

UNIVERSITÀ DEGLI STUDI DI PADOVA
Department of Land, Environment Agriculture and Forestry

Second Cycle Degree (MSc)
in Forest Science

**Diminishing knowledge of the pajuro tree in La Libertad region (Peru): what is the geographical distribution and what are the reasons of its underuse?
An ecological and socio-economic comparative analysis of two Peruvian districts**

Supervisor dr. Mauro Masiero
Co-supervisor dr. Stef de Haan

Submitted by Ankie van Dijk
Student no. 2043822

ACADEMIC YEAR 2022/2023

Table of Contents

TABLE OF CONTENTS.....	2
LIST OF FIGURES.....	3
LIST OF TABLES	4
ABBREVIATIONS AND ACRONYMS	5
SUMMARY	6
ACKNOWLEDGEMENTS	7
1. INTRODUCTION	8
1.1 BACKGROUND	9
1.2 PROBLEM STATEMENT	12
1.3 OBJECTIVES AND RESEARCH QUESTIONS	12
1.4 STRUCTURE OF THE THESIS	13
2. THEORETICAL BACKGROUND	14
2.1 DEFINITIONS.....	14
2.2 THEORETICAL APPROACHES	14
3. RESEARCH METHODOLOGY.....	18
3.1 RESEARCH APPROACH.....	18
3.2 STUDY AREA	18
3.3 DATA COLLECTION	28
3.4 SAMPLING DESIGN	30
3.5 DATA ANALYSIS	30
4. RESULTS.....	32
4.1 SURVEY WITH HOUSEHOLDS.....	32
4.2 FOCUS GROUPS	ERROR! BOOKMARK NOT DEFINED.
4.3.5 INTERGENERATIONAL AND GENDER-SPECIFIC KNOWLEDGE OF THE POROTO	ERROR! BOOKMARK NOT DEFINED.
4.3 TRANSECTS	48
4.3 PARTICIPATORY OBSERVATIONS	53
5. DISCUSSION	55
5.1 THEORETICAL IMPLICATIONS.....	55
5.2 MANAGERIAL IMPLICATIONS	58
5.3 LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH	60
6. CONCLUSIONS	64
QUOTED LITERATURE.....	66
WEB SITES.....	68
ANNEXES	69
ANNEX 1 - QUESTIONNAIRE	69
ANNEX 2 – ENGLISH TRANSLATION OF SURVEY.....	73
ANNEX 3 – FOCUS GROUP PROTOCOLS	76

List of figures

Figure 1: Pajuro cultivation and use in Venezuela (Pérez <i>et al.</i> , 2015).....	10
Figure 2: Conceptual model explaining the interrelationships between TEK and utilization for a sustainable management. Source: Shisanya (2017).....	15
Figure 3: Overview of the study area.....	20
Figure 4. Key territorial and land use features for the study area: A. Road network, B. Population distribution in Patáz, Pias and Cochorco, C. Urban areas and conglomeration of people, D. Deforestation, E. Mining areas, F. Fire-prone areas.	20
Figure 5: Lorenz curve of La Libertad region (CERPLAN, 2021).	21
Figure 6. Territorial Prioritization Index of Patáz and Sanchez Carrion (left) and number and type of investment specified in La Libertad (right) (CERPLAN, 2022) .	22
Figure 7: The allocation of money to investments and activities within Sanchez Carrion (CERPLAN, 2021).	22
Figure 8. The levels of illiteracy of the provinces Sanchez Carrion and Patáz are the highest in La Libertad (CERPLAN, 2022).....	23
Figure 9: Economic activities in La Libertad expressed in GDP (left) and contribution of departments to gold mining (right) (CERPLAN, 2022).	24
Figure 10: Distribution of different economic activities in Sanchez Carrion (CERPLAN, 2021) (left) and Patáz (Llémpen <i>et al.</i> , 2021) (right).	24
Figure 11: Amount of green area (m ² /person) (Llémpen <i>et al.</i> , 2021).....	27
Figure 12: Distribution of interviewed HH among the districts Patáz and Pias (right) and Cochorco (left).....	32
Figure 13: Distribution of interviewed HH among the districts Patáz and Pias and Cochorco.	34
Figure 14: Comparison of poroto beans production throughout the year in Cochorco (orange) and Patáz (blue).....	35
Figure 15: Uses of poroto in Cochorco and Patáz reported by interviewed households. Number of households.	36
Figure 16: Meals prepared with poroto, combined Cochorco and Patáz.....	37
Figure 17: Reasons are why households from Cochorco and Patáz (dis)like the consumption of poroto.	37
Figure 18: Most important factors for limitation of wider use of poroto.....	37
Figure 21: Poroto trees with the elevation layer from CGIAR (Jarvis <i>et al.</i> , 2008)...	49
Figure 19: The trees grow in different ecosystems in Cochorco and in Patáz.	50
Figure 20: Different climatic conditions in the study area.....	50
Figure 22: Representation of the distribution of the elevation of the trees in the survey (left) and normal distribution for comparison (right).	51
Figure 23: Boxplots separated by district Cochorco (Coc), Patáz (Pat) and Pias (Pia). Different outlier detections are used (3 in the upper figure and 1.5 in the lower figure on the right. On the left a boxplot without any factor for outlier detection is added.	51
Figure 24: Probability of the occurrence of the poroto tree based on elevation (left) or a combination of four parameters, i.e. climate, green cover, ecoregions and ecosystems (right).	52

List of tables

Table 1. The nutritional value of the pajuro fruit (Pérez <i>et al.</i> , 2015).....	10
Table 2: Underutilized crops in Peru. Source: Pastor <i>et al.</i> , 2011	15
Table 3: Peruvian crop species with the highest potential in agroforestry. Source: Aredo <i>et al.</i> , 2017. Spanish words from this Table are translated to English.	16
Table 4: Homes without access to the three basic needs: water, drainage, and electricity (CERPLAN, 2022).	23
Table 5: percentage of population with unsatisfied basic needs within La Libertad region, per district (CERPLAN, 2022).....	23
Table 6: Agriculture, pasture, and forest land in La Libertad region (CERPLAN, 2022).	25
Table 7: Native products originating from Sanchez Carrion (left) and Pataz (right). ..	26
Table 8: Overview of the eight FGs performed.....	29
Table 9: Overview of layers that were used in GIS during the data analysis	31
Table 10: Distribution of surveys conducted with either female or male heads of HH.	32
Table 11: Productive ages of poroto trees in Cochorco and Pataz (average numbers).	34
Table 12: Overview of professions of the participants of the FG in Sanchez Carrion and Pataz	Error! Bookmark not defined.
Table 13 Relevant climatic zones in Sanchez Carrion and Pataz.	48

Abbreviations and acronyms

AP = Asociación Pataz

CIP = International Potato Centre

FG = Focus Group

GPS = Global Positioning System

GIS = Geographical Information System

HH = Household

TEK = Traditional ethnobotanical/ecological knowledge

TPI = Territorial Prioritization Index

Summary

The Peruvian Andes is home to a variety of over 1400 native species and offers rich biodiversity that can be explained by the diversity in microclimates in this area (de Haan *et al.*, 2021). This thesis will focus on the pajuro tree (*Erythrina edulis*) in La Libertad region (North-Western Peru), specifically on the provinces Sanchez Carrion and Pataz. The study location is Chagual. Both provinces have a high Territorial Prioritization Index and agriculture is an important economic sector for both of them. The value of non-traditional product exports from La Libertad has increased over recent years.

Many names exist for the pajuro, including poroto which is used in La Libertad. The pajuro is associated with many benefits, for example, it contains high quality proteins with the level of 25 grams per 100 grams of seed. Additionally, the tree has promising agroforestry qualities but, despite all parts of the tree can be used, the potentialities associated with this species are still largely underused. Increasing its use can help fight food insecurity and promote biodiversity.

To advance research into underutilized crops, this thesis aims to answer the research question 'What is the current state of knowledge and level of conservation of the pajuro tree in La Libertad region in Peru?'. An ethnobotanical study has been performed. A mixed research method approach was employed, combining quantitative and qualitative methods with the use of desk-based research (literature review and use of secondary data) and the execution of fieldwork to collect primary data. Most of the households (HH) (73% in total) report to possess the poroto variety with the brown fruits rather than the one with red fruits. The parts of the tree that are normally used by growers are the bean and the leaves. Bark was also occasionally mentioned. This is consistent with the fact that all the HH eat the poroto and half of them use it as fodder (for which normally leaves are used). *Poroto sancocado* is the most prepared dish. Most HH said they like consuming the poroto beans mainly because of the taste, while there is nothing they dislike about it. The reason why poroto is not more widespread is because of a lack of knowledge of the beans, and because there is lack of market for it. During the focus groups it became evident that the level of knowledge did not differ significantly between generations, although adult men and women have more in-depth knowledge about some of the topics and students only know some uses superficially.

As regards field activities, in total 434 trees were recorded. The tree in Peru is documented at elevations from about 2300 to about 2800 meters asl. and can grow best in two kinds of ecosystems, i.e., the *matorral andino* and *zona agricola*. The poroto grows well in temperate regions with rainfall between 450 – 1800 mm (World Agroforestry). Aricapampa and Paucapampa seems to be a hot spot for conditions that are needed for the pajuro to grow. In the south of Peru there are also *anexos* that were not visited during the research but that could prove to be very suitable for growing the pajuro.

In Pataz and Cochorco mining activities are given priority over agroforestry and agroforestry qualities are currently fulfilled by eucalyptus trees in the region. Collaboration between different stakeholders is crucial to promote the pajuro. Students are also excited to learn more about this bean by the organization of workshops on schools by AP.

Acknowledgements

Asociación Pataz

The NGO that is active in the study area and that has a working relationship with CIP, is Asociación Pataz. This NGO was established in 2004 with the goal of promoting sustainable development in the Andean area. It is subsidized with money from the mining company *Poderosa* and *Compañía Aurífera Suyubamba*. Together with CIP, they are working towards linking social protection with agriculture and nutrition intervention. Asociación Pataz is active in three provinces in La Libertad: Bolívar, Sánchez Carrion and Pataz. Special thanks to Ronal Ontario for providing me with a place to stay during the fieldwork and putting me in contact with the right people and supporting me throughout the whole process.

International Potato Centre (CIP)

CIP is part of CGIAR and working towards food security worldwide. Included in its scope is also the vulnerability of agriculture to climate change. CIP has registered partnerships with CGIAR Gender, Bioversity, CIAT, CIRAD and IITA. CIP has 15 research locations, and from there, there is close collaboration together with local and regional NGOs and organizations. Special thanks to Stef de Haan, who guided me throughout the whole process and educated me on the customs of fieldwork.

University of Padua

The second year of my master Sustainable Tropical Forestry is taken place at the University of Padua. I had the pleasure of having Mauro Masiero as my supervisor, who was my professor in the course Social Responsibility for enabling me to perform this research and providing guidance where needed.

1. Introduction

The Peruvian Andes is home to a variety of over 1400 native species and offers rich biodiversity that can be explained by the diversity in microclimates in this area (de Haan *et al.*, 2021). Pajuro tree (*Erythrina edulis*) is one out of the many species that grow in the region. Archaeological evidence suggests that this tree originated in the Pachacamac area in Peru (Cardenas, 2012) and was cultivated and used by the Incas and other regional cultures settled in the Andes area and its surroundings. It was also cultivated by the edge of the Amazon and in the inter-Andean valleys near the rivers Vilcanota, Huallaga, Marañon, Condebamba, and Huancabamba and at around coastal valleys, especially in the northern region of the country. Currently the pajuro has been found in the Peruvian regions of Piura, Amazonas, Cajamarca, La Libertad, and Áncash. This thesis will focus on La Libertad. Within that, in Sanchez Carrion province, there are records of the pajuro reported for the three districts of Huamachuco, Sanagoran and Chugay (Cardenas, 2015): this thesis will focus on Sanchez Carrion, together with Pataz, building on existing knowledge about pajuro.

The pajuro tree is not present solely in Peru. It is found along the Andes in Colombia, Ecuador, and Bolivia. In Colombia, the same tree is known under the name chachafruto or balu. In Bolivia it is called sachahabas, while in Ecuador the names guato, porotón, cañara or comporuto are used (Cardenas, 2012). Even in Peru there are different names in use for the tree: picorrey, pashiga, anteporoto, pajuro, pashuro, jachapushco, poroto, pashigua, basul, sachaporoto, monteporoto, poroto serrano, antiporoto, pashu and shimpi. The numerous existing names for the plant can be seen as a clear sign for its popularity (Cardenas, 2012). Over the last 500 years, the Andean population has decreased significantly and thereby also the number of animals and plant species, among which the pajuro (Cardenas, 2012). This is supposed to have possible negative impacts since the pajuro tree is associated with many benefits. For example, the pajuro tree contains high quality proteins, with a level of 25 grams per 100 grams of seed.

Thus, the tree can contribute towards the protein transition that needs to happen worldwide by providing a supply of proteins originating from plants as an alternative to the production of animal proteins that can result in an inefficient use of agriculture and contribute to high levels of deforestation (Henchion *et al.*, 2017). Additionally, the pajuro tree has promising agroforestry qualities. The tree acts as a nitrogen fixer, so other crops can benefit from this and be enhanced if they grow in proximity of the pajuro, it does not require phytosanitary treatment, adapts to arid lands, withstands long periods of drought, controls soil erosion and provides nectar from its abundant flowers to several kinds of birds (Cardenas, 2012). Additionally, an important quality of the pajuro tree is its potential to capture above- and belowground carbon (de Haan *et al.*, 2021). Findings from the existing literature indicate that local people in La Libertad, located in the Peruvian Andes, also have a positive attitude about the pajuro tree because it supplies them with a source of food while not requiring a lot of care (Cardenas, 2012). Outside of the tropics, cultivation of the pajuro tree is not very promising, since it is very prone to cold, and cannot stand temperatures that are happening in and around temperate areas.

1.1 Background

In this section background information about the pajuro tree and its cultivation as well as use is provided.

Ecology

Erythrina edulis Triana ex Micheli is a tree genus part of the subfamily *Papilionoideae*, and from the family *Fabaceae* or legumes and produces a seed called the chacafruto. They belong to the Phaseolid group, which is referred to as the 'tropical' clade occurring in warm climates (Smykal *et al.*, 2015). The tree is named after its red flowers, that later transform into the protein-rich seeds that make the tree so unique.

Around 112 species are part of the genus *Erythrina*, distributed around tropical and subtropical areas. The dispersion of *Erythrina* is performed by water streams and with the help of several birds. The *Erythrina edulis* is leafy tree that has a height between 12 and 15 meters. The leaves have thorns on the petioles and nerves, and are light green (Cardenas, 2015). The pajuro tree generally lives up to 30-40 years. The pajuro tree can produce up to 120-400kg of fruits annually and starts fruiting after 18 months. There are two periods where the pajuro is most productive: in July and August and between November and February. The pajuro however can produce throughout the year depending on the soil; hours of sun exposure; atmospheric pressure; types and characteristics of winds and latitude and altitude (Cardenas, 2015). Like most *Erythrina* species, the *Erythrina edulis*, grows rapidly, produces high level of biomass, and is easily propagated.

Nutritional benefits

The pajuro fruits have a great nutritional value and are easily digestible. Next to the high level of protein, they contain 33% of starch and the fruits are used both in savoury and in sweet dishes, such as 'salads, soups, stews and porridge, cookies, and drinks' (Cardenas, 2012 p1). It is also reported to be converted into flour. The seed contains a lot of water and is thus best stored when dried (Cardenas, 2012). Furthermore, it is known that the pajuro contains iron, vitamin B1, B2, B3, vitamin C, iron, phosphor a and calcium (de Haan *et al.*, 2021; MINSa, 2017). Given its many nutrients and vitamins, poroto can be considered a 'superfood' (Table 1).

During a similar study done in Venezuela, it became clear that although 87% of the subjects knew the tree, only 48% knew the nutritional benefits of the tree, and only 41% eats the beans on a regular basis (Pérez *et al.*, 2015). Results of a study are shown in Figure 1. Pajuro is called chachafruto there.

Another advantage of the tree is that it produces minimal waste. The leaves that fall from the tree are good for improving soil conditions, the timber can be used for firewood or construction and branches can be fed to cattle (Cardenas, 2012). The nectar in its flowers attracts bees and hummingbirds (Cardenas, 2015).

There are a lot of different altitudinal ranges documented for the pajuro, which can vary between 500 and 3400 meters above sea level (asl). In Peru it is documented at elevations from about 2300 to about 2800 meters asl. In Sanchez Carrion, the tree grows between 2595 and 2850 meters, for Pataz there is no data readily available.

The tree grows best in sunlight but does not do well without periodic rainfall (Orwa *et al.*, 2009).

	Seed	Pod	Leave
Protein (%)	21	21	24
Carbohydrates (%)	51	24	21
Starch (%)	39	13	14
Fibre (%)	8	23	39
Water (%)	84	91	83
Fat (%)	1	1	3

Table 1. The nutritional value of the pajuro fruit (Pérez *et al.*, 2015)

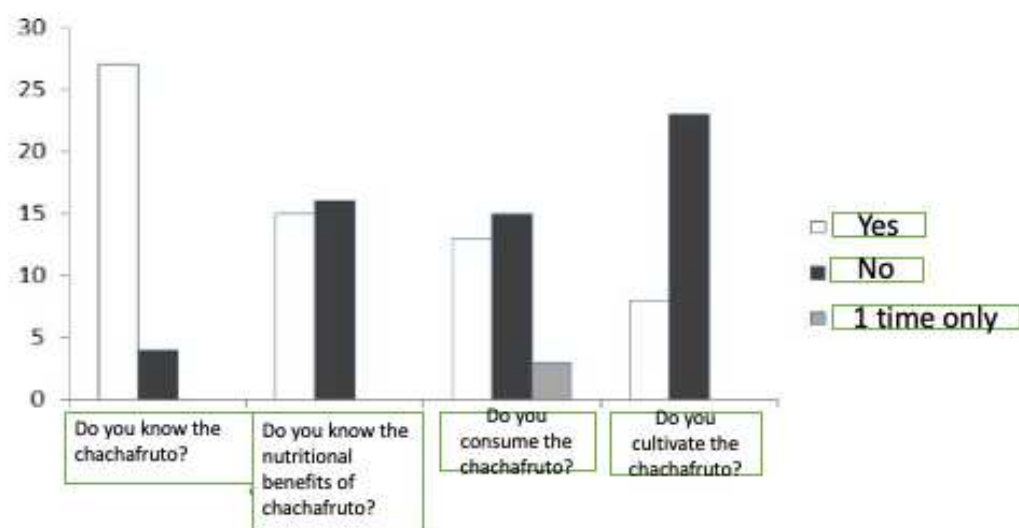


Figure 1: Pajuro cultivation and use in Venezuela (Pérez *et al.*, 2015)

Note: This is a translation of the original figure

Agroforestry

The pajuro tree has a lot of potential regarding agroforestry, providing multiple benefits. Agroforestry systems that recreate local ecosystem processes can function as livelihoods for smallholder farmers and at the same time protect forest biodiversity and endangered species from overexploitation. Among additional benefits, atmospheric nitrogen can be fixed in symbioses with the bacteria of the *Rhizobium* genus. Pajuro can also act as natural fencing, to prevent entry of people and animals, circumvent houses; it provides shelter for animals and people and creates favourable microclimatic conditions for cultivation (Cardenas, 2015). Phosphorus and other elements or compounds can also be fixed if the tree meets certain fungi, thus improving soil conditions. Next to this, the tree provides plantations with needed shade, and can help with the conservation of Andean water springs (Pérez *et al.*,

2015). The pajuro tree also serves as fodder for livestock. Bigger leaves are fed to donkeys and horses, and smaller leaves are given to guinea pigs. It acts as a nutritious food for wild animals as well (Cardenas, 2015).

In fields, the pajuro can be planted with a density of 50 cm between trees and one meter between rows. This would result in a density of 20,000 trees/ha. When the pajuro starts producing beans, pruning should be performed every three to four months to approximately 1.50-meter height. This will also decrease the need for pesticides (Cardenas, 2015).

Medicinal uses and traditional beliefs

Around 12.5% of all plant species worldwide are associated with medicinal values (Rao *et al.*, 2004). The seeds of the pajuro tree contain a certain level of alkaloids, which can be toxic if eaten raw, but this characteristic is also seen as having healing powers. In La Libertad, it is mentioned that the species is used as a medicinal plant as well (Cardenas, 2012). Examples of uses are contraceptive use for women and medicine for sick animals. In the Agroforestry database, the pajuro tree is also mentioned as treatment for the inflammation of the bladder and eye irritations (Orwa *et al.*, 2009). This is treated with a tea made with its flowers, which can also be gargled. Mixing this with orange blossom creates a medicine for heart ailments of elders and children. It is also reported that the pajuro tree is used to fight osteoporosis. Furthermore, antirheumatic, combating cellulite, treating haemorrhoids and fever are also mentioned as medicinal uses of the pajuro (Cardenas, 2015). Lastly, stomach- and headaches can be treated with the crushed leaves.

The consumption of the pajuro is also believed to be correlated with longevity. In areas where pajuro tree grows, it is common to find people over 90 or 100 years old (Cardenas, 2012). In Ecuador, the Saraguros and the Shuars use the bark of the tree to deal with high blood pressure, headache, and the healing of wounds (Tene *et al.*, 2007).

Gender and generational aspects

Medicinal care, as well as cooking, are tasks that in the Andean region are still primarily performed by women. In promoting the use of this tree, it is therefore important to be aware of this division of responsibilities within communities and families (de Haan *et al.*, 2021). It is also important to understand how traditional knowledge is passed on between different generations.

Markets and economical importance

In Áncash, there exists a market where the pajuro is sold for a price of 0.50 soles (PEN) per kilo (Cardenas, 2015). Since the exchange rate between soles and euro now is about 1 to 4, it would be possible to buy 8 kilos of pajuro with 1 euro. In the last decades, especially in urban areas, there has been a dietary change towards more processed and less nutritious food. As a response, there is also evidence of growth of markets selling native, local produce. Consumers of these products are mainly provincial migrants with an average age of 40. In Peru, some of these markets in bigger cities have been identified and these provide opportunities to include pajuro as well (Cardenas, 2015).

1.2 Problem statement

Only 30 of 100,00 species are widely planted and used commercially worldwide (Oh *et al.*, 2019). More than 50% of global consumption is dominated by maize, wheat, and rice. Rice is extremely sensitive to heat stress, rising sea levels and floods. This monoculture has led to an increase in productivity, but simultaneously led to aggravated food insecurity and a decrease in biodiversity. Increasing the use of the underused crops play a crucial role in food security, agricultural diversification, minimizing environmental impacts and mitigating climate variability (Suhairi *et al.*, 2018). Many underutilized crops can grow in less favourable conditions, which is needed to adapt to global warming and climate changes.

Unfortunately, there has not been much research done around the pajuro tree and it is not very famous outside of the Andes area. In the National Library of Agriculture, in the documents of the National Improvement Programmes by the National Institute for Agrarian Research and Development and La Molina National University, only one paper dealing with the pajuro tree was found (Pastor *et al.*, 2011). Among the little information available about the pajuro tree, most deal with the nutritional aspects of the crop.

