description of the potato diversity and calculation of potato diversity indicators were divided in five categories (Inventory of current diversity, memory banking of past potato diversity, timeline of potato portfolio, participatory GIS of current and past potato category distribution across altitudinal belts).

2.2.1. Inventory of present-day diversity at household and community level

- Sampling of cultivars:
  - 4 communities per site (district)
  - 100 households per site (Cusco & Junín; 200 in total)
  - 200 seed tubers per field for each household (random row sampling)
- Indicators (C.F. = cultivar frequency):
  - Household C.F. = (sample size of specific cultivar / total tuber sample size) * 100% Table 12)
  - Absolute Community C.F. = (number of households with specific cultivar / total household sample size) * 100%
  - Relative Region C.F. = (household C.F. 1 + household C.F. 2 + household C.F. 3 …..) / total household sample size (Table 5)
  - Overall Region C.F. = (Absolute Community C.F. + Absolute Community C.F.) / 2 (Table 5)
  - Table 6-11 no tienen indicadores aqui
- Observations:
  - Can, in principle, be applied at planting (October / November), but is ideally repeated or complemented at harvest.
  - A team of trained fieldworkers will be needed to collect the data.
  - A field sheet can be designed for data registration

- The data will allow for quantification of total and relative cultivar diversity
- If repeated at harvest, the sampling exercise can also serve to establish yield estimated (in turn of value for economics analysis of trade offs: net benefits)

2.2.2. Memory banking: "reconstruction of diversity 30 years ago"

- Focus group meeting with elders (sharing results)
    - 4 communities per site (district)
    - Drawing time-line (1979) till present (2009)
    - Listing cultivars grown 30 years ago
    - Listing cultivars presently grown, yet not known 30 years ago
    - Listing cultivar not grown at present, yet recognized to exist 30 years back
- Indicators:
    - Cultivar portfolio for 1979
    - List of "new" cultivars incorporated during last 30 years
    - List of "old" cultivars lost during the last 30 years
    - Dates of introduction and loss for group of specific cultivars
- Observations:
    - Dynamic facilitator, fluent in Quechua, needed
    - Ideally each focus group meeting is combined with a recognition of a physical sample of all cultivars presently grown in the community; this can serve to draw the time-line for a group of cultivars (year of introduction by consensus)
    - Method will provide qualitative evidence for possible "cultivar loss"
    - Ideally the focus group meetings will use a time-line based on literature and database review (see: method No. 3)

2.2.3. Literature and database review: "reconstructing cultivar diversity portfolios along a time-line"

- Literature review: see paragraph on baseline data
- Databases: see paragraph on baseline data
- Indicators:
    - Cultivar portfolios (based on vernacular nomenclature) by time-zones; e.g. < 1950, 1950-1970, 1970-1990, 1990-2010
- Observations:
    - Excellent data available for Paucartambo (really quite unique)
    - Method will provide qualitative evidence for possible "cultivar loss" (always to be checked in combination with method No. 2)

2.2.4. Participatory GIS (present-day cultivar category distribution by altitudinal belts)

- Mapping of contemporary fields characteristics and composition
    - 4 communities per site (district)
    - 100 households per site (Cusco & Junín; 200 in total)
    - Physical (on-site) mapping of all fields for each household: waypoints, altitude, area, cultivar category content (native-floury, native-bitter, improved)
- Indicators:
    - Area presently under cultivation with each of the three cultivar categories by altitudinal belts; e.g. < 3,200 m, 3,200-3,500 m, 3,500-3,800 m, 3,800-4,100 m, > 4,100 m
    - Possibly yield levels (weight / area) if (partially) applied during harvest.
- Observations:
    - This methods can be perfectly combined with method No. 1
    - A team of trained fieldworkers will be needed to collect the data.
    - A sheet can be designed for data registration in the field
    - Collaboration with Henry Juarez (RIU) needed

2.2.5. Participatory GIS ("historical" cultivar category distribution by altitudinal belts)

- Mapping of cultivar category distribution / composition for 1979 through transect walks and participatory cartography with elders
    - 4 communities per site (district)
    - Between 2 to 4 transect walks per community (elders and 2 cartographers)
    - 1 participatory GIS workshop with group of elders in each community
    - Production areas, by altitudinal belt and as they were 30 year ago, will be mapped for native-floury, native-bitter, improved cultivars.
- Indicators:
    - Area historically (1979) under cultivation with each of the three cultivar categories by altitudinal belts; e.g. < 3,200 m, 3,200-3,500 m, 3,500-3,800 m, 3,800-4,100 m, > 4,100 m.
- Observations:
    - Medium to high resolution satellite images are being used for each of the communities.

Other environment-related indicators can be assessed such as the level of agro-biodiversity maintained at the household level—that is, how the composition and share of potato varieties changes due to market participation. To measure this, four different indexes of diversity, adapted from the ecological literature, can be used: the Count, the Margalef, the Shannon and the Berger-Parker index (Magurran, 1988; Winters et al., 2006). Each of these indexes gives a different measure of diversity. The Count or

Richness index is a count of the total number of potato varieties that the household reports planting over the season of interest. Richness, or the number of species or varieties encountered, is also measured by Margalef index. The Shannon index calculates proportional abundance or evenness, accounting for the share of land allotted to each variety as well as the number of varieties. The index, thus, combines the concept of evenness and richness. The proportion of land area planted to a variety is used as a proxy for the number of individual plants encountered in a physical unit of area. The Berger-Parker index of inverse dominance expresses the relative abundance of the most common species or the most widely grown on each plot by each household. These indexes could be used to attach values to specific ranges for the extended cost-benefit analysis.

2.3. Results

2.3.1. Importance of potatoes in selected sites

In Paucartambo and Huancayo all farmer families, without exception, grow potato. However, some notable differences exist between both regions as for the relative household dedication to each of the three cultivar categories. The information coming from the biodiversity survey revealed that in Paucartambo a total of 98 households surveyed managed a total of 467 potato fields. Most potato fields contained more than one cultivar category in smaller physically separated sub-fields dedicated to a particular category. In Paucartambo most households grow each of the three categories with a slightly lower participation of native-bitter as compared to the other cultivar categories (table 3). In Huancayo the 104 households surveyed managed 370 fields. Most of these were exclusively dedicated to a single cultivar category. In Huancayo most households grow native-floury and improved cultivars, but only a quarter of the households manage native-bitter cultivars for chuño processing.

Photo 5. Farmers preparing the land for planting potatoes, Cochacochayoc, Paucartambo, Peru, 2009

Table 3: Relative household dedication to potato cropping and cultivation of different cultivar categories

Region	Households – HH (n)	HH growing potato	HH growing native-floury cultivars	HH growing native-bitter cultivars	HH growing improved cultivars
Paucartambo (Cusco)	98	100%	100%	81.6%	99.0%

Huancayo (Junín)	104	100%	71.2%	23.1%	87.5%

In terms of total potato cropping area households in Paucartambo (n=98) managed twice the amount of land as compared to households in Huancayo (n=104): 38.7 versus 18.2 ha. The actual distribution by category in Paucartambo underlines the comparative importance of native germplasm with 59.4% of the total cropping area dedicated to native-floury, 12.2% to native-bitter and 28.4% to improved cultivars. In Huancayo most of the area was dedicated to improved (48.3%) and native-floury (46.2%) cultivars. Native-bitter cultivars only occupied 5.5% of the total potato cropping area in Huancayo.

Even though the proportional area (%) dedicated to improved cultivars is lower in Paucartambo (28.4%) as compared to Huancayo (48.3%), the actual total area assigned to improved cultivars is higher: 11.0 ha in Paucartambo versus 8.8 ha in Huancayo. In Paucartambo cultivars of CIP origin occupy a high percentage of the total cropping area dedicated to improved cultivars compared to Junín (table 4).

