

ABSTRACT

ZARATE VASQUEZ, JULIO SEBASTIAN. The Politics of Potato Germplasm Conservation in the Peruvian Highlands. (Under the direction of Dr. Jason Delborne).

Agriculture significantly impacts global biodiversity, yet agricultural diversity conservation remains relatively neglected compared to other conservation priorities. This study focuses on the efforts of subsistence farmers and conservation experts in Peru to preserve Andean potato agrobiodiversity, which plays a vital role in both local diets and cultural heritage. Potatoes, grown extensively in the Peruvian Andes, embody rich nutritional qualities and are deeply intertwined with Andean cultural practices.

The International Potato Center (CIP) plays a central role in these conservation efforts, collaborating closely with custodian farmers to conserve potato germplasm through both in situ and ex situ strategies. These efforts include reintroduction activities facilitated by “repatriation agreements,” which aim to return endangered potato varieties to farming communities. Notably, initiatives like the Potato Park exemplify successful models of integrating indigenous biocultural heritage into conservation practices.

However, integrating in situ farming strategies with ex situ conservation in gene banks presents significant challenges, highlighting tensions among diverse stakeholders involved in potato conservation efforts. Despite advancements, gaps persist in understanding the full trajectory of potato germplasm conservation, especially concerning the integration of traditional knowledge and modern scientific practices.

Recent collaborations, such as CIP's partnership with AGUAPAN, a farmer-led association, illustrate ongoing efforts to integrate farmers into potato value chains and enhance germplasm collections. The development of digital platforms like Wikipapa, which integrates data from tools like Varscout for comprehensive potato species documentation, aims to bridge gaps between urban markets and rural agricultural practices.

This study employs ethnographic methods to analyze various conservation initiatives, revealing complexities in data collection, cultural representation, and the commercialization of potato biodiversity. It underscores the multidimensional nature of Andean potato agrobiodiversity conservation, highlighting intersections of care, security, sustainability, labor dynamics, and community-based conservation practices.

In conclusion, the study advocates for continued dialogue and inclusive approaches in conservation efforts to balance economic interests with cultural and environmental sustainability. By respecting indigenous knowledge and fostering collaborative relationships across diverse communities, sustainable practices can be achieved to ensure the long-term viability of Andean potato agrobiodiversity amidst evolving socio-economic and environmental challenges.

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The Politics of Potato Germplasm Conservation in the Peruvian Highlands

by
Julio Sebastian Zarate Vasquez

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APPROVED BY:

Dr. Jason A. Delborne
Committee Chair

Dr. Jean Ristaino

Dr. Michaela DeSoucey

Dr. Nora Haenn

DEDICATION

To Ketty, Diana, Rosa, and Sheila for their unwavering strength and courage, always.

BIOGRAPHY

Sebastian Zarate was born in Lima, Peru. His passion for science, policy and social sciences led him to pursue a bachelor's degree in Sociology (Peru) and a Master of Science and Technology Policy (Arizona) degree. Before coming to the U.S., Sebastian worked at Grupo de Analisis Para el Desarrollo (GRADE), a Peruvian Think Tank that fostered his commitment to integrate public policy and social sciences. After GRADE, Sebastian co-founded Sidereus Nuncius, a non-profit organization that focuses on Science, Technology and Society Studies (STS) in Peru.

In 2014, Sebastian was awarded the Francois Bouricad Prize for best social science bachelor and masters thesis. This encouraged his passion for presenting his work at multiple countries such as Brazil, Austria, Japan, Canada, Mexico, Chile and Uruguay. Additionally, he participated in non-academic venues, such as maker spaces and cultural houses, as part of Sidereus Nuncius efforts to engage the public in science and technology. In the Fall of 2020, Sebastian was awarded the AGBIOFEWs Fellowship, a National Science Foundation (NSF) graduate training program that allowed him to pursue his PhD in Forestry and Environmental Resources with a graduate minor in Genetic Engineering and Society at North Carolina State University. His research interests focus on Crop Data Governance, Andean Food Systems and Regulatory Regimes. He also was awarded the Laarman International Gift Fund Grant at North Carolina State University in 2022, and was awarded the 2024 SEEKCommons Fellowship, a collaboration between partners at the University of Notre Dame, the Open Environmental Data Project, and the HDF Group.

Sebastian will return to Peru to work in community-based conservation, and its intersection with data practices, and cultural markets in the Andean region.

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INTRODUCTION

Agriculture is arguably the primary driver of diversity loss on the planet. However, the protection of agricultural diversity has not received as much attention as other topics that are as important for conservation. Subsistence farmers and conservation experts strive to safeguard species of plants that are key to biodiversity protection and of which nutritional value contributes to diet diversity. Andean potatoes for example, have diversity and nutritional qualities that made them the basis of subsistence farming in South America (De Haan, 2019). Potatoes are grown in the Andes of Peru (Yin 2016) and are intimately connected with Andean culture and food ways. Farmers, scientists, extensionists, agronomists and other experts are involved in joint efforts to safeguard potato germplasm in situ (in fields) and ex situ (externally, in gene banks). Due to the diversity of the actors involved in farming and conservation, there is an urgent need to assess the challenges of integrating scientific and local knowledge, as well as working across different communities with different notions of what potato conservation means.

The International Potato Center (CIP in Spanish) has been working alongside custodian farmers to increase potato agrobiodiversity conservation efforts in situ and ex situ. Founded in 1971 as a research-for-development center (CIP website), CIP is considered an important organization for conducting reintroduction of potato varieties that are in danger of disappearing or that are no longer available (Westengen et al 2018). CIP has collected large amounts of data over the years to be used by scientists, extensionists and policy decision makers. CIP's reintroduction activities, undertaken through "repatriation agreements", aim to return what was collected years ago due to environmental and social factors. Since 1997, 89 farming communities received over 6000

samples of cultivated potato from CIP's germplasm bank, comprising almost 30% of CIPs collection of native landraces (Gomez 2019).

Successful repatriation agreements are described as models to be implemented elsewhere. The Potato Park (2004) is the most successful and well-documented example. Potato conservation became the focal point of this repatriation agreement, which brought rural farmers and experts together in collaborative efforts to reintroduce local varieties of native potatoes to the Potato Park communities. Even though there are similar repatriation initiatives in Latin America, this one received an important amount of international attention (Potato Park et al. 2004 quoted in Westengen et al. 2018). The rights of the farming communities that had originally contributed to the development and maintenance of agricultural biodiversity were emphasized granting them access to seeds, associated technology, and knowledge (Westengen et al 2018). The Potato Park is also considered an indigenous biocultural heritage (Argumedo 2008 quoted in Westengen et al. 2018).

One of the challenges of CIP's conservation programs is the integration of in situ strategies (led by farmers) and ex situ conservation (in germplasm banks). The dynamic conservation of genetic resources is a model developed by CIP to reconcile ex-situ (in the lab) and in-situ (in the fields) conservation strategies (Lüttringhaus et al 2021). Dynamic conservation is often portrayed as a frictionless process, in which potato farmers and scientists understand each other's needs, values, and expectations. However, this approach fails to acknowledge the tensions that emerge between the diversity of actors involved in CIPs conservation activities. Nevertheless, this model provides

opportunities to nurture convivial relationships (Büscher & Fletcher 2019) rooted in respect for indigenous people lands, knowledge, and traditions.

Previous studies highlight the custodian farmers' roles in repatriation negotiations (Hernandez & Cavero 2013, Grey 2011). However, none of those studies paid enough attention to the ways in which potato germplasm travels from the field to the lab and back again. Moreover, the insights of those studies could not be useful to understand conservation initiatives conducted after the Potato Park experience in 2004. Since 2015, CIP has partnered with AGUAPAN, a farmer-led association with members from nine regions of Peru. CIP fosters AGUAPAN growth through Grupo YANAPAI, a Peruvian NGO that works with rural farmers. Grupo YANAPAI updates AGUAPAN's website portal and social media, co-writes its financial reports, and enforces its code of conduct. Due to social factors such as age, education level, and technology literacy, AGUAPAN members struggle to keep up with technology and marketing strategies.

Seeking to integrate AGUAPAN into potato value chains and to fill the gaps in the germplasm collection, CIP developed a platform called Wikipapa. This platform pulls data from Varscout, an app designed to “record the location of where a particular crop variety is growing” (Varscout website). Extensionists used this tool while conducting conservation work (monitoreo in situ in Spanish) in different regions of the Andes. CIP aims to build a robust database of potato species found in potato fields. Data gaps will be closed as new species are identified and uploaded to the platform. Wikipapa manages popular taxonomies and nutritional, gastronomic, and agronomic information. CIP seeks to represent AGUAPAN by incorporating biographies and testimonies of its members to Wikipapa. Nevertheless, Wikipapa provides a catalog catered to urban markets.

Wikipapa, as a data infrastructure, contributes to the commercialization of potato biodiversity in Peru (Wikipapa website).

Through an ethnographic analysis of research facilities, food fairs, book presentations, meetings with farmers, and interviews with scientists, extensionists, farmers, rural entrepreneurs, and app developers, this project aims to make sense of the multiple interests mobilized as part of CIP's dynamic conservation program. When extension workers collect, curate and upload data, they facilitate data dissemination. Curators face a similar challenge when they "fill the gaps" in CIP's germplasm bank since they determine what counts as data for research. On the other hand, when CIP hosts heritage-making events such as food fairs, it rebrands potatoes as "vernacular" food for urban consumers. All these activities show the complexities of the interests at play when agrobiodiversity conservation overlaps with scientific, gastronomic, and sustainable development agendas.

These emerging challenges require a multi-sited approach to qualitative research, paying close attention to data justice (Taylor 2017), authoritative knowledge (Gluckman et al 2021 Mathews 2011), rural farmers disenfranchisement (Graddy 2014, Fan 2013, Matta 2021), scalability, and co-dependence between project managers and farming communities (Hernandez & Caverro 2013) inform CIP conservation program.

CHAPTER 1: CARE AND SECURITY IN DYNAMIC COLLECTIONS OF ANDEAN CROPS AT THE INTERNATIONAL POTATO CENTER

1.1 Introduction

Upon entering the reception area of the International Potato Center (CIP), visitors are greeted by a vivid visual showcase of the institution's efforts in preserving Andean agrobiodiversity. This space is adorned with research posters and displays of Andean crops such as labeled potatoes, maca, and yacon, emphasizing the global scale and complexity of agrobiodiversity conservation efforts. These visual representations highlight the interdisciplinary nature of CIP's conservation research, which addresses both the economic and cultural significance of agricultural diversity. Furthermore, they illustrate the interconnected networks of production, distribution, and consumption that shape Andean seed and food systems, underscoring the intricate web of factors involved in maintaining agrobiodiversity.

The engaging displays in CIP's reception area serve to educate visitors about the institution's roles in conservation science, innovation, value chain development, and agriculture. By making its work accessible and comprehensible to the public, CIP bridges the gap between scientific research and societal impact. Through guided tours and expert interactions, visitors learn about the origins and medicinal properties of various potato varieties, gaining insight into how CIP's scientific goals align with broader social objectives like food security and compliance with the legislation that governs the distribution of plant genetic materials. The institution's advocacy for the recognition and promotion of local agrobiodiversity, despite the exclusion of certain crops from international regulations, highlights CIP's efforts to balance care and security concerns

within its conservation and public engagement strategies. Routine care and security, in the case of CIP's genebank, constitutes an institutional practice that allows CIP scientists and technicians to transform crops into accessions, which can be seen as reliable, dynamic and safely transportable scientific data. Security concerns, such as spreading viruses and bacteria through CGIAR's network and the protocols put in place to mitigate those concerns, can be studied through the lens of care. Broadly, routine care examines how mundane, repetitive, and unobtrusive acts of scientific practice are imbued with subjectivity and value judgments (Mol 2011, Muller and Kenney 2014). Care can also be extended outside CIP's genebank, in the sense that caring for vulnerable populations such as rural farmers align with the goal of CIP, as part of the CGIAR network.

CIP provides plant genetic material to regions located in Asia, Africa, Latin America, and the Caribbean. CIP is part of the CGIAR network, a global partnership of research centers that focus on research on subsistence crops such as corn, rice, and sweet potato. Gene banks, such as the one managed by CIP in Peru, are part of local, regional, and global networks of stakeholders such as farmer organizations, researchers, policymakers, and private organizations. These networks facilitate gene bank-farmer interactions and provide ecosystem services, such as monitoring agrobiodiversity loss. Proponents of agricultural research view these networks as seed systems, understood as the "actors, activities, and institutions involved in the maintenance of crop diversity, plant breeding and selection, seed production and dissemination (Louwaars and de Boef 2012). Andean potato seed systems are often characterized as "informal" (Thiele 1999, Arce et al 2018), in contrast with "formal" seed systems regulated by the public sector via certification to ensure healthy seeds. Even though the literature shows that there are many

linkages between “formal” and “informal” systems (Almekinders and Louwaars 2002), this distinction can reinforce misconceptions such as that “informal” systems are not rule governed or that seed only circulates at limited geographical scales (Westengen 2023). This signals an underlying tension between ex situ and in situ conservation strategies, since ex situ conservation is considered part of the “formal” system.

One of the paradigms of CIP’s gene bank work is that the interaction between in situ (led by farmers) and ex situ (in gene banks) conservation strategies is highly dynamic. This is often regarded as CIP’s dynamic conservation model (Gomez 2019) and guides CIP’s vision and mission as a research center that seeks to deliver sustainable solutions to hunger, poverty, and natural resource degradation. Dynamic conservation has its roots in the circular model of genetic resources (Berthaud 1997), where in situ and ex situ conservation strategies are considered complementary. This model focuses on a cycle of germplasm exchange where “both use and conservation occur” (Berthaud 1997). Gene banks play an important role in conservation of cultivars since they facilitate the reintroduction of plant materials to local communities. At the same time, gene banks make genetic materials (often called genetic resources) available to researchers, students, and breeders globally. Plant material global distribution is a key feature of CIP’s gene bank routine activities.

While CIP’s dynamic conservation model acknowledges the circulation of plant materials, it fails to grasp the politics of plant data linkages (Leonelli and Williamson 2023, Leonelli 2016). This implies not only assessing the economic and legal implications of repatriation agreements outside CIP facilities (Lüttringhaus et al 2021), but also understanding how guiding metaphors

for biodiversity, such as care and security, have shaped conservation strategies within institutions and programs (Curry 2022, Chacko & Bangham 2023). Repatriation refers to the process of returning plant genetic material, such as seeds, to their community of origin. Previous studies have examined the challenges of CIP repatriation agreements (Lüttringhaus 2021) and the co-creative process of community engagement of repatriation, which in addition to returning seeds to farmers, highlights concepts from indigenous communities from the Americas like “Madre Tierra” (Mother Earth) and Pachamama (Ocampo Giraldo et al 2020).

This chapter will focus on how CIP’s collection is preserved, how plant materials and data are distributed and cared for, as well as which CIP’s protocols aim to guarantee security, such as phytosanitary strategies and safety duplication management. By paying attention to how care and security are mobilized through the seed systems, it is possible to understand the politics of dynamic conservation, as well as the infrastructures that are maintained by care labor within CIP. My main driving question is: How do care and security intertwine as plant materials circulate within and beyond the CIP-CGIAR network?

Care and security matter because they not only act as guiding metaphors for crop diversity (Curry 2022) within the lab but also operate beyond the CIP-CGIAR network. By asserting that genetic agrobiodiversity conservation can be studied through the lens of care and security in science, I argue that as plant materials circulate within and beyond the CIP-CGIAR network, limits to care-security work emerge as genetic materials travel from and to CIP’s genebank, across 'formal' and 'informal' seed systems. These limits show how the underlying tensions between those systems generate social, epistemic, and regulatory divides. Understanding how

care and security intertwine is crucial because it reveals the complexities and challenges of integrating ex situ and in situ conservation strategies. It also highlights the differing expectations and needs of rural communities regarding the utility of reintroduced materials. CIP's dynamic conservation model, which is based on the distribution of materials to rural communities across multiple geographies, fails to understand why some of those communities may have different expectations about the utility of reintroduced materials. This failure underscores the importance of integrating care and security considerations to bridge the gaps between different seed systems and address the diverse needs of communities.

This chapter explores the dynamic landscape of agrobiodiversity conservation at CIP. Grounded in theoretical frameworks that highlight the evolution of seed conservation strategies, it examines how CIP navigates complexities such as security, care practices, and the challenges of pathogen control in its genebank operations. Methodologically, the chapter expands the notion of the laboratory to encompass interactions within epistemic communities like the Andean Initiative and Social and Nutrition Science Department, emphasizing boundary work, performativity of scientific identity, and the rhythms of daily lab operations. Results reveal CIP's meticulous management of plant genetic materials to ensure purity and security, alongside efforts to foster affective ties through curatorial expertise and community engagement. By detailing the complexities of safety duplication, virus elimination protocols, and the adoption of innovative conservation strategies like cryopreservation, this chapter illuminates CIP's pivotal role in global agricultural biodiversity preservation and its broader impact as a hub for collaborative research and development in the agricultural sector.

1.2 Research for Development Strategy at CIP

To better understand CIP's dynamic model and its main goal, which is to integrate ex situ and in situ conservation strategies, it's important to examine how it became part of the CGIAR network. One milestone in that process is the institutionalization of previous potato collections before CIP was founded, as well as expeditions conducted by scientists to collect samples across the Andes and beyond to fill the gaps of the emerging collection. This shows how care and security started to intertwine as the collection became global and as international stakeholders got involved in the Andes and Latin America.

Carlos Ochoa's instrumental role in the formation of ex situ potato collections in Peru and beyond demonstrates how ex situ conservation became an institutional practice at CIP. Regarded as the "Indiana Jones of the potato," Ochoa spent over 40 years traveling across the Andes, collecting and studying various potato varieties (Ringle, 1992). In the 1950s, with the support of the Rockefeller Foundation (RF), he initiated the National Germplasm Collection in Peru (Scott 2011). He also founded the National Potato Program (Society for Economic Botany, 1998). Self-funded until CIP's establishment in 1971, Ochoa launched the Potato Research Program at the National Agrarian University (UNALM) as well as UNALM's germplasm bank that contained potato collections from expeditions in Peru (Scott 2011). One of his key contributions to ex situ conservation was the formation of the World Potato Germplasm Collection maintained at CIP (Society for Economic Botany, 1998).

After centralizing potato collections in CIP's Gene Bank, CIP's global presence expanded, particularly in Africa, Asia, and Latin America. CIP is part of the CGIAR network, a global

partnership of research centers like the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CYMMYT). CGIAR's work focuses on multidisciplinary research on specific commodity crops and ecoregions, aiming to reduce hunger (Byerlee & Lynam 2020). By centralizing germplasm collections, CGIAR's network centers sought to create efficiencies through economies of scale and scope (Byerlee & Lynam 2020), generating efficiencies and spillovers through applied research networks that freely shared materials and knowledge. Beyond research and capacity building, CGIAR's centers aimed to reduce political and bureaucratic interference in science and secure long-term funding through foreign assistance and philanthropic organizations (Byerlee & Lynam 2020). Thus, the overall goal of germplasm centralization at these centers was a security matter, in terms of food security and priority on the economic value of staple crops.

Today, CIP is recognized as the largest in vitro gene bank in the world, housing one of the most extensive herbarium collections and prominent plant cryopreservation programs (CIP Genebank website). CIP's collection management presents challenges as it grows in scale and societal impact, including in situ conservation and engagement with Andean farmers. Unlike other gene banks, CIP's collection is mostly clonal, requiring constant care and protection (Vollmer et al 2022). Caring for clonal crops involves intricate protocols and technologies, unlike the relatively simpler process of seed conservation. CIP scientists acknowledge the complexity of their work as the collection grows.

CIP's gene bank operates within a global collaborative network of genebanks (Engels et al 2024), working alongside national research agencies like the National Institute of Agrarian Innovation

(INIA) in Peru (CIP 2018). Collaborations with public and private organizations underscore a cooperative approach to genetic resource management. Despite efforts to facilitate access to plant genetic material, bureaucratic issues and budgetary constraints have limited these endeavors (Ebert et al 2023, Curry 2023). Concerns about the long-term security of CIP's collection, alongside advancements like cryopreservation technology, reflect ongoing efforts to adapt and improve gene bank practices (Vollmer et al 2022).

Another aspect of CIP's agenda is its focus on the social aspects of international agricultural research. Since its creation in 1971, CIP has been conceived as a research-for-development center (Sawyer 1971). Research for development centers are institutions focused on conducting research aimed at addressing specific development challenges, particularly in low- and middle-income countries (CIP 2021). With the arrival of the Sustainable Development Goals (SDGs) in 2012 (UN General Assembly 2012), CIP adapted its organizational structure to address goals such as reducing poverty and hunger, particularly in Africa (CIP 2019). To fulfill those goals, CIP mediates between the policy, regulatory and social dimensions of international agriculture. This mediation is generally defined as boundary work defined as the “interface between science and policy” (Clark et al 2016) and the “activities of those seeking to mediate between knowledge and action” (Clark et al 2016). However, tensions emerge at the interface between communities with different views of what constitute useful knowledge such as indigenous communities and scientists, as well as with value chain development and niche cultural markets, both strategies pursued by CIP in recent years.

Paradigms such as modernization, agrobiodiversity loss, and sustainable development shaped the international center model for agriculture research (IARC), becoming narratives disseminated by scientists, government officials, funding agencies, extension workers, and NGOs. Jennings (1988) noted that the Rockefeller Foundation (RF) focus on seeds, plants, pathogens, and yield masked the political elements of its activities such as funding local scientists to “emulate the standards and practices devised by the Foundation personnel” (Jennings 1988), displacing Indigenous voices and knowledge systems. Shepherd suggests that RF's suppression of Andean traditions was meant to appear scientifically neutral. The RF, in partnership with the Ford Foundation, played a key role in designing the IARCs (Byerlee & Lynam 2020). According to Shepherd (2005), RF's projects in Latin America aligned with U.S. political interests, using agricultural modernization to create food surpluses to feed urban populations and prevent unrest (Brooks 2011).

As international aid diminished in Latin America (Castells-Quintana and Larru 2015), CIP has had fewer resources for its activities (Fuglie and Thiele 2009). Reduction in funds coincided with the fragmentation of Participatory Research (PR) into independent localized initiatives (Thiele et al 2001). However, this changed with the implementation of participatory market chain analysis (PMCA) in 2000 that focused on improving smallholders' access to markets, especially for farmers cultivating potatoes (Ortiz et al 2020). As a result, CIP nowadays has a positive image due to its work with potato value chain stakeholders, policymakers, and farmers over many decades. CIP's Social and Nutritional Science Department has played a pivotal role in promoting the Andean potato value chain via public and private partnerships (Ordinola et al 2014). Recently, CIP's Andean Initiative sought to promote agrobiodiversity commercialization and

consumption, by facilitating collaborative science with emphasis on gender, indigenous people, youth, big data and digital solutions (CIP 2020).

1.3 Security, Care and Data Travel

The dynamic interplay between care work, security protocols, and data journeys constitute the core of CIP's genebank ex situ conservation practices. The literature on securitization of agrobiodiversity conservation, care in scientific labor, and the implications of plant data circulation, allows us to better understand the complexities and challenges faced by CIP. This approach not only highlights the relevance of safety duplication and pathogen therapy but also points out to the essential, yet often overlooked, role of curatorial expertise. By appreciating the nuanced contributions of care work and the importance of data linkages for plant data governance (Leonelli & Williamson 2023), this framework takes seriously different views of plant data use and how they relate to justice and equality.

In contrast with previous authors that often treat care and security as separate metaphors for seed banking, I propose to intertwine them to better reflect the dynamic nature of CIP's model of conservation. Thus, care-security work, in this project aims to show the limits and boundaries of care-security institutional practices within and beyond CIP-CGIAR network. Following Kleinman (1998), I am interested in the ways in which the institutional context in which CIP's genebank is situated shapes the care-security practices within and beyond CIP. This implies paying attention to how the limits and boundaries of care-security work emerge as plant materials travel to and from CIP's facilities, as well as how synergies and tensions between seed systems actors emerge and dissipate. I am expanding the notion of dynamic conservation, by

challenging the current conceptual divide between “formal” and “informal” seed systems. By making the limits of care-security work explicit, I will address the scarce attention that STS scholars have paid so far to care and security in genebanking practices that extend beyond the lab.

Cleaning is an important task for CIP scientists and technicians, in the sense that it’s at the core of their approach to ex situ protocols for distribution of plant data materials. It is also a way to guarantee safe materials, prioritizing security. Based on Douglas purity-impurity model, I argue that cleaning seeds can be associated with notions of purity and impurity in conservation science. Impurity signals disorder and gives rise to anxieties, a diffuse sense of danger (Ditlevsen et al 2021). Impure objects are categorized as dirty and dangerous (Douglas 2002). According to Douglas, pollution is a form of impurity, that can be defined as dirt “transgressing borders”; and the notion of dirt is dominated by shared knowledge of pathogenic organisms and bacterial transmissions (Ditlevsen et al 2021). In the context of my research, I am interested in exploring how the circulation of impure objects relates to the anxieties about spreading impure materials that could threaten CIP’s reputation among its partners and clients. I follow Ditlevsen et al 2021, approach to the dangers of spreading material dirt. In the context of the CIP-CGIAR network it means how anxieties about spreading viruses and bacteria inform how different protocols, data bases, and monitoring systems (e.g. labeling) are put in motion. Those systems are designed to contain impurity and justify the reliability of ex situ conservation technological infrastructures.

In the context of long-term ex situ conservation practices, Curry (2022) shows how changing notions of security, linked to economic, political and technological situations, transformed both

the guiding metaphors and the practices of seed conservation. As she mentions, early long-term cold storage facilities imbued security in robust infrastructures and the capacities of professional staff of such organizations. Social anxieties about security concerns (e.g., spreading viruses and bacteria through CGIAR's network) are intertwined with concerns about caring for long term preservation of CIP's collection. Care work here refers to human and non-human relations, such as CIP curators' knowledge and relationship with potatoes and Andean Roots and Tubers (ARTCs), a larger set of crops that include oca, ulluco, mashua, achira, yacon, arracacha, ahupa, maca and mauka. Potatoes are cleaned to guarantee security so they can be cared for in CIP genebank. Without care, security protocols don't make much sense because the collection will not be able to be kept alive, free of pathogens and distributed, all goals of ex situ conservation. In my project, curators at CIP focus on care and security at the same time, to guarantee efficient and safe dissemination of plant data materials. This is expected due to their role as gate keepers of CIP's genebank, and their close interaction other departments such as the In Vitro Collection and Phytosanitary. However, other departments, such as Distribution & Acquisition as well as Safety Duplication prioritize security, since they focus on facilitating the distribution of CIP accessions through the CGIAR network.