When promoting the use of the pajuro tree to prevent it from becoming extinct, the main focus should be to aid farmers in producing a local crop with their knowledge about sustainability. It is important to keep this in mind while doing research, because sometimes popular crops have led to exacerbated pressure on community lands (De Haan *et al.*, 2021).

1.3 Objectives and research questions

The general objective of the thesis is to contribute to advance knowledge about the pajuro tree in the La Libertad (Peru) to inform future actions aiming to support its reintroduction.

To achieve the general objective, the following specific objectives have been identified:

- 1: To understand what requirements the pajuro tree needs to grow in specific areas.
- 2: To identify the level of knowledge about pajuro tree growing, management and use in Pataz and Sanchez Carrion.
- 3: To identify and analyse any divide in knowledge among different stakeholder groups (e.g. women and men, adults and young people) about pajuro tree in the area.
- 4: Learning what is needed for farmers to decide to grow the pajuro tree.

1.3.1. Research questions

This thesis aims to address the following main research question:

What is the current state of knowledge and level of conservation of the Pajuro tree in La Libertad region in Peru?

To address the main research questions, the following sub-questions will be taken into consideration:

1. What is the number of trees currently in and around the study area?

2. In which ecological zone is the tree currently present, and what zones fit the necessary requirements of the tree to grow?
3. What knowledge about pajuro tree growing, management and use is there currently among the farmers in the study area?
4. Does the level of knowledge vary according to age or gender?
5. What are the main drivers affecting farmers' decision to cultivate (or not) the pajuro tree?

1.4 Structure of the thesis

The rest of the thesis is divided into a theoretical background (chapter 2), research methodology (chapter 3), results (chapter 4), discussion (chapter 5) and conclusion (chapter 6), followed by the quoted literature and the annexes. In the theoretical background, theories from other authors and scientific papers that are relevant to test the research questions set by this paper are introduced. Specifically, underutilized crops and agroforestry are explained. A framework by Shisanya about the sustainable management of plant resources is introduced as well as a framework by Iiyama et al. to help understand why farmers make certain decisions. The research methodology consists of the research approach, an explanation of the study area, data collection method, sampling design and the approach to data analysis. In the study area different documents are used to provide information about socio-economic information about the different provinces and to compare their development. The data collection explains both the literature review and the fieldwork, and the sampling design talks about the districts and the households specifically. The analysis includes the tools that were used while carrying out this research i.e., GIS and KoboToolbox. Then the results are divided into the results from the surveys with the households, where information regarding the distribution of the HHs, management and ecology of the poroto and the current and past uses including food were outlined. The results continuous with the results of the focus groups (FGs) organized by the different groups that were interviewed, i.e., men, women, students, and professionals. Their knowledge is compared across provinces. The transects that were made in the data analysis using GIS, R and MaxEnt are then presented followed by the participatory observations made by the researcher. Lastly, the discussion is divided into the theoretical and managerial implications and ends with the limitations and suggestions for future research.

2. Theoretical background

The theoretical background builds upon concepts and theoretical frameworks used from the existing literature. First, some important definitions will be presented, after which underutilized crops and agroforestry will be explained.

2.1 Definitions

Traditional ecological knowledge (TEK): a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generation by cultural transmission, about relationships of living beings (including humans) with one another and with their environment (Shisanya., 2017 p.161).

Home gardens: complex agroforestry systems involving many plant species characterized by different morphology, stature, biological function, and utility, practiced mostly in the humid and subhumid tropics. Home gardens were considered solely to meet subsistence demands, but with urbanization and increasing opportunities in transport and market, the crops grown here can also function as cash value crops (Rao et al., 2004 p. 112).

Sustainable land management (SLM): requires '*sufficient collection, retention and transmission of knowledge gained through years of interacting with a landscape*' (Shisanya, 2017 p. 161).

Underutilized crops = those non-commercial species that form part of the country's agricultural biodiversity, which were very popular in the past, but which today are appreciated mainly by local producers and consumers only (National Research Council, 1989 p. v).

2.2 Theoretical approaches

In this session the main concepts and theoretical approaches adopted by the thesis are presented.

2.2.1 Underutilized crops

Nowadays, the pajuro is used mostly to produce animal fodder or for fencing agricultural fields, but as reported before, it has several advantages that make it qualified for a more diverse use and can therefore be considered as one of the underutilized crops in Peru (Cardenas, 2012) (Table 2). Synonyms for underutilized in the literature are 'forgotten' 'neglected' and 'lost' crop (de Haan *et al.*, 2021 p. 28). The reason for underutilization of certain crops can have several explanations, one of them being the recent focus on increasing the productivity of homogenous foods in agriculture, specifically potato, maize, and rice (Pastor *et al.*, 2011). Unfortunately, this has led to diets being of lesser nutritional value, consisting of more processed food in developed countries, and the decrease in biodiversity has proven to result in a lower productivity overall, leading to food shortages in less developed countries. Also, fruits are not consumed to an adequate degree in low-income countries (de Haan *et al.*, 2021). Research towards underutilized crops can thus aid nutritional value across the world. By researching the pajuro tree, this thesis will try to aid in filling that knowledge gap regarding underutilized crops in the Andes region in Peru.

Cereals	<i>Cañihua and kiwicha</i>
Fruit	<i>Aguagmanto, caimito, cocona, granadilla, guaba or pacaе, marañón, mamey, pajuro, highland papaya or chamburo, sweet cucumber, pijuayo, sauco, tree tomato, and timbo.</i>
Pulses	<i>Ñuña and tarwi or chocho</i>
Tuberose and root vegetables	<i>Achira, arracacha, dale dale, mashua or ñu, mauca or chago, ñame or sacha papa, oca, olluco, bitter potato and native papas.</i>
Others	<i>Chiclayo or lacayote pumpkin and sacha inchi.</i>

Table 2: Underutilized crops in Peru. Source: Pastor *et al.*, 2011

2.2.2 Conceptual framework for sustainable management of plant resources

Shisanya (2017) presented a conceptual framework for ethnobotanical studies, arguing that there are different determinants of the level of knowledge in the community, namely ecological, demographic, social, cultural, and economic factors, and the distinction of knowledge in terms of gender, i.e., between men and women. The extent of the knowledge then determines in what way indigenous plant resources are used. Utilization can be subdivided in medicine; construction; firewood; food or economic benefit (Shisanya, 2017). The level and extent of use of the species determine whether it is managed in a sustainable or unsustainable manner. SLM is also needed to feed the future generations, since population size is expected to grow in the future. The aim of this research is to determine the level of knowledge about the poroto tree and its uses to determine what role the poroto possibly has in the future and whether intervention is needed to promote its use.

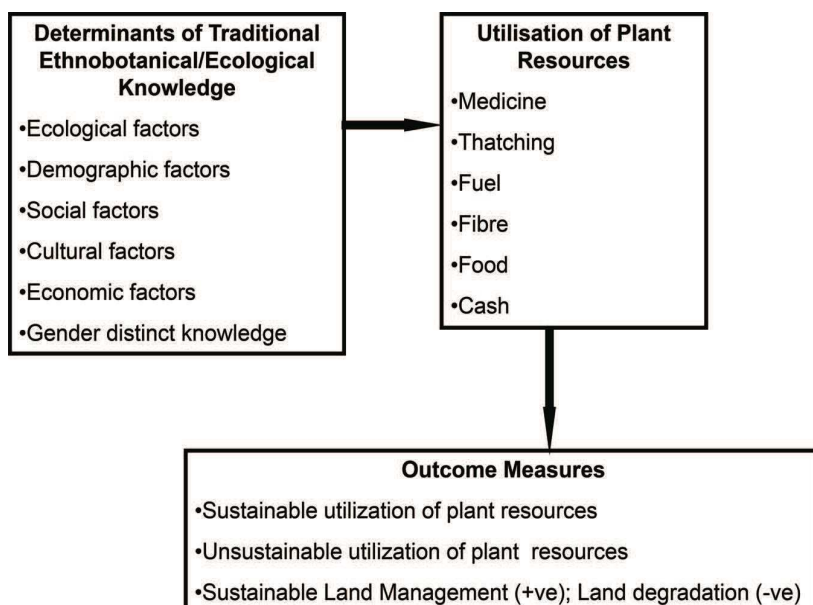


Figure 2: Conceptual model explaining the interrelationships between TEK and utilization for a sustainable management. Source: Shisanya (2017).

2.2.3 Agroforestry

Because of its main features, the pajuro tree is one of the Peruvian crop species with the highest potential in agroforestry (Aredo *et al.*, 2017) (Table 3). Aredo *et al.* (2017) performed an assessment which considered the 1403 species that are native to La Libertad: they found that the *Erythrina edulis* is one of the five species with the highest agro-industrial potential. The final score of the crop was determined by the addition of points that could be awarded according to a set of 6 criteria: Criterion 1 requires that the crop should be ready to be exploited, this means it should not be threatened with extinction; be cultivated by local communities and be accessible if it is found in the wild. Criterion 2 states that information must be available about the species and Criterion 3 that the cultivation of the species must not be harmful to the environment at any stage of the cultivation; Criterion 4 tells that it must also be economically sustainable, which means the investment must be minimal, have a short payback time and occupy a niche in the local, national, or international market. Criterion 5 requires the crop to be socially and culturally inclusive, meaning community participation is promoted and it requires no cultural change. Lastly, criterion 6 asks the crop to be of developmental importance. This could be indicated by governmental programs, or when it is known that the crop grows in poor regions (Aredo *et al.*, 2017).

Scientific name	Common name	Location	Use	Final score
<i>Smallanthus sonchifolius</i>	Yacón	Santiago de Chuco	Food	15
<i>Lupinus mutabilis</i>	Chocho	Otuzco	Food	15
<i>Chenopodium quinoa</i>	Quinoa	Santiago de Chuco	Food, Medicine	15
<i>Erythrina edulis Triana ex M Micheli</i>	Poroto	Otuzco	Food, Medicine	15
Sweet potato	Camote	Virú	Food	15

Table 3: Peruvian crop species with the highest potential in agroforestry. Source: Aredo *et al.*, 2017. Spanish words from this table are translated to English.

TEK entails a lot of knowledge of agroforestry. De Brito Quadros Gonçalves *et al.*, 2021 did research into what agroforestry activities were performed by communities and why. Their findings taught that three aspects of agroforestry are especially important for indigenous communities.

The first is food security. Reducing food waste and diversifying the sources of nutrition would lead to an increase of nutritional value and dietary diversity when agroforestry practices are employed. Productivity in agricultural lands is also improved using agroforestry systems. Next to subsistence, additional produce can be sold which can improve economic conditions of marginalized people as well.

Secondly, indigenous communities deal with a higher risk of living in negative socio-economic conditions and are more prone to diseases. Knowledge regarding food preparation, as well as medicine and management falls under the responsibility of women in most communities. This also is more focused on subsistence crops, instead of agricultural practices. However, understanding and valuing the role of women in these communities and allowing women to make decisions regarding agroforestry systems can aid to a better nutrition for both men and women.

Lastly, agroforestry can also function as a spiritual value, besides providing food, medicine, or income generation. Plant resources are seen as a wholistic contribution

to human beings, providing shade and firewood in addition to food. Caring for the lands is also important, as degradation has consequences for human beings as well.

The reasons why people cultivate the pajuro tree might be dependent on several factors. Iiyama *et al.* argue that there are four criteria that determine whether a farmer chooses to cultivate or not (Iiyama *et al.*, 2015). For this thesis, the framework is altered in such a way to include all factors that are tested for being included in a farmer's decision to cultivate or not.

- (i) The composition of species
- (ii) Utilities derived from the tree, which are subdivided in the following:
 - a. Commercial value (timber, fruit, fodder, and medicine)
 - b. Subsistence (construction and tools)
 - c. Fuel (firewood and charcoal)
 - d. Environmental services (shade, windbreak, soil fertility and erosion control)
 - e. Fencing (fences or poles)
 - f. Cultural values (traditions)
- (iii) Intensity of management needed
- (iv) Biophysical and socio-economic characteristics which are subdivided in
 - a. Biophysical factors
 - b. Preferences (personal preferences, and preferences regarding availability of knowledge)
 - c. Risk and uncertainty which is be important given the long timespans on return from investments in forestry.
 - d. Resource endowments, which include income available for innovation
 - e. Market incentives

Given the endemic nature of the tree, it is to be expected that the tree requires little to no maintenance but still provides several benefits, including ecosystem services (Iiyama *et al.*, 2015).

3. Research methodology

In the research methodology, the research approach, the study area, and the methods used in data collection are presented. The questionnaire that was used during the fieldwork is included as well as the sampling design and the data analysis.

The research was conducted in three phases:

- Desk study and methodology development
- Fieldwork
- Analysis and reporting

3.1 Research approach

To answer the research question and sub-questions, an ethnobotanical study has been performed, which focuses on the relation between the pajuro tree and the traditional values of the communities in Pataz and Sanchez Carrion. A mixed research method approach was employed, combining quantitative and qualitative methods with the use of desk-based research (literature review and use of secondary data) and the execution of fieldwork to collect primary data. Surveys were performed using both open-ended and closed questions and combined with FGs to understand the (potential) use of the pajuro thoroughly. Additionally, GPS locations were recorded of all the households (HHs) that were interviewed and the trees belonging to them. In La Libertad, two provinces - i.e., Pataz and Sanchez Carrion - were chosen with the help of Asociación Pataz to compare the results of the surveys and FGs and understand if any differences exist in available knowledge or in the use of the pajuro.

3.2 Study area

Peru can be broadly divided into three major regions due to geographical, topographic, and climatic differences: the Pacific coastal desert (La Costa), the Andean region (La Sierra), and the tropical rainforest in the Amazonian lowland (La Selva). The mountain chain of the Andes runs through Peru and rises to an altitude of over 6,700 m asl, being characterized by a large variety of vegetation. It is documented that farmers in Huanuco, Ancash, La Libertad, Cajamarca, and Amazonas - all located in the in the North-West part of Peru - regularly consume pajuro (Cardenas, 2012). La Libertad region is known for its well-developed agro-industrial sector (Aredo *et al.*, 2017). It is an area that has a great climate and thus a large biodiversity of flora can be found there. Hundreds of these flora species are not yet studied, whether they are used for medicinal, aesthetic, or aromatic purposes.

La Libertad is one of the twenty-five departments in Peru. It is made up of twelve provinces and 83 districts and covers 25,495 km². The capital city is Trujillo. In 2017, 1,779,080 people were registered inhabitants of La Libertad (CERPLAN, 2021).

Asociación Pataz, a local non-governmental organization (NGO) committed to the promotion of sustainable development in rural areas, is active in three provinces in La Libertad: Bolivar, Sanchez Carrion and Pataz. Each of these provinces consists of different districts. Since the area covered by the Asociación Pataz is quite large and research time was limited, it has been decided to focus on three districts within this area. One of the research centres managed by Asociación Pataz is in Chagual, adjacent to the river Marañon. Field trips were made departing from this point. The

river divides Pataz and Sanchez Carrion, two out of the twelve provinces of La Libertad. Pias and Pataz districts were targeted within Pataz province, while Cochorco was targeted within Sanchez Carrion province. A map of the studied area is depicted in Figure 3.

In the Andes region, communities are part of a *municipalidad and Comunidad campesina*. Within the *comunidad campesina*, there is a *presidente de la comunidad*, i.e., a head of the community. There is also a *padron*, who keeps registrations of the inhabitants of the community and most likely an overview of crops cultivated by each of the farmers, including those who cultivate the pajuro tree.

The next section will elaborate on basic socioeconomic and geographical features of the areas studied. It is important to highlight that there is limited data available about these areas, and moreover even the data that is provided is not consistently provided from all different areas. A selection of information is given however to make sure some background understanding is reached when reading this study. The section will begin by describing some information about the department La Libertad, followed by information about the two different provinces Pataz and Sanchez Carrion, followed by data on the districts Cochorco in Sanchez Carrion and Pataz and Pias, both located in Pataz.

La Libertad: Socio-economic characteristics

After Trujillo, the capital city, Sanchez Carrion is the province with the highest number of inhabitants in La Libertad. It has more than 136,000 inhabitants. Pataz has a population of 76,103 people (2017), decreasing with a rate of -0,29% per year (Llompén et al., 2021). The population distribution is visible in Figure 4.

The gross domestic product (GDP) of La Libertad was more than 21 billion soles in 2020 and accounts for 4.4% of the total GDP of Peru (CERPLAN, 2022). In La Libertad, poverty has been declining in recent years. A sharp setback has been noticed in 2019, due to COVID. This has also impacted agricultural investments. The average monthly income registered in La Libertad is 1,500 soles (CERPLAN, 2022). Compared to this the average income in Pataz and Sanchez Carrion is lower, namely 553 soles and 305 soles respectively (CERPLAN, 2021). The low income of Pataz is exacerbated due to the lack of access to national and international markets. The level of inequality is still prominent, especially for women and older people. More women have been reported to earn their own income nowadays, namely 70%, and the wage gap between men and women has been reduced to 303 soles per month in La Libertad (Figure 5).

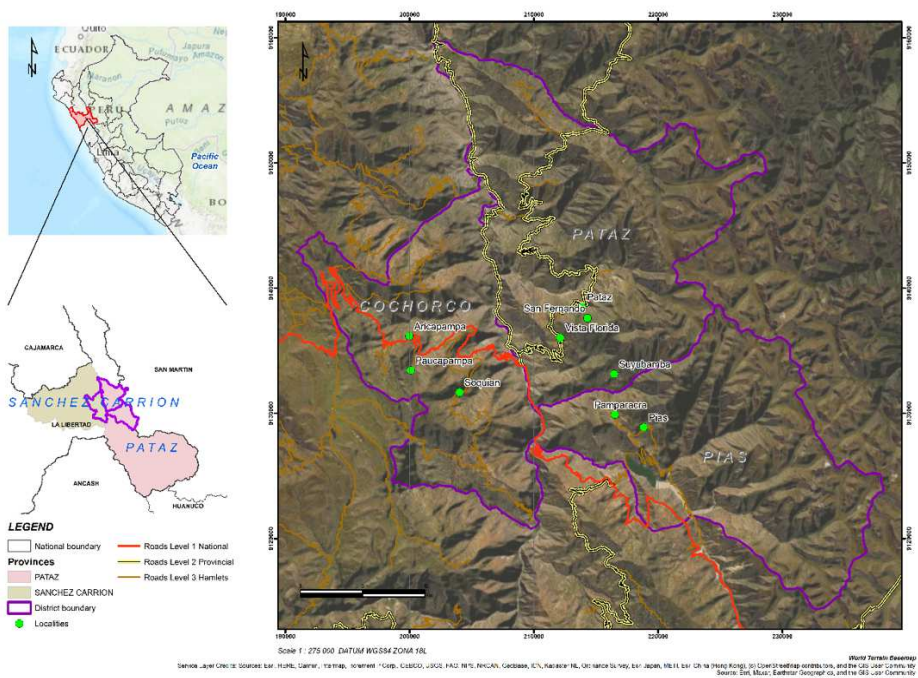


Figure 3: Overview of the study area

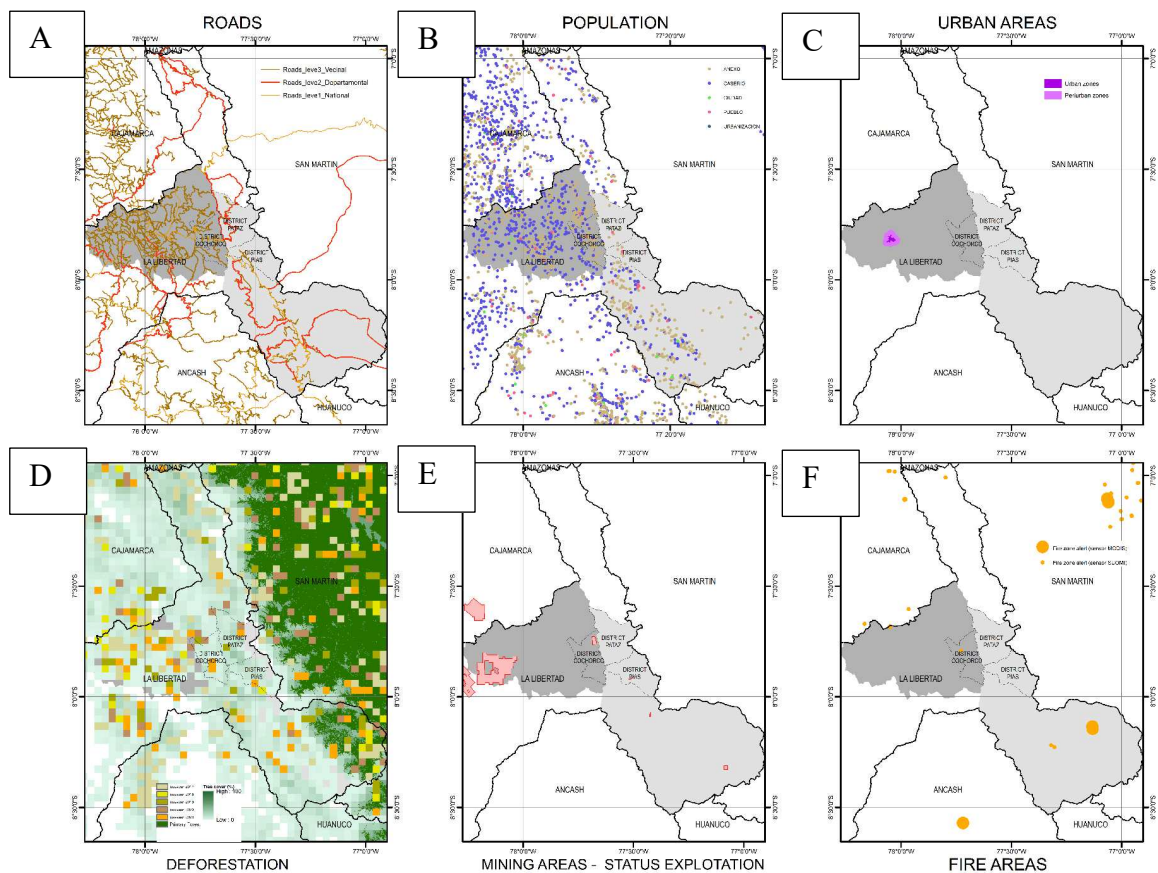


Figure 4. Key territorial and land use features for the study area: A. Road network, B. Population distribution in Pataz, Pias and Cochocho, C. Urban areas and conglomeration of people, D. Deforestation, E. Mining areas, F. Fire-prone areas.