Table 4: Relative importance of improved potato cultivars of CIP and other origin

Coverage of improved Cvs.	Improved Cvs. Paucartambo (Cusco)			Improved Cvs. Huancayo (Junín)		
	Total	CIP origin	Other origin	Total	CIP origin	Other origin
In area	11.0 ha	4.8 ha	6.2 ha	8.8 ha	1.5 ha	7.3 ha
As % of total area under improved cultivars	100%	43.6%	56.4%	100%	17.0%	83.0%
As % of total area under potato	28.4%	12.4%	16.0%	48.3%	8.2%	40.1%

2.3.2. Potato biodiversity indicators

Paucartambo and Huancayo region are extremely rich in potato cultivar diversity (table 7). Farmers in both regions particularly manage a high number of morphologically distinct native-floury cultivars. Each of these native-floury cultivars is recognized and named on the basis of local nomenclature. Even though the Huancayo region has been intensively exposed to improved cultivars from breeding programs through formal and informal diffusion networks, the total diversity of native-floury cultivars in this region is higher than in Paucartambo where technological dissemination has generally been low-key. Overall, farmers in both regions grow similar numbers of distinct improved cultivars. The total number of distinct native-bitter cultivars is highest in Paucartambo. The average number of morphologically distinct cultivars grown per farmer household is slightly higher in Paucartambo as compared to Huancayo (table 5).

Table 5: Overall and relative cultivar diversity by region (n = 202[1] / 837[2])

	Paucartambo (Cusco)				Huancayo (Junín)			
	Potato (total)	Native-floury	Native-bitter	Improved	Potato (total)	Native-floury	Native-bitter	Improved
Total number of distinct cvs. by region	158	125	17	16	194	172	5	17
Average number of distinct cvs. / household *	17.5 (±8.1)	10.7 (±6.0)	2.8 (±1.7)	4.6 (±2.0)	13.8 (±14.5)	14.7 (±14.2)	2.5 (±0.8)	3.2 (±1.8)

[1]= households; [2] fields; * calculations based on values for those households actually growing the specific cultivar category

The regional level of farmer dedication to the cultivation of a specific cultivar is defined by its Overall Cultivar Frequency (OCF). Results show that most native-floury cultivars are grown by very few or few households (table 6). In other words, the total richness of native-floury cultivars in both Paucartambo and Junín is high but the evenness of cultivar distribution is low. The same is true for most of the native-bitter cultivars grown by households in Paucartambo. By contrast, the majority of improved cultivars are grown by many or most households. A similar trend is observed when quantifying the conservation status of specific cultivars based on their Relative Cultivar Frequency (RCF) as 54% and 59% of native-floury cultivars from Paucartambo and Huancayo respectively are very scare with frequencies lower than 0.05% (1 sample out of 2000). Furthermore, 41% of the native-bitter cultivars from Paucartambo are also very scarce (table 8). On the other hand, 75% and 59% of the improved cultivars from Paucartambo and Cusco respectively are common or abundant.

Table 6: Number of distinct cultivars by household dedication (based on OCF*)

Region	Cultivar category	N	Grown by very few households	Grown by few households	Grown by many households	Grown by most households
Paucartambo (Cusco)	Native-floury	125	47	40	28	10
	Native-bitter	17	5	5	4	3
	Improved	16	1	4	4	7
Huancayo (Junín)	Native-floury	172	61	65	36	10
	Native-bitter	5	1	1	3	0
	Improved	17	2	3	8	4

* based on calculation of the Overall Cultivar Frequency (OCF): very few (OCF < 1%), few (OCF < 5%), many (OCF < 25%), most (OCF > 25%)

Cultivars grow by many or most households are also common or abundant in terms of their conservation status. These cultivars are predominantly so-called cosmopolitan native-floury cultivars and well known improved cultivars grown throughout the Peruvian Andes. These cultivars occupy comparatively large areas of the total cultivated potato area. The three most widely grown native-floury cultivars in terms of their area are Maqtillu, Muru Huayro and Peruanita in Paucartambo (Cusco) and Muru Huayro, Amarilla and Huayro Rojo in Huancayo (Junín). In both regions most of the area covered by improved cultivars is also predominantly occupied by well-know improved cultivars such as Yungay or Canchan.

Table 7: Conservation status of distinct cultivars (based on RCF*)

Region	Cultivar category	N	Very scarce	Scarce	Uncommon	Common	Abundant
Paucartambo (Cusco)	Native-floury	125	67	14	19	19	6
	Native-bitter	17	7	3	2	2	3
	Improved	16	2	0	2	5	7
Huancayo (Junín)	Native-floury	172	102	15	29	16	10
	Native-bitter	5	1	0	1	1	2
	Improved	17	1	1	4	5	6

* based on calculation of the Relative Cultivar Frequency (RCF) of each cultivar: very scarce (<0.05), scarce (<0.10), uncommon (<0.25), common (<1.00), abundant (>1.00)

Older farmers could generally not list more than 2 or 3 native cultivars that might have been lost. Most of the cultivars collected in Paucartambo and listed by Cook (1925a 1925b), Hawkes (1941, 1944) and Vargas (1949, 1956) were found to be still grown by farmers today. The 1927 Russian Potato Collection Expedition under the leadership of Sergei Bukasov collected local potatoes named Pitikiña, Puka Mama, Pichucaro, Sunchu, Chimaku and Alqay Warmi (see: Zimmerer, 1996, p.13).

2.3.3. Spatial distribution of potato diversity

Farmers in Paucartambo and Huancayo on average manage 4.8 and 3.6 separate potato fields during the main potato growing season (table 8). The management of subfields with different cultivar categories within fields is very common in Paucartambo. This means that within a single field farmers grow separate rows of native-floury, native-bitter or improved cultivars. This reality confirms that, in terms of varietal adaptability, it is possible for different cultivar categories to compete for space within a similar agroecological zone or altitudinal belt. Households in Paucartambo as well as in Huancayo manage slightly more (sub)fields of native-floury than improved cultivars. In both regions the number of (sub)fields with native-bitter cultivars per household is considerably lower compared to the number of fields with native-floury or improved cultivars.

Table 8: Average, minimum and maximum number of (sub)fields managed per farmer household in Paucartambo - Cusco (n = 98[1] / 467[2]) and Huancayo - Junín (n = 104[1] / 370[2])

		Fields: potato (overall)	Sub-fields: potato (overall)	Sub-fields: native-floury cvs.	Sub-fields: native-bitter cvs.	Sub-fields: improved cvs.
Regional (Paucartambo)	Average	4.8	8.8	4.0	1.8	3.4
	Minimum	1.0	2.0	1.0	1.0	1. 0
	Maximum	21.0	29.0	19.0	5.0	10.0
	S.D.	3.0	4.5	2.5	1.0	1.8
Regional (Huancayo)	Average	3.6	4.5	3.0	1.2	2.4
	Minimum	1.0	1.0	1.0	1.0	1.0
	Maximum	9.0	15.0	8.0	2.0	7.0
	S.D.	2.0	2.8	1.9	0.4	1.5

[1]= households; [2] fields; S.D.= standard deviation; calculations based on values for those households actually growing the specific cultivar category

In each of the research regions field plot sizes are generally small (table 9). Cropping areas smaller than 1000 m² per field are the norm. In Paucartambo exceptionally areas of 1 ha field are planted. On average, individual potato fields in Paucartambo are about twice as big as fields in Huancayo. However, at the sub(field) level plot sizes are very similar.