STS scholars and sociologists of labor have studied care as a fundamental component of human-human relations of support (Claassen 2011; Hochschild 2003; Kittay 2011; Tronto 1993; Yates-Doerr 2012) and human-nonhuman relations (Friese 2013; Martin, Myers, and Viseu 2015; Mol, Moser, and Pols 2015; Schuurman and Pratt 2002; Viseu 2015). Care brings to the foreground the role of curators who tend to remain invisible in science. STS scholars drew from feminist scholars who use the concept "invisible work", usually used to study women's unpaid domestic,

reproductive, and volunteer labor (Bangham et al 2022). Leonelli (2016) and Nadim (2021) highlight the importance of curators as having a key role in making data travel. Curators are “packaging experts”, since their knowledge, skills, and expertise in bridging between the original context of data production and that of dissemination requires training and subjective judgment (Leonelli 2016). Their extensive knowledge allows them to “recognize and respect the diversity characterizing different epistemic cultures and associated terminologies, norms, and methods” (Leonelli 2016). Further, Leonelli suggests that curators can decide on “what counts as relevant data for any specific research project”. Nadim mentions that curators can identify the bottlenecks in taxonomy, aiding data-driven discovery by identifying the “often non-existent connection between molecular (genetic) data and the published species names” (Nadim 2021). While performing taxonomic work, data curators can detect gaps in the database such as invalid or duplicate species names. Renowned CIP curators are experts in various fields such as botany, taxonomy, genetics, ecology, and geography. Curators provide reliable advice on safeguarding CIP’s collection.

Curators “package data for travel” (Leonelli 2016), allowing plant materials and associated data to circulate within and beyond the CGIAR network. Leonelli defines this movement of data as plant data journeys: “the material, social, and institutional circumstances by which data are packaged and transported across research situations so as to function as evidence for a variety of knowledge claims” (Leonelli 2016). Broadly, Leonelli defines this concept as the “movement of data from their production site to many other sites in which they are processed, mobilized and re-purposed” (Leonelli 2020). For this author, sites include “temporal locations and diverse viewpoints” (Leonelli 2020), such as genebanks, potato fields and dynamic conservation

strategies such as the ones proposed by CIP. Moreover, Leonelli claims that data needs to be decontextualized to travel, which means it needs to be stripped off contextual meaning such as cultural and social attachments to it. However, in the context of agrobiodiversity conservation in Peru, curators are deeply entangled with the heritage of Andean crops. Thus, based on Ange's work on non-human charisma and potato agency (Ange 2018), I challenge Leonelli's claim by paying attention to the ways in which curatorial work is imbued by affect practices that seek to respect local knowledge in instances where it is supposed to be decontextualized.

1.4 Methodology: Extended Lab Ethnography

The methods used in this chapter focus on lab ethnographic methods, expanding the idea of the lab to the analysis of meetings and conversations about what happens in the lab, as well as interactions with related epistemic communities, such as Andean Initiative and CIP Social and Nutrition Science Department. Proponents of the notion of expanded laboratory (Latour 1983, Latour & Woolgar 1979, Stephens & Lewis 2017) as well as scholars who view laboratories as sites of intervention (Gjefsen & Fisher 2014) suggest that lab scientific work extends beyond the lab and involves a network of actors whose interactions contribute to the production of scientific knowledge. More importantly, these frameworks allowed me to pay attention to interactions in terms of:

- Boundary work in science: the process of demarcation between science and non-science, including how scientists produce and manage collaborative products or boundary objects, such as reports, models, maps or standards (Star & Griesemer 1989, Gieryn 1983)

- Performative display of identity: repeatedly performing of acts in accordance with the cultural norms of science, such as strengthening objectivity and credibility of research (Cameron 2006, Hyland 2012).
- Rhythms of day-to-day lab work: the temporal organization of lab work, the division of labor among team members, and the role of institutional norms and policies in shaping daily routines (Barley 1996, Stephens & Lewis 2017).

To account for the circulation, care, and securitization of Andean crops germplasm, I examine the politics of dynamic biodiversity conservation at CIP. By paying attention to how care and security are mobilized through seed systems, this method reveals the performative dimension of boundary work at CIP's genebank, shaped by the rhythms of everyday activities designed to preserve and make its collection ready for travel. As an effort to make visible care work and ex situ protocols, I explore how care and security shape everyday conservation tasks. Particularly, I focus my attention on curation, safety duplication, pathogen and virus elimination protocols in the following departments:

- Acquisition & Distribution: The CIP genebank provides in vitro plantlets or small seed packets, particularly of wild species, to organizations involved in research, breeding, or training. Germplasm that has been verified to be virus-free can be shipped internationally, provided requestors furnish an import permit outlining the conditions for importing germplasm from Peru.
- In Vitro Potato & ARTCs Collection: CIP's genebank has expertise in developing and applying technologies for conservation, pathogen elimination and cryopreservation. The

goal of the department is to make these materials available for distribution and use. All the materials held in the CIP's in vitro genebank are the primary source of germplasm for most genebank activities.

- **Cultivated & Wild Potato Germplasm Collection:** CIP's cultivated potato collection consists of cultivars sourced from 17 nations, including enhanced varieties. These are maintained through in vitro preservation methods and disseminated as tissue-cultured materials. CIP houses one of the most comprehensive collections of wild potato species, encompassing 140 varieties stored as botanical seeds for extended-term conservation.
- **Phytosanitary Department:** This department oversees disease management in CIP's potato, sweet potato and ARTCs collection, emphasizing the preservation of plant health. Currently, a significant portion, 95% for potato and 91% for sweet potato, of the in vitro collections is confirmed to be free from critical pathogens like viruses, bacteria, and fungi. While diseases and their detection methods are thoroughly understood for potato and sweet potato, there's a lack of information regarding diseases affecting ARTC.
- **Safety & Backup Department:** CIP manages a total of 17,618 accessions comprising potato, sweet potato, and ARTCs germplasm in Huancayo, Peru, while duplicate collections are securely maintained at institutions such as EMBRAPA in Brazil, CIAT in Colombia, and Svalbard in Norway.

1.4.1 Methods

This project was approved by North Carolina State University IRB office, # 24908, in June 2022 and renewed in January 2023, to work with vulnerable populations such as indigenous peoples, elder populations, as well as CIP employees. I conducted 10 semi structured interviews with these

departments' heads, as well as spent five months conducting participant observation at CIP's genebank facilities from February to June 2023, in Lima and Huancayo. This involved spending time inside CIP's facilities and asking the staff about their activities and how they connect with other CIP departments. Additionally, and based on the extended lab ethnography approach to qualitative research (Stephens & Lewis 2017), I interviewed 6 members of CIP's Social and Nutrition Science department and participated in five virtual meetings with CIP's Andean Initiative, a group that specifically focuses on interdisciplinary work on agrobiodiversity conservation outside the lab, that included CIP's gene bank experts. Due to the pandemic, restrictions were implemented and access to CIP's facilities was challenging to navigate, as bureaucratic procedures needed to be followed every time I arrived at CIP.

Based on the principles of grounded theory research that focus on a process of joint data collection and constant comparison (Charmaz 2014), I developed analytical memos and examined the relationships between the following categories: ex situ, repatriation, safety duplication, curation & care, security, local potato names, pathogen and virus elimination, community engagement, distribution and circulation of accessions. These categories were used as codes to analyze the interviews as well as my fieldnotes, and then to group them in broader themes, such as care work, networks of genetic resources, cleaning and purity, dynamic conservation, and data journeys. I used the open software Taguette for qualitative analysis to identify patterns in the data to better understand boundary work, performativity and day to day lab work routines at CIP.

1.5 Security in Phytosanitary Protocols and Safety Duplication

Even though care and security are integral parts of CIP's conservation strategies, specific departments tend to prioritize one over the other. For example, CIP's phytosanitary and safety duplication departments focus more on security than care due to their constant interaction with institutions and research within the CIP-CGIAR network. These routine activities require that plant materials preserved at the genebank be ready for distribution to other facilities for research, agriculture, breeding, repatriation, commercial, or educational purposes. Security is closely tied to international regulations and stakeholders expect to prevent the spread of diseases, particularly among clonal crops. Despite rigorous protocols and innovative treatments, such as heat therapy aimed at ensuring pathogen-free materials, the task of guaranteeing complete disease eradication remains daunting. Moreover, the practice of safety duplication, while essential for mitigating risks of loss due to natural disasters or geopolitical instability, introduces complex logistical and administrative challenges. These complexities underscore the ongoing struggle to maintain the long-term preservation of genetic resources within CIP's genebank.

1.5.1 Phytosanitary Protocols and Disease Management

One of the main concerns for CIP leadership and senior scientists is avoiding the global spread of diseases, as sharing genetic materials is one of their primary activities. Diseases can devastate crops and ecosystems, so maintaining the health of genetic material is paramount. However, achieving complete disease freedom is a significant challenge due to the inherent susceptibility of clonal crops to pathogens and resistance to certain cleaning treatments. As a global hub for agricultural research and international collaboration, CIP is deeply committed to facilitating access to the genetic materials preserved in the genebank. This commitment necessitates

stringent measures to ensure the genetic integrity and health of the materials, reflecting CIP's responsibility towards global agricultural stakeholders.

Clonal crops, such as Andean potatoes and ARTCs, require ongoing maintenance through tissue culture and regeneration to prevent genetic degradation and disease susceptibility. Clonal crops are prone to accumulating diseases over time, making regular maintenance essential. CIP scientists' meticulous approach to *ex situ* genetic conservation is reflected in their dedication to ensuring the cleanliness of the plant material. Consequently, strict protocols are in place to mitigate the risk of inadvertently spreading diseases. These protocols include routine testing, quarantine measures, and careful handling to maintain high standards of phytosanitary safety, which are crucial for the safe global exchange of plant genetic resources. This meticulous approach ensures the long-term viability and health of the conserved materials. However, it is important to acknowledge that despite these rigorous measures, complete eradication of all pathogens is not always possible.

First, it is necessary to examine how similar notions of cleanliness are shared within the CIP-CGIAR network. This is important because not all materials undergo similar cleaning treatments, especially those that are difficult to clean even though they have gone through multiple rounds of treatments. The emphasis on phytosanitary security, measurable scientifically, operates as an institutional mandate of the CIP-CGIAR network. This institutional focus on cleanliness involves significant resource allocation, including the implementation of data infrastructures like labeling systems and quarantine protocols, to ensure CIP's reputation as a reliable center providing safe,

clean plant materials. This shared understanding of cleanliness underscores the importance of maintaining high standards to prevent the spread of diseases.

These efforts are critical for maintaining the trust and reliability of CIP as a leading institution in agricultural research. As long as CIP meticulously complies with cleaning protocols, it remains a reliable research center within the CIP-CGIAR network. The department's main task is to deliver pathogen-free material to the in vitro bank as well as for distribution to national and international partners, ensuring it is free from bacteria and fungi, thereby guaranteeing its safety. This process involves rigorous testing and validation processes to ensure the health and viability of the plant materials before they are shared or stored. To achieve this, three objectives must be met: freedom from pathogens, verified identity, and international support. However, not all plant materials are exchanged, because some of them cannot be completely cleaned, such as the ARTCs:

“So, for the Andean Roots and Tubers, we started some projects doing deep sequencing to identify what kind of pathogens they might have so we can guarantee that they are cleaned and that we can share with the world without any bad consequences to anyone. So that's one of the reasons why we do not share the clonal material of Andean roots and tubers with other countries because we cannot guarantee that they are free of diseases”
(Interview with CIP scientist, February 6, 2023).

For virus elimination, materials undergo initial testing, including serological and molecular diagnostics, as well as greenhouse assays. These tests are essential to detect any hidden pathogens that could threaten the health of the collection. While in post-entry quarantine, these

materials are assigned “HS0” status, indicating they are under observation. If virus-free, they proceed to the in vitro bank with “HS2” status, signifying they are safe for long-term storage. Positive cases undergo virus elimination therapy, beginning with heat treatment for potatoes at 34 degrees Celsius for approximately a month. After this treatment, the meristems are extracted, regenerated, and subjected to further diagnostics. If the results are negative, the material is deemed virus-free and can be stored in the bank with HS2 status.

To better illustrate meristem extraction, I detail how this process unfolds in practice:

“When extracting the meristem, a clean blade is always used to avoid contamination. This is key because all tissues may potentially harbor viruses, including the sap and secretions of those materials. After removing the leaf primordia, which contain these viral particles, the blade is likely contaminated, necessitating frequent changes to prevent infections. In the case of potatoes, once the meristems are extracted using specialized equipment, they are transferred to a meristem culture medium. This medium needs to be refreshed regularly to support healthy growth and ensure the continued absence of pathogens. Converting these meristems into full-fledged plants, known as lines, can take two to three months for potatoes and up to six months for sweet potatoes due to their complex nature. This careful and precise process underscores the importance of maintaining pathogen-free plant material”. (Interview with CIP scientist, February 13, 2023)

Treatments for virus elimination are regarded as therapeutic interventions, each emphasizing distinct methodologies: heat therapy, electrotherapy, and chemotherapy, with heat therapy emerging as the predominant approach, particularly in potato cultivation. CIP experts are actively engaged in efforts to standardize treatment protocols for combating viruses in these crops, with aspirations to disseminate their findings through academic publications. Heat treatment stands out for its efficacy in reducing viral load, ensuring the meristem remains uncontaminated, thereby facilitating the exchange of virus-free plant materials. Alternative methods, such as meristem culture without heat treatment or the application of antiviral agents like ribavirin, exhibit lower success rates compared to heat therapy.

CIP staff emphasize that tolerance to therapies is influenced by the inherent characteristics of Andean crops, categorized as either docile or noble. These are colloquial categories used by the staff to make sense of materials that undergo standardized procedures (e.g. potatoes) or require special attention. Potatoes, classified as more docile, are contrasted with ARTCs in this regard. Crops that resist these therapies require more attention and resources to develop standardized methods for pathogen elimination. This variation underscores the need for customized approaches to cleanliness and pathogen control across different crop types. The ongoing research into therapeutic interventions highlights the potential for novel approaches to pathogen treatments that may better suit Andean crops, including ARTCs. Notions of purity and cleanliness vary among different crops, contingent upon their tolerance to these treatments.

Even though CIP cleaning treatments appear to be straightforward, it is important to recognize that there are still gray areas that require more research in terms of developing standardized tools

to maximize clean materials available for distribution. There is a constant need to update CIP's protocols to keep up with new pathogens, as well as to document research on new treatments that are not yet widely disseminated in the scientific community. In a way, most of the uncertainties regarding not been able to guarantee clean material all the time for all crops, stem from the fact that CIP's collection has increased in recent decades. As diverse crops have been introduced in CIP's facilities, there is a risk that treatments may become ineffective over time. Additionally, the staff recognizes that disinfection risks persist, such as when the material is moved from greenhouses to the in vitro collection, or when inexperienced technicians fail to properly disinfect their cleaning tools and their stations.

In sum, the care-security practices at CIP's genebank highlight the institutional and technical means to control the status of the plants. These practices involve recognizing the status of the materials, from paperwork to labeling systems, as a fundamental form of organization and institutional support. These data infrastructures help make plants readable and make visible the phytosanitary status of the plants. Following CIP's protocols ensures that the material remains free from pathogens, verified, and supported at the international level. Cleanliness, as a standardized process, is embedded in daily operations to secure CIP's mandate as a reliable source of safe plant materials for national and international partners. Despite CIP efforts, the complete eradication of all pathogens remains a challenging goal, underscoring the complexity of maintaining a disease-free genebank.

1.5.2 CIP's Safety Duplication and Backup Strategies

Another challenge to care-security work is the necessity to make copies of materials held in the CIP-CGIAR network. This practice supports preexisting networks of “formal” seed exchange and aligns with CIP-CGIAR institutional mandates of security and reliability. Historically, making and safeguarding copies seems to have produced only an “elusive sense of security” (Curry 2022), since it has offered temporary reassurances, that have put into question as further threats emerged, such as biopiracy. In a way, making copies or making backups of backups, raise questions about the infrastructures, resources, and the staff assigned to ex situ conservation. However, safety duplication alleviates the anxieties about agrobiodiversity loss and political turmoil, even during a pandemic. While safety duplication may be considered nonscientific, it has significant implications for scientific institutional goals.

CIP scientists I interviewed emphasized the importance of maintaining the integrity and accessibility of plant genetic resources within the genebank. To this end, they highlight safety duplication, where duplicate samples are stored in different locations to safeguard against loss. This practice is crucial for clonal crops like potatoes, sweet potatoes, and ARTCs, which are prone to degradation and require regular regeneration. Safety copies are stored not only in Peru, Brazil, and Colombia but also in the Svalbard Global Seed Vault in Norway. This partnership ensures global accessibility of genetic resources during local catastrophes, such as natural disasters or political conflicts. The case of ICARDA’s genebank, which recovered from the loss during the Aleppo conflict due to duplicates stored in Svalbard, underscores the importance of safety duplications. The COVID-19 pandemic’s impact on genebank operations further highlighted the need for sustainability and disaster preparedness. This relates to the idea of a

need to quell anxieties about biodiversity loss due to non-scientific events, as well as to avoid external events compromise the integrity of the collection. In a sense, reducing political events impacts implies reducing or managing scientific concerns about losing biodiversity.

The Safety Backup area is part of CIP's Administrative & Support Department, views its work as an administrative process. This view prevents CIP scientists from fully understanding how safety duplication impacts their work, such as the resources dedicated to distributing safety copies. For the administrative staff, their work is more about logistical coordination with CGIAR network research centers and partners rather than direct scientific involvement. This does not diminish the priority of safety duplication for the institution but signals its greater relevance to those familiar with genebank security implications. This department also ensures that other departments receive necessary supplies for routine activities, managing logistics for purchasing and optimizing time and cost. They oversee the technical support in procuring and reusing essential materials, ensuring proper washing and disinfection processes, and supplying reagents for culture media preparation.

As an administrative unit, the department's activities are considered routine tasks aligning with the CIP-CGIAR network's mandates to ensure plant materials follow protocols. The Safety Backup area manages both domestic and international backup copies, coordinating their distribution. Supervisors of each in vitro unit prepare materials for backup, while the Safety Backup staff consolidates and oversees their distribution, including evaluation and shipment scheduling. The department's goal is to support CIP genebank activities to run smoothly, ensuring no interruptions, especially in collaboration with international partners. It's important to

note that safety duplication is extending security through the network, thus fulfilling a social goal, which is to guarantee the security of the formal seed system.

Backup sites exemplify care-security work implementation across the CIP-CGIAR network. Since the genebank's inception, backups have been crucial due to Peru's vulnerability to natural disasters. The department maintains backups both domestically and internationally to recover the collection in Lima if lost due to unexpected events. CIP also stores seeds in Norway, and Huancayo in the Junin region serves as a key domestic backup location. Initial backups in Huancayo expanded through collaboration agreements, facilitating safety backups without direct costs to CIP. For example, CIP sends sweet potato materials to CIAT in Colombia, storing a copy at an institution that also stores sweet potatoes. This partnership, stemming from a longstanding CGIAR connection, underscores the priority of collaboration for CIP, as well as local partnerships for enhancing security.

Creating a copy of material is an institutional process validating the work of the Safety and Backup area. To consider an accession ready for copying, it must meet specific criteria and pass through various stages. This process occurs annually for potatoes and approximately every six months for sweet potatoes, based on their condition. Evaluations determine which accessions need renewal based on their viability. Regular evaluations and database updates help identify accessions requiring renewal, those no longer viable, and those never copied. Updates occur with each shipment, typically three times a year for local copies and twice a year for international ones, depending on the partner's capacity to receive and process the material. This schedule

shows how making copies requiring continuous work, and thus represents CIP institutional routine work.

Safety duplication within genebanks leverages existing networks of plant material exchange and distribution to ensure the integrity and accessibility of genetic resources. This priority in distribution transcends CIP facilities, nurturing partnerships. Collaborating with international partners and institutions within networks like CGIAR allows genebanks like CIP to establish backup copies in diverse locations. These partnerships facilitate plant material exchange and resource sharing, reducing individual genebank's burden while enhancing global seed conservation system resilience. This collective effort fosters the conservation and sustainable use of plant genetic resources globally. Securitizing Andean crops through copies and backup mechanisms reduces anxieties about biodiversity loss due to disasters or political turmoil.

1.6 Care in Cultivated and Wild Potato Collections

Care as in affective relationships between curators and crops, is similar to the way in which farmers interact with Andean crops. This is only possible due to the way in which senior curators have learned several skills, not only scientific, but also linguistic, such as learning to speak Quechua and facilitating workshops with farmers. However, with new generations of curators being scarce, this could pose challenges to CIP, as curation is a key activity in order to make a plant into an accession, meaning introducing them into the system. The care-security work then operates as an institutional challenge to train and retain staff, as well as developing lasting mechanisms to keep in place the knowledge accumulated by curators. In contrast with safety duplication, virus elimination and cryopreservation, curation aligns more with the dynamic

model and engages more with Andean seed systems, in terms of conducting workshops with rural farmers.

1.6.1 Curatorial Practices

Curators act as arbiters of agrobiodiversity, transforming crops into accessions that are incorporated through care-security work practices to CIP's genebank, such as identifying species' morphological traits. As I spent time with the senior curator, I had the opportunity to ask about his curatorial work in the cultivated potato collection. He told me that new acquisitions undergo a genetic analysis, as well as molecular and descriptive analysis. Based on the results, a decision is made whether the material is accepted into the collection usually with passport data, which is the metadata used to identify the origin as well as the location of the accession, among other descriptors such as the acquisition date and its biological status (improved cultivar or landrace). The senior curator added that in some cases there is gap in the passport data: "we don't know where they got it from, but it was delivered to us". These gaps in knowledge, and curators' skills and expertise in trying to close them shows how their decisions have implications for care-security work at CIP.

As arbiters of agrobiodiversity, CIP curators are situated at the first stage of the ex-situ conservation process, identifying each material that arrives at the genebank. This is part of the institutional mandate of the CIP-CGIAR network, as its curators facilitate traceability of such materials. When new plant materials are incorporated into CIP's collection, they are termed "original material" because it is material that has not existed before and is freshly collected. On the other hand, in research stations like Huancayo, where the material already exists and has an

accession number, it follows certain protocols. For example, if the collector is Carlos Ochoa, the plant will be labeled as Ochoa 2045, using the collector's initials (OCH) and a number.

Additionally, there's an institutional number provided by the institution, such as CIP 762045.

This ensures traceability and helps monitor any changes or mix-ups that may occur over time.

Regenerating the material and comparing it to the original helps ensure consistency and verify the accuracy of the collection process, guarding against potential human errors.

To avoid mischaracterizing species, curators avoid relying on one method for their tasks, recognizing that their decisions have implications for the CIP-CGIAR network and thus strive their best to make robust decisions. A fundamental aspect of curators' role is the meticulous identification and prevention of duplicate specimens. Despite efforts to avoid redundancy, instances of duplication may arise. Using morphological descriptions and biochemical methods, CIP curators verify the authenticity of each specimen, ensuring the integrity of the gene bank's collections. This is one of their main tasks, since their decision to accept or reject plant materials is the stage that defines the pathway that each accession will follow at CIP. This one of the reasons for their reliance in multiple methods to classify accessions. Curators avoid relying heavily on one classification method, but at the same time recognize the amount of knowledge required for making decisions. When it comes to conservation strategies, curators recognize the strengths and limitations of each of CIP's conservation strategies such as greenhouse cultivation and in vitro conservation. Curators emphasizes a holistic approach to conservation, ensuring the long-term safeguarding of cultivated potato genetic diversity.

Potato curators realize that while the tasks they handle may not be inherently difficult, they demand unwavering concentration. Discipline and commitment are valuable for curation at CIP, providing an additional element to routine care work. Many of these tasks are deemed repetitive, such as the meticulous storage and the “mechanized” processes of accession management.

Despite best efforts, errors can emerge at any stage of these procedures, leading to potential complications down the line. According to them, one of the most challenging aspects of their work is managing doubt. To overcome their doubts, curators rely on their formal and tacit knowledge about potatoes, displaying how they are deeply invested in the materiality of objects.

Even though they possess the skills to rectify mistakes, the mere existence of doubt can generate uncertainty in their work and potentially compromise the integrity of the collection. Doubt undermines the trust and reliability they aim to uphold in their work. To address this challenge, curators encourage immediate communication among their team members. Since curators are aware of the implications of their decisions, navigating uncertainty is another skill that they develop to comply with the institutional mandates of CIP-CGIAR. Their decisions have consequences for seed systems goals such as making available reliable plant materials for distribution. However, maintaining such meticulous standards might limit training young curators, as they will require to be familiar with several methods for crop characterization. Ideally, this approach will increase transparency, facilitating prompt resolution of errors, and also fosters a culture of trust and collaboration. Curators’ assistants, including technicians, engineers, and biologists, play a crucial role in potato curation.

1.6.2 Challenges and Strategies in Potato Curation

Reporting mistakes allows for resolution or documentation, which is crucial. If mistakes are not timely communicated, they can persist over time, making them difficult to identify later.

Concentration and a sense of the work's ethic are essential for more operational tasks. This work can become a routine, like sorting seeds or tubers, which requires constant monitoring of tasks.

For instance, mistakes such as mixing samples, can occur if concentration decreases. This is where attention to detail becomes very important. In few instances where issues persist, curators set aside affected batches and neighboring ones for additional monitoring over an extended period. During this time, they draw upon historical data to diagnose and rectify the underlying problems. According to my interlocutors, it's fundamental that curators are both focused and feel connected to their tasks, understanding the significance of their role in maintaining CIP's collection's integrity. This attention extends to the *in vitro* collection, where careful handling is crucial to prevent mistakes. Even though human errors challenge the integrity of CIP's plant materials and its reputation, great care is implied by high demands on attention. Whether dealing with tubers or *in vitro* cultures, technicians and curators must remain focused and skilled in laboratory techniques.

Curator's proficiency in Quechua serves as a valuable tool in characterizing Andean potato varieties. This linguistic expertise extends to Aymara (another Andean language primarily spoken in Bolivia). The senior potato curator is more familiar with Quechua and his academic journey, notably within university settings, provided an opportunity to reinforce his Quechua language skills, a facet not nurtured within his familial environment. Recollections of feeling marginalized due to limited Quechua fluency during his earlier schooling experiences in Cusco

contrast with later linguistic growth during university visits to farming communities in the Andes. His proficiency in Quechua has enabled him to conduct farmers workshops, often challenged by the scarcity of proper terminology to engage with them. These linguistic skills are instrumental in accurately identifying and categorizing potato varieties within the gene bank.

Related to the disciplinary identity of CIP curators, interlocutors during interviews suggest that multiple disciplines compose curatorial work. This is in addition to the more practical and hands on decision making relating to characterizing species. Their disciplinary identity is composed by formal training in several areas ranging from botany and taxonomy to, genetics, ecology, and geography. The senior curator emphasized the importance of taxonomy, often overlooked by younger generations, and seeks to integrate molecular aspects into taxonomic practices to confirm findings and facilitate learning for future generations. Additionally, he suggests that some of those disciplines are not necessarily taught comprehensively at local universities. Having expertise in DNA analysis plays a key role in verifying specimen identities, safeguarding the integrity of genetic resources.