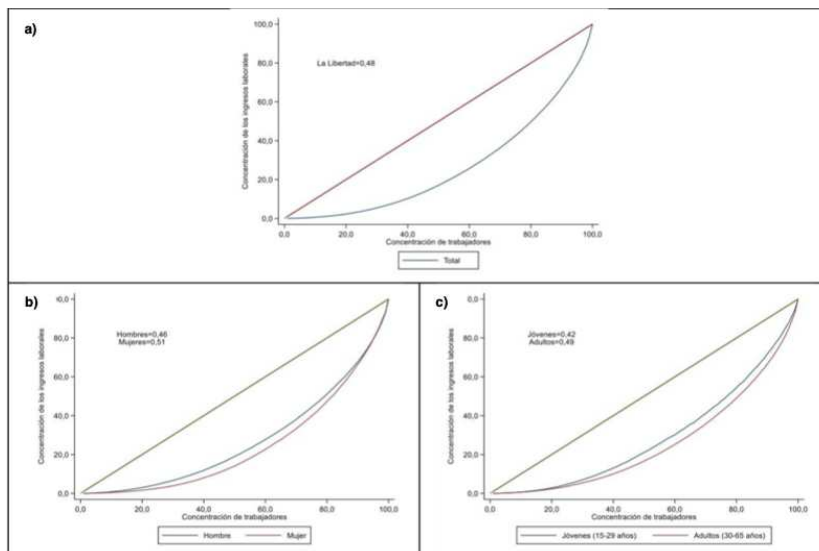


Figure 5: Lorenz curve of La Libertad region (CERPLAN, 2021).

The Territorial Prioritization Index (TPI) is based on different indicators (Figure 6). These indicators are related to social, economic, and environmental factors. Furthermore, institutional indicators and the level of infrastructure also play a role. Social indicators include anaemia, chronic malnutrition, and illiteracy. It is also based on educational levels, and the number of people that do not obtain their diploma. Related to the infrastructure, access to internet and water, drainage and electricity from homes and public places is also considered. Economic indicators relate to average family income, access to financial institutions and the budgets available for scientific research in an area. Environmental factors considered are green area per capita and the number of mining liabilities. Lastly, tax, management institutions and reported crimes are considered. The priority is assigned using quartiles, indicating gradually increasing severity. Whereas the Pataz and Pias districts have a TPI that falls within the second quartile, the district Cochorco has a TPI falling within the fourth quartile. This indicated that the general development conditions in Cochorco are worse compared to Pataz and Pias and this district is likely to deserve a higher priority when allocating time and resources into development. Although development and economic status of La Libertad shows room for improvement, this potential is hopefully realized by the number of investments in Sanchez Carrion and Pataz. The investments are mentioned in (Figure 7) (CERPLAN, 2021).

Huamachuco is the most developed part of Sanchez Carrion. This is also apparent in the amount of tax that is collected by the province. This money can be used for investments or activities. Part of the money must go towards actions to promote adequate nutrition, and the prevention and reduction of anaemia and towards assurance of the quality and sustainability of the provision of the water service for human consumption. Cochorco has the least amount of money to invest of the whole province. It is however the only district without food vulnerability in the whole province (CERPLAN, 2021). Both in Pataz and Sanchez Carrion, limited budget is available for scientific research, which is not uncommon for La Libertad. Both Pataz and Sanchez Carrion are the provinces with the most available recourses for management, aside

from Trujillo. Unfortunately, strong institutions are very scarce in this area (CERPLAN, 2022)

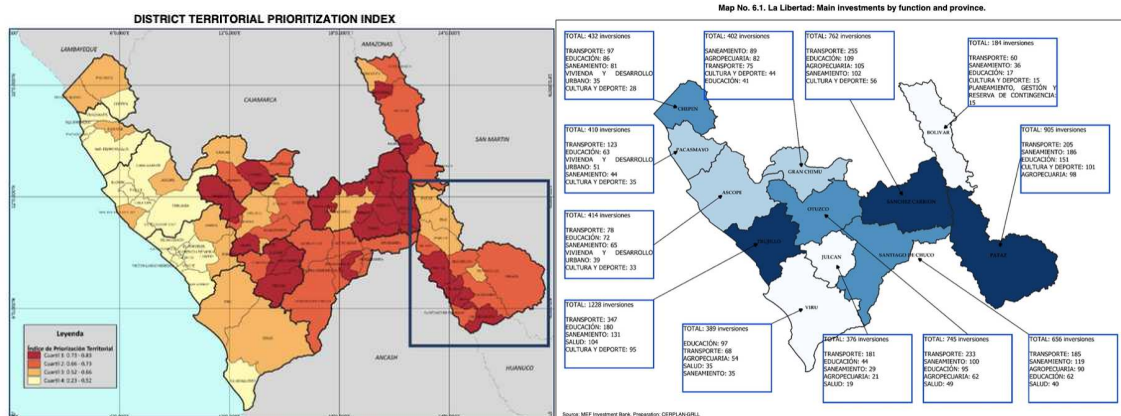


Figure 6. Territorial Prioritization Index of Pataz and Sanchez Carrion (left) and number and type of investment specified in La Libertad (right) (CERPLAN, 2022)

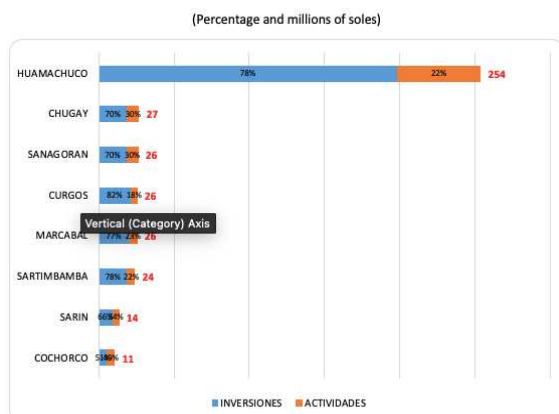


Figure 7: The allocation of money to investments and activities within Sanchez Carrion (CERPLAN, 2021).

In La Libertad, Pataz is the province with the highest occurrence of anaemia, with a recorded prevalence of 71% (Llémpen *et al.*, 2021). The low levels of iron, and the lack of awareness raising about nutritional value are both points that this paper helps addressing. Although the occurrence of anaemia is lower in Sanchez Carrion than in Pataz, the level of chronic malnutrition documented is the highest in all La Libertad, namely 35.6% (CERPLAN, 2021)

In both provinces the levels of education are poor. In Pataz, only 49.8% (2017) of the population has obtained a high school diploma, compared to 36.6% in Sanchez Carrion (CERPLAN, 2021). However, almost all students that completed high school still do not have sufficient skills in subjects such as mathematics and reading. This is also reflected in the illiteracy levels in both provinces. In Sanchez Carrion, this is 22%, and in Pataz 16% (Figure 8). More than half of the workforce did not complete any higher education, with numbers as high as 83.1% in Sanchez Carrion (CERPLAN, 2021). The unemployment rate of La Libertad is almost 9%, which is the highest in the country except for Lima (CERPLAN, 2022).

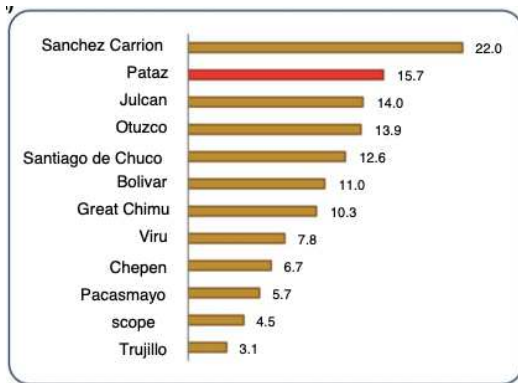


Figure 8. The levels of illiteracy of the provinces Sanchez Carrion and Pataz are the highest in La Libertad (CERPLAN, 2022).

A comparatively large part of the population in Cochorco lives without access to the basic needs of water, drainage, and electricity (CERPLAN, 2021). Compared to Pataz, the share of population that lives without access to basic needs is more limited but still significant with almost 50% (Llémpen *et al.*, 2021) (Table 4). The number of homes with internet access is also high in both Sanchez Carrion and Pataz, being 97% in both districts. 50% of the schools generally have internet access, however in Cochorco specifically, this number is only 3% and 11% in Pias. From Table 5 below, it becomes apparent that from La Libertad, the populations from Sanchez Carrion and Pataz live with the least number of basic needs met (CERPLAN, 2022).

Location:	Percentage of the population
Sanchez Carrion	70%
Cochorco	80%
Pataz	66%
Pataz	49%
Pias	46%

Table 4: Homes without access to the three basic needs: water, drainage, and electricity (CERPLAN, 2022).

Location:	% population with unsatisfied basic needs (2017)
La Libertad	19.1
Sanchez Carrion	40.7
Pataz	38.0

Table 5: percentage of population with unsatisfied basic needs within La Libertad region, per district (CERPLAN, 2022).

The most important economic sectors for the GDP in La Libertad are agriculture, livestock, hunting & forestry, manufacture & commerce. Employment rates in scientific and intellectual professions and in the information technology (IT) sector are very low. According to the employment report from CERPLAN, over 2021, the sectors expanding in La Libertad were exploitation of mines and quarries (15%) and construction (33%), whereas agriculture and the service sector are slowly declining, with 2% and 7% respectively (Fansanado, 2021). La Libertad is also the department with one of the highest contributions to gold throughout Peru. Within La Libertad, Sanchez Carrion and Pataz are the two provinces that contribute to the mining the most. In Peru, there exist three kinds of mining; *Ilegales* (no documentation), *Informales* (50-80% of the documents are in order) & *Formales* (100% of documents

are approved). Furthermore, there is a distinction between licenses that have been approved, and mining that is currently happening. This is the difference between exploration and exploitation (Figure 4). In Sanchez Carrion agriculture and services are still the most important sectors. The sector of services is relevant mainly because of Huamachuco, since in all other districts agriculture is the most important contributor to the economy (Figure 9 and 10). The main sources of income in the province of Pataz are agriculture and mining. In the Pataz district mining is a bigger income source than agriculture. Economic activities are very diverse but mostly focused on agriculture, ranching, and raising domestic animals. The list of important crops in Sanchez Carrion is more extended than in Pataz. The most important crops are hot pepper and *kiwichi* (amarant) since they are exclusive to this area. Pataz is famous for its exclusive contribution of annatto (a condiment and food colouring derived from the seeds of the achiote tree, *Bixa orellana*), and cultivates large amounts of grain pea, olluco and clover (Table 7).

The value of non-traditional product exports from La Libertad has increased over recent years. More avocados, blueberries, and processed fish products are being exported (Figure 12). In the context of this research, this is a positive trend. It means that the market is open to export of a more diverse array of products and foods (CERPLAN, 2022).

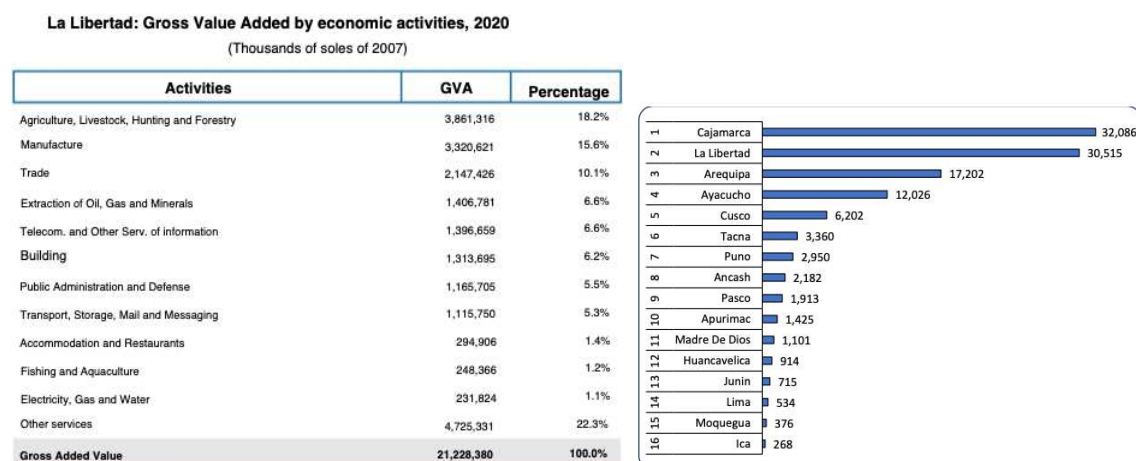


Figure 9: Economic activities in La Libertad expressed in GDP (left) and contribution of departments to gold mining (right) (CERPLAN, 2022).

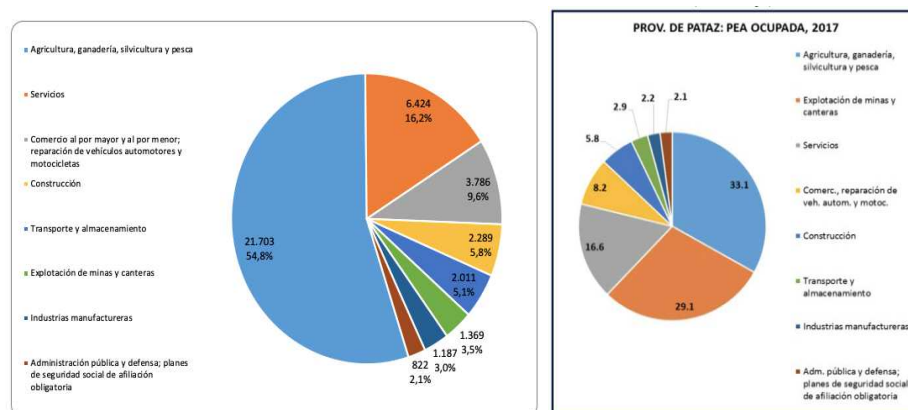


Figure 10: Distribution of different economic activities in Sanchez Carrion (CERPLAN, 2021) (left) and Pataz (Llémpen *et al.*, 2021) (right).

The agricultural, pasture and forest area for La Libertad region is reported in Table 6. Only 22% of farmers have access to a technical irrigation system and 25% has access to storage infrastructure and equipment for marketing.

More and more farms are organized and managed by business through organizations, with currently a share of 63%. Only 21.3% of the farmers apply safety practices, and only 14.2% of the agricultural producers use high quality seeds: these relative figures are both decreasing. Around 65% of the people in La Libertad contain property rights over their own land (CERPLAN, 2022).

The land in Pias and Pataz is suitable for forest production, whereas protected pasture lands are found in Sanchez Carrion (CERPLAN, 2022). Pataz is the largest province of La Libertad. It is located at an altitude of 3290 meters asl and covers an area of 4,226 km². Pataz and Pias are both located in the buffer zone of a protected area, more information about deforestation is published for Pataz. Annual deforestation has been decreasing over the last couple of years and reforestation rates have been increasing, except for 2019 () (Llémpen *et al.*, 2021).

In Cochorco agricultural land covers around 6,000 ha, while natural pastures cover around 1,100 ha and mountains and forests approximately 760 ha. Dry beans and sweet lemon are crops Cochorco is well known for (Table 7) (CERPLAN, 2021).

	Agricultural land	Natural pasture	Mountain and forest area
Pataz	63,891	203,851	5,555
Sanchez Carrion	53,485	31,838	8,270

Table 6: Agriculture, pasture, and forest land in La Libertad region (CERPLAN, 2022).

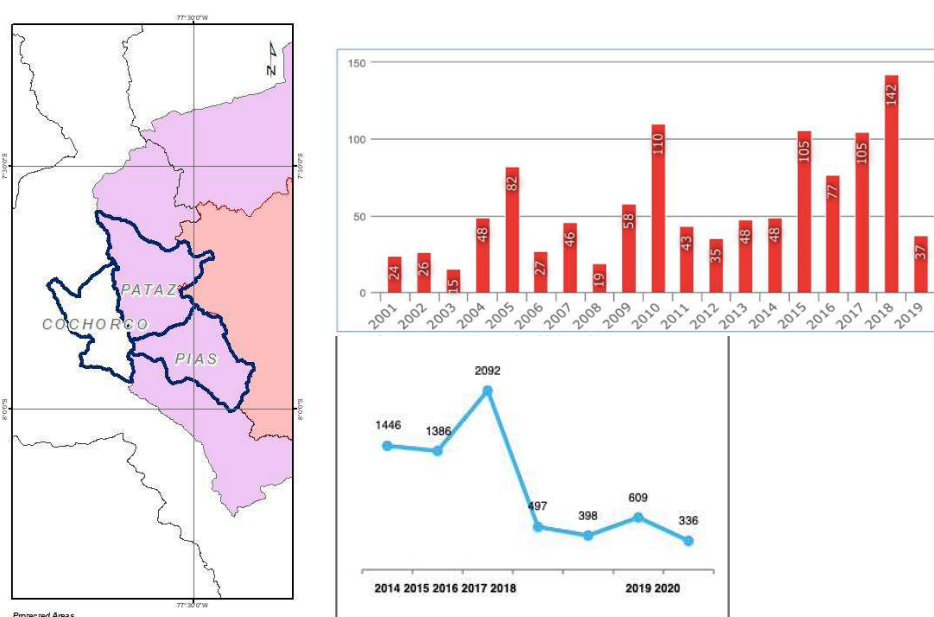


Figure 11: Protected areas (orange) and buffer zones (pink) depicted in the study region (left). The amount of deforestation of the Amazonian humid forest in the province Pataz (ha) (up). The level of reforestation in the Amazonian Forest in Pataz (ha) (down) (Llémpen *et al.*, 2021).

No.	CROPS	Campaign	
		2019-2020	
1	Exclusive	hot pepper	
two		Achita, Kiwicha, OR Amaranth	
3	Leader	Garlic	
4		Dry Grain Peas	
5		Bean Dry Grain	
6		Bean Dry Grain	
7		Green Grain Bean	
8		Corn Starchy	
9		Medlar	
10		Nuna Dry Grain	
eleven		Goose	
12		Improved Potato (Groups Improved Potatoes)	
13		quinoa	
14		Common Wheat	
fifteen		Carrot	
16		high turnout	Aji Limo (<i>Capsicum Chinese</i>)
17			Fodder Oats
18	Capuli (<i>Prunus serotonin ssp. Capuli</i>)		
19	Chinese onion		
twenty	Chinese cabbage		
twenty-one	Lettuce		
22	Dry Grain Lentil		
	Lime		
24	corn corn		
25	Olluco		
26	Radish		
27	Pea Green Bean		
28	Chocho O Tarhui GS		
29	Cabbage OR Cabbage		
30	Orange tree		
31	Papaya		
32	Tomatoes		

No.	CROPS	2018-2019
1	Exclusive	Annatto
...	Leader	grain pea dry
3		Olluco
4		Clover

Table 7: Native products originating from Sanchez Carrion (left) and Pataz (right).

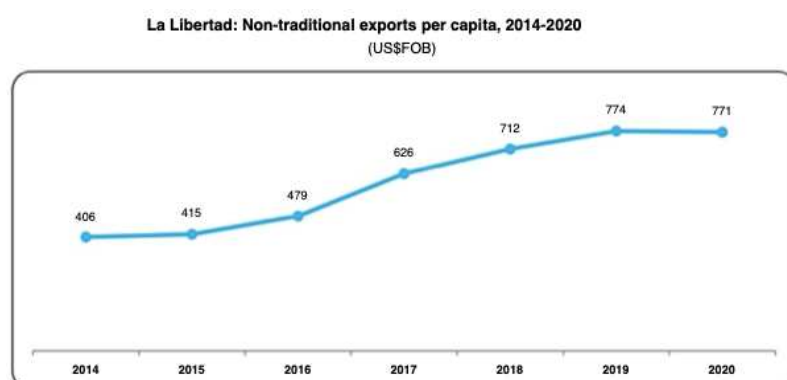


Figure 12: Total value of non-traditional product exports from La Libertad between 2014 and 2020 (US\$ per capita) (CERPLAN, 2022).

Pias covers an area of 372 km². The number of inhabitants is 1,656. Pias is known for growing papaya. The number of green areas (m²/person) is also notably high for Pias (Figure 13) It ranks the highest with 1.88 within the province of Pataz. The recommended level of this indicator by the World Health Organization is 9. The number of green areas is also an indicator for the TPI (Liémpen *et al.*, 2021).

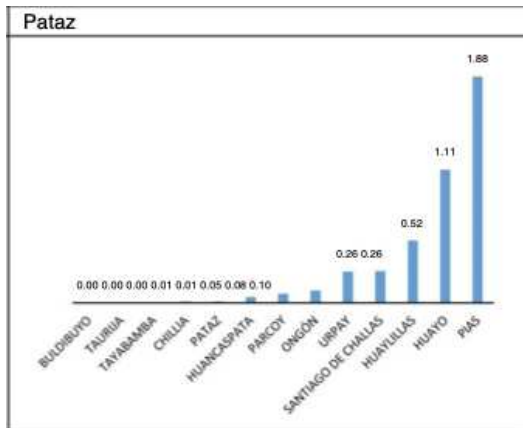


Figure 13: Amount of green area (m²/person) (Llémpen *et al.*, 2021).

Pataz covers an area of 468 km², equivalent to 11% of the total area of the province of Pataz. As for the latter, Pataz is known for growing *Nispero* and *Chirimoya*. Pataz has 8,937 inhabitants, and its population is growing fast with a rate of 1.89% (Llémpen *et al.*, 2021). Pataz, Pias & Cochorco are not densely populated, which is visible in Figure 4.

3.3 Data collection

Data collection consisted of two main groups of activities and phases: a literature review, carried out from March to May 2022, and fieldwork activity consisting of direct observations in the field as well as data collection through surveys (between June and September 2022) and FGs (October 2022).

For each of the two phases more information is reported below.

3.3.1 Literature review

The research was subdivided in several phases. First, only papers about pajuro were searched, both in English and Spanish. Research was also done into studies with similar methodological design and using synonyms for the pajuro in the Spanish language. Google scholar, the library of the University of Padua and resources provided by the International Potato Centre (Centro Internacional de la Papa (CIP)) were used.

3.3.2 Fieldwork

The fieldwork in Chagual lasted 2.5 months and consisted of different activities organised in various phases. In the earlier phases a plan was coordinated with Ronal Ontario, the chief of Asociacion Pataz, and information about the targeted districts was collected. Face-to-face interviews via *ad hoc* questionnaires were conducted to this aim and complemented by other approaches. It was possible to carry out between 8-10 interviews per day.

Overall, the fieldwork consisted of four main different parts:

- (i) Conducting interviews with HH
- (ii) Transects
- (iii) FGs
- (iv) Participatory observation.

Interviews - Upon arrival at the HH's house, HH were asked if they cultivate poroto. If yes, a small explanation was provided about the objectives of the research and the contents of the questionnaire. The questionnaire consists of different topics and starts with a form of consent. It is organized in eight sections: Basic information of the HH; knowledge about the pajuro tree and questions about the level of management; current and past general uses of the tree; nutritional value; and future opportunities for the poroto tree. A full version of the questionnaire is available in Annex 1. In total 101 interviews have been conducted with 50 participants in Pataz and 51 participants in Sanchez Carrion. Within Pataz, the division between the districts Pataz and Pias was 25 questionnaires in each district. The interviews were aimed to help forming a baseline to understand the current situation, such as the level of knowledge about the pajuro tree and how widespread is its cultivation. Furthermore, it was also aimed to identify the needs from the local communities and prepare the questions and discussion topics for the FGs to be performed later in the research. The questionnaire was held with the head of the household, present during the interview, male, female, or both. The questionnaire was in Spanish and beforehand staff from Asociación Pataz were informed about the purpose of the study and the questions, to enable them to support in the field with language barriers.