Table 9: Average, minimum and maximum (sub)field size (m²) in Paucartambo - Cusco (n = 98[1] / 467[2]) and Huancayo - Junín (n = 104[1] / 370[2])

		Fields: potato (overall)	Sub-fields: potato (overall)	Sub-fields: native-floury cvs.	Sub-fields: native-bitter cvs.	Sub-fields: improved cvs.
Regional (Paucartambo)	Average	828	447	586	320	337
	Minimum	8	1	4	1	2
	Maximum	20560	14283	14283	2705	3687
	S.D.	1416	774	1029	428	443
Regional (Huancayo)	Average	493	388	381	365	397
	Minimum	23	1	1	16	1
	Maximum	3883	3883	2365	2196	3883
	S.D.	522	472	379	529	546

[1]= households; [2] fields; S.D.= standard deviation; calculations based on values for those households actually growing the specific cultivar category

On average, individual households in Paucartambo grow more that double the total potato cropping area compared to households in Huancayo: 3947 versus 1752 m² (table 10). Households in both regions dedicate more area to native-floury cultivars as compared to improved cultivars. In Paucartambo the area each household plants with native-floury cultivars is twice the area planted with improved cultivars and four times the area planted with native-bitter cultivars. In Huancayo the difference between the total area household's plant with native-floury and improved is very modest. However, the cropping area dedicated to native-bitter cultivars is considerably smaller.

Table 10: Average, minimum and maximum cropping area (m²) managed by farmer households in Paucartambo - Cusco (n = 98[1] / 467[2]) and Huancayo - Junín (n = 104[1] / 370[2])

		Potato (overall)	Native-floury cvs.	Native-bitter cvs.	Improved cvs.
Regional (Paucartambo)	Average	3947	2343	589	1135
	Minimum	113	27	1	39
	Maximum	25516	17234	3068	5578
	S.D.	3289	2244	625	937
Regional (Huancayo)	Average	1752	1138	426	965
	Minimum	70	1	16	4
	Maximum	8002	5085	2196	5908
	S.D.	1558	1172	564	1217

[1]= households; [2] fields; S.D.= standard deviation; calculations based on values for those households actually growing the specific cultivar category

One notable difference between Paucartambo and Huancayo concerns the altitudinal distribution of the different cultivar categories. In Paucartambo most of the area of native-floury (81.9%), native-bitter (86.2%) and improved cultivars (65.1%) is concentrated between 3,600 and 4,000 m of altitude. This indicates there is significant altitudinal overlap in the spatial distribution of the 3 cultivars categories in Paucartambo. This is coherent with the finding that farmers in Paucartambo frequently plant more than one cultivar category within a single field. In fact, 77.6% of the potato crop is grown within this thin belt covering 400 m of altitude difference. In Huancayo, on the other hand, cropping areas with native and improved cultivars are to a large extent separated by altitude. Most of the area planted with native-floury (83.7%) and native-bitter cultivars (98.4%) is concentrated between 4,000 and 4,200 m while the major area of improved cultivars (64%) is located between 3,400 and 3,600 m (table 11). In Huancayo altitudinal overlap between the cropping areas dedicated to each of the cultivar categories is modest.

Table 11: Proportional distribution (%) of the potato and cultivar category cropping area by altitude

Altitudinal belt	Paucartambo - Cusco (n=866)				Huancayo - Junín (n=470)			
	Potato (overall)	Native-floury cvs.	Native-bitter cvs.	Improv. cvs.	Potato (overall)	Native-floury cvs.	Native-bitter cvs.	Improv. cvs.
3,000-3,200	0.1	0	0	0.2	0	0	0	0
3,200-3,400	2.2	1.2	1.6	4.7	1.0	0	0	2.1
3,400-3,600	12.8	9.5	1.3	24.6	33.4	5.2	1.6	64.0
3,600-3,800	28.0	29.9	17.6	28.5	10.2	3.6	0	17.6
3,800-4,000	49.6	52.0	68.6	36.6	8.5	7.4	0	10.5
4,000-4,200	7.2	7.4	10.8	5.4	47.0	83.7	98.4	5.8

There is a clear positive correlation between altitude and the level of cultivar diversity encountered within sub-fields. This is particularly so for native-floury cultivars with the average number of cultivars per sub-field increasing from 2.1 to 5.6 and 2.0 to 9.9

between 3,200-3,400 to 4,000-4,200 m of altitude in Paucartambo and Huancayo respectively.

Table 12: Average number of cultivars per subfield by altitude

Altitudinal belt	Paucartambo - Cusco (n=866)				Huancayo - Junín (n=470)			
	Potato (overall)	Native-floury cvs.	Native-bitter cvs.	Improv. cvs.	Potato (overall)	Native-floury cvs.	Native-bitter cvs.	Improv. cvs.
3,000-3,200	2.0	0	0	2.0	0	0	0	0
3,200-3,400	1.9	2.1	1.5	1.8	2.2	2.0	0	2.3
3,400-3,600	1.7	2.0	1.5	1.6	2.3	2.7	1.0	2.2
3,600-3,800	3.0	3.9	2.0	2.1	3.2	4.7	0	2.4
3,800-4,000	3.5	5.1	2.2	2.5	3.3	5.7	0	1.6
4,000-4,200	3.6	5.6	2.0	2.4	7.5	9.9	2.41	1.9

2.4. Discussion on potato diversity

Farmers in Paucartambo grow more than double the area of potato per household compared to farmers in Huancayo: 3,947 m² versus 1,752 m². Farmers in Paucartambo also manage a slightly higher number of potato fields per household compared to farmers in Huancayo: 4.8 versus 3.6 fields. This difference concerning the total area per household is explained by the relative importance of agriculture in both regions. In Paucartambo 83.3% of farmer income is generated through agriculture while in Huancayo 52.1% is generated through off-farm activities. Farmers in Huancayo frequently work off-farm and therefore have less labor time available for potato cropping compared to farmers in Paucartambo.

The total diversity of morphologically distinct cultivars, particularly native-floury cultivars, is higher in Huancayo compared to Paucartambo: 194 versus 158 cultivars. This contradicts the notion that the total cultivar diversity would be lower in areas that are i.) exposed to technological innovation over a prolonged period ii.) more integrated into national market economies, iii.) located closely to paved roads, iv.) affected by (temporal) migration. Indeed this research shows that there is no evidence to suggest a direct irreversible displacement of diverse native by improved cultivars. Older farmers could generally not list more than 2 or 3 native cultivars that might have been lost. Most of the cultivars collected in Paucartambo and listed by Cook (1925a 1925b), Hawkes (1941, 1944) and Vargas (1949, 1956) were found to be still grown by farmers today. The 1927 Russian Potato Collection Expedition under the leadership of Sergei Bukasov collected local potatoes named Pitikiña, Puka Mama, Pichucaro, Sunchu, Chimaku and Alqay Warmi (see: Zimmerer, 1996, p.13). Our biodiversity survey in 3 farmer communities included tuber samples from 4 out of 6 of these same cultivars. In conclusion, farmers maintain overall diversity and often incorporate new diversity of improved cultivars into the total pool without necessarily sacrificing native cultivars.

What inevitably occurs as new improved and cosmopolitan native cultivars are incorporated into farmers stocks is a trade-off concerning the amount of fields and land to be dedicated to each of the cultivar categories. This influences the relative abundance of particular cultivars through a gradual replacement of the area dedicated to diverse cultivars to less new improved and commercial native-floury cultivars. In conclusion, most of the diversity of native cultivars is maintained by few households and at extremely low frequencies.