The comprehensive approach to curation work at CIP necessitates dedication and a commitment to continuous learning. The senior curator emphasizes the importance of staying current in an ever-evolving field, advocating for a minimum of five hours of daily study. With new methods like computational analysis and CRISPR technologies emerging, ongoing learning is crucial for successfully navigating the complexities of potato biodiversity conservation. These emerging technologies are seen as complementary rather than replacements for existing methods. Furthermore, curators recommend fostering interdisciplinary knowledge across various CIP

departments, including distribution and acquisition, seed regeneration, plant health, biology, biotechnology, and logistics. Collaboration across disciplines is essential for effective conservation management, highlighting the need to recognize and utilize diverse expertise within the organization.

1.6.3 Interdisciplinary Approach and Community Engagement

The native and local names of Andean potato cultivars reflect specific attributes of the tubers, offering valuable insights into their unique characteristics. By interpreting native and local names associated with each cultivar, CIP curators gain insights into their unique characteristics. These names are not arbitrary but are deeply rooted in the characteristics of the Andean potatoes themselves. For instance, while a potato may be called "lengua de vaca" in Spanish, its Quechua or Aymara name might allude to its elongated and flattened shape resembling a cow's tongue. Regarding the intricacies of naming conventions for potato varieties, curators explained to me how these names often reflect key attributes of the tubers. For instance, the "pumamaki" variety, named for its tubers' resemblance to a puma's paw. Despite such vivid descriptors, the speaker pointed out that these names primarily describe tuber characteristics, rather than the appearance of the plants themselves.

Furthermore, the use of color charts and standardized descriptors are used as tools to aid in the categorization of potato varieties. These resources provide a common language for researchers and community members to communicate effectively about the diverse range of potatoes encountered in their respective regions. For example, charts with designated codes for different hues and intensities facilitate classification, ensuring consistency in documentation across

various contexts. To illustrate, consider a scenario where two potato varieties are being described: one is characterized by its reddish hue, while the other exhibits a more pronounced reddish tone akin to a tomato. In this case, the distinction between "red" and "tomato-red" serves as a crucial descriptor for accurately cataloging and identifying the potatoes. This differentiation underscores the meticulous attention to detail required in curation, where even slight variations can change the characterization.

Additionally, there are challenges associated with preserving and transmitting indigenous knowledge related to potato varieties through naming practices. Despite discrepancies or errors in naming conventions, there is a concerted effort to respect and uphold these traditional practices. This involves training researchers and technicians to navigate the nuances of local naming systems and integrate them into documentation processes. This is closely related to the dynamic conservation approach, as curators are expected to make decisions respecting local knowledge systems. There is a rich cultural heritage embedded in the classification of Andean potato varieties, which signal the importance of community engagement, cross-cultural research, and meticulous documentation practices for CIP's curators. Affective entanglements (Despret 2004; Sedgwick 2003) to the objects of inquiry is a notion that allows me to explain the way in which curators engage and respect biodiversity heritage and culture. Curators develop affective entanglements with their work, as they become familiar not only with formal disciplines but also with cultural conventions.

In contrast with culturally sensitive skills, curators currently rely on molecular approaches to reduce error, and thus enhance CIP's reputation and the credibility of their decisions. In addition to

traditional taxonomic methods, advancements in molecular identification have significantly contributed to the field. According to the curators, 98% of cultivated potato collection is characterized, facilitating molecular comparisons against the data base to identify species. While not a substitute for traditional taxonomic identification, molecular analysis provides a valuable tool for approximating species composition and enhancing understanding of agrobiodiversity. The integration of molecular data with morphological analysis promises to refine taxonomic estimations further. By correlating molecular findings with morphological traits, researchers can gain deeper insights into the taxonomic relationships within the potatoes, thus advancing our understanding of plant diversity and evolution. Accumulating, integrating and deploying such knowledge, is thus another skill developed by curators.

Working as a team is crucial for curators. For example, when CIP experts go to the field, it's not just one person; they go with the potato team, including the curator and all the staff involved in the work. Everyone has their role: some document and take field photographs, while others record data at the radio level. They meticulously characterize every aspect of the plant, from the smallest botanical structure to the color of the flower petals and the size of the perianth. This detailed work is then digitized, with each characteristic assigned a code for entry into the database. According to the interviewees, this data could potentially be visualized, allowing for a detailed representation of the plant. The goal is to recreate the plant with its surroundings, including soil type, associated flora, climate, and habitat. This digitalization process, though complex, holds immense potential for future research and documentation. However, some of these innovations would raise questions among in situ stakeholders such as farmers, who live in the surroundings of conservation sites and have different ideas about digitizing biodiversity.

CIP benefits from the expertise of an emeritus taxonomist with 35 years of experience in taxonomic identification. This is important for CIP-CGIAR reputation, since this knowledge is key to the whole process of making crops into accessions. Curators' knowledge has been enriched through collaboration with past taxonomists. Curators are engaged in learning taxonomic principles, with a focus on both cultivated and wild potatoes. Notably, wild species pose greater challenges for identification compared to cultivated varieties, as the latter comprises only eight distinct species. Efforts are underway to update CIP's knowledge on wild species. Out of the 151 recognized wild potato species, 140 have been identified, each possessing unique traits. However, learning and distinguishing these species require significant time investment, compounded by the presence of shared characteristics among them. The intricacies of taxonomy present a considerable challenge due to the genetic closeness among diverse species. In practice, genetic and practical strategies complement one another, compete, and undermine one another. Despite this complexity, some curators have acquired proficiency in discerning key taxonomic characteristics, particularly focusing on the cultivated potato, which encompasses eight distinct groups of various species.

Curators at CIP engage in a meticulous process of interpreting native and local names associated with potato cultivars, recognizing the deep cultural significance embedded in these naming conventions. Their commitment to understanding the unique characteristics of Andean potatoes reflects an appreciation for the affective entanglements between curators and the objects of their inquiry, deeply rooted in the concept of "respeto" as articulated by Ange 2018. For curators, most than other CIP scientists, developing respeto for Andean crops is a guide for care-security work. This care extends to the use of color charts and standardized descriptors, where every

detail is meticulously documented to ensure accuracy and consistency in categorization. Despite challenges in preserving indigenous knowledge, curators uphold traditional practices, recognizing their importance in preserving agrobiodiversity and honoring the rich cultural heritage associated with potato varieties. The integration of advancements in molecular identification alongside traditional taxonomic methods highlights the interdisciplinary nature of care work. Moreover, the collaborative efforts of curators and staff members underscore the collective nature of care work.

1.7 CIP's Dynamic Conservation Model and Repatriation

CIP scientists' routine shows how their work encompasses laboratory research, fieldwork, and interactions with various stakeholders. Moreover, the diverse range of visitors to the genebank offers insight into CIP's broader public engagement efforts. From government representatives and researchers to private sector actors and farmers' associations, CIP's genebank attracts a wide array of stakeholders interested in collaborating or learning more about Andean agrobiodiversity conservation. This illustrates CIP's role not only as a center dedicated to agricultural scientific research, but also as a hub for knowledge exchange and partnership building in the agricultural sector. This approach is known as the research for development model (CIP 2021), which is being spearheaded by the CGIAR network and focuses on reducing poverty and hunger (CIP 2019). In theory, CIP's dynamic conservation which proposes to engage in situ and ex situ conservation, fits well with the overall CGIAR research for development model.

1.7.1 CIP's Genebank and the Dynamic Conservation Model

Most CIP scientists believe that their work will ultimately benefit farming communities.

However, they recognize that their everyday routines are distant from farmers' realities.

This is one of the paradoxes of CIPs dynamic conservation model, that proposes that ex situ conservation strategies align with in situ strategies. While in the context of exchange of clean plant materials, the distance between both approaches fails to anticipate the needs of farmers, as well as their motivations and initial skepticism for engaging in seed exchange or repatriation. This model was conceived in 1997 by senior CIP scientists and predates the CGIAR. It even predates CIP's participatory research model, which was CIP's signature approach to farmer engagement in participatory breeding. Nevertheless, recent research on CIPs repatriation questions the viability of this program. It is worth noting that CIP has been wrestling for decades with challenges such as farmer engagement, local and scientific knowledge interface, and societal impact. This highlights the tension of the focus on demarcating the boundaries between informal and formal systems, while in practice, they advocate for synergies between them, even though some departments rely more on a narrative to dynamic conservation than an actual guide for action.

Successful repatriation agreements are described as models to be implemented elsewhere. The Potato Park (2004) is the most successful and well-documented example. Potato conservation became the focal point of this repatriation agreement, which brought rural farmers and experts together in collaborative efforts to reintroduce local varieties of native potatoes to the Potato Park communities. Even though there are similar repatriation initiatives in Latin America, this one received an important amount of international attention (Potato Park et al. 2004 quoted in

Westengen et al. 2018). The rights of the farming communities that had originally contributed to the development and maintenance of agricultural biodiversity were emphasized granting them access to seeds, associated technology, and knowledge (Westengen et al 2018). The Potato Park is also considered an indigenous biocultural heritage (Argumedo 2008 quoted in Westengen et al. 2018).

Tensions have certainly emerged during past repatriation activities. According to Argumendo & Pimbert (2006) representatives of the Potato Park communities approached CIP to ask for their stolen landraces that were collected without permission (Gray 2011). Asensio and Cavero Castillo (2013), argue that even if conflicts are resolved, tensions are likely to remain active. In this context, biodiversity conservation is not the goal. Instead, “effective misunderstandings” between farmers and NGOs explain the way in which mutual benefits are negotiated. In current repatriation activities, tensions have not been registered. Nevertheless, other issues persist, such as the lack of funding of CIP’s repatriation program, a declining involvement of young farmers due to urbanization, and climate change. Lüttringhaus et al., 2021, found that the benefits of CIP’s repatriation program are not measured even though they are acknowledged by the farmers who remain involved in the program.

Nonetheless, CIP has not yet problematized the cultural and political implications of their signature programs, such as repatriation, which has not received that support that it needs to scale among farming communities in the Andes. When I was conducting this research, the decisions regarding the repatriation program fell under a reduced group of CIP experts, that required more resources to make it viable. The expectation was that rural farmers will contact

them on their own, by word of mouth, requesting to be involved in a program that aims to provide benefits to them. Additionally, there is a narrative that focuses on the idea that farmers know that they can request their materials whenever they require to do so, which in theory makes sense, but in practice it requires monitoring and current knowledge of the benefits and motivations that farmers see in engaging with CIP. There are signs that this is changing, as farmers familiar with CIP work are aware of ex situ conservation, as they have been invited to participate more closely with CIP genebank scientists in joint projects, such as the incorporation of new varieties to CIP collection. Farmers that work closely with CIP partners are familiarizing themselves with dynamic conservation goals.

CIP's Acquisition and Distribution department is designed to address the needs of actors that are somewhat familiar with ex situ conservation. It handles all matters regarding the circulation of potato and ARTCs germplasm, including repatriation. This department directly engage with farmers, private enterprises, universities, and research institutions, both domestically and internationally. The staff at this department ensures that all germplasm exchanges adhere to established CIP policies, including international agreements governing plant genetic resources. When stakeholders' express uncertainty about their goals regarding acquisition of germplasm, the department offers guidance by inquiring about their specific goals and intended use. When dealing with potato-related inquiries, the department staff collaborate with curators to identify suitable germplasm based on the clients' needs, whether for research or agricultural improvement.

The department manages germplasm requests by processing documentation, facilitating payment and export procedures, and providing guidance, ensuring a similar process for both national and international clients. Daily routine involves managing incoming emails, addressing inquiries, and directing clients to relevant curators or CIP leaders as needed. Upon receiving a list of desired germplasm, the department's staff initiate the request process and ensure all requisite documentation is provided. For international clients who submit requests online, they facilitate the payment process by advising on obtaining a code from FAO and prompt them to initiate the export permit procedure, offering guidance on the documentation that is required. According to the department staff, this process is similar for both national and international requests. For instance, if a client, such as a farmer or a national university, requests a certain quantity of a variety covered by the genebank's costs, the genebank may cover the expenses for one variety extension. If they require more, they must pay additional costs. After sending a quote and receiving confirmation, arrangements for the distribution of the desired material begin.

For international requests, challenges arise when clients are unclear about their needs. To explain this, the department staff recalled a request by a Brazilian farmer, who requested Andean potatoes via CIP's web portal. The client was unaware that those varieties that he requested thrive at altitudes above 3000 meters, incompatible with Brazil's low-altitude conditions. In such cases, collaboration with curators and breeders is crucial to propose suitable alternatives that align with the client's objectives. To address similar challenges, the department provides clients with a list of accessions originating from their country, allowing them to select desired varieties. Typically, clients express interest in numerous varieties, necessitating a management plan within the genebank to schedule shipments. Repatriation entails providing documentation detailing the

condition of the delivered material, ensuring that any subsequent issues are not attributed to mishandling by CIP.

The management of germplasm circulation can be tedious and slow, requiring constant follow-up to obtain permits and expedite processes. Even with direct communications, responses can be delayed. Nevertheless, CIP staff strives to move forward as much as possible. Interacting with a variety of people, such as scientists and farmers, is a key part of the department staff role. In addition to managing material requests, they also trained clients on required procedures. Their work included ensuring proper recognition of CIP in the release of varieties, especially when other institutions, such as INIA, were involved. The germplasm exchange process also involves specific procedures and requirements for both import and export. In complex situations, the department staff consults with experts on specific policies and advise on requests involving complex commercial or legal interests.

1.7.2 CIP Curators' Role in facilitating Dynamic Conservation

CIP curators play a unique role in germplasm circulation, or as Leonelli calls, packaging data for travel (Leonelli 2016), blending scientific research with societal impact. During my interviews, their reflections touch upon the interdisciplinary nature of potato research, emphasizing the necessity of integrating scientific, cultural, and social perspectives. Leonelli argues that plant materials are decontextualized as a prerequisite for making data travel. However, CIP curators are particularly positioned to respect local knowledge due to their interdisciplinary scientific knowledge and Quechua skills. They recognize the importance of incorporating traditional knowledge from local farmers into research initiatives. They believe that such integration can

enrich scientific endeavors and ensure their relevance to local communities. They stress the need for a comprehensive approach that considers both genetic diversity and cultural practices to effectively address food security challenges. Curators endorse dynamic conservation in practice, as their work already overlaps with farmers classification systems. Overall, they believe that CIP research addresses food security concerns for impoverished communities through the utilization of potato tubers.

The senior curator at CIP reflects on his enduring connections with farmers, established well before his tenure at the International Potato Center. Despite the absence of financial remuneration, he has collaborated closely with farmers, emphasizing mutual respect and shared goals in preserving agricultural diversity. His initiative in cultivating his own potato collection, particularly in the Cusco region, including what is now recognized as the Potato Park, highlights his lasting commitment to grassroots engagement and community-driven conservation efforts. Curators have also been involved in the annual regeneration of CIP's germplasm collection in the field, conducting morphological characterizations and virus damage assessments. They also frequently engage with local farmers in San José de Mara, Huancavelica, where part of the collection is grown for distribution. As Lüttringhaus et al 2021 mentioned in a recent publication, this collaborative effort involved renting land from local farmers to regenerate tubers. This material, known as pre-basic seed, undergoes thorough virus cleaning processes, making it suitable for distribution. In contrast, the material grown within the station focuses more on conservation and internal management rather than distribution.

Another example that challenges Leonellis (2016) argument about decontextualization through curation work, is rooted in CIP curators' own experiences developing intercultural methods to foster local biodiversity conservation. The senior curator explained to me a novel approach to preserving and understanding potato diversity by creating a unique fingerprint for each potato variety. He described how he analyzed 461 local potato varieties and sought to understand the locals' traditional knowledge through the lens of quipus, ancient Incan devices used for record-keeping. By associating each potato chromosome with a cord on the quipu, they were able to create a visual representation of the potato's genetic makeup. He emphasizes the importance of communicating this complex genetic information in Quechua. He believes that linking the scientific approach with traditional knowledge helps bridge the gap between researchers and farmers and fosters a deeper understanding of crop diversity. Furthermore, the curator explained me how this fingerprinting method aids in identifying and protecting local potato varieties from biopiracy.

Nowadays, with the advent of the internet and email, the senior curator finds it much easier to communicate with farmers. He can now conduct video conferences using platforms like Microsoft Teams to provide advice and guidance on conservation practices. For instance, they advise farmers to isolate their potato crops to prevent the spread of viruses, especially in colder regions where there are fewer vectors for transmission. Over time, the curator has noticed a pattern emerging in his work. He came up with the idea of dynamic conservation to emphasize the reciprocal relationship between the curator and the farmers, akin to the traditional Andean concept of "ayni" or reciprocity. When farmers request potato varieties, the curator ensures they

understand the concept of repatriation, which involves returning improved potato varieties to their place of origin.

Engaging with farmers, such as AGUAPAN members during their annual meeting was a memorable experience for CIP scientists. These experiences serve as reminders of the impact of conservation efforts and the importance of preserving agricultural biodiversity. However, this has not been common in the past, or even in other settings where facilities located faraway from main research centers are not frequently visited by CGIAR experts. It's not clear what made this trend possible, but it's a direct consequence of centralizing resources in locations struggle to establish frequent interactions with decentralized units. This information was shared with me during AGUAPAN annual meeting. However, due to recent changes in CIP leadership, there seems to be more interest from CIP genebank in working closely with Andean communities and regional stations such as the Huancayo station located in Junin. Beyond curators and extensionists, most CIP staff feel relatively distant from Andean farmers, even though they acknowledge that their work addresses societal issues. In this sense, for them dynamic conservation is more a metaphor of the implications of their work than an actual guide for action.

More recently, AGUAPAN farmers shared their potato varieties with CIP genebank experts, and together, examined a population of 1000 potato accessions. These accessions were molecularly characterized, and their placement within the CIP molecular database was identified, along with their relationships to other CIP varieties. Through this process, the potato species and priority of their materials were determined, and previously unidentified accessions were discovered. In total, 88 unique accessions from the AGUAPAN region, not previously represented in CIP's

genebank, were identified. As part of a transfer agreement, these materials were requested and are now also part of CIP's collection. This initiative highlights the advantages of having characterized morphological and molecular databases, allowing for comparisons with farmers' collections to ensure the conservation of genetic diversity. When I asked farmers about this initiative, they felt that they were contributing with science and became aware of the value of CIP's ex situ conservation work. However, in past events, farmers struggled to understand the value of CIP's ex situ conservation, as it didn't directly address their production needs.

Training younger generations of scientists is a key component of CIP's genebank strategy to engage with rural farmers. Curators and other CIP scientists recounted their experiences in bringing scientists to witness local farming cultures firsthand, aiming to cultivate a deeper understanding of the context in which agricultural practices evolve in Peru. By immersing themselves in the local environment, they gain insights into the nuanced perspectives of rural farmers, enriching their skill to facilitate effective communication and collaboration between scientists and local communities. CIP scientists recognize the value of adapting scientific language and concepts to make them accessible to farmers without diluting their essence. They acknowledge the challenge of conveying complex scientific ideas, such as DNA, in a manner that resonates with farmers while ensuring accuracy. However, currently few young experts travel to the field to conduct monitoring activities. CIP's extension work is mainly conducted by local NGOs, who work with rural communities and have limited to perform several rounds of monitoring tasks. Tensions between CIP and these organizations have emerged in the past, but according to my interlocutors, both parties have learned to work together. Recognizing the support that they provide to farmers, in terms of expertise and monetary incentives for

community conservation, allows them to keep cooperating. At the same time, past CIP scientists have worked in those NGOs. In this sense, researchers who have bridged both ex situ and in situ conservation approaches, embody the dynamic approach.

1.7.3 CIP's Repatriation and its Impact on Agricultural Communities

Repatriation stands as a primary objective for the CIP, with requests often received as part of ongoing projects or regular operations. These requests are usually directed to the CIP director general or managed with the assistance of the potato curator, typically during the potato harvest. Given their role in germplasm distribution, the Acquisition and Distribution department handles repatriation as a form of distribution, focusing on the paperwork aspect to ensure smooth processing. International repatriations may involve additional verification of materials to ensure accuracy, although much of the work is managed by the bank. While potato farmers may not experience direct economic benefits, funds generated from international material use contribute to CIP projects, indirectly benefiting farmers. Certain varieties are commonly requested, including Wayromoro, Peruanita, Huamantanga Falsa, Camotillo, as well as commercially popular varieties like Única, Kanchan, Yungay, and Amarilla.

Despite initial resistance from some rural farmers, the repatriation process led to the identification of potato morphological diversity and the introduction of the concept of nominal varieties. Based on my interviews with NGOs that work with CIP scientists, it seems that CIP emphasis on providing small quantities of clean plant material does not necessarily match the interests of farmers. This supports the argument that cleanliness varies across communities of practice situated beyond the CIP-CGIAR network. They request repatriation due to the loss of

their varieties due to frost or virus contamination. Thus, providing virus free material may be not the only factor of importance for farming communities. In contrast, CIP scientists provide valuable insights into the process of repatriation, emphasizing the collaborative nature of genetic conservation efforts and the meticulous steps taken to ensure the cleanliness and viability of shared plant genetic material. Their description focuses on the practical significance of repatriation in improving crop yields for recipient farmers.

Following this, communal seed banks were established to provide farmers with access to virus-free potato varieties. The initiative expanded to include multiple communities, with the senior curator labeling the efforts as "repatriation" in 1999, emphasizing the return of genetic resources to their places of origin within Peru. This term initially faced resistance but eventually gained acceptance, leading to the establishment of numerous communal seed banks across various provinces of the Andes. The concept of repatriation continued to gain traction, eventually being recognized, and published in a journal. Since then, the repatriation efforts have continued to grow steadily, facilitated by the curator's ongoing involvement and commitment to bridging the gap between scientific institutions and local farming communities. If farmers request varieties that are not native to their area, CIP genebank considers that a distribution rather than repatriation.

Despite some reduction in distribution during the pandemic, CIP's repatriation program continued in 2021-2022, with plans for further expansion in 2023. CIP scientists stress the benefits of repatriation, including the restoration of diversity, increased yields, and food security, highlighting the importance of integrating local and scientific knowledge for land management,

post-harvest handling, consumption, and marketing. Nevertheless, there are regions that are more involved in CIP's repatriation such as Puno, Cusco, and Apurimac, in contrast with Ayacucho and Huancavelica. CIP senior curator revealed that CIP do not actively select farming communities; rather, communities come to them with requests. He mentions having engaged with around 147 communities, receiving approximately 1,515,772 samples from these communities. From these samples, 1,519 unique accessions have been identified, representing a significant portion of CIP's collection. He noted that Peru alone contributes nearly 3,000 samples, indicating that roughly half of Peru's potato diversity is preserved at CIP genebank.

Not all farmers have the same drive or knowledge to properly manage the repatriated materials. Some communities have requested materials repeatedly over the years, while others have lost them. CIP scientists consider that it's essential to provide training to farmers on how to manage these repatriated materials effectively. This includes guidance on seed banking to ensure the longevity and quality of the seeds. Without proper management, the goals of repatriation efforts may be diluted over time, leading to decreased production quality.

1.8 Conclusions

Cleaning is more than an internal guiding metaphor; it is an institutional mandate as it is embedded in practices, protocols, technologies and imaginaries about CIP's reputation. Additionally, it helps to quell the institutional anxieties about agrobiodiversity loss and spreading "impure" or "polluted" material. Cleaning is one of the most important ways in which care-security work is achieved, as it is one of the main concerns for CIP scientists and technicians, due to the nature of the clonal collection and how it interacts with other CIP

departments. Technologies and infrastructures are put into place to preserve clean plant materials that track phytosanitary status through labeling and color coding. Due to the nature of in vitro conservation (maintenance of tissue culture and regeneration of plant materials), and the perceived vulnerability and risk of CIP's collection, plant materials are being copied, stored in other facilities or transferred to cryopreservation. This enhances the emphasis on security that CIP places in the long-term management of its collection. There is emphasis on working in sterile environments, where cleaning adopts a spatial meaning: environments are sterile because they are designed to prevent impurities from contaminating plant materials. Cleaning at CIP is an institutional mandate for control that is expressed through lab practices, infrastructures and protocols designed to monitor the status of the materials that come in and leave CIP genebank.

Cleaning, in the form of therapies, also describes the relationships between the materials and the CIP scientists and technicians. Potatoes described as docile contrast with ARTCs resistance to cleaning therapies. Additional research is needed to make resistant materials docile to cleaning therapies, and thus better managed by CIP staff. Docility and resistance are important concepts to examine care-security work, because they provide more insights to understand standardization as an institutional practice at CIP. Plant materials need to be docile and clean enough to be incorporated in CIP's collection, which implies transforming crops into accessions. Docile accessions circulate with more ease through the CIP-CGIAR network, once they moved beyond quarantine, are classified and are monitored for health status. Efficiency in diagnosing and treating incoming materials is required in order to avoid spreading diseases, as well as to maintain CIP reputation as a reliable research institution that is committed to follow international regulations for accession storage and distribution. Thus, the circulation of docile plant accessions

depends on CIP's staff commitment to follow such protocols through efficient division of labor of cleaning and monitoring tasks.

CIP scientists and technicians express care-security work while curating plant materials. Here the focus is more on classifying material, as well as the implications of such assessments. In this way, striving for precision and managing doubt and uncertainty are limits to care-security work, since curators' decisions are integral for monitoring the accessions. This is a limitation in terms of integrating as well as navigating through several scientific disciplines, that in one way or another influence curator's decision. Thus, curatorial decisions represent the limits in curators' knowledge retention and knowledge put into action. For example, curators that rely on a limited body of knowledge, such as preference for molecular techniques, compromise their decision-making process and could mischaracterize incoming plant materials. At the same time, knowledge in action is the way in which curators end up making decision within the limits of their knowledge and as best of their capacities. For example, missing important details of the plants due to overreliance on one method, can also lead to mischaracterization.

Curators are more attuned to indigenous knowledge and public engagement than other CIP departments. Based on the notion of interspecies affection and respeto, curators not only discursively acknowledge indigenous knowledge, but also respect it as part of their work. Due to their commitment to preserve large collections of plant materials, past generations of curators developed methods for engaging with farmers to foster in situ conservation, as part of CIP work with farmers in regions such as Cusco. As a result of those experiences, culturally sensitive materials were developed to explain science to farmers, so they can value ex situ conservation. In

this way, due to promoting empathy as an institutional value, curators realized that developing engagement methods was another skill that they needed to cultivate to secure the preservation of plants outside the lab, as well as increasing the precision of their characterization of incoming material from new regions with unknown varieties.

Beyond fulfilling international regulations about seed exchange and requirements of the “formal” seed system, cleaning and curation inform institutional discourses about agrobiodiversity loss, crops as public goods, and anxieties about spreading plant diseases. These discourses help justify the reliability and relevance of ex situ conservation facilities and staff and help to delineate and renew the discourse about addressing social goals such as reducing poverty through increasing conservation and engagement activities. However, as communities that share different notions of cleanliness and naming practices interact with the formal seed system, it seems that CIP’s institutional capacity to respond to those needs is limited. The challenges and resistance that initially faced the repatriation program shows that CIP interactions with the “informal” seed system struggles to address in some cases, local needs. It could be argued that some of those farming communities are not interested in conservation, instead they require solutions to increase their income and secure food. CIP work related to those issues, currently focus on providing incentives for in situ conservation, but there are no clear incentives for ex situ- in situ integration. Opinions on this matter are different, since some consider that scaling repatriation could be the job of the government, while other consider that the way the repatriation program is designed prevents farmers for committing to long term conservation.