Transects - Transects were made during the interviews because acquiring knowledge regarding the number of trees cultivated by each farmer was one of the aims of the interviews. The tool used to make the transects is Kobo Toolbox, that allows creating surveys and managing GPS points. The survey can easily be transferred to android phones and be used offline during fieldwork. Kobo Toolbox also allows photos to be uploaded as additional information. During the interview, interviewees were also asked to walk to the place where the trees are growing, as to mark the exact location.

Focus Groups – Eight FGs have been organized, four in Pataz and four in Sanchez Carrion. Participants to the FGs were selected among people interviewed during surveys. Given the strong role-divide between women and men in the study areas, different FGs were organized for men and women to make sure everyone feels comfortable sharing. Women can possess a lot of knowledge regarding cultivation of the pajuro and its uses in the cuisine and thus it is relevant to also understand their specific point of view. Additionally, FGs were organised with students, in order to get the point of view of young generations, and experts, such as local agronomists, local decision makers about the agricultural sector and employees of the AP. The experts were identified and approached with help of the Asociación Pataz. The FGs were mainly aimed to formulate an outlook study of the use of pajuro tree and to identify people’s expectations as well as possible solutions or actions to address them.

In total, eight FGs were organized in various locations (Table 8).

Pataz:

Participants	Location	Date	Done by
1. Women	Pamparacra, Pias	October 9 th	Ankie, Alex, Willian
2. Men	Pamparacra, Pias	October 9 th	Ankie, Alex, Willian
3. Students	Vista Florida, Pataz	September 29 th	Ankie, Demetrio
4. Professionals	Pataz, Pataz	October 10 th	Ankie, Alex, Willian

Sanchez Carrion:

Participants	Location	Date	Done by
1. Women	Cochorco, Cochorco	October 6 th	Alex
2. Men	Cochorco, Cochorco	October 6 th	Alex
3. Students	Cochorco, Cochorco	October 11 th	Ankie, Alex
4. Professionals	Aricapampa, Cochorco	October 13 th	Ankie, Alex

Table 8: Overview of the eight FGs performed

Participatory observation – Also known as informal information is information that is collected not by means of interviewing or FGs, rather by being observant at the different locations.

3.4 Sampling Design

3.4.1 Districts

The research questions have been addressed by collecting primary data during fieldwork activities. Since the area in which Asociación Pataz is present is quite large, together with Asociación Pataz itself it was decided to focus the research on a selection of the districts they are working in, i.e., Pataz and Pias, in the province of Pataz, and Cochorco, in the province of Sanchez Carrion. This allows to compare two provinces with geographical and socio-economic differences. Moreover, these two areas are located conveniently from the research centre in Chagual. From there, Pataz is located East and Cochorco West and both can be reached within 1-2 hours by motor.

3.4.2 Households

To maximize the amount of information gathered through the survey, all HH that were interviewed cultivate pajuro. To identify them, first the *presidente de la comunidad campesina* was informed about the research and asked to provide a list of farmers cultivating pajuro. Unfortunately, since waiting for this list, after multiple reminders, took too long, it was decided to use snowball sampling instead. In the rural areas where the research was conducted the feeling of community is strong and many people in the community were able to direct interviewers to the HH growing pajuro. Since the sampling size was quite big considering the scarcity of the trees, this method enabled us to interview most of the HH with pajuro in the areas of interest.

3.5 Data analysis

Data analysis was analysed by means of both statistical analysis and spatially defined analysis according to what is reported below.

3.5.1 Surveys

The information gathered via closed questions from the survey was organized and analysed through descriptive statistics. The answers to the open-ended questions were analysed individually, taking into consideration different categories of respondents/participants to FGs as well as their location, to perform comparative analysis. Thus, for example, the answers of the women attending the FG in Pataz were compared to those by the women attending the FG in Sanchez Carrion.

3.5.2 Collection of GPS points

During the surveys, GIS coordinates were collected of both the HHs and the locations of all their planted trees. This was chosen because HH locations are handy to use with maps of different socio-economical characteristics to get a better understanding of the interviewed HHs, while the locations of the trees can provide information about the distribution of resources as well as about geographical characteristics of suitable areas for cultivating the pajuro.

After the fieldwork, several days were spent in the office of CIP working together with the GIS specialist Javier Ochoa, to organize and analyse data collected. The names of the layers used for this aim are presented in Table 9.

Layers/features	Source
-----------------	--------

Roads:	Red Nacional de Carreteras (2019)
Population:	Centros Poblados a Nivel nacional (2020)
Urban zones:	Manzanas Urbanas - Nacional (2020)
Deforestation:	Hansen Global Forest Change v1.9 (2000-2021) ³
Mining:	CASTASTRO MINERO Zona 17s by MINEM- GEOCATMIN (2022)
Fire zones:	FIRMS: Fire Information for Resource Management System ⁵ (2021)
Geographical layers	
Protected areas:	Mapa de Áreas Nacionales Protegidas (2015)
Ecosystems:	Mapa Nacional de Ecosistemas del Perú (2018)
Climatic zones:	Mapa de Clasificación Climática del Perú (2020)
Elevation	
Elevation:	CGIAR: DIGITAL MODEL ELEVATION -> SRTM Digital Elevation Data Version 4 (Jarvis <i>et al.</i> , 2008).

Table 9: Overview of layers that were used in GIS during the data analysis

Maximum Entropy Algorithm (MaxEnt) was used afterwards to predict what areas would be suitable for growing pajuro in the future. MaxEnt is a tool widely used for species distribution/environmental niche modelling. This is because the software performs better than other platforms and because it is rather straightforward in its use (Merow *et al.*, 2013). It is important to consider the biological settings of the program before plotting results. MaxEnt takes the known data, also called presence-only (PO) together with environmental predictors and does two things. First, using this data it can calculate the species density. Secondly, it can act as a predictor of where the studied species will occur. To show this, the program uses a gain function, which is a maximum likelihood function. This function explains the likelihood ratio of the average presence compared to the average background.

In working with MaxEnt, several steps come into play. First, it is important to choose the right background data and features. For selection of the features used in MaxEnt, it is important not to use layers that contain the same information to keep correlation of the different predictors to a minimum. After running the model, MaxEnt determines which factors specifically contribute the most to the model, which is called regularization (Merow *et al.*, 2013).

Although MaxEnt proves to be a useful tool, Merow *et al.* (2013) warn about using it for future predictions regarding climate change. Since these predictions include a variety of different climatic variations combined, it can be difficult to correctly estimate the associated importance of each factor individually.

The PO data is prone to the sample selection bias, as some areas were chosen to be more heavily sampled than others.

4. Results

In this chapter, the results of the data analysis are presented. Since all HH that were interviewed, knew the pajuro by the name of poroto, this name is used to describe the results. Afterwards, in the conclusion, the name pajuro is used again, since this is the name commonly used in literature and by using this name, the results of this research will be more widely understood. Section 4.1 includes the descriptive analysis of data collected via the survey. Furthermore, the results of the FGs are transcribed and reported (4.2). The results from GIS and MaxEnt are included (4.3) and at the end the participatory observations are presented (4.4).

4.1 Survey with households

Within this section the main results of data analysis from the survey with HH are reported.

Basic information of the households

In Cochorco, the surveys were conducted in the sectors of Cochorco, Aricapampa, Soquian, Paucapampa and Trapiche. In Pataz 49% of the surveys were conducted in Pias (Pamparacra and Pias) and 51% in Pataz (San Fernando, Vista Florida, Suyubamba) (Figure 14).

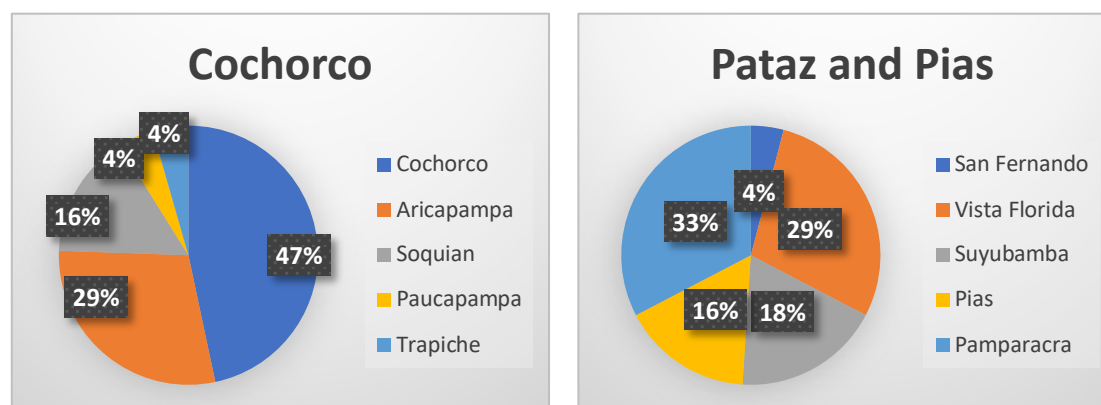


Figure 14: Distribution of interviewed HH among the districts Pataz and Pias (right) and Cochorco (left).

In both districts, there were more women than men interviewed. The prevalence of women among interviewees was mostly because during the weekdays men are away for work. Despite of this and considering the role of women the whole sample is appropriate. In some HH in Cochorco both the male and female HH head was present (**Error! Reference source not found.**).

District	Women	Men	Both
Cochorco	30 (59%)	17 (33%)	4 (8%)
Pataz	27 (53%)	23 (47%)	0 (0%)

Table 10: Distribution of surveys conducted with either female or male heads of HH.

In Cochorco all 51 people interviewed only knew the tree by the name poroto. On average people had two trees per household, with an average age of 18 years. In Pataz, we found one respondent who was familiar with the name pajuro, but overall, the tree was only known under the name poroto. On average, each HH had 6 trees, with an average age of 19 years old.

Management and ecology of the poroto

In Pataz most people had their trees planted in their home garden, while in Cochorco trees are normally planted far away – mainly in a forested area uphill of the main part of the village - and we had to walk significantly further to pinpoint the GPS of the trees. In five cases (about 10% of the total) this walk was more than 10 minutes away from the house. This is reflected in the answers to the survey where in Cochorco 22 HH (43%) had their trees in their home garden, while 18 (35%) had their trees scattered close to the home. In Pataz 26 HH (52%) had their trees in their home garden, and 16 HH (32%) had trees scattered farther from the house. Of these people only one walk was farther than ten minutes.

In Cochorco only 3 HH used seed as means of propagation, against 50 that used cuttings. Similar figures were found in Pataz, where only 4 HH used seeds for propagation. As regards the origins of propagation materials, in Cochorco 35 HH (69%) used mother plants of other farmers in the community, and 13 (25%) only their own propagation material. There was one case where mother plants from farmers outside the community was used. The other two cases do not plan on planting new trees. This is also very similar to what has been reported for Pataz, where 27 HH (54%) used propagation materials originating from other HH and 22 (44%) from their own material. 1 HH got its material outside the community, together with 1 HH that got its material outside the community and from its own material.

34 of the HH in Cochorco (67%) indicated that they never plant new trees, while 17 (33%) indicated that they do. As for those that do plant trees, the source of the location was the main aspect considered when choosing cuttings (11, 22%). In Pataz, HH are more likely to plant new trees, however still not very often. 13 HH (26%) indicated to plant new trees every 10 years or less, and 22 (44%) indicated to never plant new trees. The criteria that were considered when planting new trees were a bit more diverse from those reported in Cochorco, namely productivity, health status, and the source of the location.

Figure 15 shows the distribution of the two main poroto varieties (i.e., with red and brown fruits, respectively) among targeted HH. Most of the HH (73% in total) report to possess the variety with the brown fruits rather than the one with red fruits. There was no difference in occurrence based on the location of the different trees. All the red fruits are found in Cochorco and Pias.

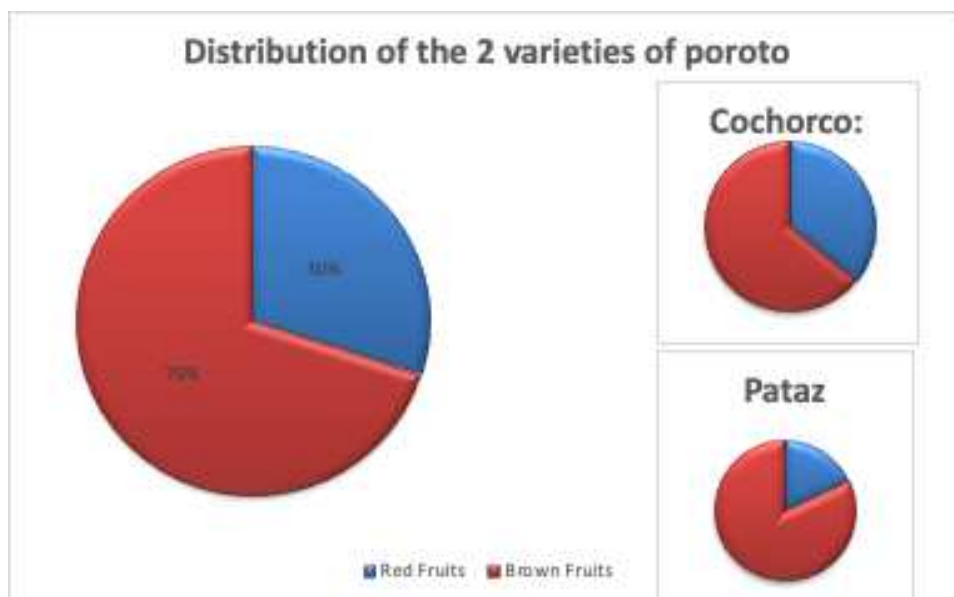


Figure 15: Distribution of interviewed HH among the districts Pataz and Pias and Cochorco.

Part of the survey was to find out which years the tree produces beans. The results from Cochorco and Pataz are shown in Table 11.

.	Cochorco	Pataz
Age tree at which it begins sprouting (average)	2	2
Age tree at which sprouting is the most (average)	6	6
Age tree until which it is sprouting (average)	68	62

Table 11: Productive ages of poroto trees in Cochorco and Pataz (average numbers).

Overall, the poroto tree is productive the whole year, with 2 peaks in production in Summer (January, February, March, and April) and Winter (August and September) in Cochorco. In Pataz, there is a clear peak in production in Winter months (June, July, and August) (Figure 16). The percentage represents the number of trees that (generally) produces some fruits, according to the HH head that was interviewed. Thus, this graph does not represent just the last year, or give any information on the amount of beans that are produced by the tree in any given month.

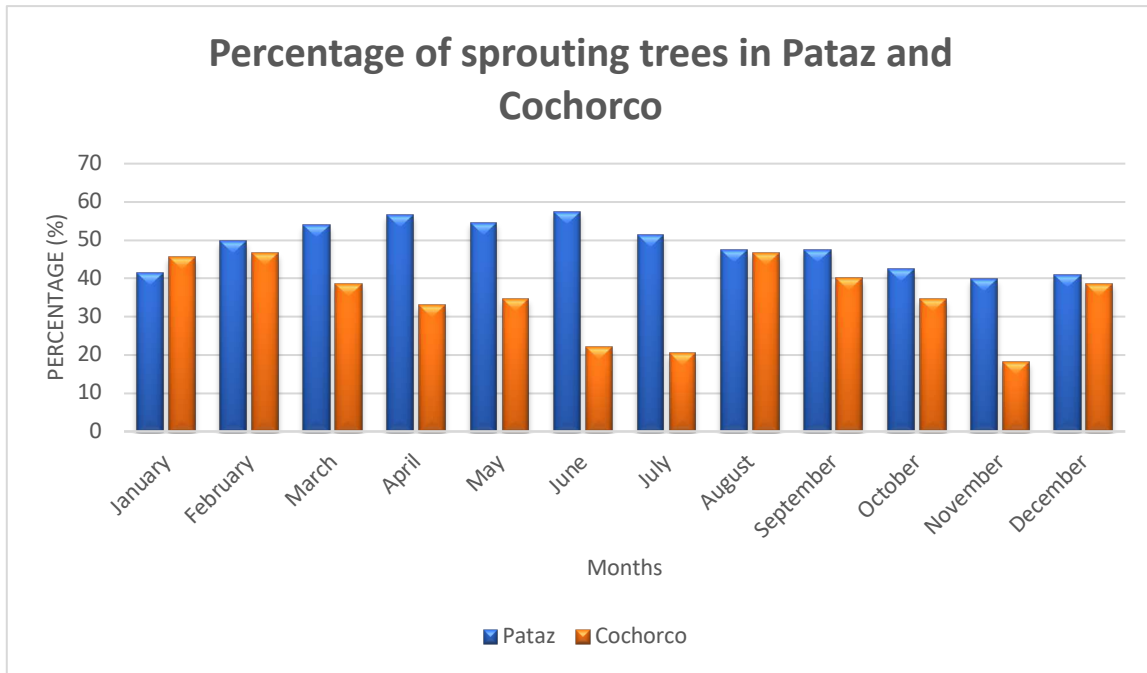


Figure 16: Comparison of poroto beans production throughout the year in Cochorco (orange) and Pataz (blue).

Current and past general uses of poroto tree and its main parts

The parts of the tree that are normally used by growers are the bean and the leaves. Bark was also occasionally mentioned. The bean was used by 100% of HH in both districts and the leaves by 25 (50%) in Cochorco and by 16 (30%) in Pataz. This is consistent with the fact that all the HH eat the poroto and half of them use it as fodder (for which normally leaves are used). A noteworthy portion of HH - 14 HH (27%) in Cochorco and 17 (33%) in Pataz - use the tree for fencing. Shade is another popular use of the tree. Surprisingly little respondents indicated to use the tree for its medicinal or agroforestry purposes (Figure 17).

In Cochorco, 18% of the HH sold the beans in addition to home consumption whereas in Pataz, none of the HH interviewed were found to sell the poroto beans but all of them solely used it for home consumption.

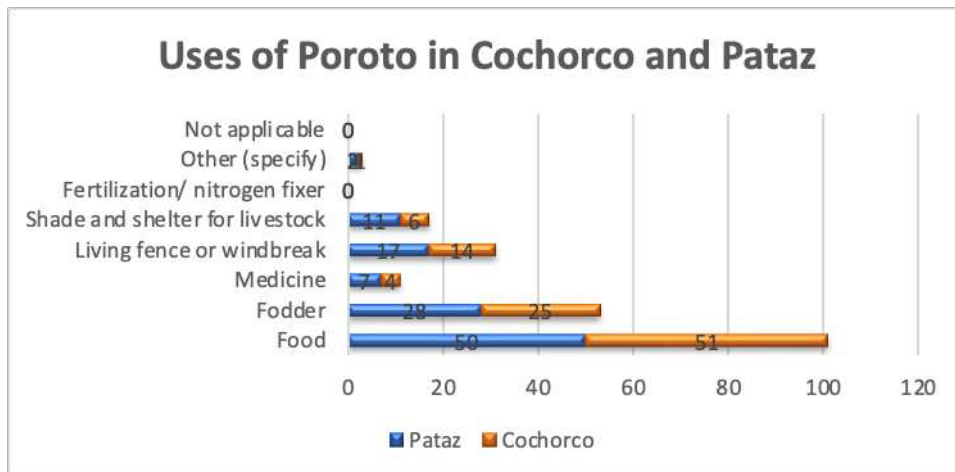


Figure 17: Uses of poroto in Cochorco and Pataz reported by interviewed households. Number of households.

When asked about the healing properties of the tree, in Pataz respondents elaborated to use its flower to treat inflammation of the urinary tract. Furthermore, the bark of tree is used for treating inflammation of the teeth. In Cochorco, the use of poroto was mentioned slightly less, with reference to treatment of gastritis as well as kidney inflammation with the bark of the tree. Internal wounds after surgery and swollen body parts are also reported to be treated with poroto. A combination with sulphur is used to treat animals who are sick.

There was consensus about a larger use of the poroto in the past. In Cochorco, 30 HH (59%) agreed that the poroto was consumed more in the past, and 23 HH (45%) mentioned that the bean was grown more. In Pataz, 47 (94%) HH mentioned that the poroto was consumed more in the past, and 35 (70%) HH mentioned that it was grown more in the past.

Food uses of poroto

When asked how much poroto they consumed, most people answered that they eat it every day or more. In both districts this means more than their grandparents, but less than their parents.

Basically, all people cook the poroto, making *poroto sancochado* (51 HH in Cochorco and 48 HH in Pataz). *Revuuelto de poroto* was the second most prepared dish (9 HH, 18%, in Cochorco and 10 HH, 20% in Pataz). In Cochorco, some more variety of dishes were mentioned such as puree (6 HH, 12%) or soup (5 HH, 10%). No sweet dishes or desserts were reported to be prepared with the poroto (Figure 18).

Most HH said they like consuming the poroto beans mainly because of the taste while there is nothing they dislike about it, although this might be biased because most of the respondents grow poroto trees and are quite used to consume it (Figure 19). Most HH agreed that the reason why Poroto is not more widespread, is because of a lack of knowledge of the beans, and because there is lack of markets for it. No one mentioned climate change as a reason (Figure 20)

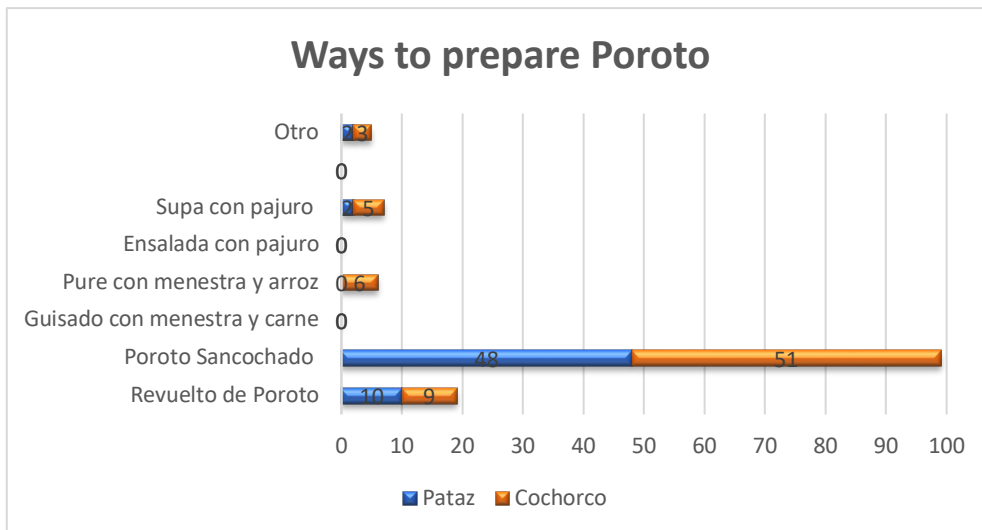


Figure 18: Meals prepared with poroto, combined Cochorco and Pataz.