Another phenomenon, which is particularly notable in the Huancayo region, is that native and improved cultivars occupy different spaces within the agricultural landscape. A principal factor driving spatial separation is altitude which can be explained in terms of risk and differential crop management, yet not by narrow adaptation of most cultivars (see: De Haan et al., 2009b; Zimmerer, 1998, 1999). Mixtures of different native-floury and native-bitter cultivars with inherent variable levels of resistance or tolerance to sources of abiotic stress, such as frost, hails and drought, are employed at the altitudinal limits of the agricultural frontier where the incidence of extreme weather events is more frequent. On the other hand, improved cultivars in single cultivar stands at lower altitudes are often better fit to confront late blight (Phytophthora infestans) due to bred resistance and/or earliness. Improved cultivars generally have a higher need for labor input as they are grown in so-called barbecho systems that require hilling. Improved cultivars are also frequently provided with external inputs such as fertilizers and pesticides. Therefore it is partially more practical to grow improved cultivars at lower altitudes closer to the villages' nucleus. On the other hand, native-bitter cultivars require frost for chuño processing and are therefore, from a logistic point of view, are preferably cultivated at high altitude where frost is intense.

3. VALUING DIVERSITY: CHOICE EXPERIMENTS

3.1. Background

Choice experiment theory has been developed around the notion that utility from consumption of a good derives from that good's attributes, i.e. utility from potatoes consumption relates to taste, color, shape, size, etc. Similarly, a potato grower's selection of varieties may be based on the particular variety's attributes such as earliness, late-blight resistance level, frost resistance in the case of Andean farmers, market acceptance, etc. For a farmer who also consumes a sizeable proportion of their crop production, variety choice also includes consumption attributes such as taste, storability, cooking easiness (because of high costs of cooking in Andean environments, where wood and other energy sources are relatively scarce), etc.

When a farmer plans on what types of potatoes varieties to plant and the relative proportion between varieties (crop structure), all these attributes are implicit in the decision because the farmer will be weighing his or her needs of the different attributes in the final choice of variety mix. Thus, the final decision on the crop structure is a matter of choice for the farmer as well, as it would be for an urban consumer enjoying a particular recreational forest its size, species composition, age diversity and landscape quality (Bateman et al., 2002, p. 278). Therefore, selecting attributes that reflect the decision on the final crop structure that a farmer chooses is a valid design and help us to address more directly the trade-offs between land race and improved varieties as the objective of the current study.

Three potential sources of bias were identified with this method. First is the dependency bias. Attributes may be interrelated among them and there can be inconsistencies in the scenarios presented; the respondent may thus stop taking the experiment seriously. To overcome this bias we will identify attributes that may act as proxies for other attributes and select and use the most appropriate attribute for the study. The second bias is that of misunderstanding and/or leading questions. To avoid this bias, the enumerators are trained to use local expressions in the survey and avoid using leading questions by following a scripted storyline explaining the exercise. Order effect was the third bias, which was overcome by randomizing the order of appearance of these choice sets across questionnaires.

3.2. Methodology

3.2.1. <u>Choice experiment model</u>

A discrete choice multinomial logit model using Limdep was run for the two study sites separately. The specification of the linear regression included each of the attributes as dependent variables. Additionally, relevant socio economic variables that were collected were also included as independent variables. Age, education level of the household head, and household size are thought to be in theory important determinants of respondents' choice and would have an important explanatory power on the value farmers might place in conserving potato biodiversity.

Age was thought to be an important because we hypothesized that younger farmers may be less attached to conserving native potatoes diversity since they might value cash crops more as an income source. Cash crops also allow younger farmers to connect to markets, and may be even a motivation to go to the market place more often. Another theoretical justification was that younger farmer were less risk averse and might take greater risks by planting improved varieties instead of the native potato ones, which are seen as more traditional crops. Therefore, as price increase younger farmers were willing to move away from the status quo at lower threshold prices for improved varieties.

Older farmers, however, usually value more their stock of land races because of tradition, heritage and as a risk reduction strategy, with lower input requirements needed for cultivating native potatoes. Older farmers have most likely endured significant more crop failures and food shortages than youngsters and therefore their willingness to give up area and number of native potato varieties should be lower.

Another theoretically important variable was household size. Larger families would be more willing to conserve biodiversity because of the need to feed a larger number of members and because the option of buying food during food shortages is restricted by income. Therefore there would be a negative correlation between household size and the change choice. Household size would also be important as labor source if families were given the chance to increase total potato area, but we hold total potato area constant on our survey design so this effect cannot be captured.

Education was the third theoretically important variable in the model since we hypothesized that more educated farmers would be more innovative and willing to adopt new practices and improved varieties. It could also be argued that education has also some effect on valuing more in situ conservation of native potatoes, since more educated farmers may have realized the importance of native potatoes for urban consumers, for example.

The estimated regression, representative of the conditional indirect utility function, is as follows:

$$V_{ij} = Asc + \beta_1 DIV + \beta_2 YIELD + +\beta_3 PRI + \beta_4 AREA + \beta_5 EDU + \beta_6 HHSIZE + \beta_7 AGE$$

Where V_{ij} is the dependent variable that represents the utility attribute i^{th} for household j^{th} and whether a respondent has selected one of the change alternatives with respect to the status quo. The independent variables are:

Asc: alternative specific constant, which captures the effects on utility of effects not included in the regression
DIV: number of native potato varieties

AREA: proportion of area under native varieties
YIELD: yield of improved varieties
PRI: price of improved varieties
AGE: age of respondent/household head
EDU: education level of respondent/HH head
HHSIZE: number of household members

3.2.2. Willingness to pay for conserving biodiversity

Falta menciona que Birol y otros usaron la misma conceptualizacion del willingness to pay.
With the price coefficient representing the marginal utility of income, the ratio between any attribute coefficient and the price coefficient is the measure of the willingness to pay for the specific attribute, or the implicit price. This measure permits the comparisons between attributes and across sites of how farmers value the different attributes in the change options. The formula is:

$WTP_i = \left(\frac{\beta_i}{\beta_{price}} \right)$, where *WTP* is the willingness to pay for the specific attribute *i* and β is the estimated coefficient of the attribute *i* and of price, respectively.

3.2.3. Attribute selection

Choice experiments were finally designed using four different attributes. To select the list of attributes and levels we draw on different sources of information: previous work on participatory plant breeding by CIP which collected farmers' criteria for varietal selection, literature review, in-situ discussions with farmers and study team own selection and priorities for the choice experiment. The selection of attributes and their levels followed a three-step procedure:

1. A preliminary inventory of different attributes was available from previous work by CIP's breeding program involving farmers' participation on Mother and Baby trials, where numerous selection criteria important to farmers have already been elicited. This list was used to discuss the selection of attributes and preliminary levels for the different attributes were predetermined.
2. A first field visit to one of the sites (Paucartambo) in November 2009 was used to test the preliminary list of attributes and levels and adjust the final selection for the choice experiments. Several logistical and methodological issues arose and the survey was redesigned after this visit.
3. The final list of attributes and levels and the choice sets were re-discussed with the study team and a new pre-test of the final survey format was conducted in the Huancayo site in March 2010.

The selection of attributes and levels and the design of the choice experiments also draws heavily on previous similar work (Birol and Rayn-Villalba, 2009; Kikulwe et al., 2010). The final choice of attributes and their levels is as follows:

Native potato cultivar diversity : defined as the absolute number of distinct native potato cultivars planted by each household. It can be constructed based on the cultivar frequency measure of the biodiversity survey and includes all categories of native cultivars (bitter and floury, for own use and for trade or exchange). An assumption implied by the experiment is that single households' decisions affect the overall community diversity. Other assumptions are that non-market valuation is for the set of native cultivars as a group, and that all decisions are made on the group and can affect any of the single varieties with the same probability.

The definition of the attribute also implies that several single non-market attributes that are identified as relevant for farmers (i.e., cultural, prestige, cooking quality) are embedded in the decision to plant land races. The more the number of land races planted, the more the individual attributes are valued by farmers. The attribute definition does not select any of these particular non-market values of native potatoes but rather different combinations of all of them. The specific combination for each farmer, though, is not known.