If the dynamic model is expanded, acknowledging the politics of the circulation of plant materials within and beyond the CIP-CGIAR network, stakeholders with diverse notions of cleanliness and indigenous classification would pay more attention to ex situ strategies as a complement to their own practices. However, to do that it is necessary to reframe the way in which nonwestern systems of classification and conservation are regarded by the ex-situ community. In countries with a strong emphasis on family agriculture, an important part of the production comes from the “informal” system. By recognizing the limits on care as well as security within the CIP-CGIAR network, ex situ stakeholders would need to rethink the way they interact with actors outside the “formal” system, to develop partnerships based on culturally sensitive and context dependent factors such as willingness to repatriate, or commitment to long term exchange and collaboration. This may well exceed CIPs genbank work, but at the same time, it will force the institution to rethink how they address social goals embedded in the CGIAR network alignment with sustainable development agendas.

CHAPTER 2: UNCELEBRATED LABOR: THE CONTESTED RELATIONSHIP CONSERVATION AND COMMERCIALIZATION OF ANDEAN POTATOES

2.1 Introduction:

Javiera squatted on the rough asphalt of the Quilcas weekly fair, her 6-year-old daughter playing nearby. After hours under the sun, she had sold just 60 soles (16 US dollars) worth of potatoes. Despite the meager earnings, Javiera felt a quiet satisfaction. Each sale represented not just a financial transaction, but a connection between her and the people who took home her potatoes, colloquially called “caseros”. She knew that these few kilos of potatoes wouldn't cover her production costs, but the act of bringing them to market was an important part of her tradition and livelihood. She looked forward to the annual Huancayo fair, hoping it would bring better opportunities, despite the uncertainty surrounding its organization by local authorities.

In stark contrast to the weekly hustle of local fairs, the annual fair in Lima was a spectacle of colors, flavors, and pride. Sponsored by the government and value chain stakeholders, the event transformed a sprawling urban park into a vibrant showcase of Peru's agricultural diversity. Tents and stalls were adorned with banners proclaiming the richness of Andean potato varieties. Here, farmers stood behind meticulously arranged displays of potatoes. Urban consumers, many of whom were part of Lima's middle class, wandered through the fair with curious eyes, sampling the various offerings and listening to explanations from the farmers. For these consumers, the fair was an opportunity to explore new gastronomical horizons and support the preservation of agrobiodiversity. For farmers, participating in these fairs is a chance to temporarily increase their sales and gain recognition, albeit in unfamiliar settings.

These contrasting scenes—Javiera's day at the weekly fair and rural farmers' participation in urban fairs—illustrate the dual nature of potato conservation in the Peruvian Andes. On one hand, everyday conservation is a humble, often unrecognized effort carried out under the harshest conditions. On the other hand, institutional branding elevates conservation to a celebrated status, but often obscures the daily struggles of rural farmers. Stakeholders such as regional governments, municipalities, research centers, private companies, and NGOs seek to reconcile these contrasting scenes by sponsoring food and biodiversity fairs across Peru, to increase urban consumption and raise awareness about potato diversity.

Due to the “rediscovery” of Andean food and cuisine by Peruvian urban middle-class consumers, Andean potato agrobiodiversity is now celebrated in food and biodiversity fairs. In these spaces, potato farmers sell their produce to curious and sometimes picky urban consumers who are aware of the importance of protecting agrobiodiversity. They purchase potatoes due to their gastronomical uses, place of origin, unique colors, and distinctive flavors. Potatoes are named in Quechua and Spanish, making it difficult for consumers to remember all their names and the traits associated with each name (e.g., color, shape). Nevertheless, Andean potatoes are celebrated for their uniqueness and health benefits. What happens in fairs is not only important for those involved in the potato value chain, such as vodka producers, chip firms, and rural entrepreneurs. More importantly, food and biodiversity fairs challenge us to ask questions about the value placed upon agrobiodiversity, the expectations regarding its future, and the roles farmers, scientists, chefs, government officials, NGOs, and extension workers play in its promotion.

Andean potatoes are not just crops; they are cultural objects that are exchanged, sold, and branded as national treasures and heritage (Sayre et al 2017, Graddy 2013, Mayer & Glave 1999). Food heritage is a global process since objects, spaces, and practices have been invested with a “heritage” value (Ascione 2017, Kirshenblatt-Gimblett 2006). In the case of Peru, national heritage is expressed through “nation branding,” a process that highlights how certain artifacts produce collective narratives, citizenship models, and a sense of belonging (Canepa & Lossio 2019). However, who benefits economically and politically, and in what ways, from commercializing potato agrobiodiversity? This question is relevant because everyday conservation conditions are often precarious, and the tensions between commercialization and conservation distract from addressing issues such as the aging of farmers as well as their struggles for autonomy and securing stable income. At the same time, these tensions reproduce existing class-based inequalities expressed through racial and ethnic identities (e.g., Indian/mestizo) as well as tastes and consumption trends (Matta 2021).

Due to the Peruvian gastronomic boom (Matta 2014) and the proliferation of food and biodiversity fairs, the attention of potato value chain stakeholders is focused on scaling rural entrepreneurship around the commercialization of Andean crops. Agrobiodiversity protection is mainly viewed as a driver of economic growth as well as an opportunity to include custodian potato farmers in the value chain. The combination of economic and cultural factors involved in the promotion of Andean potatoes as heritage foods shapes the power dynamics behind Andean potato conservation. However, rural potato farmers do not benefit as much as they could from potato agrobiodiversity because there is a conflict between commercialization and conservation at multiple social levels and across geographies. This chapter investigates the tensions between

conservation and commercialization of Andean potatoes in Peru at multiple sites (e.g., fair stalls, farmers' assemblies, farming communities, Andean households, press conferences) across three regions: Huanuco, Junin, and Lima. Moreover, I am interested in understanding how these tensions reconcile or widen political, economic, and cultural gaps between farmers and value chain actors.

I argue that commercialization and conservation in the context of potato agrobiodiversity represent a paradox: both are mutually reinforcing and are somehow at odds with one another. On one hand, if popular varieties of Andean potatoes are not commercialized in fairs, farmers lose a strong incentive to safeguard their collection. On the other hand, if demand grows, farmers will face logistical challenges to grow and commercialize their potatoes. To increase their production, they would need to acquire more land, increase their costs, and have access to pest control strategies, thus threatening the diversity of their collection. Either way, small-scale Andean potato farmers struggle to benefit from the commercialization of their agrobiodiversity.

To reconcile this paradox, I examine the ways in which individual farmers and farmer-led grassroots organizations navigate these challenges by selling their products at affordable prices, developing amicable relationships with their clients, participating in biodiversity and food fairs, and making their voices heard in settings beyond fairs, such as press conferences. Overcoming these tensions requires earning stable income despite low prices, meeting standardized urban tastes, and challenging tensions associated with class and ethnicity that were associated with Andean potatoes (poor farmers' foods) not long ago. At the same time, I pay attention to the way in which farmers, local authorities, government agencies, and value chain actors interact in the

different discursive arenas. Urban venues focus more on celebrating potatoes as fostering the connections with value chain products; rural venues aim to highlight the process of turning potato farmers into rural entrepreneurs.

2.2 Commercial and Native Potatoes in Peru since the 2000s

Since 2015, potato consumption in Peru has grown significantly due to a combination of public and private initiatives. Projects focusing on rural infrastructure, the expansion of supermarkets, and fostering strong relationships between producers and the gastronomic sector have contributed to this growth (Campos and Ortiz 2020). The private sector, particularly the gastronomic boom, has played a key role in promoting potatoes to different markets. These efforts have created niche urban markets that focus on fresh consumption and potato-based snacks. The gastronomic sector has also developed new potato products, including frozen fries, liquor, and cosmetics, driven by the economic growth of the early 2000s, which allowed for increased investment in foreign markets (Campos and Ortiz 2020). Simultaneously, local value chains linked farmers to local markets, seemingly validating inclusive economic growth.

Inclusive value chain development is defined as a “positive or desirable change in a value chain to extend or improve productive operations and generate social benefits and other development goals” (UNIDO 2011). In the context of potato production, this effort was led by the International Potato Center (CIP) and various private and nonprofit stakeholders. However, critics argue that participation in these value chains does not necessarily benefit all small-scale farmers (Campos and Ortiz 2020). Although policies and institutional arrangements help minimize risks associated with value chain participation, high-value markets typically require

more investment and assets than local markets. Lower-income farmers face limitations in access to credit, networks, opportunities, and education (Campos and Ortiz 2020). Despite these challenges, the private sector, gastronomic stakeholders, and international donors have improved opportunities for farmers with sufficient resources to participate in these initiatives. Andean potatoes once considered “poverty foods” (McDonnell 2019), have transformed into products requiring a price premium, similar to quinoa (Andrews 2017), millet (Shah et al 2023, Finnis 2015), and burnt grain pasta (Counihan 2021).

In biocultural environments like the Peruvian Highlands, farming communities have cultivated food in challenging settings since pre-colonial times, overcoming ecological stress, shocks, and extremes (Arce et al 2018, Argumedo et al 2020, FAO Alliance of Biodiversity International CIAT 2021). Indigenous communities in the Andes have unique methods for using, exchanging, and providing access to Andean crops (De Haan 2021). These communities leverage their lands and seed exchange networks to produce food and preserve crops. With the institutionalization and consolidation of global markets, agrobiodiversity stewardship is now connected to international agriculture and research (De Haan 2021). As demand for regional products in gourmet markets increases, agrobiodiversity conservation becomes relevant for urban consumers and gastronomic organizations. Renowned Peruvian restaurants, such as Central, use Andean crops as key elements of their culinary approach, showcasing the biodiversity of Peru through their dishes (Ardila 2018). Despite this visibility, the needs of indigenous communities are not always addressed. In a context of pressing sustainability challenges (Argumedo et al 2021), such as providing food for a growing population, Andean potato conservation efforts seem at odds with the commercialization of these crops.

Native potatoes, or Andean potatoes, are the result of years of domestication and selection of diverse local genotypes, highly valued by custodian farmers (Devaux et al 2020). Associated with ancestral and traditional cultivation methods, native potatoes are often contrasted with improved varieties developed by breeding programs for specific traits such as higher yield or pest resistance (Devaux et al 2020). According to Fajardo-Escoffié, native potatoes result from indigenous cultivar management, which privileges mixed seed planting systems (Fajardo-Escoffié 2022). At fairs, native potatoes grown this way are called “mezcla” or chaqru in Quechua. This process enhances gene flow, genetic variation, and mutation among planted species (De Haan et al. 2010, Brush et al. 1995). During the 1980s, researchers found that even though native varieties were not profitable, farmers continued cultivating them (Mayer & Glave 1999). Programs like Papa Andina, which aimed to improve the competitiveness of Peru’s potato sector, have since elevated native potatoes to food heritage status and made them central to the gastroboom (Devaux, Ordinola, and Horton, 2011). Chefs and restaurant staff socially shape their “nativeness,” relating potatoes to Peruvian history, territory, indigenous farmers, and healthiness (Abbots 2014).

2.3 Heritage Food, Gastropolitics, and Public Transcripts

Often regarded as national treasures, potatoes are considered heritage foods by various actors across the value chain. At local, regional, and national food and biodiversity fairs, decision-makers such as government officials, local authorities, NGOs, researchers, and rural entrepreneurs regard Andean potatoes as an integral part of the identity and culture of “custodian” farmers. “Heritage food” is a cultural construction involving both ideological and mundane tasks, as suggested by scholars such as Appadurai (1981), Matta & Garcia (2019), and

Jordan (2015). Governments and other actors participate in the “heritagization of food” (Klein 2018; Grasseni 2014; West 2016), claiming the “historical legacy” of food (Weiss 2016). For example, by using the media to highlight the origin of potatoes as from Peru, value chain actors emphasize sentiments of national pride to increase consumption. These activities define national heritage boundaries, engaging in the Othering of ethnicities rooted in the desire to rediscover authentic and exotic foods (Hooks 1992). In the case of potato agrobiodiversity, this can be achieved through tasks like sorting potatoes and structural activities such as organizing national food fairs.

Potatoes are not only crops but also an integral part of Peruvian cuisine and are often regarded as versatile food since many dishes can be prepared using them (Ordinola et al., 2007). Peruvian national cuisine is not merely a culinary phenomenon, but a performative project rooted in identity politics and the recognition of marginalized foods and populations (McDonnell 2019; Fan 2013; Canepa 2013). As a national project that garners public support, national cuisine often obscures the reality that it is an amalgamation of regional and local food practices (Appadurai 1988). Additionally, national food agendas may neglect the colonial heritage of food (Garcia 2013; Markowitz 2018). Understanding the interplay between national and local cuisine requires the concept of gastropolitics, encompassing both everyday food politics and formal regulations shaping the food system (De Soucey 2016).

Gastropolitics allows us to explore how national cuisine incorporates or excludes local heritage-making activities. In Lima, food and cuisine reflect a top-down concern with economic potentialities, cultural recognition, and social inclusion (Fan 2013; Matta 2011). The

commercialization of potatoes is a central aspect of the national rebranding of Peruvian cuisine, aiming for inclusive development, racial reconciliation, and national unification (Matta & Garcia 2019). As Peru integrated into the global market, Andean food became key to rebranding the nation as diverse, with the government capitalizing on the gastronomic boom (Matta 2021). This rebranding involved crafting narratives of tolerance and inclusion to profit from Peruvian food. The Peruvian gastronomic boom aimed to bridge ethnic and racial divides through these narratives. However, reconciling these divides is complex due to the socioeconomic and cultural stigma attributed to rural communities, depicting them as racial and culturally inferior due to lack of formal education, their peasant origins, and the fact that wealth is derived from agricultural work (Ponce 2016). Additionally, previous studies about economic interactions between farmers and value chain intermediaries such as wholesalers (Scott 1985) show a lack of trust between insiders and outsiders (McDonnell 2019).

Conversely, bottom-up gastropolitics, as conceptualized by Garcia (2021), highlights local and regional forms of agency and resistance to dominant narratives, making the notion of “vernacular” relevant for farmers who have become rural entrepreneurs and participated in national fairs. Despite the persistence of top-down gastropolitical narratives, vernacular forms of gastropolitics highlight collaboration between farmers and value chain actors while critiquing dominant inclusion narratives (Garcia 2021). It shows that farmers' participation in urban spaces does not necessarily mean they consider racial and social divides to be absent. Instead, it shows that farmers have learned to navigate these environments. At the same time, excluding farmers is undesirable for value chain stakeholders, as farmers manage diversity and nurture seed networks (Tobin et al., 2016; Arce et al., 2018), with additional challenges for female rural farmers in

terms of land ownership, opportunities, and decision-making power (Zeigler 2021; Molina et al., 2022).

Recently, scholars like Matta have focused on bottom-up or grassroots gastropolitics (Matta 2023) within indigenous food systems. These studies examine indigenous perspectives on food cultures, often overlooked in heritage declarations and biodiversity preservation programs (Matta 2023). Grassroots gastropolitics initiatives decolonize diets and reattach stories and memories to local foods, contrasting with state-led activities (Matta 2023). New farmer-led organizations such as AGUAPAN, a national association of Peruvian potato farmers from nine regions, have been participating in their own terms in grassroots gastropolitics. As an emerging organization attempting to generate robust accountability structures, AGUAPAN is navigating inclusion narratives emphasizing their own voices among urban-based value chain actors to benefit more from agrobiodiversity conservation and commercialization.

From a grassroots perspective, navigating dominant inclusion narratives in the context of agrobiodiversity conservation implies paying attention to resistance and compliance behaviors, such as advocating for just prices and adjusting prices when they struggle to sell their potatoes. Resistance and compliance often occur “offstage,” away from direct observation by powerholders (Scott 1990). Powerholders craft and disseminate public transcripts, defined by Scott as the “open interaction between subordinates and those who dominate” (Scott 1990). In contrast, hidden transcripts involve offstage speeches and practices that may confirm or contradict public narratives. These hidden transcripts are often produced for different audiences under varying constraints of power, offering a nuanced view of power dynamics in food heritage

(Scott 1990). These transcripts, in the form of intimate conversations and exchanges between farmers and specific actors they trust, are not as visible as dominant inclusion narratives in decision-making arenas. In terms of gaining an ethnographic understanding of resistance and compliance between rural farmers and chefs, scholars have also paid attention to self-representation and negotiation of stereotypes, strengthening livelihoods and self-determination (Garcia 2021). Farmers must adhere to familiar expectations to maintain their client base while rescuing the ongoing work in communities prior to the gastronomic boom (Garcia 2021).

The literature on gastropolitics and nation branding has focused on public discourses and visual representations of food as national heritage (Canepa & Lossio 2019; Anderson 2006). This debate can be enriched by considering the implications of the materiality of Andean potatoes, with their unique characteristics (color, shape, size, taste, culinary uses), appealing to diverse publics. Custodian farmers interact with these potatoes affectionately, seeing them as entities with agency (Ange 2018). Institutional and grassroots dynamics that facilitate affectionate encounters with potatoes shape their value as commodities, turning them into gastropolitical objects (Appadurai 1986). As gastropolitical objects, Andean potatoes are standardized to ensure consistency and circulate across the value chain. Processes of packing, branding, and certifying food aim at commercialization (Weiss 2011; Besky 2014; Grasseni 2003; Paxson 2014; Klein 2018; Brulotte and Di Giovine 2014). The standardization of Andean potatoes ties to broader regimes of food value, impacting their commercialization (Matta 2013).

2.4 Methodology: Multi-sited Ethnography

I adopted a multi-sited ethnographic approach (Marcus 1995) to immerse myself in the lived experiences of potato farmers engaged in everyday conservation work. This involved moving across multiple sites across the Peruvian Andes, following potato farmers as they move from their communities to urban venues, such as regional and national food fairs. For this chapter, I focus on three types of food and agrobiodiversity fairs: 1) local fairs that happen weekly in rural areas and are self-organized, 2) regional fairs that are organized annually by regional government authorities and local municipalities, and 3) national fairs that are organized annually by national government agencies as well as municipalities in Lima. In most of these food and biodiversity fairs, I follow AGUAPAN partners and focus my attention on how local stakeholders such as NGOs, government agencies, regional and local authorities disseminate public transcripts about Andean potato conservation.

Specifically, I situate my work in the following spaces and communities:

- AGUAPAN annual meetings and related workshops and events: As part of the logistics of my fieldwork, I coordinated with AGUAPAN members and with Grupo Yanapai leaders to have access and participate in AGUAPAN's 2022 and 2023 annual meetings in the cities of Huancayo and Huamachuco. I attended multiple meetings with AGUAPAN leadership, helped facilitate workshops, and invited local authorities. I attended these meetings in August 2022 and July 2023.
- Monte Azul and Churumbamba: These are examples of farming communities in contrast with the experience of AGUAPAN partners. Both communities are located in the region of Huanuco, which is promoted as having high Andean potato diversity. Even though

located in the same region, Monte Azul has a more open approach to visitors and students and avoids using pesticides. On the other hand, Churubamba farmers are attempting to control an unknown pathogen affecting their crops. I visited these communities in March 2023.

- **The National Potato Day Fair:** This is an example of a national food fair organized by the Peruvian government and municipal authorities in Lima. Food fairs organized in Lima usually have national exposure in the media and to urban consumers who are willing to explore and purchase Andean products. Participants are pre-selected and usually sponsored by policy stakeholders or value chain actors. In these fairs, the relationship between the value chain and the role of farmers in showcasing national biodiversity becomes relevant. I visited this fair and other Lima fairs in May 2023.
- **Quilcas and San Jeronimo:** These are examples of weekly fairs in the region of Junin. These fairs are not sponsored by external sponsors, and local people do not consider them biodiversity fairs. Instead, these fairs resemble more flea markets that offer a variety of daily products, such as groceries and cooking appliances. However, some of the potato farmers who participate in those fairs offer Andean potatoes at lower prices than fairs organized in Lima, due to lower transportation costs. I visited these fairs in June 2023.
- **Muru Raymi:** This is an example of a regional fair organized by regional authorities in the region of Huanuco. Highly promoted by regional and local authorities as a tourist destination, this annual fair showcases how rural development narratives intertwine with agrobiodiversity conservation goals. As a result, Andean potatoes are the protagonists of these dominant narratives, and farmers are incorporated as rural entrepreneurs, functional to these development agendas. I visited this fair and other rural fairs in June 2023.

In order to comprehensively understand the dynamics between everyday conservation work and the commercialization of Andean potatoes, this study employs a qualitative approach to identify and discuss how hidden and public transcripts about heritage foods (such as native potatoes) circulate at food and biodiversity fairs. This sheds light on the contested relationship between conservation and the economic and political interests tied to the commercialization of agrobiodiversity in Peru. Based on fieldwork conducted between May 2022 and July 2023 in the regions of Junin, Huanuco, and Lima, I focus on exploring AGUAPAN's partners' struggles for autonomy as they participate in local fairs and assemble once a year to discuss organizational challenges such as implementing internal accountability mechanisms. However, AGUAPAN partners are not necessarily representative of other custodian farmers who engage in conservation but are not part of any organization. This is important because of the high skepticism regarding farmer-led grassroots organizations. For this reason, I include non-AGUAPAN potato farmers, who are not necessarily experiencing similar struggles as AGUAPAN, to provide a situated view of everyday conservation work in their local communities.

2.4.1 Methods

This project was approved by North Carolina State University IRB office, # 24908, in June 2022 and renewed in January 2023, to work with vulnerable populations such as indigenous peoples, elder populations, as well as CIP employees. Through participant observation, I spent extended periods in Peru over the course of 6 months (August 2022, March-July 2023), particularly in areas where agrobiodiversity is a significant aspect of local livelihoods such as Huancayo, Huanuco, and Lima. This involved actively participating in local fairs, interacting with farmers, and understanding the challenges and motivations that shape their potato conservation practices.

Since I accompanied the AGUAPAN partners in various fairs, I stayed with them at their stands to assist in selling their crops. Staying at the AGUAPAN stands helped me understand how AGUAPAN partners interacted with urban consumers. I also conducted 19 semi-structured interviews with key stakeholders in the potato value chain, including farmers, AGUAPAN partners, NGOs, and extension workers. Research partners at the International Potato Center (CIP) facilitated access to AGUAPAN partners, NGOs, and extension workers based on past collaborations. I also negotiated consent with participants based on my human subject research protocols for this project. Participants were recruited based on their recurrent presence at signature fairs, workshops, and meetings, as well as their limited availability during those events to be interviewed or have informal conversations. These interviews aim to capture diverse perspectives on the value, challenges, and potential of Andean potato agrobiodiversity conservation. Most interviews were conducted in Spanish, and a few were conducted in Quechua to ensure a comprehensive perspective of my interlocutors' testimonies. I translated the necessary materials/outputs to English for analysis.

Based on the principles of grounded theory research, which focus on a process of joint data collection and constant comparison (Charmaz 2014), I developed analytical memos and examined the relationships between the following categories: Andean household, autonomy, authority, agency, commercialization, consumer preference, culture and heritage, diet and nutrition, entrepreneurship, food and biodiversity fairs, food security, gastronomic uses, gender, identity, in situ conservation, migration, local government, politics, representation, rural development, sovereignty, and value chain. I used the open software Taguette for qualitative analysis to code my interviews and identify results. To uncover hidden transcripts, I focused on

examining my field notes, considering dominant narratives and the perspectives and voices that are not overtly expressed in public spaces. Over the course of my fieldwork, I had access to spaces where hidden transcripts circulate: homes of farmers, stalls at the fairs, closed meetings, and workshops with AGUAPAN members. Spending time in these spaces and building trust with farmers, NGO leaders, and rural extension workers was essential. In contrast, public transcripts are mostly open to the public, as they circulate at fairs and are often public speeches made by local authorities.

2.5 Everyday Conservation and Commercialization in Rural Spaces

The interplay between commercialization and conservation of potato agrobiodiversity highlights the complex challenges faced by rural potato farmers across various social and geographical contexts. Market dynamics observed at the San Jeronimo and Quilcas fairs reveal how economic pressures often lead farmers to prioritize commercial varieties over native ones, diminishing the importance placed in preserving agrobiodiversity. Moreover, the experiences of communities like Monte Azul and Churumbamba highlight the enduring impact of historical distrust and market isolation on farmers' ability to balance commercial interests with conservation efforts. Despite their commitment to preserving local potatoes driven by heritage and practical necessity, these communities navigate socio-economic hurdles and traditional gender dynamics while relying on traditional farming methods and lunar rhythms. Thus, these tensions between commercialization and conservation reveal that potato farmers do not fully benefit from potato agrobiodiversity. Fully benefiting from agrobiodiversity, will include the opportunity to foster fair prices, gain public recognition based on their efforts, and become visible to wider audiences in multiple venues.

2.5.1 Quilcas and San Jeronimo Weekly Fairs

In examining the weekly markets of San Jeronimo and Quilcas, it becomes evident that these fairs serve different roles within their respective communities, despite their geographic proximity. The San Jeronimo fair is characterized by its large number of stalls and wide variety of products, catering to a diverse and expansive consumer base. In contrast, the Quilcas fair is smaller, fostering a close-knit community environment that strengthens the connections between farmers and local consumers. These two fairs are not explicitly focused on the preservation of agrobiodiversity but rather reflect the economic and social realities faced by farmers. Instead, contestation in these markets plays out in the need to sell potatoes at prices that rural people can afford, the desire to maintain "casero" relationships, and the persistence of social hierarchies. These dynamics often lead to prioritizing commercial potato varieties over native ones, thereby decreasing returns to agrobiodiversity. By exploring the dynamics of these local markets, we can gain insight into how farmers navigate commercial pressures and community relationships while maintaining their agricultural practices and cultural traditions.

In these spaces, it becomes apparent that preserving agrobiodiversity is not necessarily the main goal of these fairs. Despite being located close to one another (less than 5 miles apart), the San Jeronimo and Quilcas weekly fairs serve distinct functions within the local landscape. San Jeronimo hosts approximately 80-100 outdoor market stalls, offering a diverse array of products including poultry, produce, everyday items like plastics and pans, and various local and regional foods. San Jeronimo emphasizes quantity and diversity, reflecting a broader array of products and a larger consumer base. In contrast, Quilcas hosts about 10-25 outdoor market stalls with similar products but in smaller quantities. The Quilcas fair provides access to a close-knit

community, allowing farmers with small quantities to build closer ties with local consumers. These fairs are not branded as agrobiodiversity fairs but are considered flea markets by consumers accustomed to buying weekly groceries.

“On the first day that I attended both fairs, the diversity of native potatoes was very limited, with predominantly commercial varieties like Peruanita available in most stalls. The prices per kilo of potatoes were notably lower than in urban fairs in Lima, even if by chance you were able to buy native potatoes. Conversations with locals confirmed a trend observed in Lima—mixed varieties were not high in demand. Before attending these fairs, I anticipated that local fairs in rural spaces would offer a wider diversity of potatoes. However, potato diversity is highly variable, even within specific regions. For example, Andean potatoes sold in mixture or chaqru are not common in San Jeronimo, but I was able to purchase them in Quilcas from an AGUAPAN partner who shared her experiences selling potatoes” (Field notes, June 21-28, 2023).