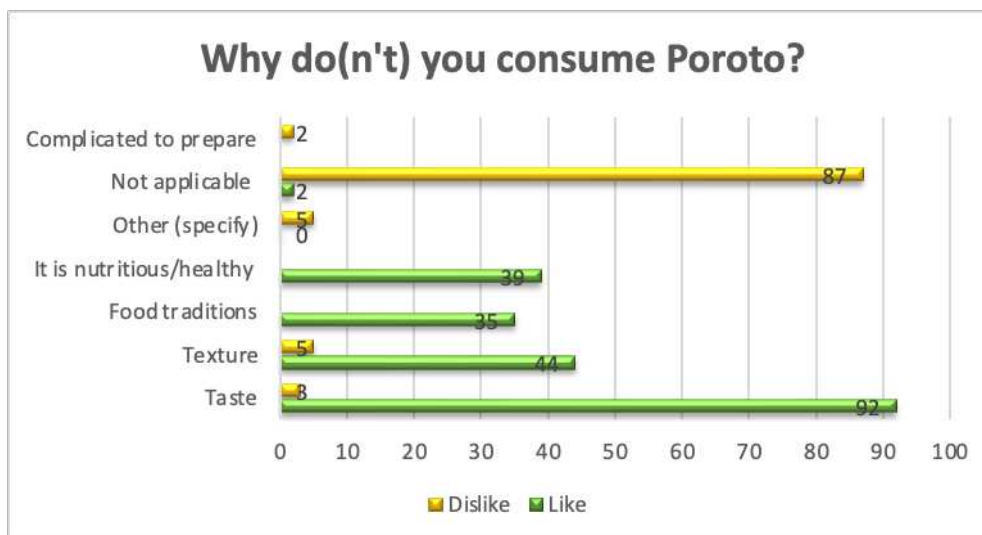


Figure 19: Reasons are why households from Cochorco and Pataz (dis)like the consumption of poroto.

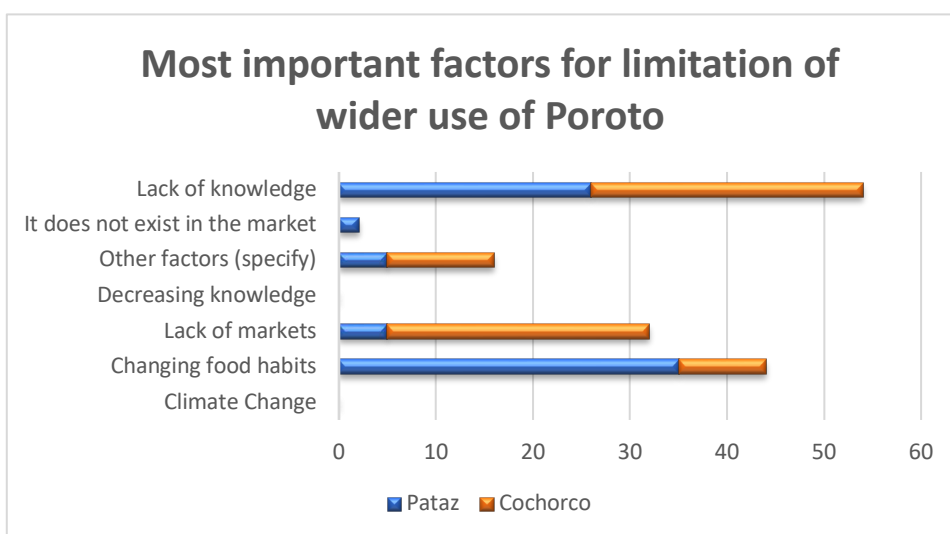


Figure 20: Most important factors for limitation of wider use of poroto

4.2 Focus Groups

The results from the eight FGs are organized in the same order as they are reported in Table 8. The results are ordered by group of participants rather than by location, to compare the answers of the same group of participants and to test if there is any difference in their answers regarding the poroto across the different districts.

4.2.1 Women

Past use and early nutritional, economic and social importance of poroto

This first question was answered mainly with knowledge regarding food. Different kinds of dishes are prepared with poroto by the women in Sanchez Carrion. If the bean is ripe when it is harvested, it is used to make *poroto sancochado* but when it is still unripe it is used to make *aji de chocho*. The poroto is consumed because it has many vitamins. The flowers of the tree are boiled and used to make *agua de tiempo*. For breakfast the poroto is consumed as *chuffla*. When the beans are not ripe, they do not have great taste, but when they are ripe the poroto is sweet. In Pataz, many adult women mentioned that *poroto sancochado* is prepared too. *Poroto sancochado* is prepared by boiling the beans only with water. *Poroto revuelto* was mentioned as the most nutritious and chosen to cook as an alternative to *poroto sancochado*. Lastly, pure, soup, and cream were mentioned. How often it was consumed varied greatly, varying from never to every day, to when it is available.

In Sanchez Carrion, some knowledge regarding medicine is present. Flowers are used to heal wounds and decrease inflammation. The shell is boiled and is used to treat kidneys and cancer. The bark can also be used as medicine when it is boiled. This treats urinary infections. In Pataz, the women also reported to use poroto for treating infections (the bark) and as an anti-inflammatory. In Pataz, other social importance of the poroto is linked to providing firewood, as well as providing shade. Poroto provides a lot of foliage making it an excellent tree to provide shade. It is also used as a fence because the trees grow quickly. In Sanchez Carrion, these social aspects were not mentioned.

In both districts the leaves are fed to guinea pigs as an alternative to grass.

Since there is currently no market for poroto in both Pataz and Sanchez Carrion, the economic importance was not discussed thoroughly.

Current use and changes that have occurred regarding the importance of the poroto

In Sanchez Carrion positive and negative changes about the the importance of the poroto were mentioned. Selected statements by the interviewees are reported below, distinguishing between positive and negative changes.

The positive changes relate to the ignorance of its nutritional value in the past which led to limited consumption, while now that the value is known more, people will likely begin to consume it more. There are also more markets where poroto is sold. With more economic opportunities, people would probably plant more trees. In the past, it

was not sold, rather it was eaten and used to feed animals. Someone mentioned that they want to consume the poroto more because they like it. Another respondent reported to have a young tree that is not yet producing, and they must buy the fruit to consume it.

Negative changes are for example that in the past the plants were not attacked by insects, but now they must be fumigated. Also, children do not consume beans nowadays, because their parents do not push them to do so.

In Pataz no significant changes were mentioned in this FG regarding the quantity and the ways in which poroto is prepared. It is not consumed much, which is seen as something negative. The children were said to consume the poroto as well. One respondent said that it is easier to prepare now, and one woman wanted to plant more trees.

Currently, there is still no market for poroto, but there is a need to create one. The women were excited to sell the poroto if such a market would exist in the future. One can consume the beans at other places, even if they don't have any but it would be good to promote the the cultivation of the poroto to take advantage of its nutritional values.

4.2.2 Men

Past use and early nutritional, economic and social importance of poroto

The men know less about preparation compared to the women that were interviewed. In Sanchez Carrion, *poroto sancochado* was mentioned as a dish the men consumed when they were younger. This makes the beans taste sweet. It was mentioned that no change in consumption is noted between when FG participants were young and nowadays. In Pataz, a dish combining poroto with spicy eggs is consumed.

The medicinal function of the bark to treat (kidney) infection is known by the men in both districts. In Pataz, it was highlighted that not many people are aware of this use and therefore poroto remains largely underused for medicinal purposes.

The use of fodder is also mentioned in both districts.

In Sanchez Carrion, the men use the leaves to feed their guinea pigs and rabbits. In Pataz, pigs are being fed with the shells and fruits of poroto, and leaves are used to feed guinea pigs.

In Pataz a participant of the FG is working with poroto and compensated for his labour. This labour entails managing the trees and harvesting the fruits. In Sanchez Carrion, no respondents are working with the poroto.

Current use and changes that have occurred regarding the importance of the poroto

In Sanchez Carrion, the tree is seen merely as a native plant. Although now, the tree is known more for the nutritious and medicinal value as well. In the future, planting more trees and watering and cultivating them will be more common practise. The

perceived importance of this tree has been reported to be increasing. One FG participant reported to want to plant more trees but does not have more area to plant it. Presently in Pataz, there is less consumption and less propagation of the poroto because local people tend to replace it with other crops, above all with potatoes. This is mostly because with potatoes it is easier to make a variety of dishes, but also because people are not familiar with poroto. One person reported that their grandfather used to believe that whoever planted poroto, dies when the tree begins to produce, explaining their limited planting.

In Sanchez Carrion, the fruits of the tree are eaten by insects in the summer. And the winter, there are almost no insects, so there are more fruits to enjoy. In Pataz, one of the changes currently noticeable, is that more trees are subject to plagues and diseases, such as worms. Trees are normally cut down instead of treating the infection. This is because the treatment is expensive, and it is not profitable, also considering that people generally don't like consuming poroto enough to deal with these kinds of problems.

In Pataz, changing climatic conditions have also been referred to among factors that may influence poroto cultivation and production, mostly in the form of less rainfall than in the past. This causes the production of the poroto to decrease. In Sanchez Carrion, these factors were not mentioned.

Other topics that were addressed

During the FG in Sanchez Carrion the similarity of poroto to balsa wood emerged. Both do not weigh much and do not serve as firewood. The poroto provides habitat for other species, for example it serves as a good place for birds of the fields to rest in, and it also ensures additional benefits to humans, for example it provides shades and cools the homes.

In Pataz, during the FG, people were enthusiastic about the idea of any project in Pamparacra to promote the planting of poroto. Because they themselves have limited time, they prefer public or private institutions to take this on. Also, promotion of the nutritional value of the poroto was more of a job for women in their eyes. Another interesting conversation was about the introduction of poroto. If a market would be created, the best place for it would be in the town nearby. Many people mentioned that no one is really interested in buying poroto, however if there would be a market, all the men that were present would plant more trees to make money.

4.2.3. Students

In Sanchez Carrion, 6 students participated to the FG and three of them belong to one HH that grow poroto. Not all students have poroto themselves, but they had all heard of the tree. The youngest of the participants was 7 and the oldest were 17. There were 2 boys and 5 girls. In Pataz, there were 7 students present: 5 boys and 2 girls, aged 14-15.

Knowledge and importance of the bean

In Sanchez Carrion, the characteristics of the tree known by the students are that it is a very large tree, approximately 2.5 meter tall. The bean is green, and the fruit is brown, and is shaped like an eye. In Pataz, the characteristics known by the students were that it is a large tree with brown fruits and red flowers, that it grows in the Sierra in the rainy season.

The students know that the fruits are edible. In Sanchez Carrion dishes that are known as being made from poroto are *poroto sancochado*, *guisado de papa* or *en chinde* (poroto boiled for three to four hours with water and wheat, peas, and beans). Another way of preparing the poroto is like a minestra (with vegetables, cooked vegetables, and some meat). It is considered delicious, nutritious, and very healthy by the students. Overall, people enjoy consuming the poroto because it has a nice taste and a soft texture. Students consider the poroto delicious and similar to the potato, and consume it frequently, up to 2-3 times per week in some cases. Those who reported to consume it less frequently indicated that this is because they are more used to other foods (e.g., seafood) and one respondent indicated they would like to consume it more often if they had the chance. In Pataz, it was mentioned that it was consumed by ancestors.

Many good effects of poroto for human health were mentioned. For instance, by preventing getting sick and good for digestion. The beans helped some of the students grow and get strong, both in Sanchez Carrion and Pataz. The poroto is rich in nutrients, contains some vitamins and a lot of proteins. They know how to eat it and to use it as a medicine because this is taught by their parents. In Sanchez Carrion specifically, the poroto leaves are used as incense, when babies are sick.

In Sanchez Carrion, when there is irrigation water, the tree produces all the time. One person specifically mentioned that it produces in October, December, and January, and in August as well. Besides producing food, poroto is also known for being used for construction of furniture in Sanchez Carrion. In Pataz, no specific months or other uses were mentioned by the students.

Current use and changes that have occurred regarding the importance of the poroto

In Sanchez Carrion, the changes that were noted were mostly negative, for example that there are less opportunities for the sale and the consumption of the bean. Also, there are more plagues now than before, and numerous pesticides are used to control it. Mining has been prioritized over farming, which led to the neglecting of farms and now even more pesticides are needed to grow the trees.

In Pataz, three types of answers were given:

1. Nothing changed: When discussed, it became evident that the comments regarding staying the same were related to the phenotypic aspects of the tree; or how FG participants have used (i.e., preparation; level of consumption) the beans in their own life.
2. The importance is now less than it used to be in the past: Comments regarding the lesser importance of poroto relate to the cultivation and consumption of the poroto. In the discussion it was mentioned that the potato used to be unable to grow in Pataz, and thus other products like the poroto were consumed more. Now, there is more

access to products from outside the area as well, which are preferred over the poroto. There were also people that had not tried the poroto before.

3. The poroto grew in importance. Comments regarding increasing importance were related to the nutritional value of the poroto, which was not very well known before but has gained increased focus right now. Some comments were made on how the dishes with poroto have evolved and have become finer.

The students in Sanchez Carrion do agree with those in Pataz that there is an increase in medicinal knowledge noticeable.

Future importance of poroto

In Sanchez Carrion the students agreed that the consumption and the sale of poroto should be promoted because of its nutritional properties. A market for the poroto should be promoted so they can be sold in the market and consumption increases and can be spread to different areas. Social networks e.g., Marketplace on Facebook, and the radio as promotional channels can be utilized for this promotion. In Pataz there was general excitement about promotion of the poroto in the future. They saw opportunities in the production and export of the poroto and were not opposed to the idea of working with poroto later. In other areas in Peru (i.e., cities as Lima), the poroto is not well known and before export to other countries is feasible, the spreading of knowledge should first be focused on a domestic level. Young people are open to the idea of organizing workshops to increase awareness and knowledge about the poroto. These could be held at school, for instance organized by organizations like Asociacion Pataz or in their classes that prepare them for future jobs. A possible set-up for this workshop is cooking with the kids while teaching them about ways of preparation. In this workshop there could be room to explain the benefits of the poroto as well. Field trips to explain how to regenerate and grow the plants are also a good idea.

4.2.4. Professionals

Table 12 shows a list of professional profiles who attended the dedicated FGs in Sanchez Carrion and Pataz.

Sanchez Carrion:	Pataz:
Psychologist	Municipality: Civil engineer
Nutritionist	Municipality: Environmental engineer
Doctor	Municipality: Agronomist
Nurse	Municipality: Administrative staff
Lawyer	Municipality: Psychologist
Farmer	Professor
Agronomist	Asociación Pataz: Agronomist
Livestock expert	

Table 12: Overview of professions of the participants of the FG in Sanchez Carrion and Pataz

Past, current, and future importance of poroto. What role has the bean to promote income, better nutrition, and agroforestry in the future?

In Pataz, the answers to these questions were given in three different rounds. But the answers were combined to make it more comparable to the answers from Sanchez Carrion. In Sanchez Carrion one respondent was not familiar with the poroto.

In Sanchez Carrion, there was consensus about the fact that poroto has lost importance over time both for families and local authorities, to the point that it has disappeared. Most of the population currently uses the bean as a live fence and does not give it importance for food. It is a legume with a high iron content that can improve nutrition, but people are not aware of the nutritional value. The professionals in Sanchez Carrion know that the bean is important for having nutritional properties, such as high levels of vitamins and iron, which is a mineral to transport oxygen to the body and can prevent anaemia. Consuming poroto is also able to reduce the rate of protein malnutrition and caloric malnutrition. In the past it was largely cultivated, but due to superstitions this is no longer the case. People believe that the devil takes possession of those who eat poroto. In Pataz, pajuro is not very common. Only in rural areas such as towns in the highlands is it an important tree. In the past the poroto had greater importance mainly because it was consumed more frequently. It was part of the diet of elderly people, but the current generation does not consume it anymore.

In Sanchez Carrion the importance for livestock was also mentioned. It represents a great source of nutrients for cattle there. In Pataz, agriculture does not have much economic importance, because most attention is dedicated to mining activity.

In Sanchez Carrion, the participant that did not know the plant advocated for a workshop that addresses the nutritional properties of the poroto. Next to the nutritional source for the families of Sanchez Carrion, the poroto would also generate economic income. The professionals of Sanchez Carrion came up with a list of possibilities to promote the poroto. This includes:

- A) Eradicating irrational beliefs about the bean tree
- B) Coordinating, educating, and raising awareness of the bean harvest together with farmers
- C) Advertising the nutritional properties of the bean
- D) Implementing nursery gardens
- E) Working with the social program '*juntos and 65*', which is a support program for the poorest directed by the Peruvian government
- F) Looking for more areas to plant more beans
- G) Promoting economic income through sale promotion
- H) Organizing gastronomic fairs to promote their consumption
- I) Bringing together different parties with knowledge of the poroto, for instance employees of the hospital and municipality.

In Pataz, the professionals considered it important to promote the poroto as well. This includes projects financed by the local government and private enterprises should be promoted and executed. Seeds and other necessary inputs to promote production can be provided, considering that the tree does not require many expenses to be cultivated. First, the farmers should be taught and educated, so that they know the nutritional and economic benefits of the poroto bean. This can be done through studies and nutritional workshops by specialized professionals.

Future role of the poroto in (new) markets to increase farmers' income

In Sanchez Carrion, the professionals suggested a good first step to creating a market, is by planting the trees for consumption and thereby increase its numbers and then plant them specifically to sell. Training about the plants could encourage farmers to cultivate poroto. New markets would also promote the knowledge of the bean. To increase demand of the poroto, its nutritional value must be reported and this must be compared to the nutritional properties of tarwi, beans and different legumes. It is seen as beneficial to hire a marketing specialist to present the tree to the population in new light and oversee its promoting. For instance, its great nutritional value and amount of protein makes it excellent fodder, and it is used for animal fattening. Important is also to eliminate false beliefs to generate production and create a local market with gastronomic fairs, cooking workshops and advertising on social networks.

In Pataz, the nutritional value and forms of preparation are also unknown, and the professionals are therefore afraid that the product will not be bought even if markets would emerge. However, there is an idea to organize a fair where poroto together with other underused products can be promoted. This could be in the form of an itinerant market that promotes both cultivation and sales. It would be good to invite educational institutions and farmers; representatives of health posts, entrepreneurs, and young people to maximize impact. Furthermore, activities can be organized such as preparing culinary recipes where children can be invited to participate. Getting used to preparing and eating the poroto on such events, can contribute to a consumer culture. Different flavours from different recipes will make the bean attractive to different kinds of consumers and bring people to the market. The farmers should also be invited to stimulate the use of poroto and incentivise market creation. Promotional activities can be advertised on the radio and via social media, like Facebook. These media can also be used to broadcast the beneficial properties of the crop.

Future role of the poroto regarding landscape restoration and agroforestry

In Sanchez Carrion, the answers to this question were divided in two main opinion blocks. Some people reacted positively to advocacy of this role of the poroto. They mentioned that its flowers are very attractive, and thus it would be a good idea to plant the trees to improve landscape aesthetics. It is considered to have a colourful life cycle and can provide ornamental value to homes or tourist sites. The tree can be promoted best in the mountains (La Sierra). By training farmers about the benefits of beans, it is likely that some producers will be interested in changing some crops for poroto. In Pataz, potential areas to plant poroto that were mentioned are public spaces such as schools, parks, and gardens. Poroto planting can be promoted through school nurseries in district schools. A second group of participants included people who were more negative of this role for the poroto, because other plants such as eucalyptus or avocado are preferred for purely economic reasons.

In Pataz there is also more focus put on the use of the eucalyptus or pine that is used for timber. The poroto is not usable as timber in mining. In Pataz there is also currently a lack of workforce and qualified farmers. There is a lack of salary incentive to show recognition of afforestation work of the poroto. Therefore, there is little will of the farmers to start working with the poroto. There is also very little demand for poroto from the consumers, and thus this exacerbated the trend. Encouraging farmers to work with poroto is seen as a good option.

Future role of the poroto as a plant-based alternative to animal protein

In Sanchez Carrion, the opinions regarding this role were also dichotomous. Some professionals thought it was achievable because there are households that do not have the economic resources to buy meat, therefore the legume could act as a substitute. The bean is an excellent source of protein and even better if its consumption is complemented with cereals such as rice. Other respondents found the poroto to be a good replacement for certain foods, such as other legumes or vegetables. However, it could not totally replace meat or fish because the absorption of proteins provided by poroto beans is limited.

In Patataz, people recognized that introducing poroto would be an opportunity, however they tend to believe that changing the food culture regarding bean consumption would be very complicated. In general, the residents of Patataz consume a lot of protein, but they are accustomed to modern dishes, and they no longer consume poroto. The consumption of beans should be promoted especially to the elderly, due to its high protein content. Possible ways to stimulate poroto reintroduction in meals would be to introduce it to the market as well and include actions like promoting famous dishes, such as broaster chicken with bean flour (*pollo broaster con harina de poroto*), in representative restaurants of the district. It could also replace potatoes or stews (*la menestra*). Additionally, it has been suggested to find ways of preparing bean-based preparations at school kiosks so that children learn about the flavour and its great nutritional value. In conclusion, it would be an alternative to accompany the common diet.

Current and future policies regarding climate change and the availability of irrigation water

In Sanchez Carrion, there are ideas to maintain the water sources through storage in reservoirs which can be used in the dry months. With the support of micro-reservoirs, it would be possible to face the lack of water in the dry season, and to be able to irrigate the bean crops throughout the year.

As for current and future policies regarding climate change and the availability of irrigation water, in Patataz local government plans and policies to conserve natural reserves and control productive activities due to the generation of polluting gases should be implemented. Afforestation and reforestation should also be encouraged with programs 'if you cut a poroto, plant two' as well as by encouraging mining companies to plant bean seedlings when they close their mines. Furthermore, attention should be paid to local sourcing, for example by making sure that essential products are brought from the surrounding provinces.

On an individual level, excessive energy consumption and the use of plastic must be avoided, moreover people should participate in reforestation activities and use public transport.

4.3.5 Intergenerational and gender-specific knowledge of the poroto

Knowledge distinction between men and women

From the surveys, it becomes apparent that the variety of dishes prepared with poroto is limited. Besides poroto sancochado, only revuelto de poroto is mentioned sporadically. In the FG, there are more dishes mentioned. During the FGs, the men knew less about preparation than the women. The men talked about two different dishes while the women knew much more, including aji de chocho, agua de tiempo and chufra, poroto revuelto, pure and soup in addition to poroto sancochado. The dishes also depended on the ripeness of the bean. More focus on the nutritional level of the dishes was also considered by the women. Both men and women agreed that not much changed regarding the way that poroto is prepared, and how much they consume it. The women were more aware of how much the children consume the poroto right now. Men mentioned that poroto is being replaced by potatoes a lot, because of the larger variety of dishes that can be prepared with them.

Regarding medicine, women were also more knowledgeable. Men mentioned the medicinal power of the bark to treat (kidney) infection, while the women were aware of more medicinal uses of the bark, in addition to medicinal uses of the shell and flowers. Other social uses besides medicine such as firewood, shade and fencing were also stressed by women, making them better informed than men about the social uses of the poroto overall. Men were more aware of the spiritual meaning of the poroto, such as the superstition that men who plant poroto, die when the tree begins to produce. Women and men are putting more focus on the nutritional and medicinal values of the poroto, which will increase its consumption in the future.

Men were more conscious about the use of fodder of the tree, and several parts of the tree to different animals at home. Women only used the leaves to feed their guinea pigs.

Very little economic importance exists right now according to both men and women. Only 1 man was aware of how poroto can have economic importance. Women expressed their excitement about participating in possible future markets for poroto. In Sanchez Carrion, growing market opportunities were mentioned.