Levels of land race diversity should be ideally defined according to the current situation in each study site, with the average land race diversity representing the current situation. On average and for both sites, plausible diversity ranges are less than 10 native cultivars for low levels, between 10 and 20 for median level, and more than 20 for the higher numbers of native cultivars kept by a single household. To represent these levels with more precise figures we used four different levels of diversity at the household level: less than 5, between 5 and 15, between 15 and 25, and more than 25. Precise pictures were used to represent each of these levels (see Annex 2).

The lowest land race diversity level could theoretically be 0, which means that all household plots are planted to improved varieties. However, this level is hardly found in the communities under study and was discarded. The highest level could be defined as the highest number of land races found in an individual household in each community/study site, but given the large variance of this measure with respect to community averages it could become not realistic for many of the participating households (e.g., one individual household in one community keeps more than 100 different cultivars).

Planted area of native potato cultivars: defined as the absolute number of hectares planted with native potato cultivars by individual households relative to total area planted to all potato cultivars (land races and improved varieties). The attribute definition intends to measure the incentive farmers have to increase the area planted with commercial, improved varieties with market demand, reducing the area planted to land races. One critical assumption is that total area of the farm should be held constant, meaning that farmers cannot choose to increase area planted to any group/variety without decreasing the area planted to other varieties. The relevance of the attribute is that as farmers reduce the area to land races to increase that of improved varieties, even though the absolute number of land races is not decreased (i.e., they still plant the same number of land races) the area allocated to each of them is decreased and there is an increased risk that more land races could be lost in any particular season due to complete crop failure.

The current average area planted in each community to land races should represent the current level of the attribute. Four levels were proposed: 10%, 30%, 60% and 90% of the total potato area planted to land races. Again, in theory the minimum level could be 0%, representing the situation when the total area of the farm is planted with improved varieties. However, as noted before this situation is hardly found in the communities under study. We represented these levels by means of precise graphics showing a number of different plots planted each with either improved or native cultivars.

A consequence of the ceteris paribus assumption of the exercise is that based on the attribute's definition, any increase/decrease of area of land races represent a similar decrease/increase of area under improved varieties.

Expected yield of improved commercial varieties: defined as the total crop production per unit of land planted with improved varieties. The attribute represents the incentive farmers have to adopt new improved varieties (e.g., developed by NARS alone or in collaboration with CG centers) with higher yields with respect to the varieties they currently grow. If such choice becomes available for a farmer, then the farmer has the incentive to adopt the new variety and increase the crop productivity per unit of land.

The current average yield level should be set as the baseline and minimum level of the attribute, free of any current recently seasonal pattern (e.g., yields decreases/increases in the past seasons due to particular diseases/climatic conditions). The levels of the attribute are defined with respect to the current average yield (status quo) and as increases of 25% and 50% with respect to the current yield. Since yield per unit of land is a difficult concept for Andean farmers, we used graphics where the current yield was be represented by four bags of potatoes and the proposed increased levels were one or two extra bags accordingly.

Expected price of improved commercial varieties: defined as the farm-gate price in local units received by farmers per unit of weight sold at local markets. It represents the incentive to shift to improved varieties with higher market demand, either because of quality or because of the potential to fill some specific market niches, such as earliness that allows commercialization of the crop before the bulk of potatoes arrive and saturates the market. An increase in price is a strong incentive for farmers to shift to improved varieties as they become more commercially oriented. The price attribute also allows the valuation on money metrics of the other attributes selected for the choice experiment.

Levels of the attribute should be represented with respect to an average of the last three years for the most popular commercial variety, and represent an increase with respect to that level of 25% and 50%, and also a decrease of 25% with respect to the current level.

However, at the beginning of the survey, in March 2010, prices were higher than the three-year average due to the particular cropping season, where higher than average precipitations in the rainy season caused extensive damage to potato fields in some areas and an increase on expected prices by farmers. To accommodate these expectations and make the choice experiment exercise realistic to farmers we adjusted our initial estimation of levels accordingly. The current weight unit for potato sales is the arroba, a measure amounting to 11.5 kgs. The average price and the proposed percentage changes were set in Soles (local currency) per arroba, with current average price (status quo) defined at 8 soles per arroba.

Table 13: Attributes and levels

Attributes	Levels
1. Diversity in native potato cultivars planted	Low number of cultivars (range <5 varieties)
	Medium-low number of cultivars (range 5 - 15 varieties)
	Medium-high number of cultivars (range 15 – 25 varieties)
	High number of cultivars (> 25 varieties)
2. Expected yield of improved commercial potato varieties	Current yield (4 bags)
	Increase of 25% of current yield (5 bags)
	Increase of 50% of current yield (6 bags)
3. Expected price of improved commercial potato varieties	Decrease in 25% of current average: 6 soles/@
	Current average price: 8 soles/@
	Increase in 25% of current average price: 10 soles/@
	Increase in 50% of current average price: 12 soles/@
4. Planted area of native potato cultivars	Native cultivars occupy 10% of total potato area
	Native cultivars occupy 30% of total potato area
	Native cultivars occupy 60% of total potato area
	Native cultivars occupy 90% of total potato area

3.2.4. Choice sets

An orthogonal design on SPSS was used to produce 32 choice sets with combination of the different attributes and their levels. The design was 'blocked' into 4 parts so that each respondent only received 7 choice sets to answer. A total of 28 choice sets were finally used. Four spare choice sets were left over in case one of the alternatives change options were similar to the current situation of the respondent. Then, the choice set with the duplication was dropped and one of the spare choice sets used instead. An example questionnaire presented to the respondents is shown in Annex 2. The complete list of the final choice sets is attached in Annex 3.

3.2.5. Enumerator training

Given the complexity of implementing the choice experiment questionnaire as well as the technical expertise of completing the biodiversity measurement survey, enumerators with at least a technical degree or first year university level were trained and pre-tested the survey with the support of members of the study team in each location. There were five enumerators in Quilcas (Nicolas and Cecinio from Colpar, Daniel from Llacta, Samuel from Rangra and Nicolas from Casacancha) and five in Paucartambo (Mario Abel, Julio Mena , Omar Salcedo, Soledad Valencia and Nalia Gonzales from the University of San Antonio Abad of Cusco). The trainee which showed better understanding of the process was selected as supervisor and was responsible for receiving and checking the information from the other enumerators on a daily basis. On one hand, the biodiversity surveys included basic information to identify the farmer and its actual level of diversity based on the information collected previously for the diversity measures. On the other hand, the choice experiment exercise included a script for the enumerators to follow as initial explanation of the exercise to the respondent. A sample of the survey instrument is included in Annex 1.

Photo 6. Local enumerators tested choice experiments surveys, Huancayo, Peru, 2009

3.3. Results

3.3.1. <u>Coefficient estimation</u>

The results in table 6 show that the estimated coefficients for the attributes *native potato cultivar diversity* and for *expected yield* and *price of improved varieties* are highly significant (at 1% confidence level) for both study sites. The significance level for the attributes included in the choice experiment indicates that all these three attributes are indeed significant on households' selection of potato crop structure and variety choice. Area under native potatoes cultivars, on the other hand, is not significant in Huancayo and is significant at the 10% level in Paucartambo.

Table 14: Coefficients of conditional logit model estimates and willingness to pay, by study site.