Weekly fairs like Quilcas and San Jeronimo don't provide the same opportunities as annual fairs in terms of significantly increasing farmers' income. Based on informal conversations, farmers sell an estimate of 48 kilos of potatoes on Sundays and 20 kilos on Wednesdays at the weekly fairs. In contrast, they can sell 200 kilos at the annual Huancayo fair. However, weekly fairs offer farmers a stable space to sell their products closer to their villages, reducing transportation costs. Lower prices drive consumer attention in rural as well as urban spaces, providing "a little something to earn" (Mayer & Glave 1999). The contrast between potato prices in rural and urban

spaces illustrates challenges regarding their value for urban consumers who, according to my interlocutors, drive the demand and raise the value of Andean potatoes.

Even though small-scale commercialization of Andean potatoes is not highly profitable, farmers continue this practice (Mayer & Glave 1999). Annual fairs, organized by regional and local authorities, can be uncertain. Upon my arrival, uncertainty loomed over the realization of the regional fair, as the Huancayo municipality delayed its official announcement, casting doubt on farmers who rely on these fairs to increase their income. One farmer expressed uncertainty about where to sell her produce if the Huancayo fair was not confirmed. Despite this, she was determined to keep attending the weekly fair and potentially travel to La Libertad for the AGUAPAN meeting, hoping to sell her potatoes at a higher price.

Weekly fairs foster a close-knit community that allows farmers to secure loyal clients familiar with their products. This dynamic enables farmers to estimate their earning potential on a daily and weekly basis, determining the most profitable days and times. The Quilcas fair, occurring on Sundays and Wednesdays, sees better sales on Sundays. Vendors, familiar with each other due to the close-knit community, engage in barter activities, exchange life advice, and support each other's merchandise. Despite camaraderie, farmers compete in terms of quality, pricing, and client loyalty. They find ways to stand out, such as offering lower prices, higher quality products, or better customer service. An AGUAPAN partner mentioned that her cultivation practices allow her to sell potatoes at 1.30 soles per kilo, below the average Andean potatoes price (5 soles per kilo) in Lima fairs.

The "casero dynamic" exemplifies the relationship between farmers and consumers, fostering trust and loyalty through personalized transactions and discounts. In Peru, a "casero" is both a customer who frequents the same grocery seller and a seller from whom products are frequently purchased (DiPeru 2022, Infobae 2022). This dynamic, which involves active negotiation between customers and sellers, allows consumers to "cash in" their preference for specific farmers' products and receive discounts for their loyalty. Some customers even get their groceries delivered as part of the casero arrangement. In Quilcas, farmers personally know most of their customers and peers, creating a sense of trust and belonging:

“During my last day at the Quilcas fair, I closely observed the casero dynamic in action. An influx of people, particularly middle-aged women, attended the fair to shop for the week. After initial informal queries, local consumers openly negotiated the price and weight of the produce. This shift occurs when customers show interest by asking questions or examining the product. When farmers notice higher consumer engagement, they let them presort their products. Customers and farmers use arrobas instead of kilos to measure weight, with customers inspecting potatoes closely before deciding on quantities. There were minimal queries about the origin of the potatoes” (Field notes, June 21-28, 2023).

In observing the San Jeronimo and Quilcas weekly fairs, it becomes apparent that these spaces, though geographically close, serve distinct functions within the local culinary and economic landscape. While the San Jeronimo fair boasts quantity and diversity, reflecting a broader array of products and a larger consumer base, the Quilcas fair fosters a close-knit community

atmosphere, allowing for stronger connections between farmers and local consumers. However, despite the differences in scale and community dynamics, the preservation of agrobiodiversity is not necessarily the primary focus of these markets. Instead, farmers navigate market demands and economic realities, often prioritizing commercial varieties over native ones to meet consumer preferences and maximize profits. Despite the challenges of profitability and uncertain market conditions, farmers continue to engage in small-scale commercialization, leveraging community ties and customer loyalty to sustain their livelihoods. The "casero dynamic" exemplifies this relationship, fostering trust and loyalty between farmers and consumers through personalized transactions and discounts. In navigating these complex dynamics, farmers demonstrate resilience and adaptability, finding innovative ways to navigate market pressures while preserving cultural heritage and culinary diversity in the Andean region.

2.5.2 Monte Azul and Churubamba Farming Communities

Monte Azul and Churubamba show a profound interplay of tradition, resilience, and adaptation in the conservation and commercialization of Andean potatoes. Despite geographical proximity to urban centers, these communities face economic isolation and historical distrust from potato value chain stakeholders, rooted in past agrarian inequalities. Yet, against these odds, farmers exhibit a deep-seated commitment to preserving agrobiodiversity. Their efforts, driven by both heritage and practical necessity in the face of threats like late blight and changing climates, highlight the multifaceted significance of potatoes beyond mere economic transactions. Gender dynamics and traditional roles shape farming practices, highlighting the need for gender-inclusive approaches to agricultural development. Moreover, the communities' reliance on lunar

rhythms and traditional farming methods, coupled with concerns about soil quality and external pathogens, reveal the intricate challenges and adaptations in Andean potato farming.

Farming communities such as Churumbamba and Monte Azul are distant from potato value chain stakeholders, more so in economic terms than geographically. Farmers from these areas reported facing discrimination when dealing with value chain intermediaries and farmer-led associations, leading to deep-seated mistrust and skepticism. This distrust is rooted in past experiences with wholesalers and associations, a dynamic documented in the literature on economic actors and farmers' relationships from the 1980s (Scott 1985). However, recent studies focusing on potato value chain analysis (Tobin et al., 2016a) and payment for ecosystem services (Narloch et al., 2013; Tobin et al., 2016b) do not delve into how mistrust and skepticism influence the conservation and commercialization of Andean potatoes.

Monte Azul farmers prioritize everyday conservation based on heritage, viewing it as a crucial household economic activity. This conservation is not only a cultural heritage but also a subsistence activity that can supplement income from other agricultural practices, often focusing on commercial potato varieties. Historically, previous generations did not sell their potatoes but grew them for self-consumption, considering potatoes as essential as "pan de cada dia" (daily bread). Today, farmers take a portion of their potatoes to the weekly fair in Huanuco and the annual Muru Raymi fair to participate in contests, which motivate them to preserve various potato varieties. When agrobiodiversity loss occurs due to factors like late blight, Andean weevil, or climatic changes, farmers recover lost varieties by prospecting neighboring fields or exchanging them at the annual fair. According to my interlocutors, Monte Azul households

maintain around 200 potato varieties each, with late blight being directly linked to biodiversity loss.

Women in Monte Azul, as in many rural Peruvian farming communities, work in the fields when paid labor is unavailable. They share conservation tasks with men, although traditional gender roles persist, with women primarily responsible for cooking, feeding animals, cleaning, and washing dishes, while men handle tasks like making furrows and irrigation. The gendered division of labor, studied by scholars such as Molina et al. (2022), reveals that women also assist in harvesting when men are occupied with other tasks. Some potato varieties are lost as farmers age and are no longer physically capable of maintaining them. Historically, female farmers had no access to education due to exploitation by landowners, and male migration to cities often left women to manage conservation tasks alone. During interviews, women took longer to respond and often avoided eye contact when unsure, though they appeared more confident when helping with practical tasks like sorting potatoes. This behavior reflects cultural stigmas and racial divides that inclusive narratives have yet to reconcile.

Poverty and social inequities are significant issues in everyday potato conservation in rural communities like Churumbamba and Monte Azul. Poverty in these areas is often referred to as an intimate understanding of the "reality of rural farming," as expressed by extension agents and local authorities. This reality is fragmented; studies on rural poverty in Peru show difficulties in reaching a consensus on its measurement and highlight unequal poverty distribution, with the elderly and women being most affected (Clausen & Trivelli 2019). The perception of poverty among farmers in Churumbamba underscores a stark division between rural and urban poverty,

correlating with differing potato farming practices. Churumbamba residents note sharp social divides among farmers, with small-scale Andean farmers experiencing extreme poverty while those near urban centers face less severe conditions. The pandemic has exacerbated rural poverty, with recent assessments indicating that those already impoverished have become poorer (Trivelli 2023).

Elevation significantly influences farming practices in these regions. As one ascends the Andean mountains, the customs, traditional costumes, and challenging climate become more pronounced. Potato fields are typically located uphill, where rural farmers manually harvest and transport potatoes without machinery, navigating steep terrain. Local farmers adeptly traverse this terrain daily. Additionally, farmers at higher elevations are more likely to speak only Quechua, unlike their bilingual counterparts at lower elevations who are accustomed to visitors. In the same way that rural and urban poverty are correlated with local farming practices, elevation adds another layer of complexity. Rural potato farmers, located in the most elevated regions of the Andean mountains, who generally speak Quechua, are perceived as the poorest, isolated and skeptical of economic intermediaries in contrast with farmers located at lower elevations. These challenges add up when it comes to commercialize their products, since farmers are required to travel longer distances and position themselves in unfamiliar settings.

Churumbamba farmers use local knowledge to take advantage of lunar rhythms for farming operations such as tilling, planting, and harvesting. They disinfect seeds before sowing, fumigate them after three months, and apply fungicides purchased from urban areas to control pests like the Andean weevil and late blight. However, they believe overuse of synthetic fertilizers has

degraded soil quality. There is a rumor about an unknown pathogen linked to U.S. anti-drug policies in the 1990s that spread to Huanuco. Farmers fumigate native potatoes, which are considered vulnerable to local climate changes. Most farmers I interviewed in Churumbamba could not recall all the varieties' names and maintained fewer varieties than those in Monte Azul. Varieties with poor flavor were not conserved. During the pandemic, some Churumbamba farmers continued growing their varieties and did not lose them, unlike those in Monte Azul. In examining the experiences of Monte Azul and Churumbamba, it becomes evident that the conservation and commercialization of Andean potatoes are deeply intertwined with socio-economic challenges, historical distrust, and cultural heritage. These communities, while geographically close to urban centers, face significant economic isolation and discrimination from value chain stakeholders, rooted in past agrarian inequalities. Despite these barriers, the commitment to preserving agrobiodiversity remains strong, driven by both heritage and practical needs. Gender dynamics play a crucial role in farming practices, highlighting the necessity for inclusive agricultural development approaches that recognize the contributions of both men and women. Traditional methods, including reliance on lunar rhythms and local knowledge, demonstrate the farmers' adaptability in navigating environmental and economic challenges. This detailed exploration underscores the resilience of these farming communities in maintaining their cultural heritage and agricultural biodiversity amidst modern pressures, emphasizing the multifaceted significance of Andean potatoes beyond economic transactions alone.

2.6 Conservation and Commercialization at Food Fairs

Larger food and agrobiodiversity fairs in Peru serve as discursive arenas where the celebration of agrobiodiversity masks the deeper socio-political challenges faced by the farmers, underscoring

the need to incorporate their perspectives into policy and practice for meaningful and sustainable conservation efforts. Despite efforts to emphasize local potato agrobiodiversity at these fairs, practical challenges and aspirations linked to development agendas often fall short of concrete benefits for rural farmers due to bureaucratic hurdles and divergent views on agricultural development. Decision-makers at these fairs articulate varying strategies, from bureaucratic initiatives to tourism-based economic inclusion, to promote agrobiodiversity conservation. However, these strategies occasionally neglect the nuanced realities faced by rural farmers, treating agrobiodiversity as resource rather than complex cultural and ecological heritage. Nevertheless, both fairs remain vital discursive arenas where local aspirations intersect with external developmental agendas, showcasing a shared commitment to sustainable practices and the preservation of Andean crops while navigating the complexities of rural development in Peru. Therefore, it is imperative to recognize the critical role of farmers in agrobiodiversity conservation and to ensure that their voices are heard, and their needs addressed in policy-making processes and agricultural development initiatives.

2.6.1 Muru Raymi Fair, at the Kichki district

The Muru Raymi Fair exemplifies an intersection of public transcripts within rural spaces, specifically highlighting how local authorities and potato value chain actors navigate the discourse of agrobiodiversity conservation. This event serves as more than just a celebration; it acts as a platform where diverse stakeholders come together to voice and address overlooked needs and concerns, while also projecting visions of regional rural development. Through my interactions and observations at the fair, I witnessed the ritualized emphasis on local potato agrobiodiversity within public discourses, often articulated by local authorities and rural

entrepreneurs. These discursive arenas, like the Muru Raymi Fair, provide a stage for sharing accumulated experiences and aspirations related to agrobiodiversity conservation, with discussions ranging from practical challenges to aspirational goals linked to development agendas.

Local authorities visiting traditionally isolated rural communities relates to what scholars in cultural anthropology call “the margins of the state” (Das & Poole 2004), referring to how “peripheral” sites shape alternative political and economic imaginaries about the nation. Sentiments of State abandonment have been prevalent for many decades in rural Peru, specially related to environmental controversies, rural to urban migration, and corruption (Sierra 2022, Valdivia 2023, Beteta 2021, Tovar 1992). The presence of local authorities in isolated communities suggests a newfound visibility for those fostering agrobiodiversity conservation. However, more visibility does not necessarily translate into more benefits for farmers. Instead, it facilitates spreading narratives that view farmers as mostly economic actors, or producers.

The Muru Raymi Fair has grown in media presence over the years, attracting not only media outlets but also local and regional authorities. Thus, it is an event that congregates most of the regional and local policy makers and authorities. For this reason, and because it is a public event, the Muru Raymi Fair provides an important opportunity to examine how public transcripts circulate at rural spaces. In the next paragraphs, I will provide detailed descriptions of how these public transcripts are performed by different actors: the Kichki mayor, rural entrepreneurs, representatives of the regional government, the mayor of a neighboring district, NGOs and representatives of rural and economic development.

After the pagapu, an Andean ritual that honors Mother Earth by offering potatoes, and other inaugural events, the Kichki mayor began his speech by welcoming attendees to the fair and extending greetings to the authorities, farmers, and other decision-makers present:

“After greeting the authorities and the farmers, the Kichki mayor said: "We are the district with the highest quantity of potatoes that feed the entire world. That makes us feel proud and happy," adding that he promotes the work of the conservationist farmers "forgotten" by the state. He mentioned that "we must preserve genetic diversity because each year we lose affects the coming generation" and "food has never been lacking" because custodian farmers have "fed the city" during the pandemic. The mayor commits to continuing to seek funding for sustainable development projects and keep "knocking on doors" for support. “Just as Cusco has its Inti Raymi, Huanuco has its Muru Raymi, which is important for the food chain," emphasizes the mayor, acknowledging the role of the rural entrepreneurs” (Field notes, June 17, 2023).

Public discourses, led by authorities and rural entrepreneurs provide a public platform for sharing experiences and aspirations related to potato agrobiodiversity conservation, from practical challenges to aspirational goals linked to development agendas. Nevertheless, these discourses contribute to the idea that rural potato farmers don't benefit enough from agrobiodiversity conservation, since the expectations shared during these events aren't always realized. This idea was shared by the representative of the economic management of Huanuco, who confessed that during his administration a project “slept the sleep of the just”, for many years:

“The representative of economic management points out that in 2016, he thought that the Muru Raymi fair could "be magnificent not only for Peru but for the world." He confessed that during his administration, a native potato project began, which "slept the sleep of the just," implying that it was not carried out at that time. However, he adds that this project will be implemented in 2024 with a budget of 25 million soles. The aim of this project is to value the "guardians of the seeds," and it would be "something concrete" that is being worked on with the Directorate of Agriculture and Irrigation. He states that "processes are slow in the public sector" and suggests that it is key to “invest in the countryside”. He asserts that "production without the market does not advance”. “If we don’t have the market, then it is useless”, he mentions. He then requests that decision makers should value the work of farmers, both by buying directly from local farmers and in high-value markets. Finally, he stated that the Muru Raymi should become a "development tool" and "worldwide celebration”. (Field notes, June 17, 2023).

The emphasis on developing concrete projects, amidst bureaucratic hurdles signals how in public transcripts, decision makers tend to focus more on rhetorical or unpractical projects that are bogged down by slow bureaucratic processes. By focusing the public attention on the bureaucracy, decision makers at local spaces tend to avoid individual responsibility for not being able effectively pass policies that benefit farmers in their regions. Additionally, it is also important to note that the notion of investing in the countryside allows broadening out the discourse to the point that rural farmers are not viewed as the protagonists of such local development projects. Finally, by stating that production without the market does not advance, the representative signals the tension between agrobiodiversity conservation and

commercialization, suggesting that it is difficult to untangle conservation from agricultural production.

Beyond bureaucratic hurdles, other decision makers focused on tourism as a discursive strategy for economic inclusion. Again, expectations shared during public discourses may take long to be implemented, and thus they may not provide concrete benefits for rural farmers in the short or medium term. However, they make compelling public transcripts as they focus on cultural projects that highlight local pride and identify based on what Kichki, as an agrobiodiverse region, may offer to “world” and to Peru in contrast with projects from other regions such as Cusco:

“The mayor of a neighboring district highlighted the relevance of implementing development projects that can be included in tourist circuits. Before handing over the floor to the next speaker, he reaffirms his support for Kichki. As the day before, the local NGO representative was asked to speak. Like the day before, he emphasized the role of rural farmers during the pandemic and added that his organization seeks to promote Kichki as a "biodistrict" free of agrochemicals. He suggests that "tourism must enter the countryside" alongside farmers and provide accommodations and food based on local products. This project will require support from the regional government and other Huanuco districts. He concludes by stating that "Poverty persists in the countryside. Competitiveness is born in the countryside; emerging economies must be developed within the framework of the agroecological revolution".” (Field notes, June 17, 2023)

The intersection between tourism and economic development is prevalent in these public transcripts about agrobiodiversity. Moreover, the importance placed on designating places as biodistricts, shows how classifying regions as touristic destinations can help bring more attention and funding to agrobiodiversity conservation. However, this idea was contested by experienced rural extension workers, who suggested that designating a place as zone of agrobiodiversity, often carried out by the Ministry of the Environment, can have unexpected implications for farmers that do not necessarily consider themselves stewards of potatoes, or that just have a different take on how their families should benefit from conservation. It is important to pay attention to the local context before designating a place as a site of potato conservation.

Another group of decision makers at the fair highlighted the potential that Kichki has as a site for becoming a touristic resource, connecting the scripts about entrepreneurship and economic development with the notion of pride. For this, it would be necessary to work in collaboration with “our countryside brothers”, meaning working with famers to increase the production (not the conservation) of crops and their consumption, both economic drivers of commercialization of agrobiodiversity. What surprised me was that decision makers in these settings view agrobiodiversity as ecological niches that need be taken advantage of. This view understands agrobiodiversity as extractable natural resources, such as minerals. This resonates with the notion of fallacious prosperity, by the historian Jorge Basadre (Lynch 2013) who wrote about the cycles of economic prosperity and the inability of the Peruvian government to take advantage of them:

“Kichki has a lot of potential, said the representative, indicating that his institution and a local university seek to promote diverse projects in tourism. "The Muru Raymi is already

classified as a touristic resource," adds the representative. "We have to turn our brothers from the countryside into entrepreneurs," says the representative, who gave the floor to an official from Huanuco's regional agriculture department. After emphasizing the relevance of "coordinated work" within the "framework of genetic biodiversity," the official stated, "We have to be proud of the producers," emphasizing the diversity of Andean potatoes expressed in the diverse native varieties. After mentioning that he has experience working with "our countryside brothers," he states that support for agrobiodiversity fairs should continue. "We have to produce and consume what we have. Peru is rich in its ecological niches; we must take advantage of that," he adds". (Field notes, June 17, 2023)

The discourse surrounding agrobiodiversity conservation at events like the Muru Raymi Fair intertwines with development agendas and projects, reflecting a combination of local aspirations and external expertise. Public transcripts articulated by local authorities and stakeholders not only address immediate agricultural challenges but also serve as a platform to promote and advertise regional development goals. This discourse not only reaffirms the knowledge and prestige of external experts but also highlights the shared commitment to sustainable practices and the preservation of Andean crops. By engaging in these dialogues, stakeholders leverage public transcripts to showcase their visions for rural development, aligning past development policies with future aspirations. Thus, the Muru Raymi Fair emerges as a discursive arena, where local agrobiodiversity conservation converges with external developmental agendas.

2.6.2 The National Native Potato Day, at Lima

The National Native Potato Day Fair organized by the Municipality of Lima, the Institute of Agricultural Innovation (INIA), the International Potato Center (CIP), and AGUAPAN shows how public transcripts revolving around native potatoes and agrobiodiversity took center stage at an urban setting. This fair aimed to enhance potato consumption and popularize various potato-based products, such as chips and vodka, alongside showcasing native potato varieties from different regions. This fair prioritized mainstreaming value chains and engaging consumers with Andean products. Key stakeholders shaping public discourse included gastronomic experts, private companies, and research agencies, initiating a shift towards commercial narratives highlighting economic potentials and cultural significance. This dynamic redefines public transcripts by emphasizing culinary innovation, economic interests, and scientific expertise, all aimed at reshaping urban consumption related to potato varieties. The involvement of private entities and research institutions shows the convergence of commercial interests and scientific knowledge, steering narratives towards consumer interests and economic agendas related to nutrition, and family farming.

The Municipality of Lima organized a fair to commemorate the National Native Potato Day in coordination with the Institute of Agricultural Innovation (INIA), the International Potato Center (CIP), the CITE Papa, AGUAPAN, the Agriculture Platform in Lima, the Peruvian Association of Consumers and Users (ASPEC), and the Columbia Institute. The fair took place in the Parque de la Exposición, located in downtown Lima, providing a prime location for customers to approach and acquire potato-based products such as chips, vodka, among others. Many consumers were familiar with the fair's location, as in previous years, there were other food fairs

for Andean products like Mistura. According to the local press, the fair offered an opportunity to "enjoy more than 100 varieties of native potatoes" such as yellow, huayro, yellow tumbay, Huamantanga, from regions including Cusco, Puno, Junin, Pasco, Huanuco, Huancavelica, Ayacucho, and Lima. The Native Potato Day fair featured various activities such as gastronomic events, direct sale and exhibition of native potatoes, and cultural activities including traditional dances and cooking shows by two renowned Peruvian chefs. This fair is designed to promote the potato value chain and increase the consumption of native products, both raw and processed. Thus, the benefits for farmers were not clearly incorporated as a byproduct of these fairs, just increase their temporary earnings while at fairs. Nevertheless, it's important to notice how farmers efforts are not necessarily the main topics discussed.

One of the first stakeholders that took center stage was a member of La Poderosa mining company, that recently funded the publication of the latest potato catalog from the region of La Libertad, where Pataz Association, a local NGO operates. It's surprising how this firm supports agrobiodiversity, and at the same time engages in extractive activities in Northern Peru. When I visited this region, I noticed how Pataz worked very closely with local farmers to organize another fair in the city of Humachuco. As the La Poderosa member stated, this signals an ongoing partnership between farmers, Pataz and local authorities:

“The representative of La Poderosa stated that "Inti (Sun deity) accompanies us" and that the Andean potato is the "most authentic product of our culture" that "fills us with pride." She expressed gratitude to the farmers of Pataz and the municipality of that region and added that they have been working for many years in the area with a "good neighbor"

policy, fostering good relationships in the district and the province of Pataz. She mentioned working with the Pataz association to promote local development through farmer committees, as well as their partnerships with public and private entities. Other highlighted points included addressing needs such as health, education, and childhood anemia. According to her, La Poderosa supported agricultural organizations to improve their farming practices”. (Field notes, May 26, 2023)

La Poderosa is a mining group that has been supporting breeding commercial potatoes such as improved varieties like the INIA 325 PODEROSA, which was announced to be released later that year. Mining companies in Peru have had a complicated relationship with Andean communities in the last 20 years. Since 2004 socioenvironmental conflicts were recorded by the Ombudsman’s Office of Peru. Based on Ombudsman data, Paredes states that socio-environmental conflicts—defined as conflicts related to the control, access, and use of the environment and its resources—represented 68% of all conflicts (Paredes 2017). Of these, 62% conflicts were related to the mining industry. To improve mining image, firms in this sector have been implementing corporate social responsibility models (Vogel 2006, Porter & Kramer 2006, Freeman 1984, Perez et al 2016) into their operations. Public transcripts related to agrobiodiversity promotion can be interpreted as corporate social responsibility strategies, partnering with local organizations, allowing mining operations to continue in Pataz.

Subsequently, a representative from the Ministry of Agriculture took the floor, stating that he feels happy because, in his view, the native potato "allows us to understand urban consumers." However, this focus was more on bringing consumers closer to farmers, and not increasing

farmers benefits from conservation. The attention is on the product, in this case potatoes, that need to become quality products, in terms of being appealing to urban tastes:

“The government representative understands potatoes as capable of bringing together urban and rural spaces, connecting farmers and consumers. He then points out the importance of working with organizations like CIP, the Pataz Association, and the "producers." For him, this reflects a "joint effort," such as the recent catalog that emphasizes the "varieties of the country" and their "potential richness." Then, the representative thanked La Poderosa, stating that it is “possible to invest" and that small farmers can cultivate a "quality product." "Potatoes will save humanity in the future," he adds. Therefore, for him it is important to work with private companies and CIP so that other companies join and can be replicated in other regions of the country. Based on his experience of "over 30 years in the public sector" and his work in different regions, he emphasizes the importance of ensuring the sustainability of ecosystems and the value given to potatoes”. (Field notes, May 26, 2023)

Government representatives understand custodian potato farmers as producers, as well as partners willing to join their efforts and other value chain actors to make use of potatoes as quality natural resources. Nation branding strategies that have been put in place as public transcripts in the gastronomic sector, are used in potato conservation with the same goal: to promote urban consumption and value chain integration. Because Andean potatoes are also public goods and heritage foods, expectations around saving future generations from hunger as well as providing nutritious and diverse diets consolidate. Experts highlight the nutritional

properties of potatoes, thus making it a healthy alternative to incorporate in urban diets. The value of potatoes rest in its potential to fulfill those promises. At the same time, Andean potatoes need to fulfill the expectations of nation branded foods, and thus they should be marketed as a symbol of Peruvian identity in food and biodiversity fairs.