Regarding the changes that have occurred regarding the importance of the poroto, the view of men and women were similar, although specific to each location. In the FG of both men and women in Sanchez Carrion, there was an increase mentioned of the importance of the poroto, while in Pataz there were little or negative changes perceived. The increase can be explained by the expansion of knowledge regarding its nutritional value and emerging of markets, and the negative change is because HH in Pataz seem to replace the poroto with potato.

Both men and women were aware of the increase in need for pest control. In Sanchez Carrion, the fruits are eaten by insects and generally more plagues and diseases are noticed in the tree, while in Pataz more worms are found in the trees. They must be fumigated or cut down if the treatment is considered too expensive according to both sexes.

Only the men in Sanchez Carrion mentioned the threat of climate change in the coming years. Less rainfall is causing the production of the tree to decline.

Knowledge distinction between adults and students

The students were only interviewed during the FG. They are only familiar with the variety with red flowers.

Information given in the FGs by adult men and women was mostly known by the students as well, although the answers of the students were more focused on physical aspects of the tree. Several dishes that can be prepared with poroto were known by the students. In the FG of the students in Sanchez Carrion, more focus is put on the types of dishes that can be created with the poroto. In that focus group, there were 5 girls present that participated more actively than in the FG in Pataz.

The students were also knowledgeable about the periods the fruits grow. The medicinal properties were also recognized, but the exact uses were not known. More focus was put on the nutrients it contains, that helps small children grow strong and big, and its administering to babies when they are sick. Both the knowledge of food and medicinal uses were taught by their parents.

Students did not have much knowledge about other social uses, fodder, and economic importance that was mentioned in the FG with the adults. The students were positive about the possibilities of introducing a market where poroto can be sold, and excited to learn about opportunities of working with poroto, for instance in school.

Both the professionals and the students suggested several social media for promoting the consumption and cultivation of the poroto.

Overall, the level of knowledge did not differ enormously, although adults have more in-depth knowledge about some of the topics and the students only know some uses superficially.

4.3 Transects

In this chapter, different figures using GIS and MaxEnt will be presented. As mentioned before, the GPS points of the HHs will be used for socio-economic variables and the GPS points of the trees will be used for geographical variables.

4.3.1 Spatial analysis

To predict in what areas the poroto can grow, the ecosystems and climatic conditions of the current poroto trees were mapped. This provides information on characteristics of possible new locations where the poroto can be planted. From Figure 22 it becomes obvious that the tree can grow best in two different kinds of ecosystems. These are the *matorral andino* and *zona Agrícola* (Figure 22). The characteristics of the two ecosystems are explained below.

Matorral andino is an Andean ecosystem with wide distribution at the national level that includes three types of scrub (montane scrub, dry puna scrub and Andean scrub), with an altitudinal range of 1,500 to 4,500 asl. It is characterized by the presence of woody and shrubby vegetation of variable composition and structure, with a ground cover greater than 10% that extends over more than 0.5 hectares, and whose height above the ground does not exceed 4 meters. In the dry puna scrub, there are extensive areas of “tola” (*Parastrephia* spp.), as well as *Lepidophyllum quadrangulare*, *Baccharis* spp. and other species; in the montane scrub we can see sclerophyllous shrubs and small trees up to 2 meters and the presence of epiphytes; and in the Andean Scrub proper, thickets with sparse trees and cacti dominate.

Zona Agrícola includes areas dedicated to crops. They can be transitory crops, that is, those that after the harvest must be sown again to continue producing (vegetative cycle is short, from a few months to 2 years); or permanent crops, those whose vegetative cycle is greater than two years, producing several harvests without the need to replant. In remotely sensed images, they usually have a typical pattern of regular polygons (squares, rectangles, and eventually triangles).

Furthermore, the land suitability for poroto can also be predicted. There are nine climate zones that can be disguised in Pataz, Pias and Cochorco (Figure 23). The relevant climatic zones are described in Table 13.

Colour	Code	Description
Light blue	B (o, i) B'	Rainy with dry autumn and winter. Tempered
Pink	C (o,i) B'	Semi-dry with dry autumn and winter. Tempered
Light green	B (r) B'	Rainy with abundant humidity all seasons of the year. Tempered
Dark green	C (r) B'	Semi-dry with abundant humidity all seasons of the year. Tempered

Table 13 Relevant climatic zones in Sanchez Carrion and Pataz.

From these results, it is possible to conclude that the poroto grows well in temperate regions. Furthermore, it needs at least some degree of rain but can also flourish in semi-dry areas, given its lesser productivity in winter (June and July) in Cochorco. In

Pataz, the production of beans is more constant throughout the year, which coincides with the level of humidity throughout the year.

Figure 21 shows poroto trees distribution at different altitude levels. It was made with the digital elevation model by CGIAR (Jarvis *et al.*, 2008). From the figure it becomes evident that the poroto grows best at elevations 2,000 to 2,500 meters asl.

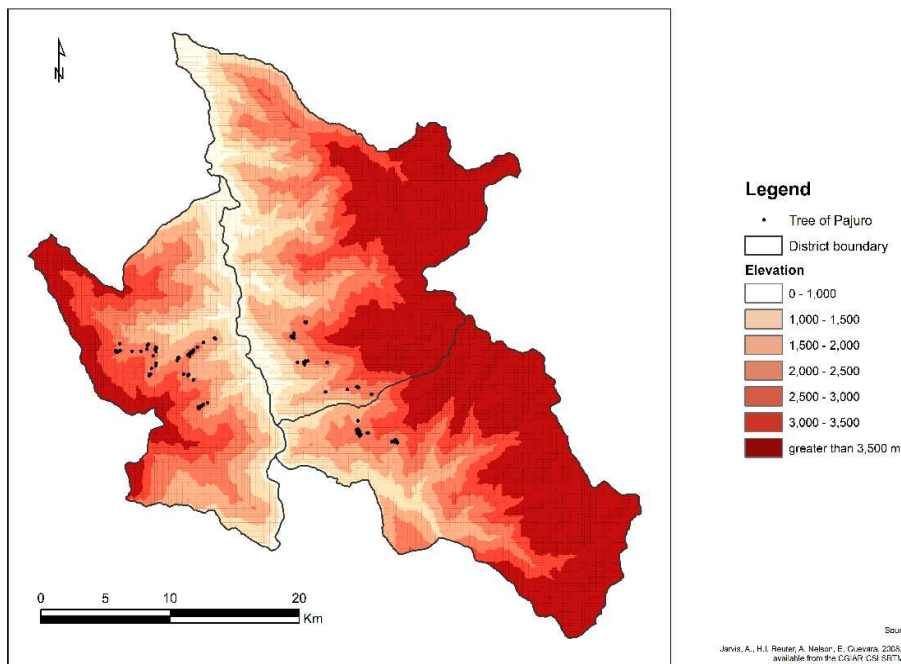


Figure 21: Poroto trees with the elevation layer from CGIAR (Jarvis *et al.*, 2008).

4.3.2 Statistical analysis

With R Studio, a histogram was created to show the distribution of the elevation of the trees in Pataz, Pias and Cochorco. The elevation of the trees follows a normal distribution (Gaussian Distribution) (Figure 24). In total 434 trees were recorded. After plotting the distribution, R studio was used to make a boxplot to show the range of elevation that the poroto is found at. Normally an outlier detection of 1.5 is used, in which 356 trees are found but in this specific case we chose to use an outlier detection of 3 instead. By using a larger outlier detection, the number of outliers is more limited, and the elevation of more trees is included, in this case 414. It is visible that with the outlier detection of 1.5 less outliers are included and thus the range becomes smaller. Figure 25 has its shape due to 1 single outlier that represents an incorrect value.

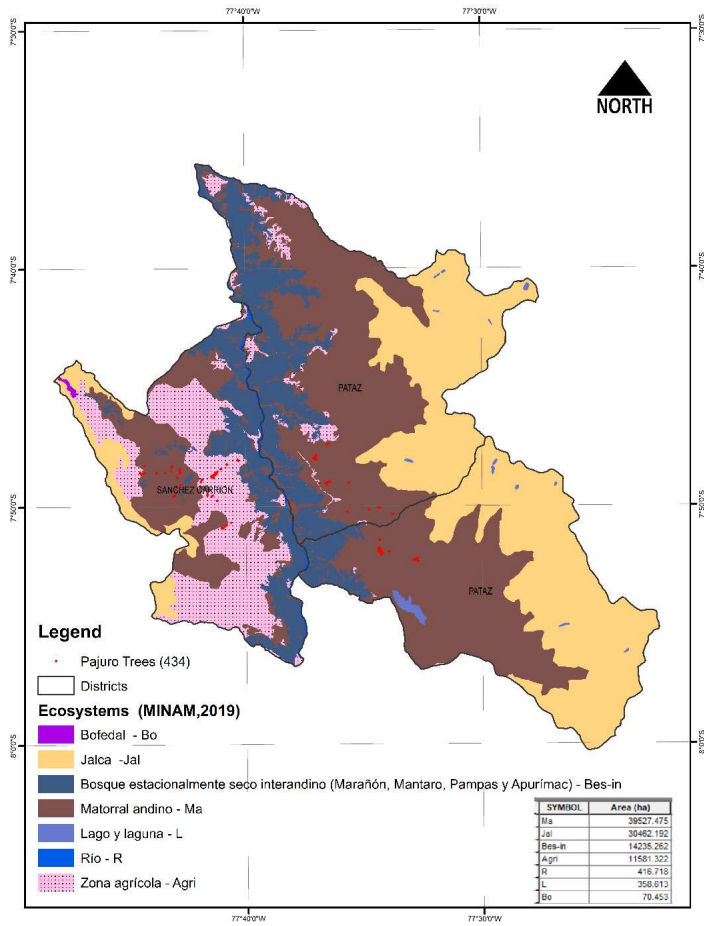


Figure 22: The trees grow in different ecosystems in Cochorco and in Pataz.

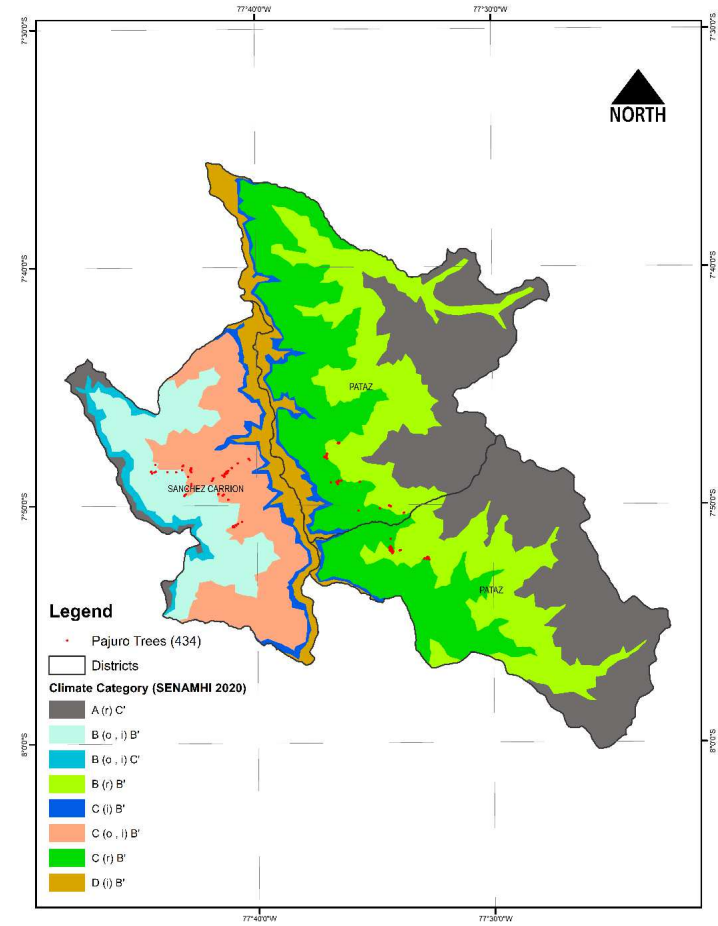


Figure 23: Different climatic conditions in the study area.

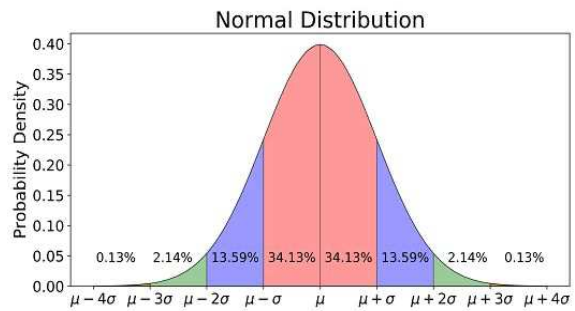
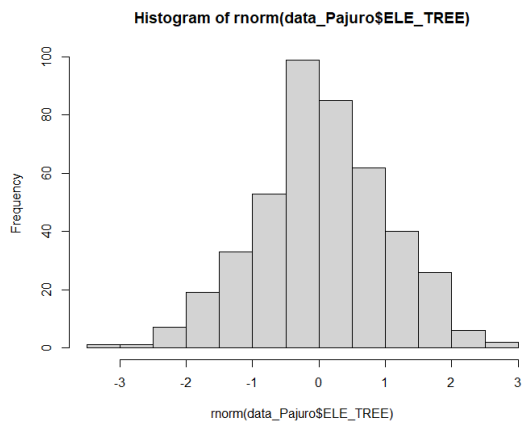


Figure 24: Representation of the distribution of the elevation of the trees in the survey (left) and normal distribution for comparison (right).

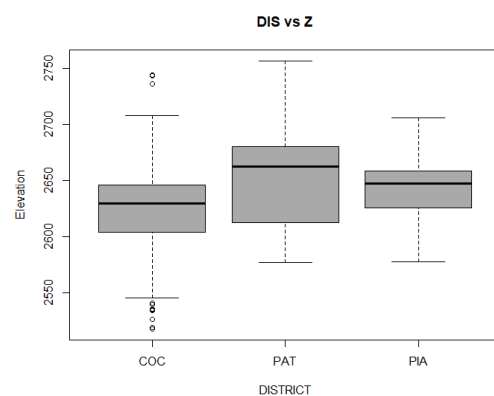
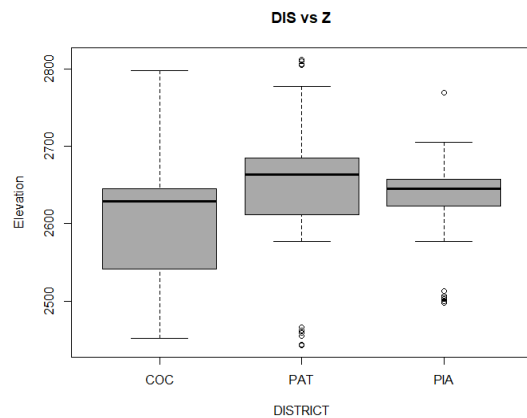
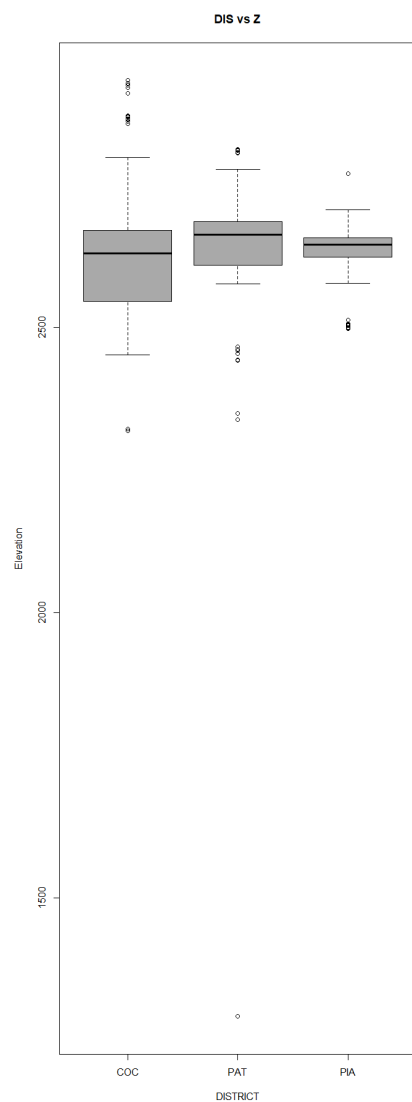


Figure 25: Boxplots separated by district Cochorco (Coc), Pataz (Pat) and Pias (Pia). Different outlier detections are used (3 in the upper figure and 1.5 in the lower figure on the right). On the left a boxplot without any factor for outlier detection is added.

4.3.3 MaxEnt

MaxEnt was used to elaborate and plot two sets of data. The first set was made using only a layer for elevation from NASA (NASADEM). It differs a bit from the one provided by CGIAR but to such a small extent that the difference was neglected. With the DEM layer, the probability was calculated that poroto trees would be present in different areas. On Figure 23 (on the left) it is visible that the poroto trees solely grow on specific elevations. And it is thus expected that the poroto will grow in other locations with the same elevations too. Figure 23 (right) four different layers are used:

1. Climate classification (SENAMHI)
2. Greencover (MINAM)
3. Ecoregions (MINAM)
4. Ecosystems (MINAM)

The more layers that are used, the more specific the areas where poroto trees are likely can be found can be calculated, at least if information from different layers does not overlap. The relative importance of each layer in influencing the probability of the occurrence of poroto tree is visible from Figure 26. The red colour indicates better conditions for the poroto to grow, and this is a better representation since more layers were utilized. It is visible that in Cochorco there exists some locations that would be suitable for planting trees. The area in the middle of Sanchez Carrion around Aricapampa and Paucapampa seems to be a hot spot presenting conditions that are needed for the poroto to grow. In the south there are also *anexos* that were not visited that could prove to be very suitable for growing the poroto.

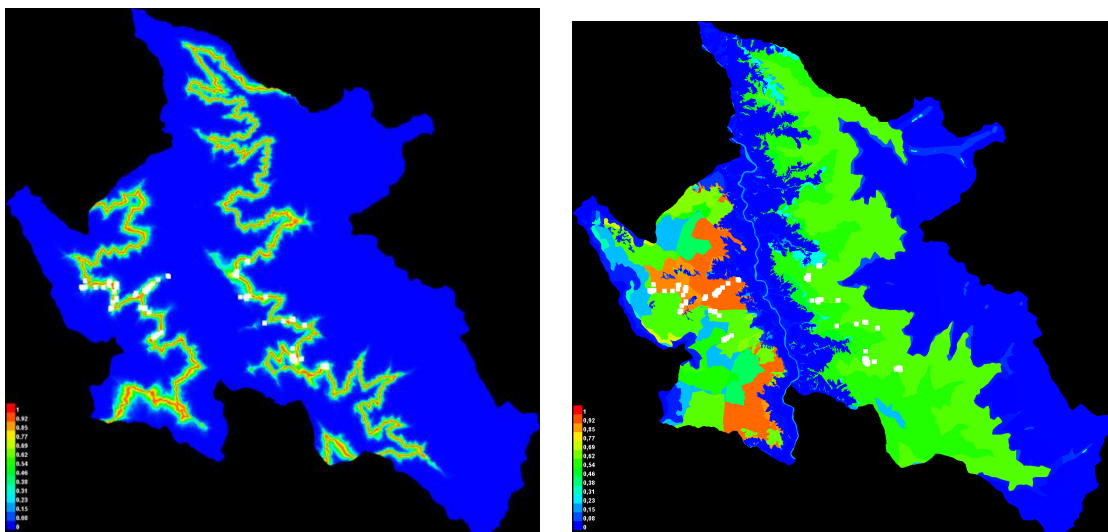


Figure 26: Probability of the occurrence of the poroto tree based on elevation (left) or a combination of four parameters, i.e. climate, green cover, ecoregions and ecosystems (right).

4.3 Participatory observations

During the period of the research, the researcher stayed in Chagual, in between Pataz and Sanchez Carrion. Chagual is reachable by *colectivo* from Trujillo via Huamachuco with a trip of 8 hours. Many employees of AP work in areas around Chagual and travel back and forth for workdays using *colective's* or their own motor. Asociación Pataz is an organization with hard-working people, and male dominated. Workdays start around 7am and can continue up to late at night for some people. This is also because of the intense heat that can be experienced in the middle of the day. Everyone was very willing to help, although at times it proved to be difficult to execute plans that were made beforehand. Not everyone is as solution oriented as expected in areas in Peru and this can prove to be difficult in collaboration. The employees worked 20 days consecutively, followed by 10 days off. Saturdays were generally not seen as a holiday and Sundays were spent eating and drinking together. Excessive alcohol use is practised by some of the men and done while driving in the mountains. Traditions and celebrations are taken very seriously, and dancing and eating is a big part of this celebration. Generally, the biggest meal during the day is lunch, and thus dietary change is most likely to happen there. Many people are also very proud to be Peruvian, especially proud of the local dishes, music, and the different landscapes that Peru is made up of.

Many farmers, besides growing their own fruits, also are self-sufficient regarding the meat they eat. Many HH own poultry and other domestic animals such as pigs and cats. There is a big problem with stray dogs. Many are not vaccinated or neutered and can be quite aggressive on the streets. Many respondents indicated that free-roaming donkeys were eating the poroto, which was considered a pest.

Working in CIP proved to be very positive experience. Although many people were working remotely at the time, also since transport in Lima can be a challenge, everyone was very helpful and knowledgeable.

The large proportion of unsatisfied basic needs and lack of access to water, drainage and electricity in La Libertad was clearly visible. People live in small villages in the mountains and built their own homes with brick. The research centre in Chagual was well equipped, but the homes itself lacked proper sanitation and sleeping facilities. In some houses kitchens were available, but in many cases all cooking was done on fire outside, and people slept on plain mattresses on the floor in dark rooms with no light. Additionally, modes of transportation besides walking were very limited. Some cars (pick-up trucks) and motors were owned by HH, but if not, this proved to be difficult in choosing a location for the focus groups. No addressed are used or needed.

During the research, snowball sampling was easily used since many inhabitants know which HH grow poroto and where these HH live. The HH that were interviewed were most of the time willing to participate and sometimes even excited to talk to someone from Europe. The knowledge of English was poor, and all communication was done in Spanish. Learning English was seen as very valuable by many people, and crucial to create better opportunities for the area

and the people. No landlines were available, and while most people had access to phones, service was sometimes very weak or not available, especially in Pias and Suyubamba.

Most of the young people move to the city to look for job opportunities and better economic conditions, and this ultimately resulted in an ageing effect on population. Better schools were in Trujillo, and if financially possible, parents chose to send them there. Some elder women were unaware of their age or date of birth as this is not always registered in La Libertad. On the other hand, some of the young underaged students being interviewed are being forced to grow up quickly, for instance by starting a family at a young age. The family care also increases the role divide between men and women. During interviews most women were at home or working in their shop while men were off for work. During the questionnaires, everyone was willing to talk to both the researcher and the employees of AP, but sometimes language barriers prevented inclusive conversation. No powerplay was experienced between the researcher and the respondents.

5. Discussion

In this section the theoretical and managerial implications of the research are reported, as well as the limitations to the study and suggestions for further research. For the discussion, the results of the questionnaires, FG, the transects and the participatory observations are used to compare to the literature review.