	Huancayo (Junín)	Paucartambo (Cusco)
	Mean coeff.; (s.e.) ; (p=prob. z>|Z|)	
ASC	- 0.424 (0.405) ; (p=0.296)	1.358** (0.616) ; (p=0.027)
Diversity of native potatoes	0.016*** (0.006) ; (p=0.0098)	0.024*** (0.006) ; (p=0.0001)
Yield of improved potatoes	0.760*** (0.264) ; (p=0.004)	0.711*** (0.263) ; (p=0.007)

Price of improved potatoes	0.132*** (0.025) ; (p=0.000)	0.071*** (0.024) ; (p=0.003)
Area of native potatoes	- 0.111 (0.185) ; (p=0.549)	- 0.329* (0.185) ; (p=0.075)
Education of household head	0.056 (0.126) ; (p=0.655)	- 0.044 (0.328) ; (p=0.894)
Household size	0.065 (0.045) ; (p=0.150)	0.038 (0.071) ; (p=0.596)
Age of respondent	- 0.002 (0.006) ; (p=0.761)	- 0.002 (0.010) ; (p=0.866)
Sample size	102	93
Normalized Hannan-Quinn	2.17	1.86
Log likelihood	-759.4	-588.9
WTP – Diversity of native potatoes	0.12	0.33
WTP – Yield of improved potato varieties	5.74	9.99

Source: Model estimates of the discrete choice (multinomial logit) model. *** Significant at 1% level, ** Significant at 5% level,, * Significant at 10% level

The relative importance between the attributes is also similar in both study sites. Yield of improved varieties is the factor that most affects farmers' decisions. In both Paucartambo and Huancayo farmers are likely to accept production alternatives which include increase yields of improved varieties. The increased yields implicitly include characteristics of improved varieties such as increased late blight resistance and would mean more production for sale in the markets. The second most important attribute is the price of improved varieties, which together with yield are the factors that affect the total revenue farmers make from the crop. Farmers in both locations are looking for improved potato varieties with higher yields and which can sustain competitive prices as cash crops. Prices are normally pushed downwards when the bulk of the regional harvest invades the markets, and finding ways to keep prices competitive is an attractive alternative for farmers and would induce them to plant more under improved varieties.

The third attribute in relative importance is diversity of native potatoes and indicates that farmers do pay attention to the number of native potato cultivars they can grow. Also, since the statistical significance of the area attribute is lower for both locations, it confirms one of the underlying arguments of the displacement hypotheses that farmers give relative more importance to the number of native potato varieties than to the area under native potatoes they grow.

Socio economics characteristics of the households and respondents are not significant for any of the variables included (age, education and household size) and for any of the locations and seem to have not affected decisions in this choice experiment. The result rejects the previous hypotheses that younger farmers, for instance, would be willing to give up diversity more than older farmers.

Comparing across sites, we find similar levels for the coefficients of the statistical significant variables (yield and price of improved varieties, diversity of native cultivars,). Yield and price of improved varieties are slightly higher for Huancayo than for Paucartambo, while diversity is slightly higher for Paucartambo. This result may show that Paucartambo farmers, who have had much worse infrastructure conditions in the past (and therefore limited access to markets) than in Huancayo, still see that in their crop structure native potatoes cultivars play a more important role than for Huancayo farmers. This is despite that fact that both sites are probably much similar in these days than they were before in terms of access to markets.

Another result supporting the previous interpretation is that the coefficient for the attribute of area under native varieties is significant (at the 10% level) for Paucartambo but not for Huancayo. Therefore, at least comparing between both sites, area under native cultivars is more important for Paucartambo and reveals their relatively higher isolation to markets as an alternative for food provision and their higher reliance on the crops they can grow on their own.

The significance of the constant (*Asc*) for Paucartambo (at the 5% confidence level) indicates that there are unexplained factors in the choice decision that were not captured by the independent variables included in the model, and that decision making of farmers in this site was not completely captured by the selected attributes. This was somehow expected, since more complex situations and production systems in Paucartambo most likely consider include other factors during the decision process that this simplified model does not include. By contrast, the constant is not significant in Huancayo and thus the explanatory power of the systematic component of the model is higher in this site, meaning that the selected attributes and socioeconomic variables capture more fully the decisions making criteria of Huancayo farmers compared to Paucartambo.

3.3.2. Estimation of the willingness to pay

The estimates of willingness to pay for diversity of native potatoes and yield of improved potato varieties are higher in Paucartambo (0.33 and 9.99) compared to Huancayo estimates (0.12 and 5.74). This result means that farmers in Paucartambo are willing to pay more for increased yields of improved varieties and for additional units of native cultivars than Huancayo farmers. A potential explanation of this result is that yields in Paucartambo are generally lower than in Huancayo and therefore farmers are in more need to increase them, as they also are more willing to increase their current stock of native varieties. The willingness to pay estimates results also mean that for both locations, increasing yields is of higher value than increasing the number of native potatoes cultivars. Due to the relative low average yields of potato crops in both locations, this seems to be plausible as farmers realize the importance of achieving higher productivity. Se puede hablar algo de las discrepancias de usar el willigness to pay de la forma como la hemos usados y Jeff Bennett criticó

3.4. Discussion on choice experiment analysis

The choice model study results revealed that for farmers in the selected sites, diversity defined as the number of native potatoes cultivars is still an important factor contributing to crop structure decisions. Farmers are willing to give up area planted with native cultivars more than reducing the number of native cultivars they grow, valuing more the diversity of native cultivars they grow than the total area dedicated to them. The result is similar to those in previous studies, particularly the study by Brush et al. which was based on surveys carried out in comparable locations more than 20 years ago. The result also contributes, with quantitative estimates of farmers' preferences, to reinforce the interpretation of the displacement hypotheses that farmers at initial stages of adoption of improved varieties give up area under native cultivars faster than at later stages, although managing to conserve the number of native cultivars they grow. Complementing the results of the choice experiment shown in this study with current measures of real area under native cultivars relative to total potato area would give additional information to confirm or reject this hypothesis, based on stated preferences, with actual revealed preferences.

The fact that the significance of the diversity, yield and price attributes is the same between both locations is an indication that farmers in the two study sites are weighing the criteria equally when deciding about crop structure, and that expected and previous differences in behavior between both sites have been reduced. Amongst other factors, improvements in communications and roads in Paucartambo in the past 10 years may be playing a role in reducing the gap in the infrastructure conditions, including access to markets and information, between both locations. In some sense, both regions are closing a gap and converging to similar behavior in terms of farmers' decisions about crop structure and criteria about variety selection, and Paucartambo farmers now value the option of planting improved varieties as much as farmers in Huancayo do. However, even though the gap may be closing, the site lagging behind (Paucartambo) still value diversity and area under native varieties more than the one thought to be more advanced (Huancayo), because their ability to resort to markets for food supply is more recent. There are historical reasons for planting native cultivars that cannot be disregarded and farmers in Paucartambo may be also cautious about the sustainability of the infrastructure improvements that have given them access to markets recently.

The fact that farmers value both attributes related to improved varieties (yield and price) and diversity in native potato cultivars similarly also confirms previous hypotheses about a preference for a mixed crop structure using both improved and native varieties. Improved varieties, which offer the expectation of higher yields and can be grown as cash crops, become more important and farmers are willing to devote additional area to these varieties as long as a certain minimum threshold level of diversity (in terms of numbers of native potato cultivars planted) is maintained. Area planted to native potato cultivars seems to be less of a concern for Huancayo farmers than in Paucartambo.

4. CONCLUSIONS

4.1. Comparative among methods

Our biodiversity survey concluded that farmers maintain overall diversity and often incorporate new diversity of improved cultivars into the total pool without necessarily sacrificing native cultivars.

Preferences seem to be consistently homogeneous between the two sites in valuing more number of landraces than area, although the specific value for each attribute vary, and therefore the relative value of the rest of the attributes (yield, price), although expected, is not homogenous across sites

Results combining stated and revealed preference are consistent leading to evidence that strategic behavior of respondents has been minimized.. se necesita desarrollar mas esta relacion en las conclusions.