Next, the representative of the Center for Productive Innovation and Technological Transfer of the Potato (CITE Papa) takes the floor, emphasizing that Andean potatoes bring people together. In contrast with other actors of the value chain, this representative acknowledged the effort put in place by farmers, thus signaling that agrobiodiversity value comes from conservation work as labor. She goes even further, recognizing that rural farmers are great scientists in constant search of the perfect potato. However, as we have shown in earlier sections, not all rural farmers are so invested in conservation work, and thus describing them as going through a quest for the perfect potato may misrepresent all of them:

“The representative highlights the importance of returning to hold in-person events after the COVID 19 pandemic. She requests a minute of silence for those farmers and individuals who died due to COVID. Then, she states that fairs bring together the "entire value chain." She adds that the "producers" have made an effort to attend the fair, like the other actors in the value chain. She then makes a reference to the origin of the potato, mentioning that there is "no scientific doubt that potatoes were domesticated in Peru." Additionally, she argues that potatoes travel around the world, are venerated and should be given "the best added value." Referring to custodian farmers' work, she indicates that they are great scientists because they "never discarded any potato variety" in the search

for the "perfect potato." She states that since 2005, Potato Day has been celebrated, and it is essential to recognize the people who were part of that process". (Field notes, May 26, 2023)

Bringing people together is a cultural element recognized by potato farmers as well as consumers familiar with Andean products value as more than national resources. It's a communal dynamic, in the sense that potatoes have the potential to bring together the value chain actors, in the same way that farmers come together to exchange seeds and meet peers from other regions. This is not to say that the economic value is not a priority, but rather that the value of Andean potatoes cannot be reduced to their value as a resource. This relates to the idea of the "added value" of potatoes that comes from the labor, and the social relations that are possible due to the materiality of the crop (ease of transportation, diversity of shapes, colors and flavors), as well as the value that results from exchanging, caring for and commercializing them. A portion of that value also rests on farmers local knowledge, to not quickly discard varieties due to economic reasons.

The public transcripts shaped during this fair underscore the pivotal role of collaborative efforts, scientific insights, and in situ conservation work in fostering initiatives that celebrate and safeguard Peru's potato legacy. One key aspect of this event was the interaction with gastronomic actors and value chain stakeholders, who actively sought to accumulate media presence and shape public narratives around native potatoes. While rural farmers participated eagerly, striving to be protagonists, challenges persisted in generating business synergies that truly benefited

them. Despite the efforts to showcase their products, obstacles hindered integration into broader economic networks in their own terms.

2.7 AGUAPAN – Bridging Diverse Commercialization and Conservation Settings

This section intersects with the challenges that AGUAPAN faces as an organization that seeks to participate in the potato value chain. Tensions between commercialization and conservation emerge, as AGUAPAN aims to scale up operations. Hidden transcripts become organizational goals, challenging previous public transcripts and ideas of rural development. This section illustrates how AGUAPAN struggles to find a space and channel to participate in the gastronomic boom in their own terms. As an organization conformed by small scale farmers, they seek to participate in national gastropolitical spaces such as government fairs. I will explore how AGUAPAN struggles to become an autonomous organization. Even though it was conceived by CIP and Grupo YANAPAI, AGUAPAN's members consider it legitimate. However, it depends on Grupo Yanapai expertise and support to carry out most of their activities, as well as CIP's mediation to secure international funds to support Andean agrobiodiversity.

2.7.1 AGUAPAN and Community-Based Conservation

AGUAPAN is a national association of small farmers who conserve 50 or more varieties of native potatoes in Peru. It was established in 2014 with 43 small farmers, who were called "potato guardians" (Huanay et al 2023). AGUAPAN receives monetary incentives from the Dutch companies HZPC and AGRICO, which each contribute 15,000 euros annually to directly support 101 farmers (Ccanto et al 2023). Of these funds, 80% is allocated to direct bonuses, and

the remaining 20% is used for legal advisory payments, registration of the board of directors, meetings, and the annual AGUAPAN assembly. In accordance with the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), AGUAPAN aims to share the benefits of agrobiodiversity conservation and to uphold the farmers rights. Since 2009, AGUAPAN has been conducting an inventory and morphological characterization of the native potatoes of its members (Ccanto et al 2023). As a result, 909 unique varieties have been found in five regions of Peru, and seed storage in mixtures (chaqru) has been carried out for each region.

AGUAPAN includes 101 small farmers from nine regions of Peru, each conserving more than 50 varieties of native potatoes (Huanay et al 2023). Every year, AGUAPAN organizes a seed and knowledge exchange meeting in different regions. To date, seven such meetings have been held, and the participation of the AGUAPAN network, local governments, and academia is steadily increasing. Before the establishment of AGUAPAN, native potato farmers were scattered, each participating in their own communities (Huanay et al 2023). Farmers exchanged seeds at local fairs in their community or neighboring communities and visited various markets and festivals organized by local and regional governments. The most representative events for them are National Potato Day and Farmer's Day. With the creation of AGUAPAN, farmers who were previously disconnected began to travel to meet each other, exchange seeds and develop friendships. According to Huanay et al (2023), non-monetary cooperation (94%) between members (e.g. seed exchange) is the main strategy that AGUAPAN relies for community-based conservation.

AGUAPAN represents a case for exogenous community-based conservation, since it was conceived by external actors, such as HZPC and AGRICO that provide funds for activities related to conservation. According to De Haan (2021), for communities and farmers, conservation is rarely an objective in itself. Instead, conservation is the outcome of the active use and utility of genetic resources for food consumption, income generation or cultural purposes (De Haan 2021). This signals that preserving genetic resources is mostly within the interest of external stakeholders, or that conservation is understood differently with communities, such as for instance preserving local cultural heritage. Thus, agrobiodiversity conservation intertwines with social and cultural factors, such as traditional knowledge. Additionally, it is important to note that in the context of community-based conservation, collectively crop diversity is managed as a common pool resource, with different communities establishing specific rules and norms for access, use and exchange (De Haan 2021). For instance, in the case of AGUAPAN, they have established their own dynamics around seed exchange at fairs. As an association that has a national scope, it's interesting to note how AGUAPAN is trying to integrate often heterogenous norms for common pool resource management that are defined at the household level (Mayer & Glave 1999), with gender and age considered as key factors for different conservation practices.

In contrast, from a grassroots gastropolitics point of view, AGUAPAN also represents an attempt to challenge market-based approaches that seek to develop value chains for crop diversity, such as matching potato farmers needs with firms that work with chips (Tobin et al 2018). However, AGUAPAN is considered as part of a corporate social responsibility model since it is funded by two private companies. Thus, even though in some instances it aims to focus on cultural reaffirmation approaches to conservation that seek autonomy, it depends on external support to

develop capacities to reach such autonomy. This is another paradox, since initiatives that advocate for autonomous community-based conservation require ongoing external support to be sustainable. This external support group is usually distant from AGUAPAN evolving needs, except for extension partners who are closer to the members concerns. The external group opinions about AGUAPAN, may not be reliable to understand farmers views on the support they get. In consequence, it is relevant to ask AGUAPAN members what they think about their organization.

When asked about their opinions on this matter, AGUAPAN partners mentioned that they felt proud to be members of AGUAPAN and share benefits with other members from other regions, such as a communal health insurance and a bonus for preserving potato varieties. They thanked the organizations involved in securing institutional support mechanisms, but above all they felt grateful to their potatoes: “potatoes have united us”. Even though they have different varieties in each region, they share their commitment for caring for potatoes as well as the joy of sharing their local traditions. Nevertheless, when asked about if their lives have changed since becoming AGUAPAN partners, they mentioned that even though they are recognized by external entities, selfishness persists between them and non-AGUAPAN growers. As AGUAPAN grows and includes more partners, they will need resources such as transportation and local authorities’ support to host meetings and provide technical assistance. To achieve that, AGUAPAN members reasoned that its organization needs to decentralize, so it can gain organizational cohesion. They pointed out that there are certain commitments that they need to uphold, such as preserving at least 50 varieties of potatoes per household.

Women and youth involvement became a recurrent theme for AGUAPAN partners as they listed the challenges of their organization. They estimated that roughly, 60% of AGUAPAN partners are male while 40% are female. However, they mentioned that female farmers usually tend to focus on their families, and they do not have time left for AGUAPAN. Even though female participation has increased in farming activities, AGUAPAN female partners feel that they are not comfortable with an overwhelming presence of male farmers in agriculture. They mention that as a custom, male farmers go “in front” of their female partners, meaning that they assume decision making roles often. The division of labor is based on gender roles, with women tasked with seed sorting and selection, and men tasked with activities that require more strength. Female AGUAPAN partners highlighted that single mothers are usually more active in AGUAPAN activities. I corroborated this during interviews with women who assumed leadership roles, and attended the events organized by AGUAPAN. Regarding youth involvement, they were aware that full members need to assign replacements in case they were not able to attend the meetings. This represents an opportunity for younger generations of farmers to step up and learn to appreciate conservation in the same way as their older relatives.

According to the AGUAPAN partners, one of the main challenges of their association is achieving internal cohesion as well as developing stronger outreach and communication strategies. When asked about the support received, the partners acknowledged that they depend on Grupo Yanapai’s support to organize themselves, and that needs to change. They compared their relationship with Yanapai to a father-son relationship, in the sense that they will need at some point to learn to “walk by themselves”. Even though they consider that the bonuses they receive help to support them, some AGUAPAN partners consider that it is not enough to sustain

their activities in the long term. They acknowledge that some AGUAPAN partners have gotten used to those benefits, and thus they participate to avoid losing them. Thus, there is not much interest in developing cohesion since some partners do not show initiative. Additionally, most partners live far away from each other, and maintaining communication between them is difficult. Some don't know how to read or write, so they ask other household members to answer text messages. Nevertheless, partners who frequently attend the meetings value the communication and outreach skills they have developed. They would also expect to see changes in leadership roles. According to AGUAPAN partners, decision making is centralized.

AGUAPAN exemplifies the complexities of community-based conservation, uniting over a hundred farmers across Peru to preserve native potato varieties. While crucial support from HZPC and AGRICO underscores the tension between external dependence and internal autonomy, AGUAPAN's activities emphasize communal cooperation and traditional knowledge sharing. This blend of social, cultural, and agricultural practices highlights the broader significance of agrobiodiversity, encompassing community resilience and cultural heritage. However, challenges such as internal cohesion, gender dynamics, and youth involvement need addressing to ensure effective governance. Improved communication and decentralization are critical as AGUAPAN strives for greater self-sufficiency. Members' pride in their association and gratitude towards their potatoes and supporting organizations illustrate the deep cultural significance of their work. In summary, AGUAPAN's journey is a testament to the power of collective action and the role of agrobiodiversity in sustaining communities, with internal and external challenges to address for long-term success and sustainability.

2.7.2 Navigating Autonomy and Scaling Up: AGUAPAN's Struggles for Visibility

To better understand AGUAPAN struggles for autonomy and strategies on scaling up of their operations, I participated in their annual meetings (August 2022 and July 2023) as well as spent many days with them selling potatoes at food fairs (May 2023). In the next paragraphs, I am going to focus on these experiences, with a focus on how grassroots gastropolitics allowed AGUAPAN to become gradually visible to decision makers and value chain actors supporting potato conservation despite facing organizational and logistical challenges.

The first annual meeting of AGUAPAN held in Huancayo, Junín region in August 2022 was initially postponed due to political unrest following events surrounding President Castillo's removal. Once conditions stabilized, the meeting convened with AGUAPAN partners engaging in activities like press conferences, an annual assembly, and an agrobiodiversity fair:

“After changing into traditional attire, AGUAPAN partners, attracted attention of the public and answered questions about native potatoes from journalists at the press conference. Speakers from tourism, consumer protection, and FAO highlighted the significance of native potatoes and agricultural challenges. AGUAPAN partners emphasized their association's growth and role in preserving agrobiodiversity but faced challenges in articulating their vision. The mayor stressed the importance of agriculture and local identity, lamenting government neglect. Journalists queried officials on support for agriculture, pesticide usage, and infrastructure concerns. After the press conference, AGUAPAN partners reflected on missed opportunities to convey their message effectively and expressed communication challenges within their association. This

meeting shows the need for improved communication and strategic focus to advance AGUAPAN's mission". (Field notes, August 16, 2022)

Often, when interacting with decision makers, AGUAPAN farmers struggle to convey their point of view regarding farming and conservation. What usually happen is that decision makers dominate narratives about the value and meaning of Andean potato conservation. I observed this not only in press conferences, but also during the annual assemblies and workshops. As a result, AGUAPAN keeps relying on external support to write financial and organizational reports. I helped and was asked to draft letters, press releases and reports of the annual meetings activities. Usually, Grupo Yanapai focuses on these tasks. However, they are aware that AGUAPAN should become autonomous at some point, and thus host their own meetings and their own assemblies. Currently, AGUAPAN leadership struggles to make decisions about commercialization of native potatoes, including and excluding members, offering benefits such as health insurance, and developing partners. Challenges will increase as AGUAPAN operations scales up. These issues have been pointed out by Hernandez & Cavero (2013), regarding dependency on development brokers to "speak" the language of international aid.

AGUAPAN members with most experience in public speaking and organizing often occupy leadership positions within the association. These members have previously occupied leadership positions in the communities, and in some cases, have occupied leadership positions more than once in AGUAPAN. Of all AGUAPAN members, the leaders usually participate in public events and speak in representation of the organization. When asked about their roles, they were happy to occupy these positions, but at the same time they recognized that it requires to invest more

time. Leaders speak up about issues that matter to them, but at the same time seek to position themselves as rural entrepreneurs, since they are more likely to represent the association in different venues and interact with value chain stakeholders. Some of them are very interested in commercialization and argue that they will be able to ship potatoes to different destinations if demand increases:

“The AGUAPAN partner highlighted the scale of AGUAPAN, stating that it represents the nine regions that make up the organization. He stated that it is necessary to invest in "large-scale" agroecological projects in Kichki that use zero pesticides. He adds that his work is ecological to protect the environment. Then, he explicitly mentions the mayor, stating that he is the "son of a producer who knows the reality", meaning the everyday working conditions of farmers. With this phrase, the AGUAPAN partner refers to the empirical knowledge that farmers have about living and preserving their potatoes in their villages”. (Field notes, June 17, 2023).

He emphasized AGUAPAN's broad representation and called for large-scale, pesticide-free agroecological projects. Highlighting the mayor's firsthand farming experience, he stressed farmers' empirical knowledge and the need for collaboration, advocating for partnerships to support rural farming. Due to the State abandonment, according to the AGUAPAN partner, it is necessary to “articulate” and collaborate. Articulation, in this context, implies generating lasting partnerships among different organizations involved in agriculture and conservation that support family farming. This discourse reveals pressing concerns about isolation, exclusion from the

value chain, and lack of government support. It also focuses on the need to incorporate marginalized voices into policy and practice for meaningful and sustainable conservation efforts:

“Unlike other speakers, the first AGUAPAN representative explicitly invited the audience to approach the stands to taste and buy potatoes. Before giving the floor to another AGUAPAN partner, he thanks the support of La Poderosa, the Patata organization, and mentions that the government should not only worry about farmers for just one day but “every day of the year”. The second AGUAPAN representative, mentions the difficulties some of his peers had traveling to Lima, which involved a 25-hour journey. He stated that the potato is a global product and thanked La Poderosa. "Since childhood, I have worked the land", and "sweated hard as a farmer." He adds that they have had to transport potatoes for an 8-hour walk before packaging it for ground transportation. The AGUAPAN representative values educating "professional children" thanks to the income from selling potatoes. "We, as peasants, live off this tuber," told him, adding that he is "sending the message for the minister to support us." He specifies that "in some cases, there is, and in other cases, there is not enough to sustain ourselves." Finally, he calls on the current Peruvian president to "have the conscience to help us," as agriculture is essential for children and their nutrition”. (Field notes, May 26, 2023)

In contrast with other stakeholders, AGUAPAN partners, who represent a small group of potato farmers and are described as rural entrepreneurs, made emphasis on the value of their labor, and being acknowledged by the government. In this sense, their demands are also critiques to the government for forgetting them most of the time and selectively include them in few events. This

relates the sentiments of State abandonment, but at the same time it speaks of State selective inclusion in selected government sponsored fairs. The idea of participating in these events, allows them to send a message for the government officials, in hope that they take their demands for visibility and support more seriously. At the same time, conservation work allows them to achieve other goals that are very important to them, such as providing education for their family.

Despite AGUAPAN newfound role at public speaking, most of them feel more comfortable at fairs selling potatoes. However, at these fairs, they also need to communicate to urban consumers who are not familiar with their products. Fairs are important not only because they are site for the circulation of public transcripts about agrobiodiversity conservation, but also because fairs are key sites where farmers attempt to increase temporarily their income by engaging with the public. Thus, they are arenas where AGUAPAN farmers need to perform as custodians, which means dressing in a specific way, speaking about their products with fondness and nostalgia, and developing negotiation abilities to temporary increase their income.

AGUAPAN farmers, due to their involvement in training sessions about climate change and agroecology, are, in theory, more prepared to communicate the benefits of consuming potatoes. Nevertheless, they face challenges, such as interacting with the media, explaining how to prepare potato-based foods, and performing as the protagonists of conservation that appeals to the notion of nation branding of food. In this way, they struggle to be included in unfamiliar spaces. I observed interactions where AGUAPAN stands attracted farmers, entrepreneurs, chefs, and gastronomy students, reflecting a growing interest in native potatoes. Consumers, both familiar

and new to AGUAPAN's products, engaged with partners over potato origins, nutritional benefits, and culinary uses:

“During the first day of National Native Potato Day Fair, AGUAPAN members remained concerned because sales had not increased: "Take some potatoes, collaborate with us so I can afford my fare." The day before, the partner from Pasco and her daughter sold only 5 kilos, while other AGUAPAN partners sold a similar quantity. The expectation among AGUAPAN partners was that urban customers would flock to the fair. Urban consumers typically sought potatoes with specific characteristics. Others were looking for other crops such as oca and tocosh. Additionally, some urban customers purchased potatoes because their relatives and friends were familiar with the origin of AGUAPAN potatoes: "My dad is also from Ancash, he will be happy that I bought something from his land." Something I noticed while observing the nearby AGUAPAN stands was that farmers and entrepreneurs from other stands approached AGUAPAN members to observe their products. At the same time, chefs as well as gastronomy students approached AGUAPAN stands to explore ways to prepare native potatoes. In contrast, farmers from other stands approached to buy or exchange varieties they lacked”. (Field notes, May 26, 2023)

While some customers inquired about the origin of the potatoes, another group of consumers carefully inspected the potatoes to ensure they showed no signs of rot or imperfections:

“Those consumers who were already familiar with the origin of the potatoes established a personal connection with AGUAPAN partners. Others were still amazed by the variety of

colors and shapes of the potatoes. To attract them, AGUAPAN partners mentioned the virtues of their potatoes: "You're eating antioxidants when you eat the red ones." Other consumers, who advocated for diverse and healthy diets, were aware of the nutritional properties of Andean potatoes. They pointed out that diets should change, especially to reduce rice consumption, including Andean products. Some customers expressed joy at having bought native potatoes: "Look at the beautiful, smiling potatoes I bought!" On the other hand, a customer mentioned that they would only buy purple potatoes to decorate their table. A minor group of consumers critiqued and even questioned the origin and price of the potatoes, dismissing AGUAPAN partners". (Field notes, May 26, 2023)

As more customers passed by, they asked questions related to the properties of the potatoes, such as what types of varieties grow in specific altitude zones. Despite efforts to showcase diverse varieties and promote healthy diets, some consumers questioned prices and origins. Talking to other representatives of the organizing entities, they noted that customers tend to buy cheap. Thus, discussions about fair prices for conservation work are a priority for farmers, as well as strategies to increase sales:

“One question that arose while observing these fairs, was the request to set the price at 5 soles per kilo of potatoes. Representatives affiliated to entities familiar with AGUAPAN's business model explained that if AGUAPAN lowers potato price, its partners will likely compete against each other for clients. As I returned to the AGUAPAN stands, the partner from Pasco finished selling another potato bag. She and other partners commented that, although the number of attendants had increased, their

sales had not increased much. Some clients stated that they bought potatoes to "collaborate because they are fellow countrymen." They learned that they have a greater margin of negotiation since they could purchase the varieties they were looking for at a different price in other stands. Even if it results in fewer sales, participating in events embedded with a sense of local identity that facilitate direct transactions brings joy to AGUAPAN partners". (Field notes, May 26, 2023)

Later that day, the demand for specific varieties of potatoes surprisingly increased. As demand intensified for specific potato types, AGUAPAN partners adapted their sales strategies, emphasizing variety and allowing customers to hand-select potatoes, yet sales did not accelerate as anticipated.

"Do you have 'sangre de toro' (bull's blood) potatoes? In another stand, they told me it's called 'ojo de chancho' (pig's eye)." As more consumers made these requests, AGUAPAN partners realized that it was more effective to place their sacks in front of their stands (thus simulating local market dynamics) so that customers could hand pick which varieties they wanted to buy. Instead of selling potatoes in bags, they decided to sell them by weight without changing the price. AGUAPAN partners had separated their potatoes by varieties, making it easier for them to sell since customers could select directly from the sacks. Other partners continued to offer bags and opened their sacks for customers to choose. Nevertheless, sales did not increase at the pace AGUAPAN partners expected. Some customers combined potato colors or bought from partners in various

regions. Partners emphasized the importance of biodiversity so that customers would consume potatoes "of all flavors." (Field notes, May 26, 2023)

In reflecting on the challenges and aspirations of AGUAPAN, it becomes evident that this grassroots organization is navigating complex terrains of gastronomic participation while striving for autonomy and sustainability. The interplay between hidden transcripts, encapsulated by the organization's internal cohesion and outreach strategies, and public transcripts manifesting through engagements at government fairs and press conferences, encapsulates AGUAPAN's evolving narrative. Despite dependencies on external support, AGUAPAN members express a desire to forge their path, recognizing the need for decentralization and enhanced communication to achieve their mission effectively. The organization's journey embodies a broader struggle faced by grassroots movements seeking to assert their voices within larger socio-economic frameworks, challenging conventional narratives of rural development and agricultural participation. Moving forward, the narrative of AGUAPAN underscores the importance of fostering genuine grassroots agency, where autonomy aligns with broader societal goals of sustainable agriculture and inclusive community development.

2.8 Conclusions

This chapter started with the contrast between everyday (mundane) conservation, and the institutionalized promotion of agrobiodiversity. This contrast aligns with prevalent divides between rural and urban poverty, isolation, economic dynamics, agricultural practices, and expectations around the value of potato agrobiodiversity. On one hand, urban consumers celebrate potatoes and farmers (in that order), if they are made visible by value chain and

government agencies. On the other hand, the same consumers treat potatoes as crops in rural settings, where they are not celebrated, and instead are thought of as mundane. Thus, farmers in rural spaces develop strategies to retain loyal consumers, such as the casero dynamic to temporarily increase their income while at the same time allowing them to have agency while setting prices, which cannot exceed prices that do not take into consideration the labor placed in Andean potato conservation. Native potatoes compete in price with the commercial potatoes, which lower prices since consumers are not necessarily looking for diversity in native potatoes when they buy groceries.

A deeper dive into the conditions in which potatoes are preserved shows how rural farmers do not benefit as much as they could from Andean potato agrobiodiversity because there is a tension taking place between commercialization and conservation at multiple social levels and across geographies. Everyday conservation and commercialization decreases returns to farmers as these are built around tensions such as the need to earn a stable income despite low prices, and the desire to meet standardized urban tastes, as well as social tensions associated with class and ethnicity. These tensions are prevalent, are related to historical and ongoing processes thought which farming communities and Andean crops have been associated with rural poverty and indigeneity. For this reason, when one travels across the Peruvian Andes, it's not possible to separate notions about potatoes from indigenous farming communities, in the sense that both embody the contradictions of inclusion narratives. Both are neglected by the State and decision makers, and both made visible as long as they are able to satisfy urban/elite expectations and value chain demands. They are temporarily visible and celebrated, only to be neglected until the next annual fair comes along.

Venues are important for potato agrobiodiversity conservation, in the sense that they help showcase diversity to consumers, decision makers and value chain stakeholders. Lima is considered a more lucrative venue than rural spaces, and farmers expectations are usually high when they attend urban settings. However, venues often serve another purpose rather than focusing on increasing rural farmers benefits: they represent discursive arenas where public transcripts about unfulfilled aspirations about inclusion narratives circulate. Thus, these arenas provide an opportunity for decision makers and value chain stakeholders to spread promises of rural development that have yet to come in the long term, or that have not a clear timeline. For instance, these promises can rely on incentives for rural farmers, implementing policies that emphasize tourism as an avenue for development, as well as stronger integration with the value chain. It's important to highlight that these promises are not unfulfilled because of individual actions, instead, failure to raise farmers benefits is places on structural issues such as bureaucratic hurdles or absence of proper incentives for turning farmers into entrepreneurs.

Attempting to reconcile societal and cultural divides via public declarations is a common tactic used in these venues. Nevertheless, what results from the circulation of dominant public transcripts is the displacement of farmers voices, which are often hidden and that claim for visibility and cultural affirmation. Moreover, if public transcripts about Andean potato agrobiodiversity remain aspirational, they risk increasing mistrust and skepticism about external interventions and partners. In this chapter, it is useful to think about these discursive aspirations as temporary “fixes” for failed or uncertain development projects. Temporary fixes increase anxieties about the prevalent notion of State abandonment, or partial integration to the value chain. Additionally, these anxieties or failed expectations cannot be resolved by government PR

campaigns or media attention to agrobiodiversity since they signal persisting social issues that require a comprehensive approach to the heterogeneity of local conditions of farming communities.

To increase their benefits, AGUAPAN farmers sought to build a network of partners in diverse regions. With the aim of cutting down the middleman to increase their income, AGUAPAN members seek autonomy by establishing consensus around fair prices for their potatoes. The discussion about fair prices is related to acknowledging the effort that rural farmers place on preserving Andean potatoes, which are different from the commercial varieties which they compete against. These efforts are not openly recognized by the value chain actors, who focus more on the scalability of Andean potato commercialization. AGUAPAN's efforts to advocate for fair prices and direct market access reflect broader aspirations to cut out intermediaries, yet scaling up operations remains contingent on incorporating new partners and addressing internal governance challenges. Even though AGUAPAN partners recognize the importance of renewing leadership positions and expanding their operations, most of them refuse to lose their benefits. At the same time, they struggle to sanction current members due to unjustified absences to the annual meetings or due to inactivity. As they acknowledged, partners depend on external organizations to run operations and to implement accountability mechanisms.

This signals a paradox of scalability: as AGUAPAN scales up its operations, it potentially threatens agrobiodiversity, since it will require more lands and increase production of their potatoes based on urban demands. These demands, as witnessed in the fairs, tend to be standardized, and as a result only certain varieties will be prioritized over less popular varieties.

Since AGUAPAN benefits depend on the promise of delivering agrobiodiversity, scaling commercial operations could threaten its brand. On the other hand, if AGUAPAN does not scale up its operations, its members could lose incentives to keep preserving their varieties and could potentially risk losing international funds due to inactivity or failure to preserve local varieties. The dependence that AGUAPAN currently has on its external partners hinders its own process of autonomy, which have been voiced by the leadership during past assembly meetings. However, with difficulties to develop robust accountability measures for inactive members, and skepticism about including new members, AGUAPAN faces at the same time key internal challenges that add up to the external pressures to remain active. As a result, even if farmers are temporary benefiting from AGUAPAN, it's unclear if the association will be able to guarantee stable benefits in the long term despite being one of the few associations of custodian farmers that focuses on preserving agrobiodiversity globally.