5.1 Theoretical implications

Ecology

Two varieties of *Erythrina edulis* are known in La Libertad. Both varieties have red flowers. However, one kind produces pink fruits that turn red when ripe and the other one produces white fruits that turn brown when ripe. Most of the HH in the study area had the variety with the brown fruits. It is unknown if there is a difference in the name of these trees.

From the literature, it is known that the pajuro can live up to 30-40 years. In this research, HH indicated to have trees that could produce fruits up until 65 years, in Cochorco some HH even reported to have trees that were productive until the age of 200. Also, the age at which the tree started sprouting in La Libertad seemed to align with the expected age from the literature, with a difference of 6 months. Cardenas (2015) found that there were two peaks in the production of the beans: from January to April and from July to August. The first one, from January to April, deviates a bit from the winter peak observed in this research, which was from November to February. However, these periods both include a warmer climate. The second peak found in this study was from June to September, which is longer than the peak from July to August described in literature, but the period does overlap. Additionally, the climates in these periods are approximately the same. In Patatz, the production of fruits was more consistent throughout the year in comparison to the production in Cochorco.

Nutrition

The pajuro tree has several elements that can be used for consumption. More importantly, the fruits/beans of the tree were reportedly consumed by all the households visited. 90% of the HH did because of the taste of the pajuro, and only 40% because of its nutritious benefits. By far the most eaten dish was *poroto sanchocado*. Especially adult women were more knowledgeable about the different recipes, but no sweet dishes were reported to be prepared. While all respondents had pajuro trees in their garden, most of the respondents also stressed the limited knowledge about this species that exists in the areas. Educating especially policy makers about the nutritional benefits can enable its promotion in La Libertad for lowering the occurrence of anaemia and food insecurity. Potatoes are more readily available in La Libertad and given their more diverse choice in recipes, they are currently consumed more than pajuro. The children were said to consume the pajuro as well. The effect of spreading knowledge is already visible, given that most people consume the bean more than their parents.

Agroforestry (knowledge)

Knowledge existed in La Libertad about some of the uses regarding agroforestry. 30-50% of the HHs used the pajuro leaves to feed their cattle, but bark was not used in 90% in the cases. Around 30% of the HH used the tree as a natural fence and 17% of the HH cultivated the tree for its shade. However, no HH reported to use the tree as a nitrogen fixer or for firewood. During the FG with women in Pataz, firewood was briefly mentioned but this did not become evident from the surveys alone. In Cochorco, it was mentioned that the wood of the pajuro is used for construction. A small number of HH is planting the pajuro for their beneficial properties on nearby crops in the field. Agroforestry qualities are currently fulfilled by eucalyptus trees in the region, since this is cheaper, but of course for the future diversification is preferred, and pajuro can supplement the eucalyptus in its role.

Medicine

Very little HH knew (all) the medicinal properties that the tree possesses. Medicinal uses that were mentioned in the surveys were to treat the urinary tract. Anti-inflammatory function was also mentioned, for instance in the teeth or after a surgery. Furthermore, the pajuro was used when animals were sick. There are several older people that were interviewed that believed the pajuro was the reason why they (or other people) lived up to 90 and over. It was also known how to prepare the medicine out of the flowers of the pajuro. Although these healing properties were known, only 10% of the HH that were interviewed indicated to use the tree as medicine.

Economic importance

Unfortunately, there are almost no markets for pajuro recorded in the area for La Libertad. When asked about the wish for its existence, most respondents were keen on selling their fruits on the market and enjoying the economic benefit, but almost no one indicated to be interested in buying the fruits. This may be the results of only interviewing HH that cultivated the pajuro. But if markets were to be created, the first step in La Libertad must be spreading the beneficial and enjoyable characteristics of the fruit, to get HH excited to start buying it. In the focus groups of the adult men, it became evident that there is little excitement about participate in the spreading of knowledge themselves, and this is seen as a role for women and/or the professionals.

As mentioned in the theoretical framework, the level of TEK is determined by ecological, demographic, social, cultural, economic factors, and gender distinct knowledge. The ecological factors in La Libertad are right for the inhabitants to know about pajuro cultivation since it is found there. Demographic factors also play a role, since people above 30 are more knowledgeable about the tree, as well as women. A lot of younger people move to more urban areas and learn less about the native plants from the rural area. Social factors play a role in the sense that most people get their cuttings from other people in the community, and thus information about the tree can be exchanged as well. Culturally, the recipes that are passed down through generations can be important for their conservation, as well as the knowledge about the medicinal purposes of the pajuro tree. Also, cultural beliefs like the devil that can take possession of tree influences the popularity of the tree. There are very little market opportunities, decreasing the amount of traditional knowledge. The plant is used for medicine, and food but

little record exists for its use for thatching, fuel, or cash. Increasing these resources can aid in sustainable utilization of the tree.

Gender and generational aspects

From the FG, it becomes clear that regarding medicinal uses and food, women have a better understanding of the pajuro. Men knew more about its uses for fodder. Since women participate more in (street) markets, they are generally excited if they can participate and make money from the beans. The men were also excited about this prospect, just less about the participation therein. Both genders were aware of the specific pest threats, but men and professionals were also beware of the future threats related to climate change.

Food security can be improved if more HH decide to cultivate the pajuro. Other crops can grow better and if markets exist for the bean, an increase in livelihoods can be realised. Women in the community have more knowledge about the pajuro with regards to consumption and non-timber forest products (NTFP) of the tree. If the role of women becomes more prominent, and they start being included in the decisions regarding agroforestry, that could result in better socio-economic conditions for the HH.

Although students did know significant number of nutritional properties, and medicinal uses, they did not know much about other agroforestry uses or economic importance. They were also asked more about facts about the pajuro instead of its importance maybe explaining this difference. The students were positive about the possibilities of introducing a market where poroto can be sold, and excited to learn about opportunities of working with poroto, for instance in school.

From this thesis, it becomes apparent that people make the decision to cultivate mainly on the utilities derived from the tree namely, construction and fencing and fruit, fodder, and medicine. The intensity of the management is low, which can also be a predictor as to whether a farmer chooses to cultivate the tree or not. Furthermore, in La Libertad, the biophysical factors of the area are right for the pajuro to grow in. Many farmers also prefer the pajuro because of its traditional value. To ensure more farmers will choose to cultivate the tree, possible focus can be put on the agroforestry knowledge with regards to the composition of other species; to increase its commercial value and create market incentives if budget is made available to innovate.

As it was expected, very little management was performed by the members of the household. Most HH indicated that the management practices executed were minimal, but that currently there are more pests i.e., worms and insects present in both provinces that make intensify the management level needed for pajuro. The most used means of propagation was cuttings, and most mother plants of the cuttings were located within the community. This is also a reflection of the community feeling within the anexos and barrios. The knowledge regarding sprouting was also similar in both locations. In both Cochorco and Pataz, most of the trees were in the house garden, only in some

instances the trees were located further from the house. When the pajuro starts producing beans, pruning should be performed every three to four months to approximately 1.50 meter. This will also decrease the need for pesticides. In both districts, the use of the pajuro was both for subsistence use mostly, but more market opportunities exist in Cochorco.

Spatial analysis

Part of answering the RQ, was to understand how many trees are still present in the area. In Pataz, two districts were studied and thus it was easier to find HH that cultivated the tree. In Cochorco, among 100 HH, the number of trees encountered was 127. In Pataz, among 100 HH, the number of trees encountered was 304. Notice that this last number is spread out over 50 HH in Pias and 50 HH in Pataz. From the GIS plots it is evident that the pajuro tree grows best in elevation from 2,000 to 2,500 meters above sea level. In Pataz, the range of the elevation where trees were between 2,338 m and 2,812 m, and 2,318 – 2,924 m in Cochorco. This corresponds with the documentation of pajuro trees at elevations from 2,300 and 2,800 meter in Peru. Next, the climatic zones that the pajuro is currently present in a temperate climate. This can either be rainy or semi-dry temperate climate with dry autumn and winter in Cochorco and a rainy or semi-dry with abundant humidity all seasons of the year in Pataz. Furthermore, all trees that were pinpointed are growing in the ecosystems *materrol andino*, and *zona Agricola*.

5.2 Managerial implications

For the management plans in the future, the results from the FG with the professionals is used as the main source of information. The advice written down here is also targeted to the employees of the municipality in Sanchez Carrion and Pataz. This is mostly because they oversee the policies, but also since there is a lack of motivation of the adult men and women to participate in organizing promotional activities and they do not generally have the means to do so. Collaboration between different stakeholders is crucial to promote the pajuro. Governmental bodies, together with private enterprises and farmers should work together to combine their knowledge and maximize their reach for promotion. Hospital staff that is knowledgeable on the impacts of health can also contribute to this project. A marketing specialist can also aid in creating a strategy for promotion of the pajuro.

Promotion of markets

Following the FGs, it becomes clear that in Pataz and Cochorco mining activities are considered as major economic activities and given importance, while there is little economic incentive for farmers to start selling the pajuro. Afforestation is not remunerated fairly. To combat this, it is also important that seeds are readily available for farmers who are interested in cultivating the pajuro. Afforestation and reforestation programs should be included with programs 'if you cut a poroto, plant two' and mining companies should be encouraged to plant trees when they close their mines.

Additionally, there currently does not exist a market for the pajuro in La Libertad, and this seems to hinder its popularity specifically as well. Many adult

men and women are excited about the prospect of bringing pajuro to the market. If a market were to emerge, it is best to start on in a neighbouring town. If that goes well, the next steps would be relocating the markets to bigger cities and even internationally if possible. A solution needs to be found to store the seeds well, since the high amount of water in the beans makes this difficult. Future research can aid in understanding this process better. In the studied region, there is consensus to make sure there is an actual demand for the pajuro, its positive characteristics need to be promoted first.

Promotion of pajuro

A positive trend is already happening where more and more people are aware of the nutritional values of the pajuro. One generation ago, the consumption of the beans decreased because of the changing diets, and the introduction of the potato in the area. The nutritional properties need to be advertised and can be clarified using the nutritional values of similar legumes. It is also important to realise that most people react very positively to the taste of the bean, and thus this aspect should also be emphasized. Nowadays, only one dish is commonly prepared with the pajuro. Educating HH about the variety of dishes that can be prepared, can also improve its popularity. Ideas to promote this are to organize cooking fairs. These fairs should be held on popular holidays. By sharing recipes and cooking together, preparing poroto is associated with positivity and learning about different ways to prepare the bean also makes it easier for local people to adopt the bean in their diet. By creating different dishes there is a higher chance for more people to like the taste of the poroto. In these fairs, other underutilized products can be promoted as well. Next to gastronomic fairs, workshops can be organized. Social media such as Facebook and radio can also be utilized for the promotion of pajuro, i.e., to promote the gastronomic fairs and workshops that are organized or to directly spread information of the benefits of the bean.

Promoting the bean as an alternative to animal protein is feasible but should be done with precaution since not many people have access to supplements to complement vitamins and minerals from animal protein. Furthermore, framing pajuro as an alternative to meat might have decrease its popularity instead of increasing it. Also, some kinds of meat are traditionally combined with pajuro and thus the combination might add to increasing its consumption.

Farmers also need to be targeted when promoting the pajuro. They need to be made more aware of the management that is needed for the pajuro, and how little effort is needed to maintain a healthy tree. Pruning as a solution to pests should also be made more widely known, as to not cut down the trees completely. Farmers should also be educated about the nutritional properties of the bean. Farmers can also be invited to the cooking fairs or helping with the organization of these days.

The other social aspects also can be spread more widely. This is also important to not lose existing TEK. Eradicating negative beliefs through education is also important aspect prior to promoting the pajuro. The tree is not used as much for medicinal purposes, which becomes clear from the questionnaires. Some agroforestry qualities are known and used by the HH, such as shade or as fencing, but fertilizing qualities are not used at all. Agroforestry qualities are

currently fulfilled by eucalyptus trees in the region, since this is cheaper, but for the future diversification is preferred, and pajuro can supplement the eucalyptus in its role. Ways to reach HH about the pajuro are social networks, such as Facebook and the radio. This is also a good medium to reach younger people and get them excited about working with the pajuro.

Planting the trees in more places is also a good solution to increase its importance. Nursery gardens can be implemented. The tree has beautiful red flowers and is such a garden, the tree can also fulfil an ornamental purpose. Next to this, public places need to be found such as schools that can be used as area to plant the trees. This can be combined with educating students about the cultivation of the pajuro. Students are excited to learn about working with this tree, and AP can take the lead in organizing workshops, since contact with schools is already established. Classes in school are taught about future job possibilities and this is a good opportunity to introduce young people of the possibilities to cultivate pajuro and thereby contributing to biodiversity in the area.

Using GIS and MaxEnt are both valuable tools in predicting needed climatic and ecological criteria for the tree to grow. From the results there are already specific areas where the pajuro is expected to grow well. The next step here would be to promote the pajuro there and have a better understanding of the wishes and preferences of the population there. Is the pajuro already present in that area? To what extent? Do people have a positive attitude towards the pajuro? These are all questions that need to be answered in follow-up research.

Future policies

During the FGs with the professionals, it becomes evident that very little policies exist currently regarding climate change. Maybe this is not very noticeable in the studied region, but in Trujillo, a bit more west effects are already starting to show. Furthermore, a decrease in rain has been noticed that has an effect not only on the pajuro but also on other crops. Policies should be put in place to create resilience in the future to climatic changes by studying which crops are able to withstand the future conditions and by diversifying the crops produced in the region. In Cochorco, water sources should be maintained through storage in reservoirs to be used in the dry months. With the support of micro-reservoirs, it would be possible to face the lack of water in the dry season, to be able to irrigate the bean crops. This, to protect the livelihood of the families and farmers and continue economic possibilities into the future.

5.3 Limitations and suggestions for future research

This section reports research limitations and describes possible future research developments. To organise this section, a SWOT analysis is being used.

5.3.1 Strengths and Limitations

Currently, there exist little knowledge about underused crops. Many are faced with extinction, and this paper aids in conserving that knowledge. Regarding pajuro specific, there are only a small number of papers available, and many relate to nutritional data only, instead of understanding its uses and practices. This paper aids in filling this research gap. With this study, knowledge about the

pajuro, local name poroto, available in La Libertad is collected. Furthermore, predictions are made about what possible areas would be suited to plant the future trees. In the process of this research, some setback and limitations were encountered, described below:

Deviating from the research proposal, no contact could be established with the *padron* and no Spanish-speaking student could be found to help with the translation of the survey. As a solution, snowball sampling was used as sampling design, and the answers were collected in Spanish with help of the people from Asociación Pataz that were later translated.

Although much interesting information was collected with the survey, it also presented significant data gaps, highlighting access to complete and reliable information, including basic ones, to be a real bottleneck for conducting research in the area. For example, data collection failed to include the occupation of the HH heads, and whether they would be interested in cultivating more pajuro in the future. Some people were also not aware of their own age, so this is not always included. Additionally, some respondents had very young trees and did not know yet which colours the fruits would be. Regarding transportation, the field work is carried out on motor, but this is not always easy since many roads are unpaved and sometimes roads are blocked by heavy rainfall or by authorities asking money to pass through.

Some more organizational difficulties were found while organizing and performing the FGs. During surveys participants were not systematically asked about their willingness to participate in FGs later, nor was any contact information shared. This made it a bit more difficult to invite the most knowledgeable people after the surveys as sometimes it was unknown what their exact location was. Furthermore, some people could not participate because of personal reasons or preferred not to, because of the distance to the sites where FGs took place.

Asociación Pataz works with a work schedule a bit different than the standard 9am-5pm. Employees are in the field for a period of 20 days, after which they are 10 days free. This posed a challenge in the sense that sometimes information was not passed on correctly. And sometimes, work was suddenly stopped without explaining it to the next person that started their next 20-day shift.

Furthermore, language barriers existed between the facilitator and the participants. As mentioned, no (student) translator was found. It was not very feasible to let the FGs run by the employees from Asociación Pataz, since their main goal was to collect answers on sticky notes, and not facilitate a discussion. This problem was solved by including a local English professor from the schools within the team, who could function as a translator between the facilitator and the FGs.

Sending official invitations happens a bit different than in Europe where dates are proposed and either accepted or denied. Because here, we were dependent on a minimum participation of six people, the first step was to inquire the availability of the desired participants, and later agree on a date together. This led to chaos and changing of dates frequently. Because of abovementioned obstacles, the

process of organizing ten FGs took more than two weeks. Furthermore, feedback was provided late for the first day of FGs, causing it to be delayed and the facilitator was sick on the day where three FGs were planned in Cochorco. Because there was no willingness to change the date for these FGs, they were facilitated by Asociación Pataz, leading to results without discussion notes. The reason for their unwillingness was that there was arranged a location, translation, transportation, and participants which had been a lot of work.

Some FGs were held with different compositions then agreed upon beforehand. Examples of this include that in the FGs of the professionals there were no employees of Asociación Pataz present and many times there were not the minimum of six people present to perform the FG. After repetitive reminders of the requirements this was still not resolved fully.

Further Research and Threats

Strategies to promote the inclusion of underused crops into the diet of people include promoting dishes that can be prepared using these foods. The Forgotten Foods network is an initiative where recipes are collected and can be accessed by anyone interested in popularizing specific foods (Gregory *et al.*, 2019). Another useful platform is SelectCrop, which is an Automatic Land Suitability Assessment system, and uses information of climate, soil, and land-use to show which crops would be able to grow in which locations. Using these two networks can enable knowledge sharing and help improve the availability of knowledge about the pajuro and other underutilized crops.

Further research could be focused on more ecological aspects in this region. Introduction of new species in areas always comes with uncertainty and risks. Further research needs to be done to better understand how non-traditional systems affect local soil and other endemic specie composition (Rao *et al.*, 2004). While this thesis focuses mainly on species and management practices that people know and use, no soil samples or other measures were taken regarding the health of the tree or the plot to understand which characteristics make the tree grow best. This thesis also does not have a strong focus on land tenure, however, most people own the houses they live in, as they have built them themselves. In the future, it can also become important to understand the ecological disturbances and pests and their associated risks.

Underutilized crops are important in rural areas because they can provide an extra source of income for smallholder farmers. Furthermore, it is also important to identify commercialization potential of underutilized crops apart from biophysical and land qualities (Oh *et al.*, 2019). To increase market access for the smallholders in La Libertad, a possibility is to engage in collective action (Gyau *et al.*, 2013). Smallholders are not always aware of the current information regarding pricing in urban areas. Furthermore, it can be difficult to compete with larger markets where quantities in bulk can be purchased and sold for lower prices. Oh *et al.* (2020) introduced an economic feasibility assessment framework for underutilized crops. To understand what impact the production of pajuro can have on the livelihoods of the communities in Pataz and Sanchez Carrion, an important next step is to evaluate this or another model alike.

In the future, it is highly likely that the effects of climate change will start to become more visible in La Libertad. To build resilience and understand the changes that will occur, more research is needed into vulnerable areas like La Libertad. A decrease in water can seriously threaten the food security in La Libertad, leading to crop failures or roads that are used for transportation being blocked. Underutilized crops can supplement regular diets, lessening food insecurity and diversification needed to adapt to climate differences, for instance by being resistant to dry periods. Different management needs to be implemented to promote the use of available underused crops.

Cultural values are also decreasing because of globalization. Conserving TEK and the cultural values associated with the pajuro can boost the use of pajuro.

6. Conclusions

One of the objectives of this research was to know the number of trees currently present in the area and to understand in which conditions it grows best for future promotion of the pajuro in the two provinces. In the duration of the fieldwork, there were 431 trees encountered, of which 127 were found in Sanchez Carrion and 304 in Pataz. The tree grows best in elevation from 2,000 to 2,500 meters above sea level. The climatic zones that the pajuro is currently present in a temperate climate, which is rainy or semi-dry. Furthermore, all trees that were pinpointed are growing in the ecosystems of bofedal, materrol andino, and zona Agricola. The area in the middle of Sanchez Carrion around Aricapampa and Paucapampa seems to be a hot spot presenting conditions that are needed for the poroto to grow. In the south there are also anexos that were not visited that could prove to be very suitable for growing the poroto. Given that MaxEnt makes the best predictions if more components are being weighed, more layers could be added to increase the preciseness of these locations. Also, some trees should be tested in these areas, to see if these predictions are indeed correct, or if there are other factors that are not being considered that would halt this development. Moreover, the willingness of HH to plant the pajuro should be assessed, and farmers should be educated about the beneficial aspects of cultivating the pajuro.

Another objective of this study was to understand the level of knowledge regarding management, tree growing and use in the area. HH that cultivate the pajuro are knowledgeable about the tree growing and the management needed for the pajuro tree. More attention can be put towards the uses of the pajuro. The pajuro requires very little maintenance and produces a lot of beans, that can be used for a variety of dishes. The most used is *poroto sanchocado*, but it would be good to promote the consumption of the pajuro by teaching HH about different dishes that can be prepared with the bean. Other social uses can also be promoted in Sanchez Carrion and Pataz, such as medicine and agroforestry use.

From the FG is became clear that adult women were more knowledgeable regarding social uses of food preparation and medicinal use. Since it is important to spread this knowledge, adult women should be taken seriously when decisions are made regarding cultivation and resource allocation. Giving them a stronger voice, can lead to an increase in dietary diversity and a decrease in food insecurity, now and in the future. Since the TPI in both provinces is still high, this can prove to be a challenge since strong role divide and gender inequality are related to this index, extra attention should be focused on this aspect.

Students also have knowledge about the pajuro, although less specific. Social uses are something that they know less about then the adults that participated and thus should be put extra focus on in the promotion. Planting the trees in schools and organizing workshops are all ways in which they will learn more about the tree. Formats for promotion include organizing fairs and workshops by the municipality of the districts with help from the farmers, schools, and other professionals. A working group regarding the pajuro can be initiated including people with different expertise.

One of the objectives that hasn't been reached fully from this research, is understanding the reasons behind cultivation or not. A conscious decision has been made to only interview HH that cultivated the pajuro. From the questionnaire, it becomes clear there is a need to increase the familiarity of the pajuro in La Libertad, however, this sometimes is not a clear result from this thesis, since much focus is put on HH that are familiar with the tree.

The next steps parting from this research are projects organized by the municipality in collaboration with AP that will promote the nutritional value and other uses of the pajuro, for instance in workshops or fairs that can be promoted using social media. Pajuro is an underutilized crop with high agroforestry potential and by promoting this tree they can distinguish themselves with a unique scarce product which is delicious, nutritious, and easy to manage. To promote the trees in other regions, research should be focused on the highlighted area in Figure 26 in Cochorco, where the pajuro is predicted to grow well. Policies should be created anticipating climate change and an increase in pests in the coming years, to prevent further shortages of pajuro trees. Furthermore, this research can be used as a template to research other underutilized crops in Peru, to collect all available TEK there is and to help using the full potential of the climate of Peru and its wide variety of unique species.

Quoted literature

Aredo, V., Carranza-Cabrera, J., & Siche, R. (2017). Inventario de especies vegetales de La Libertad (Perú) y análisis de su potencial agroindustrial: Inventory of plant species in La Libertad (Peru) and analysis of their agro-industrial potential. *Agribusiness Science*. 7(2). 87-104.