4.2. Lessons and further research

Beyond the research results, there are lessons learned from the application of valuation methods that were part of the objectives of the study and are worth to take stock of. The study has been useful to understand the difficulties of applying choice experiments in difficult contexts, where farmers speak native Quechua language, have hardly primary school education, and access to markets is difficult. Farmers living in these conditions have difficulties in understanding the abstract exercise that a choice experiment represents and become somehow overwhelmed when faced to a long list of choices sets, even showing uneasiness and wanting to finish the questionnaire as soon as possible, normally after the fourth or fifth choice set. Therefore, more than the 7 choices sets as proposed was not feasible. However, proper design of the questionnaire and use of simple and clear graphics for the attributes and levels made the exercise viable after extensive training of enumerators and field testing. Enumerators were also asked to stick to a previous script written in the local language to avoid bias when applying the questionnaire. University level students were hired as enumerators to be able to control for the ability to understand and manage the exercise more thoroughly, even though this increased the costs significantly.

In the Andean conditions, farmers live long distances one to each other and surveying can be challenging. For the choice experiment, the use of focus groups was tried in one of the pre-test exercises to make more efficient use of the available resources, but caused biased answers, with farmers following choices made by the previous farmer or by those playing leadership roles.

Misunderstanding of the project objectives and how the information collected would be used made difficult the access to some of the communities of Paucartambo. To work with farmers in those communities and motivate them to participate willingly, special authorization from Community leaders needs to be asked for prior to enter the area. Use of the information was a special sensible issue and reassurance was only given when the study team included breeders with previous successful experience in the area. In exchange for their participation farmers received copies of the GIS maps produced of each community, access to seeds of improved varieties for all farmers, sports t-shirts and small gifts for family members.

Finally, lack of experience and training on the use and application of the choice experiment model by CIP's staff delayed and made the process slow, particularly during the initial stages and to process and analyze the data. Extensive consultation with SPIA consultant Jeff Bennet was extremely valuable and made the study viable. Significant capacity building is being made within CIP staff and we hope to continue strengthening this capacity with future applications of the methods, for which funding has been already secured. This additional study will extend the choice experiments to two new locations and will therefore be an excellent opportunity to refine the methods and at the same time build a larger data set on the value of the selected attributes to produce more robust results.

Based on the experience gained with this study, we can conclude give a positive response to the fundamental issue raised by Adamowics and Whittington (2010 that asking complex questions to poor farmers in developing countries about their preferences is a challenging but feasible task for both farmers and researchers.

More research designed at investigating heterogeneity of preferences and identifying explanatory variables, including a model specification that includes interaction between socio-economic characteristics of respondents and attributes.

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6. ANNEXES

6.1. Annex 1: Choice experiment survey instrument

Formulario de Encuesta del Proyecto: Mejoramiento Genetico y Conservacion de la Biodiversidad en los Andes - SPIA

Nombre: Melecio Manrique Inga

Comunidad: Casacancha, Ingenio Fecha: ___/___/___

VARIEDADES DE PAPAS NATIVAS EN CHACCRU O CHALO EN LA ULTIMA CAMPAÑA

1. Huamantanga	11	21
2. Huayro	12	22
3. Limeño	13	23
4. Muro huayro	14	24
5. Papa negra	15	25
6. Peruanita	16	26
7. Regalo	17	27
8. Wansa	18	28
9	19	29
10	20	30

CUAL ES LA VARIEDAD MEJORADA DE PAPA MAS IMPORTANTE QUE TIENE ACTUALMENTE?

[ ]

CUANTOS SACOS DE PAPA PRODUJO UD. EL AÑO PASADO CON ESTA VARIEDAD EN SU PARCELA MÁS GRANDE?

[ ]

CUANTAS PARCELAS CON PAPAS NATIVAS UD. TIENE ACTUAL-MENTE EN CHACCRU O CHALO?

2

CUANTAS PARCELAS CON PAPAS UD. TIENE ACTUALMENTE EN TOTAL?

3

CUANTO LE PAGARON POR ARROBA DE SU VARIEDAD DE PAPA MEJORADA MÁS IMPORTANTE?

[ ]

ESE PRECIO LE PARECIÓ:

1. BUENO
2. REGULAR
3. MALO

Nota:
“Q’ompis”, “huayru”, “majtillo” y “peruanita” son variedades comerciales de papas nativas.

Ejemplos de variedades comerciales mejoradas tenemos:

- Tomasa Tito Condemayta
- Revolución
- Canchán
- Perricholi
- Única
- Yungay
- Capiro
- Amarilis
- Mariva
- Serranita

	ALTERNATIVA 1	ALTERNATIVA 2	ALTERNATIVA 3
JUEGO: ☐			
JUEGO: ☐			
JUEGO: ☐			
JUEGO: ☐			
JUEGO: ☐			
JUEGO: ☐			
JUEGO: ☐			
JUEGO: ☐			

Importancia del estudio:

El Centro Internacional de la Papa trabaja desde hace muchos años en desarrollar nuevas variedades de papa que sirvan para mejorar la producción de papa al hacerla resistentes a diferentes plagas y enfermedades. Varias de esas variedades Ud. la conocen, como la variedad Canchán, Amarilis, Serranita, entre otras tantas.

El CIP esta ahora interesado en saber si las variedades de papa que se han liberado hasta ahora han de alguna forma influenciado su producción de papas nativas y las prácticas culturales que implican la adopción de estas variedades (la siembra en cchaccru o chalo y por qué).

Con este trabajo que vamos a realizar ahora, el CIP va a poder entender como ustedes toman las decisiones de sembrar papas nativas y papas comerciales y cuales son los criterios más importante que Ud. tienen. De esta forma podremos dirigir nuestras investigaciones para que les sirvan a ustedes para tener una mejor vida en los Andes.

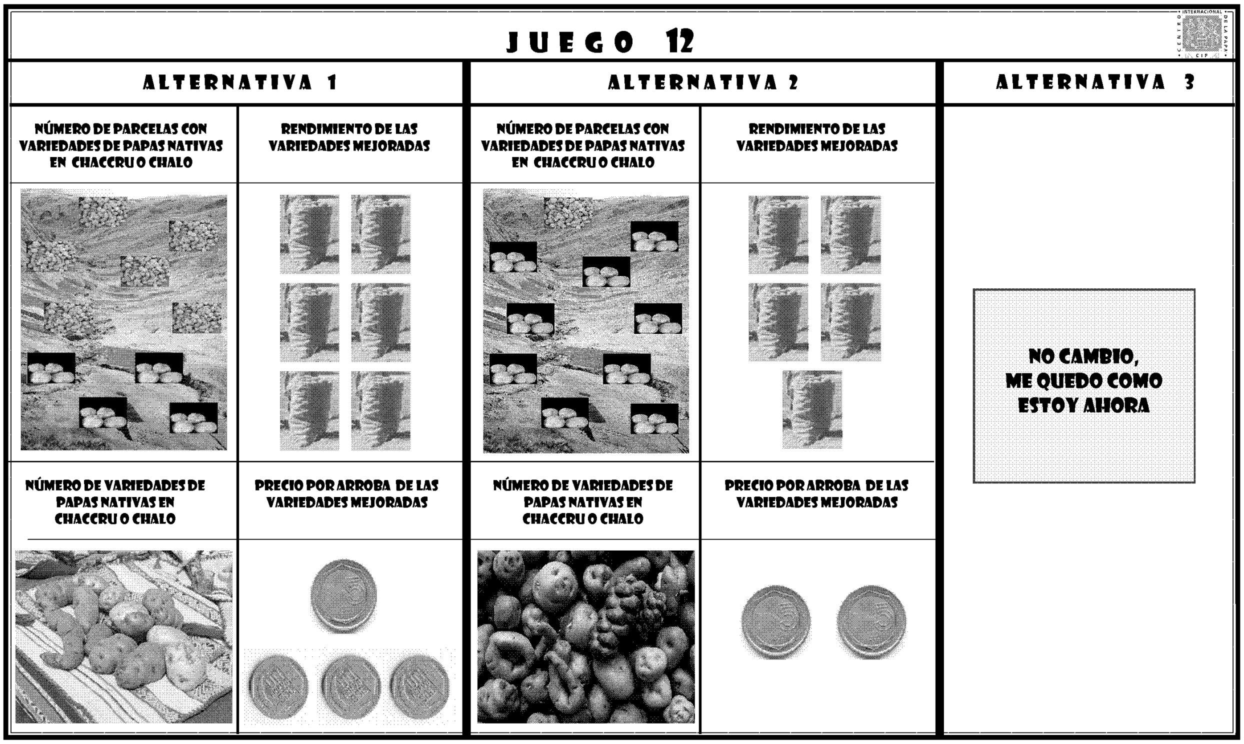
Como introducir los escenarios:

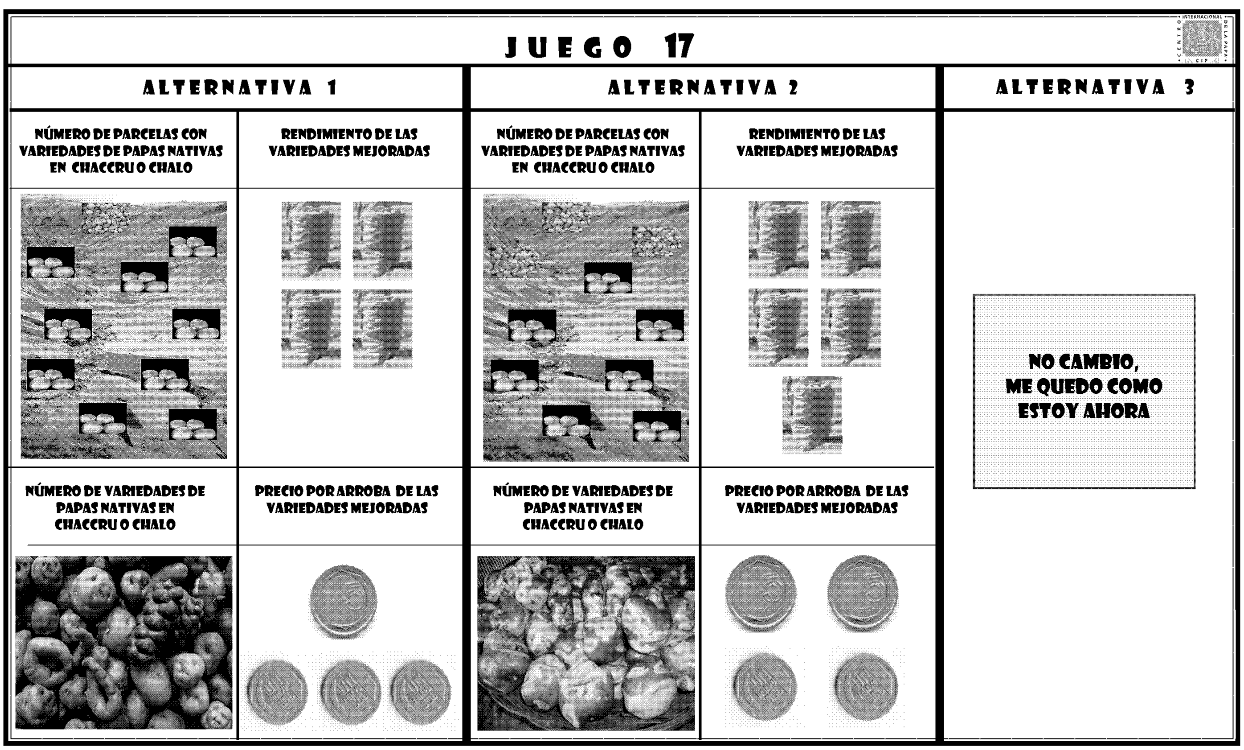
Hemos desarrollado una metodología que usa 4 características que pensamos son las más importantes que ustedes tienen para decidir sobre la siembra de papa: (1) la diversidad de variedades, (2) la cantidad de área destinada a papa, (3) el rendimiento y (4) el precio. Con esta metodología ustedes van a señalar que opción les conviene más y su respuesta reflejará los criterios que usted considera más importante para decidir que sembrar. No hay respuesta mala, pero lo importante es que sea sincero en su respuesta.

“..ahora quiero que Ud. imagine que Ud. puede decir que cultivar, tanto en papas nativas como papas comerciales, y que Ud. puede saber de antemano que rendimiento de papa mejorada va a tener y el precio al que las va a vender dentro de por ejemplo 5 años, en el 2015. Ud. tiene tres opciones, dos de esas opciones implican un cambio de su sistema de producción actual y una implica que conociendo que puede tener un cambio de sus situación actual, decide no hacerlo”.

Ahora vamos a empezar con el primer escenario de los 8 que le vamos a mostrar en este “juego”……..

6.2. Annex 2: Examples of choice sets





6.3. Annex 3: List of choice sets

	Alternative 1				Alternative2			
Choice set	Diversity 1	Yield1	Price1	Area1	Diversity 2	Yield2	Price2	Area2
2	25	current	increase in 25%	decrease of 50%	5	increase of 25%	decrease in current5%	decrease of 50%
3	25	increase of 50%	current	decrease of 50%	less than 5	current	increase in 25%	increase of 50%
4	25	current	decrease in current5%	increase of 50%	5	current	increase in 25%	less than 10%
5	less than 5	increase of 25%	current	no change	5	current	decrease in current5%	increase of 50%
6	less than 5	increase of 50%	decrease in current5%	decrease of 50%	25	current	increase in 50%	decrease of 50%
8	15	increase of 50%	decrease in current5%	no change	5	increase of 50%	increase in 50%	no change
9	25	current	increase in 50%	no change	25	increase of 25%	increase in 50%	increase of 50%
10	5	increase of 50%	increase in 50%	less than 10%	15	current	decrease in current5%	decrease of 50%
11	5	increase of 25%	decrease in current5%	decrease of 50%	less than 5	increase of 25%	current	no change
12	5	increase of 50%	current	no change	15	increase of 25%	increase in 25%	less than 10%
13	less than 5	current	current	increase of 50%	15	current	increase in 50%	no change
15	5	increase of 25%	increase in 25%	increase of 50%	less than 5	current	increase in 50%	increase of 50%
16	15	increase of 50%	increase in 25%	less than 10%	5	current	current	increase of 50%
17	15	current	current	less than 10%	less than 5	increase of 25%	increase in 50%	decrease of 50%
18	5	current	decrease in current5%	less than 10%	25	increase of 50%	increase in 25%	increase of 50%
19	less than 5	current	increase in 25%	no change	less than 5	increase of 50%	increase in 25%	decrease of 50%
20	25	increase	increase	less	15	increase	increase in	less than

		of 25%	in 25%	than 10%		of 50%	50%	10%
21	25	increase of 50%	increase in 50%	increase of 50%	less than 5	increase of 50%	decrease in current5%	no change
22	15	current	increase in 50%	no change	less than 5	current	current	less than 10%
23	15	current	decrease in current5 %	increase of 50%	15	increase of 25%	decrease in current5%	increase of 50%
24	25	increase of 25%	decrease in current5 %	no change	15	current	current	decrease of 50%
25	5	current	current	increase of 50%	5	increase of 50%	current	decrease of 50%
26	5	current	increase in 25%	no change	25	current	decrease in current5%	no change
27	15	increase of 25%	increase in 50%	increase of 50%	25	current	increase in 25%	decrease of 50%
28	15	increase of 25%	current	decrease of 50%	25	increase of 50%	decrease in current5%	less than 10%
29	less than 5	current	increase in 50%	decrease of 50%	15	increase of 50%	current	increase of 50%
30	less than 5	increase of 50%	increase in 25%	increase of 50%	25	increase of 25%	current	less than 10%
31	less than 5	increase of 25%	increase in 50%	less than 10%	5	increase of 25%	increase in 25%	no change