CHAPTER 3: DECODING DIGITAL POTATOES: CITIZEN SCIENCE PLATFORMS FOR POTATO AGROBIODIVERSITY CONSERVATION

3.1 Introduction

In recent years, biodiversity monitoring has become a citizen driven activity. Platforms such as Inaturalist and Ebird, have sought to incorporate citizens' observations to conservation science. This is the case of Wiki Papa and VarScout, two complementary agrobiodiversity monitoring platforms that seek to engage potato farmers, students, extension workers and researchers in Andean potato conservation in Peru. Wikipapa is a curated website hosting records of local potato varieties, encompassing agronomic, geographical, and gastronomic traits. VarScout, allows its users to collect on-the-ground data, such as local names, color, frost resistance, and yield, directly from farms. Data collected by VarScout users is curated and uploaded to Wikipapa, forming an integral part of an online agrobiodiversity monitoring system supported by the International Potato Center (CIP) and local data chain actors. App developers, data curators, and tech assessment consultants seek to provide rural farmers access to the value chain. Recently, Wikipapa developers have considered incorporating e-commerce features to the platform via Miski Papa, an online website designed to promote and deliver Andean potato consumption among urban consumers.

Citizen science platforms aim to reduce knowledge and societal gaps between experts and non-experts (Cooper 2016, Kimura & Kinchy 2019). Moreover, “opening up” potato agrobiodiversity monitoring implies incorporating notions of Open Science (OS) such as the FAIR and CARE to citizen science platforms. These OS principles promote findable, accessible, interoperable, and

reusable data (FAIR) respecting indigenous knowledge and self-determination (CARE).

However, fostering openness through these principles may not necessarily be fair to “those from whom the data are gathered and those whose lives may be affected by specific uses of the data” (Leonelli et al 2021). New concerns regarding the platformization of science (Fecher et al 2024) and the privatization of common pool resources (Bakker 2007) raise questions about the commercialization, production, and dissemination of science. As app developers are considering adding e-commerce features to these platforms, it is still not clear what kind of resource these platforms can become.

This research, conducted through ten interviews with data scientists, academics, and NGO representatives, two workshops with farmers and extension workers, and ethnographic data collected between 2022 and 2023, explores how economic interests are incorporated and mobilized through the Wikipapa data chain. Additionally, it seeks to understand if fairness results from the implementation of the FAIR and CARE principles to open infrastructures in the context of agrobiodiversity conservation.

Despite these challenges, local data chain actors believe that enhancing market access for potato farmers can effectively address their economic needs. Based on ethnographic data collected during semi structured interviews and workshops, I argue that promoting the use of Wikipapa and VarScout in their current form risks diminishing the visibility of local knowledge and reducing farmer’s involvement in potato conservation. This thesis is supported by three main sub arguments:

- **Relevance to Farmers:** From the perspective of farmers and NGOs, citizen science platforms struggle to address issues that are relevant to farmers without imposition. Moreover, farmers can feel pressured to provide positive feedback to “look good” or “please” supporting institutions and donors.
- **Challenges of Digital Literacy and Cultural Attachment:** The platformization of agrobiodiversity within a context of limited digital literacy and strong cultural attachment to Andean crops presents challenges in the use and understanding of citizen science platforms among local data chain actors.
- **Decontextualization of Local Knowledge:** Wikipapa & VarScout, in prioritizing Western classification such as morphology, and agronomic descriptors, may inadvertently decontextualize local knowledge. If prompt user feedback is not responsibly integrated, developers risk underestimating indigenous classification systems and local knowledge.

3.2 Cataloging Andean Potato Agrobiodiversity

As Andean communities continue to employ traditional methods of potato classification and preservation, advancements in digital platforms have offered new opportunities for documenting and safeguarding potatoes. Cataloging potatoes has played a pivotal role in shaping our understanding of biodiversity monitoring, laying the foundation for the development of online interfaces such as Wikipapa. Through regional catalogs, we gain insight into classification work (Bowker & Star 1999), which often encompass Western classification principles and emphasizes quantification. These catalogs, compiled by CIP’s partners as well as Andean households have served as physical repositories of knowledge. In examining the transition to online platforms like Wikipapa, we observe the continuation of these classifying principles, albeit with a notable shift

towards citizen science-driven approaches. Unlike traditional methods reliant on extension agents, Wikipapa emphasizes user engagement through apps, marking a significant departure in biodiversity monitoring practices. By exploring this evolution from traditional cataloging to online interfaces, we can better understand the complexities and nuances of agrobiodiversity conservation in the digital age.

Andean farmers have been sorting different varieties of potatoes since before the arrival of the conquistadores. Oral traditions and knowledge helped preserve cultivars known as native potatoes or “papa tarpu” in Quechua. Peruvian Quechua farmers employ an indigenous classification system that is based on hundreds of years of intense in situ management of potato genetic resources (De Haan et al 2009). Commonly applied and recognized folk knowledge used for identifying, classifying, naming, and relating potatoes and other living organisms is known as indigenous biosystematics (De Haan et al 2009). Folk descriptors and indigenous nomenclature are embedded in social relationships and local contexts. Farmers may use metaphors to characterize potatoes shape, size, color, cultural and gastronomic uses. Potatoes can be named after animal body parts, persons, objects, crops, and plants. Keeping up with all the meanings of the potato cultivars can be a challenge for those not familiar with Andean potatoes. Indigenous classification systems logic, linguistic structure, and consistency may help us understand the cultural and social values attached to in situ conservation.

CIP cataloging activities can be thought of as a continuation of CGIAR’s efforts to gather plant genetic resources since the 1950s (Montenegro 2016). Previous missions such as Britain’s network of botanical stations (MSB 2024) and US National Seed Storage Labs, pursued similar

goals (Montenegro 2016). Potato collections began years before CIP's foundation in 1971, with expeditions led by Peruvian scientists such as Carlos Ochoa (Ringle, 1992) across the Andes. In the early 1950s, with the support of the Rockefeller foundation, Ochoa started the National Germplasm Collection (Scott 2011).

Wikipapa was launched by CIP in 2021, but the idea of designing a repository of potato varieties can be traced back to earlier elaborations of potato agrobiodiversity catalogs by CIP and its local partners. The first CIP catalog was developed in 2006 in the region of Huancavelica, featuring 144 varieties and 21 households. Fifteen years later, another catalog from the same region was elaborated, this time featuring 185 varieties and 16 households. Other catalogs include Apurímac 2014, La Libertad 2015 and 2023, and Junin 2017 (Wikipapa 2024). These catalogs highlight the dynamic nature of potato agrobiodiversity, with variations observed within catalogs of the same region, reflecting the diverse contributions of participants.

Wikipapa, as an online catalog, builds upon this legacy by incorporating a wealth of information, including previous catalog varieties and new field observations by Wikipapa users. As of January 2024, Wikipapa includes 964 varieties and 1532 observations, demonstrating its potential as a comprehensive repository of potato diversity in the Peruvian Andes. Past CIP-sponsored catalogs were assembled by two local NGOs that work with rural farming communities: Grupo Yanapai and Asociacion Pataz. Co-sponsors of past CIP-related catalogs include the Ministry of Agriculture, the National Institute of Agrarian Innovation (INIA), regional government agencies and local municipalities. Local farming communities actively engage in cataloging tasks as they assemble catalogs together with extension workers. Farmers short biographies are included.

While CIP-sponsored catalogs have been instrumental in documenting diversity, there are catalogs developed by other local institutions that serve similar purposes.

Usually, the first sections of these potato catalogs cover a wide range of topics such as an overview of the regions, communities and households surveyed. Farmers are described as “custodians” of Andean potato agrobiodiversity, and an excerpt of their family biographies is included with names of all household members surveyed. At biodiversity fairs, these same farmers proudly display catalogs, considering them as artifacts that allow them to be visible to consumers and the value chain. Their photographs are included, often with all members of their family accompanying them while working in the fields. Recent catalogs include complementary information such as the agronomic calendar, ancestral practices (e.g. phases of the moon), climate change & conservation, cultural uses of crops, and local economy. Most of the information presented in these first sections is descriptive, and the language used is intended for decision makers, experts in Andean agriculture, and the public.

The second section of these catalogs is more “technical”, in the sense that it focuses on classifying Andean potatoes based on morphological, agronomic, and gastronomic descriptors. In addition, it defines the terminology provided in this section such as nomenclature, morphology & genetic characterization, species, relative abundance, genetic fingerprint, agronomic traits, nutritional value, and culinary uses. Each potato variety is photographed and characterized based on this catalog terminology, including infographics and pictures of the tuber, the plant, the leaf, and the flower. It’s worth noting that catalogs include synonyms and meanings of the local names which can be overlooked if one focuses on other descriptors. One of the

preferred descriptors for potato farmers and extensionists alike is tuber skin color. However, it is not the deciding factor since multiple descriptors are considered such as tuber shape, tuber pulp color, growth habit, stem color, flowering degree, flower color, bud color, etc. Finally, there are qualitative descriptors that are based on information provided by farmers' practices, such as cultural and culinary uses.

Wikipapa and VarScout use these classifying principles found in potato catalogs albeit with a shift towards citizen science approaches. Wikipapa is a virtual repository that allows frequent feedback from its users. It allows online data curatorial work conducted by potato curators with experience in in situ agrobiodiversity monitoring, that consists in visiting farming fields and classifying potato varieties held by local farming communities. VarScout is an app developed by Resonanz Group, a Swiss tech company, that was adapted to the potato conservation context by Metrika Group, a Peruvian tech startup. Currently, it is the main tool that potato farmers and other citizens possess to upload information to Wikipapa. VarScout is mainly designed for data collection, and Wikipapa is designed for showcasing curated data. The information of previous regional catalogs is incorporated in Wikipapa, as well as curated observations by VarScout users. It is not clear, however, whether all observations made will be curated, or just those of novel varieties not yet classified in previous catalogs. At the same time, as of this time of writing, it is not clear if funds will be available to continue the development of both platforms.

Before Wikipapa and VarScout were designed, extension agents relied on biodiversity monitoring activities to account for local potato agrobiodiversity. Monitoring tasks are based on participatory research, conducted together with farmers at their own fields.

To provide a better account of how potato classification is usually conducted on the ground, I will rely on my own field observations of monitoring tasks:

- Face to face mediation between farmers and extension workers is still the main method to conduct in situ biodiversity monitoring tasks. This mediation is based on farmer's knowledge and is carried out with a diverse team of professionals, including agronomists, and social science specialists. Once the farmer agrees to be interviewed, they are asked to display their collection for classification. Then, the team, based on their practical knowledge, begins to classify the varieties into groups without giving them names. Simultaneously, the social specialist collects sociodemographic data such as name, production methods, cultural practices, education, access to local markets, as well as information about other household members. Usually, this process is carried out outdoors as the team gains further knowledge about the farmers' attitude. If it is friendly, then the interview proceeds without setbacks. If it is hostile, the extensionists attempt to reduce tensions by using their negotiation strategies. Other community members are often in sight of these interactions.
- Afterward, the farmers give names to the potato varieties previously classified by the specialists. At this point, there is a possibility to amend erroneous names or repeated varieties. This process occurs in Quechua, and the names appeal to morphological traits and gastronomic uses of Andean potatoes. This process is horizontal, as other household members also participate. There is a possibility that farmers may not know the name of a variety, or they may not remember it very well. In such cases, extension workers label those varieties as "SN" (sin nombre, without name). Then, photographs of the varieties

are taken. In this process, professional cameras are used, and the team must corroborate the number of varieties the farmer claims to have. Some varieties may be repeated, or they may be the same as those kept in CIP's germplasm bank. In some cases, it can lead to overrepresentation, thinking that there is more diversity than there actually is.

The goal of citizen science platforms such as Wikipapa and VarScout is to replicate to some extent these biodiversity monitoring tasks online. During workshops conducted by a team of supply chain experts from UTEC, a local university focused on engineering and innovation, farmers were asked to collectively identify and label their potatoes. They then used VarScout to upload photos and identify key morphological and agronomic descriptors. Nevertheless, most of them struggled to conduct these tasks on their own, since they are used to face to face interactions.

3.3 Open Knowledge Infrastructures and Governance

With the emergence of open platforms, such as biodiversity cataloging applications, the discussion of what is open, to whom, when and why has raised diverse questions about the technical, economic, social, and ethical dimensions of open science (Pasquetto et al 2015). These debates are situated around understanding knowledge as commons (Hess and Ostrom 2007) and the politics of knowledge infrastructures (Edwards 2010) in the context of citizen science platforms (Hine 2020). Most of the scholars in these fields have focused their attention on exploring how OS principles complement each other and facilitate engagement, address data justice and accountability, or further private and commercial interests.

In the context of this chapter, data fairness focuses on “the quality and credibility of the research processes through which data are produced, gathered, pooled, analyzed and interpreted” (Leonelli et al 2021). In the context of citizen research, data fairness aligns with data justice defined as “fairness in the way people is made visible, represented and treated as a result of their production of digital data” (Taylor 2017). Data fairness as well as data justice, allow us to examine how fairness informs the different stages of citizen science research, such as platform design, data collection, storage, processing, and interpretation (Leonelli et al., 2021). Additionally, scholars have not yet explored how citizen science platforms might incorporate e-commerce features or transition to e-commerce startups with citizen science elements. In the context of agrobiodiversity and potato conservation, these considerations become particularly pertinent as tensions between the commercialization and preservation of seeds and tubers resurface, given the differing interests of Wikipapa and Varscout users. Rural potato farmers (with mixed ethnicities), students, and extension workers are the primary users, presenting a unique opportunity to examine if fairness results from the implementation of open science principles (FAIR and CARE) and how commercial interests are incorporated and mobilized through the Wikipapa data chain.

Around 1995, scholars started to make connections between information and commons, which coincided with the emergence of the Internet (Hess and Ostrom 2007). Thus, the idea of knowledge commons began to be conceptualized to study dilemmas around the rise of distributed digital information (Hess and Ostrom 2007). Some of the main topics discussed were virtual communities and commons (Rheingold 1993; Brin 1995; Hess 1995; Kollock and Smith 1996) and dilemmas such as congestion and free riding (Huberman and Lukose 1997; Gupta et

al. 1997). Recently, open-source software projects are described as tools that produce public goods through a common property regime (Benkler 2002; Boyle 2003). In the context of indigenous seed systems and bio cultural heritage, a major concern for indigenous peoples is the privatization of seeds through intellectual property rights (IPRs), such as patents and plant variety protection. According to Swiderska and Argumedo (2022), IPRs threaten norms regarding collective custodianship and sharing of seeds, criminalizing informal seed systems and restricting seed commons (Sievers-Glotzbach et al., 2021; Wattnem, 2016).

More recently, STS scholars and citizen science practitioners have turned their attention to knowledge infrastructures to explain how scientific knowledge is created, maintained, and transmitted. Knowledge infrastructures focus on collaborative development and a collective benefit from use (Edwards 2010); thus, they are important to understanding the architecture of open data platforms. Defined as “robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds” (Edwards 2010), knowledge infrastructures can foster accessibility, transparency, and inclusivity. For example, digital libraries such as the Internet Archive, are examples of open knowledge infrastructures, as well as citizen science websites such as NASA Citizen Science projects. Open infrastructures tend to advocate for more decentralized, participatory approaches to managing and using knowledge commons. Thus, commoning data represents a shift from individual ownership and consumption to collective stewardship (Mayer 2024).

However, a set of assumptions and power relations that are embedded within knowledge infrastructures may be taken for granted as these infrastructures are developed (Bowker 1994;

Bowker & Star 1999; Star & Bowker, 2006). To avoid this, STS scholars proposed to practice an “infrastructural inversion”, which consists in examining and questioning the prior assumptions that infrastructures embed, as well as the often-invisible work that goes into creating and sustaining them. Infrastructures are viewed as a “set of relations between technologies, people and practices” (Hine 2020). Bowker, Baker, Millerand & Ribes (2009), argue that if one engages with infrastructures that capture and distribute information, it is important to figure out if problems are technical or social and decide on how to “distribute work and responsibilities between databases, users, and institutions” (Bowker et al 2009). Other authors point out that infrastructuring, generally defined as the participatory processes of designing and modifying infrastructure systems (Mayer 2024), can help to resolve tensions between different dimensions of a problem domain (Mongili and Pellegrino 2014).

It’s important to highlight that open knowledge infrastructures may act as sites of labor and political action. When designing open knowledge infrastructures, one must settle on a set of data to represent that knowledge (Ribes & Bowker 2009). In that process, one favors one set of perspectives over others, thus silencing “forms of experience that do not fit into the data structure” (Bowker & Star 1999). For instance, Hine argues that the labor of designing systems and curating data fails to fit in with the recognition and reward systems of publication and citation (Hine 2006). In the context of citizen science apps, those who contribute to science, even though their work does not fit with scientific reward systems, may not regard themselves as unskilled laborers (Lin et al., 2016). Even in initiatives that motivate contributions through gamification, participants may find their labor meaningful as science rather than as pleasure (Ponti et al., 2018). Scholars examining issues of data justice aim to address issues of power and

marginalization, as decisions are made about how knowledge should be represented and, thus, whose knowledge should be represented (Karasti et al., 2016a, 2016b, 2016c and 2016d).

Knowledge infrastructures in the context of citizen science research, may establish their products as authoritative and legitimate (Strasser et al., 2018). Hine identified two types of knowledge infrastructures involving citizen science participation: those characterized by top-down relationships where the ‘ultimately authority to determine the criteria for what is to count as knowledge resides with developers working within the domain of professional science ’ (Hine, 2020) and those with bottom-up relationships that ‘develop emergent standards for authenticity and accountability that differ radically from the conventional scientific model’ (Hine, 2020).

Sterner and Elliot point out that Hine’s typology does not properly address the process by which participants acquire authority and legitimacy for their contributions in citizen science initiatives by way of establishing relationships with other stakeholders such as funders, users, universities, and other infrastructures (Sterner & Elliot 2023). Thus, they propose to examine how a “broader range of parties” influence knowledge infrastructures through negotiating what counts as knowledge and who has the authority to decide.

As an agrobiodiversity data portal, Wikipapa facilitates the maintenance, and use of pooled data resources. As a citizen science platform, Varscout facilitates the data collection process by enabling its users to record the location of where a particular potato variety is growing. Both are examples of open knowledge infrastructures that rely on users’ knowledge and labor to showcase curated versions of local potato varieties. According to Stern & Elliot, biodiversity data portals are “social organizations whose collective activities constitute a spatially and socially distributed

network of relationships among people and places” (Sterner & Elliot 2023). Biodiversity portals usually establish norms and policies for data governance (Frischmann et al., 2014) in relation to the aims and values of their users and stakeholders. Stern & Elliot define data governance as “the assemblage of institutional mechanisms, norms, and policies that regulate the rights and responsibilities of people or organizations to produce and use data” (Sterner & Elliot 2023). FAIR and CARE are examples of principles for data governance. Their implementation through knowledge infrastructures can foster justice and fairness for data chain actors.

FAIR and CARE principles seek to establish norms for whose contributions to data should be recognized and who has authority over access rights and appropriate uses (Sterner & Elliot 2023). FAIR stands for findable, accessible, interoperable, and reusable data. The principle of findability focuses on having a globally unique name for each dataset, using it to locate a dataset in an online repository, and determining what type of information can be found in the data set (Wilkinson et al 2016). Identifiers are useful for facilitating the accessibility of data and metadata. Additionally, FAIR principles help examine whether access protocols are free, open, and implementable, as well as whether metadata persists after data is lost or deleted (Wilkinson et al 2016). In contrast, proponents of the CARE principles identify the principles’ value as bringing ‘a people- and-purpose orientation to data governance, which complements the data-centric nature of the FAIR principles’ (Carroll et al., 2020). Intended to address the status and importance of Indigenous Peoples in making decisions about the use of data related to themselves and their lands and waters, CARE principles do not necessarily oppose making Indigenous data align with FAIR principles. However, as Stern & Elliot point out, CARE does

not address non-Indigenous groups, such as African Americans or rural communities, that have also experienced oppression (Sterner & Elliot 2023).

The emergence of open platforms, such as agrobiodiversity cataloging applications like Wikipapa and Varscout, highlights the diverse dimensions of open science, particularly concerning knowledge as commons and the politics of knowledge infrastructures. Few scholars have investigated the integration of e-commerce features into citizen science platforms. In agrobiodiversity, tensions between commercialization and preservation emerge, underscoring the need to examine fairness in data governance, particularly through principles like FAIR and CARE. Collaborative development of open platforms fosters accessibility and inclusivity but also embeds power relations that require critical examination. The design and curation of data within open knowledge infrastructures may favor certain perspectives, marginalizing others. Understanding these dynamics is crucial for ensuring equitable representation and authority in knowledge production and governance.

3.4 Methodology: Methodological Data Fairness

Proponents of online field work argue that there is a significant overlap between online and offline life in contemporary societies (Gatson and Zweerink 2004; Hampton and Wellman 2003; Miller and Slater 2000; Murthy 2008; Wilson and Atkinson 2005). This overlap can be studied by multi-sited ethnography (Marcus 1995), which proposes following participants as well as issues beyond predetermined parameters or to the different places where it plays out (Hannerz 2003). Marcus defines multi-sited ethnography as involving “chains, paths, threads, conjunctions, or juxtapositions of locations in which the ethnographer establishes some form of

literal, physical presence, with an explicit, posited logic of association or connection among sites that in fact defines the argument of the ethnography” (Marcus 1995). However, Burawoy points out that “bouncing from site to site” can generate barriers to achieve deep understanding of any one context (Burawoy 2003). To avoid those issues, Fitzgerald suggests that researchers should develop a “clear theoretical orientation” and engage in strategic site selection (Fitzgerald 2006).

Offline and online interactions can facilitate the creation of meaningful relationships and togetherness (Goodsell and Williamson 2008). One salient factor of this fluid interplay of offline and online interactions, is the way in which computer mediated communication (CMC), fosters the construction of identities and communities (Watson 1997). In this way, even if face to face and virtual interactions happen at different places/sites, they are still part of the same community. For example, rural farmers uploading potato data offline due to limited data access, are part of the same community as rural extension workers who generally have access to the Internet. However, few citizen science projects are targeted at farmers or explore agricultural topics (Dehnen-Schmutz et al 2016).

To address the interplay of FAIR and CARE principles in citizen science research, I rely on Leonelli’s work on methodological data fairness (Leonelli 2021) to examine whether citizen science platforms foster fairness in the context of Andean agrobiodiversity conservation. This approach focuses on “how the treatment of data during the course of a study affects the credibility and justice with which the outputs of the study portray and affect all sections of society” (Leonelli 2021). Leonelli’s main concern is with the quality and credibility of the processes through which data are produced, gathered, pooled, analyzed and interpreted, thus

affecting the whole research cycle (Auffray et al 2016). Thus, potential injustices can be mitigated by data practices that actively counter existing prejudice about what counts as appropriate/relevant/adequate evidence, as well as data practices that leverage diverse sources of knowledge to counter existing prejudices (Leonelli 2021). Methodologically, this can be studied through a multi-sited approach to offline and online interactions among the users, developers, and consultants of Wikipapa and Varscout. I will follow these actors as they make sense, interact, and engage in citizen data practices through workshops as well as in interviews.

Since I am also interested in exploring how commercial interests are incorporated and mobilized through the Wikipapa data chain, I pay attention to the commodification of potato biodiversity data and immaterial labor in the data chain (Cohen 2016; McGuigan and Manzerolle, 2013).

Currently, most apps in agriculture are designed by commercial companies, providing information or services in a unidirectional linear flow, from the developer to the user (Dehnen-Schmutz et al 2016). Even though citizen science apps are designed to be collaborative and tend to be developed by charities, scientific or academic institutions, and government agencies (Dehnen-Schmutz et al 2016), they can encourage top-down data practices (Hine 2020). The cultural commodities literature has studied the labor issues that arise from platform-dependent cultural production (Nieborg and Poell 2018). Recently, this scholarship is studying the transformation of cultural commodities in the context of platform markets and holders.

Examining the transition of a citizen science app that showcases curated cultural commodities such as Andean potatoes, to a platform that incorporates e-commerce features, represents an interesting case for this literature.

In this chapter I will examine two data platforms integral to Andean potato agrobiodiversity conservation and citizen science:

- Wikipapa: As an online platform dedicated to curating data about Andean potatoes, Wikipapa operates as an interactive repository of agrobiodiversity. However, with the incorporation of e-commerce features to Wikipapa's interface questions about what type of resource it can become emerge. This chapter examines how commercial interests are incorporated and mobilized through the Wikipapa data chain.
- Varscout: Varscout was repurposed by Wikipapa's developers to aid potato farmers, extension workers and students in scouting, collecting, and uploading data on local potato varieties. It was introduced as the main tool for agrobiodiversity conservation during a series of workshops in several regions of the Peruvian Andes. Nevertheless, Varscout's users faced many difficulties while testing the app, challenging the FAIR and CARE principles. Thus, this chapter aims to explore if true fairness results from the implementation of such principles in the context of potato conservation.

3.4.1 Methods

This project was approved by North Carolina State University IRB office, # 24908, in June 2022 and renewed in January 2023, to work with vulnerable populations such as indigenous peoples, elder populations, as well as CIP employees. I conducted 10 semi structured interviews with the Wikipapa data chain, composed of: the Wikipapa developers and data curators (3), the Miski Papa representatives who run an online delivery platform for Andean potatoes in Lima (2), the UTEC university team responsible for organizing three citizen science workshops with farmers,

students and extensionists (2), the Yanapai Group (3). I helped facilitate all three workshops with the UTEC team in the regions of Junin and Huanuco. The first workshop gathered insights from AGUAPAN members. AGUAPAN is the Peruvian Association of Native Potato Guardians, a farmer-led association whose members participated in the development of the regional potato catalogs. 14 AGUAPAN members participated in the first workshop, representing the regions of Junin, Ayacucho, Lima, Pasco, Huancavelica and Huanuco. Based on the UTEC's consulting team report, 66% participants were male and 33% were female, 60% of them spent one hour or less a day using digital platforms, and 40% of them didn't use smartphone apps. The next workshop focused on gathering perspectives from rural extension workers from local NGOs or government agencies. 11 extensionists from organizations such as Grupo Yanapai, INIA and FOVIDA participated in the workshops. All the extensionists had smartphones, and 83% of them used between 1 and 5 smartphone apps in the last month. The last workshop focused on gathering insights from students from a local university. According to the UTEC's team report, 76% of them were between 20 and 30 years old. Similarly to the extension workers, all the students recruited owned smartphones and spent between 3 to 4 hours a day using smartphone apps.

Additionally, I compiled and examined the information from the three latest regional potato agrobiodiversity catalogs (La Libertad 2023, Huancavelica 2021 and Junin 2017) that were incorporated into Wikipapa. I developed a Python code to transform the information in the catalogs to Excel tables. I kept the same descriptors used in the catalogs to characterize each cultivar variety: variety name and synonyms, morphological descriptors, nutritional value, agronomic traits, abundance, and culinary uses. My goal was to document the way in which

agrobiodiversity is represented by western categories to understand Wikipapa's infrastructure as well as potato curation. Finally, I complimented my analysis with informal conversations with farmers as well as value chain actors during AGUAPAN meetings and food and biodiversity fairs between May 2022 and August 2023. Based on the principles of grounded theory research that focus on a process of joint data collection and constant comparison (Charmaz 2014), I developed analytical memos and examined the relationships between the following categories: data science, data justice, citizen science app, digital literacy, e-commerce, western classification, value chain, tech acceptance, local potato names, and internet access. I used the open software Taguette for qualitative analysis to code my interviews and identify results.