Brush, S.B.; Carney, H.J.; Huamán, Z. (1981). Dynamics of Andean Potato Agriculture. *Economic Botany*. 35(11). 70-88

Cardenas, S. E. (2012). El Pajuro (*Erythrina edulis*) alimento andino en extinción: The Pajuro (*Erythrina edulis*) Andean food in extinction.

Cárdenas, Simón Escamilo. (2015). El pajuro: tesoro alimenticio escondido en los Andes. USMP, Universidad de San Martín de Porres, Fondo Editorial,

CERPLAN (2022). Plan de Desarrollo Regional Concertado La Libertad.

CERPLAN. (2021). Brechas Potencialidades y ambitos de intervencion Provincia de Sanchez Carrion. Centro regional de planeamiento estrategico.

CERPLAN. (2021). Mapeo de intervenciones en La Libertad Provincia de Sanchez Carrion. Centro regional de planeamiento estrategico.

De Haan, S., Zeigler, M., & Guzman Vidal, F. (2021) LOS ANDES Y LOS ALIMENTOS DEL FUTURO 50 Andean Future Foods. Centro Internacional de la Papa (CIP).

Elith, J., S. J. Phillips, and T. Hastie. (2011): "Dud1' k M, Chee YE, Yates CJ." A statistical explanation of MaxEnt for ecologists. *Diversity and Distributions* 17: 43-57.

Fasanando, Ing. Hernán Perea. (2021). "Sistema De Información Regional." SIR, Centro Regional De Planeamiento Estratégico, http://sir.regionlalibertad.gob.pe/obsreportes_detalle.aspx?id=210.

Gonçalves, C. D. B. Q., Schlindwein, M. M., & Martinelli, G. D. C. (2021). Agroforestry systems: a systematic review focusing on traditional indigenous practices, food and nutrition security, economic viability, and the role of women. *Sustainability*. 13(20). 11397.

Gregory, P. J., Mayes, S., Hui, C. H., Jahanshiri, E., Julkifle, A., Kuppusamy, G., ... & Azam-Ali, S. N. (2019). Crops For the Future (CFF): an overview of research efforts in the adoption of underutilised species. *Planta*, 250, 979-988.

Iiyama, M., Derero, A., Kelemu, K., Muthuri, C., Kinuthia, R., Ayenkulu, E., ... & Sinclair, F. L. (2017). Understanding patterns of tree adoption on farms in semi-arid and sub-humid Ethiopia. *Agroforestry systems*, 91, 271-293.

Llempén Colonel, M. F., Ruiz Diaz, L. R., Polo Campos., Á. F. (2021). agenda para la competitividad y desarrollo territorial de la provincia de Pataz. Centro Regional de Planeamiento Estrategico.

Merow, C., Smith, M. J., & Silander Jr, J. A. (2013). A practical guide to MaxEnt for modeling species' distributions: what it does, and why inputs and settings matter. *Ecography*, 36(10), 1058-1069.

National Research Council (1989) *Lost crops of the Incas: little-known plants of the Andes with promise for worldwide cultivation*. National Academies Press.

Oh, M. S., Chen, Z., Jahanshiri, E., Isa, D., & Wong, Y. W. (2020). An economic feasibility assessment framework for underutilised crops using Support Vector Machine. *Computers and electronics in agriculture*, 168, 105116.

Pastor, S., B. Fuentealba, and M. Ruiz. (2011) "Underutilized Crops in Peru: Some conceptual and political consideration." Lima: *Crops for the Future*.

Popenoe, H. "Basul." (1989). *Lost Crops of the Incas: Little-Known Plants of the Andes with Promise for Worldwide Cultivation: Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation ...*, National Academy Press, Washington, 165–172

Rao, M. R., Palada, M. C., & Becker, B. N. (2004). Medicinal and aromatic plants in agroforestry systems. In *New Vistas in Agroforestry: A Compendium for 1st World Congress of Agroforestry, 2004* (pp. 107-122). Springer Netherlands.

Shin, O. M., Yuan, C. Z., & Isa, D. (2015). Methodology for underutilized crops in order to increase rural economic growth thru economic value chain prediction. *Asia Pacific Journal of Contemporary Education and Communication Technology*, 1(1), 193-202.

Shisanya, C. A. (2017). Role of traditional ethnobotanical knowledge and indigenous institutions in sustainable land management in Western Highlands of Kenya. *Indigenous people*, 159.

Suhairi, T. A. S. T. M., Jahanshiri, E., & Nizar, N. M. M. (2018, June). Multicriteria land suitability assessment for growing underutilised crop, bambara groundnut in Peninsular Malaysia. In *IOP conference series: earth and environmental science* (Vol. 169, No. 1, p. 012044). IOP Publishing.

Web sites

Adminpataz. "Reseña Histórica." Municipalidad Distrital De Pataz,
<https://www.munipataz-lalibertad.gob.pe/index.php/resena-historica/>.

Asociación Pataz. <https://www.asociacionpataz.org.pe/contacto.php> Accessed on May 12th, 2022.

Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara. 2008. Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database:
<https://srtm.csi.cgiar.org>

NASA JPL (2020). NASADEM Merged DEM Global 1 arc second V001 [Data set]. NASA EOSDIS Land Processes DAAC. Accessed 2020-12-30 from doi:10.5067/MEaSURES/NASADEM/NASADEM_HGT.001-

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., Simons, A. 2009. Agroforestry Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya. Accessed on May 12th, 2022.
<https://www.worldagroforestry.org/output/agroforestry-database>

Annexes

Annex 1 - Questionnaire

Forma de consentimiento

Se le invita a participar en una investigación sobre el conocimiento del árbol de Pajuro y la distribución geográfica de este cultivo. Este estudio está siendo realizado por Ankie van Dijk en colaboración con la Asociación Pataz y el Centro Internacional de la Papa (CIP). Su participación es completamente voluntaria y puede retirarse en cualquier momento.

El propósito de esta investigación es hacer un transecto (mapa) de la distribución geográfica actual del árbol de pajuro y comprender qué conocimiento sobre el cultivo, manejo y uso del árbol de pajuro existe actualmente entre los agricultores del área de estudio. No se le identificará individualmente y cualquier información se tratará de forma confidencial y se utilizará únicamente para los fines de este estudio.

La entrevista tendrá una duración aproximada de 30 minutos. Después de la entrevista, se le pedirá que muestre sus árboles de pajuro para comprender la ubicación exacta donde están creciendo, si corresponde.

Al firmar este documento, acepta participar en este estudio y confirma que ha leído y entendido este consentimiento.

.....
Se realizarán dos cuestionarios. Uno para agricultores que cultivan pajuro y otro para agricultores que no cultivan pajuro (más). Esto, para comprender las razones por las que se optó por no cultivar el árbol. El cuestionario se hará en su mayoría con preguntas cerradas, para minimizar la pérdida en la traducción y maximizar la efectividad del tiempo.

1. INFORMACIÓN BÁSICA DEL HOGAR

La entrevista es con: (1) jefe masculino de HH, (2) jefa femenina de HH, (3) pareja (hombre + jefa femenina de HH), (4) grupo mixto (grupo diferente de encuestados)

nombres:

Siglos:

Géneros:

Ubicación - Provincia:

Ubicación - Distrito:

Ubicación - Comunidad Campesina / Centro Poblado:

Ubicación - Anexo / Barrio / Sector

Ocupación principal: (1) agricultor, (2) jornalero, (3) empleado, (4) negocio, (5) otro

Coordenada GPS de la casa

2. INFORMACIÓN BÁSICA SOBRE PAJURO / POROTO

¿Cuál es el nombre común que le das al árbol? (1) pajuro, (2) poroto, (3) antiporoto, (4) chachafruto (5) basul (6) Otro (especificar)

¿Reconoces más de una variedad? (1) sí, (2) no)

En caso afirmativo, favor indicar nombres y características básicas de cada variedad reconocida.

Variety	Name	Characteristics
1		
2		
3		
4		

¿Cuántos árboles tienen usted y su familia? XX

¿Cuál es el rango de edad de los árboles que usted y su familia tienen? XX hasta XX

3. GESTIÓN Y ECOLOGÍA DE PAJURO / POROTO

¿Dónde y en qué lugar cultivas los árboles? (1) jardín de la casa (cerca de la casa), (2) cercas vivas (cerca de la casa), (3) cercas vivas (lejos de la casa), (4) árboles dispersos (cerca de la casa), (5) árboles dispersos (lejos de la casa), (6) parches de bosque/plantaciones (cerca de la casa), (7) parches de bosque/plantaciones (lejos de la casa), (8) otro (especificar)

¿Cómo se propaga el árbol? (1) esquejes, (2) semilla, (3) No aplicable

¿Con qué frecuencia usted y su familia plantan nuevos árboles? (1) cada año, (2) cada 2 a 5 años, (3) cada 6 a 10 años, (4) cada década o más, (5) nunca, (6) no aplicable

Cuando planta nuevos árboles, ¿qué fuentes de semillas utiliza? (1) solo material propio, (2) plantas madre con otros agricultores de la comunidad, (3) plantas madre de agricultores fuera de la comunidad, pero dentro de la provincia, (4) plantas madre de agricultores fuera de la comunidad y fuera de la provincia, (5) no aplicable

Cuando plantas nuevos árboles, ¿hay algún aspecto en particular que tomes en cuenta? (1) productividad, (2) morfología o fenotipo, (3) estado de salud, (4) variedad, (5) ubicación de la fuente, (6) otro (especificar), (7) ningún criterio tomado en cuenta, (8) no aplicable

¿A qué edad del árbol se empieza a cosechar los frutos? XX, no sabe

¿A qué edad es más productivo el árbol? XX, no sabe

¿Hasta qué edad máxima es productivo el árbol? XX, no sabe

¿En qué meses del año cosecha las legumbres/frutos? XX hasta XX

¿Hay algún tipo de manejo regular que realice durante el desarrollo de los árboles? (1) fertilización, (2) poda, (3) control de plagas, (4) control de enfermedades, (5) otro (especifique), (6) ninguno

4. USOS GENERALES (ACTUALES Y PASADOS)

¿Consumes pajuro en casa o también lo vendes? (1) consumo doméstico, (2) para venta, (3) tanto consumo doméstico como venta, (4) ninguno (otros usos)

¿Qué usos generales tienen usted y su familia para el pajuro? (1) alimento, (2) alimento, (3) medicina, (4) cerco vivo o cortavientos, (5) sombra y refugio para el ganado, (6) fertilización/fijador de nitrógeno, (7) otro (especificar), (8)) no aplica

Para los usos indicados, proporcione más detalles sobre cómo se usa el pajuro. Espacio para transcribir texto/registro

¿Hay tradiciones/historias/hechos destacados sobre el pajuro/poroto que le gustaría compartir? Espacio para transcribir texto/registro

¿Se usó pajuro más o de manera diferente en el pasado? (1) Sí, (2) No (= lo mismo)

¿Si es así por qué? (1) lo consumíamos con más frecuencia, (2) cultivamos más árboles, (3) Otro (especifique), (4) no aplicable

Por favor, explique los cambios en el cultivo y uso del árbol que ha observado y explique estos cambios. Espacio para transcribir texto/registro

5. USOS ALIMENTARIOS DEL PAJURO

¿Con qué frecuencia consume pajuro actualmente cuando está disponible? (1) 2 o 3 veces/semana, (2) 1 vez/semana, (3) 1 vez/2 semanas, (4) 1 vez/mes, (5) no aplica

¿Con qué frecuencia sus padres/abuelos consumen pajuro cuando estaba disponible? (1) 2 o 3 veces/semana, (2) 1 vez/semana, (3) 1 vez/2 semanas, (4) 1 vez/mes, (5) no aplica

Por favor nombre las preparaciones/platos más comunes que prepara con pajuro?

Preparation	Name	Brief description
1		
2		
3		
4		
5		

¿Qué le gusta o valora del pajuro como alimento? (1) sabor, (2) textura, (3) tradiciones alimenticias, (4) es nutritivo/saludable, (5) otro (especifique), (6) no aplicable

¿Qué es lo que no te gusta del pajuro como alimento? (1) sabor, (2) textura, (3) complicado de preparar, (4) otro (especificar), (5) no aplicable

¿Consideras que el pajuro es un alimento nutritivo? (1) Sí, (2) No

6. SITUACIÓN, OPORTUNIDADES Y DESAFÍOS

En su opinión, ¿cuáles son los factores más importantes que limitan un mayor uso y cultivo del pajuro? (1) cambio climático, (2) cambios en los hábitos alimentarios, (3) falta de mercados, (4) disminución del conocimiento (5) otros factores (especifique)

¿Le interesaría cultivar más árboles en el futuro? (1) Sí, (2) No

Explique su respuesta a la pregunta anterior. Espacio para transcribir texto

7. COORDENADAS GPS DE ÁRBOLES (visita a las plantaciones)

8. INFORMACIÓN ADICIONAL

imagen de la casa

Annex 2 – English translation of survey

1. BASIC INFORMATION OF THE HOUSEHOLD

Interview is with: (1) male head of HH, (2) female head of HH, (3) couple (male + female head of HH), (4) mixed group (different group of respondents)

Names:

Ages:

Genders:

Location - Provincia:

Location - Distrito:

Location - Comunidad Campesina / Centro Poblado:

Location - Anexo / Barrio / Sector

Primary occupation: (1) agricultor, (2) jornalero, (3) empleado, (4) negocio, (5) otro

GPS coordinate of the house

2. BASIC INFORMATION ABOUT PAJURO / POROTO

What is the common name you give to the tree? (1) pajuro, (2) poroto, (3) antiporoto, (4) chachafruto (5) basul (6) Otro (especificar)

Do you recognize more than one variety? (1) yes, (2) no

In case affirmative, please indicate names and basic characteristics of each variety recognized.

Variety	Name	Characteristics
1		
2		
3		
4		

How many trees do you and your family have? XX

What is the age range of the trees you and your family have? XX till XX

3. MANAGEMENT AND ECOLOGY OF PAJURO / POROTO

Where and in which location do you grow the trees? (1) home garden (close to the house), (2) living fences (close to the house), (3) living fences (far from the house), (4) scattered trees (close to the house), (5) scattered trees (far from the house), (6) forest patches / plantations (close to the house), (7) forest patches / plantations (far from the house), (8) other (specify)

How do you propagate the tree? (1) cuttings, (2) seed, (3) Not applicable

With what frequency do you and your family plant new trees? (1) every year, (2) every 2 - 5 years, (3) every 6-10 years, (4) every decade or more, (5) never, (6) not applicable

When you plant new trees, what seed sources do you use? (1) only own material, (2) mother plants with other farmers in the community, (3) mother plants from farmers outside the community but within the province, (4) mother plants from farmers outside the community and outside the province, (5) not applicable

When you plant new trees, are there any aspects that you consider? (1) productivity, (2) morphology or phenotype, (3) health status, (4) variety, (5) source location, (6) other (specify), (7) no criteria considered, (8) not applicable

At what age of the tree do you start to harvest the fruits? XX, does not know

At what age is the tree most productive? XX, does not know

Till what maximum age is the tree productive? XX, does not know

During which months of the year do you harvest the pulses / fruits? XX till XX

Are there any types of regular management you perform during the development of the trees? (1) fertilization, (2) pruning, (3) pest control, (4) disease control, (5) other (specify), (6) none

4. (CURRENT AND PAST) GENERAL USES

Do you consume pajuro at home or do you also sell it? (1) home consumption, (2) for selling, (3) both home consumption and selling, (4) neither (other uses)

What general uses do you and your family have for pajuro? (1) food, (2) feed, (3) medicine, (4) living fence or windbreak, (5) shade and shelter for livestock, (6) fertilization / nitrogen fixer, (7) other (specify), (8) not applicable

For those uses indicated, please provide more detail about how pajuro is used?
Space to transcribe text / record

Are there any traditions / stories / noteworthy facts about pajuro / poroto that you would like to share? Space to transcribe text / record

Was pajuro used more or differently in the past? (1) Yes, (2) No (= the same)

If YES, why? (1) we consumed it more frequently, (2) we grew more trees, (3) Other (specify), (4) not applicable

Please, explain about changes in the cultivation and use of the tree that you have noted and explain these changes. Space to transcribe text / record

5. FOOD USES OF PAJURO

With what frequency do you currently consume pajuro when it is available? (1) 2 or 3 times / week, (2) 1 time / week, (3) 1 time / 2 weeks, (4) 1 time / month, (5) not applicable

With what frequency do your parents / grandparents consume pajuro when it was available? (1) 2 or 3 times / week, (2) 1 time / week, (3) 1 time / 2 weeks, (4) 1 time / month, (5) not applicable

Please name the most common preparations / dishes you prepare with pajuro?

Preparation	Name	Brief description
1		
2		
3		
4		
5		

What do you like or value about pajuro as a food? (1) taste, (2) texture, (3) food traditions, (4) it is nutritious / healthy, (5) other (specify), (6) not applicable

What do you dislike about pajuro as a food? (1) taste, (2) texture, (3) complicated to prepare, (4) other (specify), (5) not applicable

Do you consider pajuro to be a nutritious food? (1) Yes, (2) No

6. SITUATION, OPPORTUNITIES AND CHALLENGES

In your opinion, what are the most important factors limiting wider use and cultivation of pajuro? (1) climate change, (2) changing food habits, (3) lack of markets, (4) decreasing knowledge (5) other factors (specify)

Would you be interested in cultivating more trees in the future? (1) Yes, (2) No

Please explain your answer to the previous question. Space to transcribe text

7. GPS COORDINATES OF TREES (visit to the plantings)

8. ADDITIONAL INFORMATION

Picture of the household

Annex 3 – Focus group protocols

Protocolo de Talleres Focales La situación de poroto (*Erythrina edulis*) en la sierra de la Libertad

Talleres focales con hombres / mujeres

Objetivos

- *Conocer las perspectivas personas conocedores locales (agricultores) y jóvenes (rurales) sobre cambios percibidos en el uso y la importancia del poroto*
- *Explorar si hay una diferencia entre hombres y mujeres / personas mayores y jóvenes en cuanto a estas percepciones*

No de participantes

- *Mínimo 6 máximo 12 por grupo*

Perfil de participantes

- *Grupos de hombres / mujeres mayores de 50 años. Conocedores del poroto y los usos / costumbres locales.*

No de talleres

- *2 talleres con hombres (paisaje 1 / 2)*
- *2 talleres con mujeres (paisaje 1 / 2)*

Duración total

- *60 – 90 minutos por taller*

Secuencia

Hora	Tema / Pregunta Guía	Ejercicio	Producto
1-15 min	Introducción y bienvenida	Explicar el objetivo del taller	Todos están claros sobre el propósito
15-60 min	<u>Hombres / mujeres mayores (H/M):</u> ¿Cuánto ustedes eran jóvenes como se utilizaba el poroto? ¿Qué importancia alimenticia, económica o social tenía antes?	Se expone la pregunta y se estimula una discusión. Anotar en tarjetas / paleógrafos los puntos expresados.	H/M: Lista de usos Lista de factores que determinan la importancia
60-105 min	<u>Hombres / mujeres mayores:</u> ¿Qué cambios han notado ustedes a la actualidad en cuanto al uso y la importancia del poroto? ¿Qué han sido estos cambios? ¿Por qué se dieron estos cambios? ¿Son positivos o negativos?	Se expone la pregunta y se estimula una discusión. Anotar en tarjetas / paleógrafos los puntos expresados.	Lista de cambio percibidos (+/-) Lista de causantes de los cambios
105-120	Otros temas que el grupo desea expresar y clausura	Dar espacio para cualquier comentario y agradecer por la participación	Lista de temas adicionales

Protocolo de Talleres Focales
La situación de poroto (*Erythrina edulis*) en la sierra de la Libertad

Talleres focales con jóvenes rurales

Objetivos

- *Conocer las perspectivas personas locales jóvenes (rurales) sobre cambios percibidos en el uso y la importancia del poroto*
- *Explorar si hay una diferencia entre hombres y mujeres / personas mayores y jóvenes en cuanto a estas percepciones*

No de participantes

- *Mínimo 6 máximo 12 por grupo*

Perfil de participantes

- *Jóvenes entre 16-18 años. Viven en Pataz and Cochorco*

No de talleres

- *2 talleres con jóvenes mixtos (paisaje 1 / 2)*

Duración total

- *60 – 90 minutos por taller*

Secuencia

Hora	Tema / Pregunta Guía	Ejercicio	Producto
1-15 min	Introducción y bienvenida	Explicar el objetivo del taller	Todos están claros sobre el propósito
15-60 min	<u>Jóvenes (J):</u> ¿Qué conocen ustedes del poroto? ¿Qué importancia tenía para ustedes en la alimentación mientras que crecían?	Se expone la pregunta y se estimula una discusión. Anotar en tarjetas / paleógrafos los puntos expresados.	J: Lista de temas que conocen Lista de factores que determinan la importancia
60-105 min	<u>Jóvenes:</u> ¿Qué cambios reconocen ustedes que se pueden haber dado en cuanto a los usos y la importancia del poroto? ¿Por qué se dieron estos cambios? ¿Son positivos o negativos?	Se expone la pregunta y se estimula una discusión. Anotar en tarjetas / paleógrafos los puntos expresados.	Lista de cambio percibidos (+/-) Lista de causantes de los cambios
105-120	Otros temas que el grupo desea expresar y clausura	Dar espacio para cualquier comentario y agradecer por la participación	Lista de temas adicionales

Protocolo de Talleres Focales
La situación de poroto (*Erythrina edulis*) en la sierra de la Libertad

Talleres focales con profesionales

Objetivos

- *Conocer las perspectivas personas locales jóvenes (rurales) sobre cambios percibidos en el uso y la importancia del poroto*
- *Explorar si hay una diferencia entre hombres y mujeres / personas mayores y jóvenes en cuanto a estas percepciones*

No de participantes

- *Mínimo 6 máximo 12 por grupo*

Perfil de participantes

- *2 people from the municipality*
- *2 people from Asociación Pataz*
- *2 people that are actively working in forestry*

No de talleres

- *2 talleres con profesionales (paisaje 1 / 2)*

Duración total

- *60 – 90 minutos por taller*

Secuencia

Hora	Tema / Pregunta Guía	Ejercicio	Producto
1-15 min	Introducción y bienvenida	Explicar el objetivo del taller	Todos están claros sobre el propósito
15-60 min	<u>Jóvenes (J):</u> ¿Qué conocen ustedes del poroto? ¿Qué importancia tenía para ustedes en la alimentación mientras que crecían?	Se expone la pregunta y se estimula una discusión. Anotar en tarjetas / paleógrafos los puntos expresados.	J: Lista de temas que conocen Lista de factores que determinan la importancia
60-105 min	<u>Jóvenes:</u> ¿Qué cambios reconocen ustedes que se pueden haber dado en cuanto a los usos y la importancia del poroto? ¿Por qué se dieron estos cambios? ¿Son positivos o negativos?	Se expone la pregunta y se estimula una discusión. Anotar en tarjetas / paleógrafos los puntos expresados.	Lista de cambio percibidos (+/-) Lista de causantes de los cambios
105-120	Otros temas que el grupo desea expresar y clausura	Dar espacio para cualquier comentario y agradecer por la participación	Lista de temas adicionales