3.5 FAIR and CARE principles in Wikipapa's Data Chain

This section delves into the processes of agrobiodiversity data curation within the platforms Wikipapa and Varscout, focusing on their alignment with FAIR principles. It examines the initial steps taken during the development of Wikipapa to understand and organize data from previous agrobiodiversity monitoring projects, demonstrating a commitment to open and accessible biodiversity data. Through interviews with developers and insights gained from workshops, I explore the challenges and strategies involved in data curation, such as incorporating synonyms for potato varieties, addressing translation concerns, and ensuring accuracy and reliability. This section shows the complex interplay among FAIR principles, indigenous governance (CARE), and the realities of data platform development and implementation, offering insights into data fairness in agrobiodiversity conservation efforts. I argue that even though FAIR principles are integrated into Wikipapa and Varscout, both platforms struggle to develop robust CARE protocols for indigenous data governance. Thus, there are persistent fairness and inclusivity

barriers in Wikipapa and Varscout interfaces, related to user feedback, data ownership and sharing protocols.

3.5.1 FAIR Principles in Agrobiodiversity Data Curation

The incorporation of FAIR principles in Wikipapa and Varscout has positively influenced the accessibility and findability of related potato agrobiodiversity data. The first step to develop the Wikipapa website was to understand and curate data from past CIP agrobiodiversity research projects such as the CIP-sponsored potato catalogs. The effort to organize data from previous projects aligns with FAIR principles and shows a commitment to open and accessible potato biodiversity data. By 2022, Wikipapa developers and curators started to develop a database of potato varieties from agrobiodiversity catalogs and CIP's records. The diversity of potato cultivars and the identification of atypical names were considered by Wikipapa developers using statistics and processing algorithms. This shows an initial commitment to the CARE principles for indigenous data governance:

“The same variety can have a different name, different localities, so you always have to know how to code them. The other issue was the use of images. They usually take the photo, and there it stays, but you always must code the images. All of that involves a bit of “information cleaning” (Interview with Wikipapa Developer 1, February 16, 2023).

Wikipapa's team of developers placed significant focus on data curation, often called the "cleaning" process, indicating a commitment to high quality standards. This process seeks to guarantee that the data provided is accurate and reliable, essential aspects of the FAIR principles.

This process ran concurrently with the development of Wikipapa over three months. The resulting database expanded with the addition of photos that accompanied the curated metadata. Since then, Wikipapa has been integrating more information, such as tuber skin color, tuber size, culinary uses, and yield per kg. This process mirrors how the data and related western descriptors are included in the potato agrobiodiversity catalogs that are still published in physical form. Currently, experienced CIP curators assist farmers, students and extension workers interested in uploading their potatoes to Wikipapa.

Including synonyms for potato varieties makes Wikipapa more accessible to rural farmers, aiding in the findability of relevant information. Efforts were made to incorporate synonyms for varieties used in regional catalogs, attempting to make the platform more accessible to rural farmers, and allowing them to identify local varieties using familiar terms. Wikipapa developers consider that "you cannot force, nor can you change the way farmers think." (Interview with Wikipapa developer 2, March 21, 2023) The incorporation of synonyms for local varieties in catalogs is a practice that allows sensitivity towards local names of Andean potatoes in Quechua. This acknowledges the relevance of indigenous classification for potato conservation research, thus far respecting the CARE principles. However, there is a risk that users "may not find it (potato) with the name they know" (Interview with Wikipapa developer 2, March 21, 2023), according to the Wikipapa developers. For instance, while some regions register just 7 varieties with 3 or 4 synonyms, other regions register 41 varieties with 3-8 synonyms or 64 varieties with 3-7 synonyms. Thus, navigating diverse naming practices generates barriers for users that know the same variety with different names, or that struggle to decide which name to prioritize.

Agrobiodiversity overlaps with cultural diversity, in terms of local naming practices as well as data curation practices. Curators play a crucial role in “formalizing” data and building trust between users and Wikipapa, contributing to the accessibility and reliability of the information. The role of curators in formalizing data and building trust between users and curators aligns with principles of CARE and FAIR, ensuring the reliability and integrity of the information provided. According to the Wikipapa developers, even expert curators “might not find all the native potatoes in one or even 100 trips, and some excellent varieties may be lost over time” (Interview with Wikipapa developer 2, March 21, 2023). Usually, seasoned potato curators go to the field to monitor varieties in potato farming fields and at fairs. According to the interviewees, the cultural value comes from farmers; while the role of science, in this case, would be data curation. This indicates that from the developer’s perspective, science would have a supportive role. However, in practice, western descriptors are the default way to characterize potato agrobiodiversity, in terms of morphology (color and shape), and agronomic descriptors (frost resistance).

The Wikipapa developers mention that data curation does not imply the loss or alteration of users’ observations. Rather, it integrates the assistance provided by expert and specialized knowledge. Professional curators, according to them, help “formalize” users’ observations, which would be akin to giving them a “birth certificate”. Then, curators have the power to decide which observations are “correct”: “if everything is correct, the curator will give you a check” (Interview with Wikipapa developer 2, March 21, 2023). Curated observations are then “formally” incorporated to the Wikipapa database. With the potential involvement of multiple data curators, discussions on how to validate users’ observations will emerge according to the Wikipapa developers. They predict that Wikipapa users could then follow these discussions

through the data platforms, interacting with curators while retaining the “ownership” of the data collected. However, they did not provide additional details on how users could retain ownership through Wikipapa. This represents a challenge to CARE principles, since “formalizing” user observations places user’s knowledge on hold until data is verified. In practice, data science is not playing a supportive role, rather it facilitates filtering out information.

During the workshops, a Wikipapa curator showed me how observations were first revised and then later edited and approved. Additionally, few observations are considered reliable by curators since most users are still learning how to use Varscout to collect data. Training new users is important for the Wikipapa team since it will reduce incomplete observations and expedite the data collection process. The team considers that this process aids users and respects local knowledge. At the same time, ensuring users that only they can edit the information would increase the sense of privacy among them. Trust is an important issue for the team, and they believe that accountability measures should be implemented among potato data curators and administrators of both platforms.

Another topic highlighted by the Wikipapa developers’ team is the user's ability to edit their observations. In theory, curators will not be able to invalidate or edit users’ observations. However, in practice Wikipapa curators operate as arbiters of potato agrobiodiversity since they filter out incomplete observations and decide which of them are ready to be included in the dataset. This suggests that Wikipapa curators are self-conscious about institutional legitimization of expert curation, even if they are committed to FAIR and CARE principles. This signals a prevalence of top-down citizen science, where users contributions tend to remain invisible or not

relevant for scientists filtering out data. Nevertheless, this could also be an unintended consequence of the design of Wikipapa, since developers are still wrestling with the implementation of user's feedback mechanisms.

Despite acknowledging local knowledge during the cleaning process, Wikipapa developers and curators believe that by “formalizing” users’ observations they contribute to science. They see data integration as the main goal of Wikipapa, instead of weaving in (Hopkins et al 2019, Kimmerer 2013) local knowledge to data infrastructures. This fact poses challenges to ensuring fairness, despite Wikipapa’s compliance with FAIR principles, particularly in terms of respecting indigenous self-determination and addressing negative impacts on users contributing data.

Braiding Indigenous knowledge with Western science implies developing safe and ethical spaces where “different world views can be respected and explored in a way that is meaningful to participants” (Hopkins et al 2019). This approach to fairness implies paying attention to power inequities in the data chain as well as ensuring that the research is culturally safe, consistent with the CARE principles. While Wikipapa developers address key translation concerns and recognize the importance of local knowledge, fairness in terms of inclusivity remains a challenge, especially for new users.

3.5.2 Navigating CARE, Fairness and Inclusivity

The Wikipapa team has been working on integrating Varscout, a data collection platform, to aid in the conservation of potato agrobiodiversity in the Peruvian Andes. This effort involves adapting Varscout to the specific needs of potato farmers and other stakeholders, addressing challenges in user interface design, language barriers, and the need for offline functionality.

Collaborating with the Swiss tech company Resonanz Group, the team aims to enhance the synergy between Wikipapa and Varscout. This section explores the experiences and feedback from various users, the obstacles faced in the adaptation process, and the ongoing efforts to ensure the platforms are user-friendly and compliant with FAIR and CARE principles.

The Wikipapa team considers Varscout a platform that allows citizens to “contribute to science.” They view Wikipapa and Varscout as complementary platforms. The developers mentioned that they have been able to adapt Varscout to the context of Andean potato conservation. Initially, Varscout was designed as a tool to collect data for purposes other than conservation, such as real-time decision-making on investments in breeding and seed systems in Africa (MacMillan 2024). Varscout’s African partners are working with the Ministry of Agriculture in Kenya to train extension officers to use Varscout to collect varietal data from bean, maize, and potato farmers to determine the abundance, turnover, and performance of different crop varieties and mitigate climate change (CGIAR 2024). In Peru, Varscout is being modified to monitor potato agrobiodiversity. According to the Wikipapa team, prompt feedback is necessary to implement updates to the latest versions of Varscout and avoid confusion.

Near the end of the first stage of the project, the Wikipapa team contacted the Resonanz Group to implement updates and strengthen the synergy between Wikipapa and Varscout. The Resonanz Group is a Swiss tech company that has developed platforms focusing on traceability and compliance with food safety, field trials management systems, and micro-insurance solutions for smallholder farmers (Resonanz website). Interoperability is the end goal of both teams of app developers and data scientists.

"So, we had to explain that we need more things that they have (Resonanz), and implement more things, like the catalog of potato varieties, which they don't have."

(Interview with Wikipapa Developer 2, March 21, 2023)

First-time Varscout users struggled to navigate its interface, which was presented during the workshops as the main tool for data collection. The Wikipapa developers believe that Varscout can be more user-friendly and adapted to different users, not just rural farmers. During the workshops, students and extension workers were included. The Wikipapa team believes that the amount of data to be uploaded may overwhelm some inexperienced users. During the workshops and field tests, even users already familiar with Varscout spent many hours uploading just a small portion of their collection with the assistance of experienced data curators.

Although Varscout is already in Spanish, the translation of its modules could still be improved to make it more understandable to users that use other units to measure land or yield, such as rural farmers. The Wikipapa team acknowledged that there is another “language” used by Andean communities that should be incorporated into the platform. This “language” makes references to alternative units of measurement, which often encompass indigenous classification principles such as practical estimations of weight and local potato variety identification practices (e.g., post-harvest variety characterization).

Rural potato farmers' experiences and opinions are crucial to understanding fairness and CARE principles. During the same workshops, many rural farmers shared their experiences using Varscout when asked about their challenges with the app. Unlike other users, potato farmers

were not introduced to Wikipapa, which was considered disrespectful by some of the workshop facilitators, and only contributed to conversations about Varscout use. The farmers that were recruited were already interested in interacting with technologies such as WhatsApp to get technical assistance for pest management, such as the Andean weevil. Thus, they don't necessarily represent most rural farmers, especially those that don't have access to the Internet or don't own or use smartphones. Peru's National Household Survey (ENAHO) shows that only 20.7% of rural households have Internet access (INEI 2023).

During the Varscout pilot in 2022, temporary solutions were devised by the Wikipapa team to address offline functionality:

"Basically, what was done is to collect everything possible, everything was saved in the memory of the cell phone, and once everything was collected, they went down to where there was Wi-Fi, meaning the city. From there, it was uploaded, and synchronization occurred." (Interview with Wikipapa Developer 1, February 16, 2023)

Farmers' concerns about Varscout's user interface, including problems with its design and accessibility, indicate potential barriers that may disproportionately affect certain groups of users, emphasizing the need for inclusive design. This puts into question FAIR and CARE compliance and thus shows barriers to achieving data fairness at this stage of Wikipapa and Varscout development. Wikipapa's infrastructure remains invisible or inscrutable for some first-time users who interacted with Varscout, such as farmers. At the same time, Wikipapa is more accessible to students and rural extension workers, who are currently familiar with similar

platforms for environmental monitoring such as KoboCollect. Most of Wikipapa's features remain unclear for first-time users, who struggle to understand how Wikipapa and Varscout complement each other.

Realizing that users might experience difficulties using Varscout and Wikipapa, developers pointed out that the platforms need to be simpler to use. According to them, users must have an “intuitive experience” and should feel motivated to upload data themselves rather than it being an imposition. However, users' experience was not intuitive. Instead, most of them identified issues with the interface, such as intense brightness of the app, difficulty reading small fonts, sun reflection, and color. During the workshops, farmers expressed that they enjoyed taking photos of their potatoes but faced issues locating images within the app. It was difficult for them to re-log into Varscout after they took pictures or used another app. Another issue was the measurement units used in the app. Farmers claimed that “we do not know exactly the amount of land, but we calculate in other units.” For example, they measure yield by the number of sacks they can fill at harvest. During workshops, farmers preferred to use "arobas" instead of kilos to estimate yield. Arobas was not included in Varscout's latest version, as were other non-western measuring practices.

Based on the CARE principles, it's important to recognize and value the contributions of all stakeholders, including indigenous communities, to ensure fairness and equity. Expressing the need for incentives and acknowledgment for their contributions, farmers emphasized the importance of recognizing and valuing their efforts. This is an important step to ensure compliance with the CARE principles. Developers, students, extension workers, and potato

farmers agreed that continuously using the app would be an optimal scenario for everyone, as well as providing incentives. Nonetheless, farmers requested that their observations and contributions to the app should be clearly acknowledged. They suggested that Varscout should allow them to sort potatoes based on their uses and monitor fertilizer use.

Regarding Varscout's operability, farmers stated that "it should not be mandatory to fill out everything, but it could be important to have the knowledge." This is in reference to the forms required by the app to set up their user profiles and background information, as well as the forms that require western categories, such as morphological and agronomic descriptors. Often, farmers felt overwhelmed by the level of detail required by the app since the time and input required by the app are confusing to them. For them, the most exciting feature of Varscout is that it allows them to take pictures of their potatoes and then locate them on the app's map. During the workshops, farmers were asked about how many observations each of them could provide per week to estimate their interest in the app. They responded that it would depend on several factors during each campaign. However, some mentioned that they would be able to upload most of their collection to the app given more time.

When asked about these issues, Wikipapa developers mentioned that "there is a learning curve to operate Varscout." (Interview with Wikipapa Developer 1, February 16, 2023). According to them, since Varscout was adapted from another software package, it needs to constantly undergo updates to newer versions to better suit conservation features. Many of the challenges in adapting Varscout to the Andes context are related to the multiple dimensions of Andean potato conservation in Peru, such as the strong interplay of food heritage and economic interests.

Additionally, small-scale farming is considered very different from large-scale farming, usually closer to the potato value chain interests (such as rotisserie chicken chains). As an app that seeks to engage Andean farmers, Varscout currently struggles to accommodate the unique characteristics of potato conservation in Peru: local agrobiodiversity conservation goes hand in hand with cultural diversity. For instance, due to the scale of seed networks and exchange practices, local names may overlap or replace traditional names recorded in the catalogs.

3.5.3 Toward Equitable Conservation Beyond OS Principles

Wikipapa and Varscout represent innovative approaches to the conservation of Andean potato agrobiodiversity, leveraging open-source principles and data science. These platforms aim not only to quantify and monitor biodiversity but also to bridge gaps between formal scientific approaches and farmer-led conservation practices. This section explores their implementation and impact, highlighting challenges and insights from stakeholders like the YANAPAI team. By examining practical considerations, farmer feedback, and the broader implications for equitable technology access and cultural representation, this section seeks to illuminate the complexities and potentials of integrating digital tools in agricultural conservation efforts.

The application of open-source (OS) principles in agrobiodiversity monitoring may not guarantee fairness, necessitating additional considerations to balance the interests of conservation actors. Recognizing and bridging the gap between formal and farmer-led conservation approaches demonstrates a nuanced strategy that considers the diverse needs of local stakeholders beyond OS principles. This acknowledgment implies an actionable effort to enhance mutual understanding. According to the Wikipapa developers, achieving a "symbiosis"

between potato cataloging methods is crucial for mutual comprehension. They advocate that data science should support conservation efforts, emphasizing the integration of indigenous descriptors—such as cultural uses—into the formal classification process, rather than merely translating potato names into Quechua.

The Wikipapa team describes Wikipapa as an "information engine" aimed at becoming a "reliable source of information," monitored by knowledgeable individuals. Data curators and agrobiodiversity scientists are deemed crucial for assisting users and validating observations uploaded to the platform. For the developers, data science plays a pivotal role in quantifying and validating information, thereby mitigating errors in overestimating biodiversity. Estimating the actual number of local potato varieties remains a shared concern among developers and extension workers, crucial for monitoring agrobiodiversity loss:

"Sometimes farmers tend to overestimate their variety count; they might claim to have 1000 varieties, but data science often reveals duplicates and triplicates, resulting in fewer unique varieties." (Interview with Wikipapa Developer 1, February 16, 2023)

Addressing practical considerations such as estimating production and cultural uses of potatoes shows a holistic approach that goes beyond open-source principles to meet the contextual needs of diverse stakeholders. Practical considerations such as estimating production, focusing on yield per variety, and sorting potatoes based on cultural uses are essential for understanding the contextual needs of users and ensuring that the platform meets their requirements. To reduce overestimation, farmers propose to characterize their potatoes using Varscout near harvest time.

Instead of focusing on the overall yield, farmers preferred to focus on yield per potato variety to estimate their production. "We evaluate the quantity; we calculate accordingly,". Farmers highlighted that VarScout could assist them in estimating the yield per variety and performing post-harvest assessments.

Highlighting equitable technology access and voluntary contributions underscores a commitment to fairness and inclusivity. Insights from the YANAPAI team are pivotal in evaluating the fairness and ethical considerations of long-term Wikipapa and Varscout adoption. They advocate for recognizing and rewarding farmers for their contributions, stressing that without farmer interest, these platforms may falter:

"Those of us in institutions seek data that can inform us. However, we must understand that without farmer engagement, these efforts will fail." (Interview with Grupo Yanapai 1, February 16, 2023)

The YANAPAI team emphasizes the importance of being cautious when engaging with farmers in the technology adoption, since their responses during workshops are likely different from their everyday practices. They mention that farmers can feel pressured by the institutions organizing the workshops and provide positive feedback to "look good" or "please" those institutions. For this reason, the YANAPAI team insists that data platforms should meet the real needs of farmers to be adopted locally. They consider that regional agrobiodiversity catalogs do well in showcasing Andean food heritage: "it's not only about making genetic resources visible but also highlighting the family and cultural values related to biodiversity conservation" (Interview with

Grupo Yanapai 1, April 9, 2023). Regarding Wikipapa and other online platforms, the YANAPAI team would like to see implemented features such as filtering data by gender and weaving in users feedback over time.

While the information collected in potato catalogs may have significant value for extension workers and agrobiodiversity experts, it may not necessarily benefit farmers. According to the YANAPAI team, being visually represented in catalogs is what captures the attention of farmers. When they see their photographs, farmers' interest in potato conservation grows: "We showed them their photographs as they can find themselves on that page and so they can see their own varieties on this page" (Interview with Grupo Yanapai 1, April 9, 2023). Farmers actively participated in selecting which photos are going to be shown in catalogs: "From Friday until today, four of them wrote to me on WhatsApp... 'Hey, I want you to update my photo because I don't like the picture you put in the catalog, I look ugly'" (Interview with Grupo Yanapai 1, April 9, 2023). Photographs hold significant value for farmers in terms of representation. According to the YANAPAI team, farmers participate when they perceive that they will be "seen" by others. Likewise, if they do not feel adequately represented or visible, they actively request to be included: "Some tell us why we don't appear in the catalog... we don't have the photo of our community" (Interview with Grupo Yanapai 1, April 9, 2023). The YANAPAI team considers that making farmers visible would motivate them to continue conserving Andean potatoes.

Overall, the YANAPAI team believes that significant improvements are needed in Wikipapa and Varscout to ensure long-term farmer engagement. They suggest these platforms currently cater more to rural extension workers than to farmers, and propose that younger, more technologically

adept individuals may find them more suitable. Addressing functionality and interface concerns, they stress the importance of unified information storage and display to minimize confusion caused by diverse local names across regions and farming communities relying on Wikipapa.

The exploration of Wikipapa and Varscout reveals both promising advancements and critical challenges in the realm of agrobiodiversity conservation. While these platforms leverage open-source principles and data science to enhance biodiversity monitoring and farmer engagement, they must navigate complex issues such as equitable technology access, cultural sensitivity in data representation, and the genuine alignment of platform functionalities with farmer needs. Insights from stakeholders like the YANAPAI team underscore the necessity of continuous adaptation and improvement to ensure long-term farmer participation and the effective conservation of Andean potato agrobiodiversity. Moving forward, addressing these challenges with sensitivity and responsiveness will be essential in maximizing the impact of Wikipapa and Varscout in fostering sustainable agricultural practices and preserving cultural heritage.

3.6 E-commerce and Commercialization in the Wikipapa Data Chain

This section explores the significant shift in citizen science platforms exemplified by the proposed inclusion of e-commerce features, specifically through Miski Papa, into the Wikipapa platform. This integration holds the potential to uplift the livelihoods of potato farmers by providing tangible incentives and facilitating direct market access. However, developers must navigate a complex landscape of logistical challenges, uncertainties, and priorities. Integrating e-commerce into agrobiodiversity conservation platforms raises critical questions about balancing commercialization with conservation efforts. Insights from experts on technology adoption,

economic motivations, and conservation practices within the context of potato agrobiodiversity are crucial for understanding how this integration might influence Wikipapa's original conservation goals. Additionally, this integration sheds light on the complexities of farmers' decision-making processes and their interactions with technology, markets, and conservation efforts. Therefore, designing effective strategies for combining Miski Papa and Wikipapa is vital to ensure the sustainability of agrobiodiversity conservation initiatives.

3.6.1 The Wikipapa-Miski Papa Synergy

Wikipapa developers are actively considering the addition of e-commerce features to the platform, indicating a potential shift towards commercialization within the Wikipapa data chain. This development has the potential to provide tangible incentives for farmers to access other markets, significantly improving their livelihoods. Integrating Miski Papa into Wikipapa is viewed by the Wikipapa team as a key step towards online commercialization. This move is generally seen as a positive development for increasing farmers' involvement in the value chain and reducing intermediaries. However, as the Miski Papa team notes, practical challenges in logistics, production, transportation, and consumer preferences must be addressed. Additionally, other actors within the Wikipapa data chain often view farmers as rational decision-makers, struggling to understand the heritage value of conservation activities and their interplay with household economies.

Miski Papa, the AGUAPAN brand, is expected to be integrated into Wikipapa soon, a move seen as part of stage three of Wikipapa's development process. This integration is intended to encourage rural potato farmers to confidently upload their data and benefit from online

commercialization. The strategy currently targets a small group of urban consumers in Lima yet faces challenges outside the agricultural campaign when it becomes difficult for these consumers to order potatoes online. Wikipapa developers consider that farmers will be eager to continue participating in conservation not only by providing their data but also by supplying actual tubers for sales. However, they fail to grasp that farmers' motivations are not necessarily financial, and that few of them are willing to increase their production to scale up commercial operations.

The interoperability between Wikipapa and Miski Papa is a key priority for developers. Initially designed as a citizen science app to showcase information from farmers preserving crop varieties, Wikipapa has evolved to include integration with the Andean potato value chain through Miski Papa. This integration aims to address transparency issues in traceability for Andean crops sold online, allowing urban consumers to identify the origins and growers of the potatoes. Miski Papa's website already displays profiles of some AGUAPAN members with their contact information, enhancing consumer trust and engagement. However, this information is not comprehensive in terms of not providing updated information about recently incorporated AGUAPAN members, as well as those who are no longer part of the organization.

Traceability has been recognized as a unique selling point for Andean agrobiodiversity by Wikipapa developers. Urban consumers are increasingly interested in the origins of the products they purchase, particularly at fairs. Initiatives like Miski Papa play crucial roles in showcasing Andean products in Lima, providing income opportunities for potato farmers, especially during the pandemic. Due to the restrictions imposed by the government, digital platforms like Miski Papa were able to temporarily support rural potato farmers during the pandemic, minimizing

intermediaries, despite limited experience in online sales of Andean products. It's important to note that Miski Papa was able to achieve this without Wikipapa integration, since its strategy focused on leveraging social networks and close contacts to deliver potatoes.

Increased sales in 2021 and 2022 highlighted the potential for agrobiodiversity to generate high incomes for potato farmers. Miski Papa, as a complementary component of Wikipapa, facilitates transactions during potato campaign seasons through Google Forms. Looking ahead, the developers are considering a shopping cart feature to streamline the purchasing process, making it more akin to an e-commerce experience. By refining existing methods using platforms like Google Forms and WhatsApp, they aimed to extend Miski Papa's reach, fostering interactions between urban consumers and producers and enhancing the overall user experience. Currently, it's not clear if Miski Papa strategy is effective, since a portion of their client base has changed since the pandemic. At the same time, potato farmers at fairs are relying on providing their own contact information (mobile number) to make the sales directly with new customers, through Yape, a mobile app designed to transfer money using mobile numbers or QR codes that has been used since 2020 in farmers markets (La Lupa 2020).

Miski Papa, originating from AGUAPAN farmers' participation in the Mistura fair in 2011, has changed significantly. Initially showcasing surplus native potato harvests from AGUAPAN members, Miski Papa aimed to ensure year-round food security within an agro-food system of self-consumption. Before the pandemic and due to AGUAPAN's ongoing involvement in ecological fairs in Lima, the number of farmers willing to participate in commercialization increased sharply. However, due to unknown reasons, the project became inactive until it was

relaunched in 2020 amid the pandemic, leveraging a pre-existing network of contacts to successfully implement potato delivery services. It is not clear what motivated Miski Papa's relaunch, especially since its sources were not able to confirm what happened with the brand between 2013 and 2019.

Despite its successes during the pandemic, Miski Papa faces challenges in achieving self-sufficiency due to insufficient profits to cover expenses. The business model for marketing remains undefined, and establishing a separate bank account for AGUAPAN members remains uncertain. Managing retail sales, distribution, delivery costs, and financial transactions has proven challenging. The person handling these tasks often ends up fronting urgent payments, highlighting the need for a more sustainable financial model. Lately, AGUAPAN farmers and other stakeholders such as Grupo Yanapai, have questioned the viability of Miski Papa's model altogether, arguing that it has proven ineffective during the last agricultural campaign.

The upcoming potato harvest season will see AGUAPAN members decide who wishes to take on commercialization, although it remains uncertain whether they will sell through Miski Papa, given its current viability concerns. Miski Papa representatives argue that expecting farmers to handle the entire value chain is somewhat exploitative, as it requires extensive efforts, time, and expenses that could be better spent on enhancing productivity and quality.

“It's overlooked that farmers no longer need to handle the extensive efforts, time, and expenses associated with retail marketing activities. They can focus on enhancing productivity, quality, and scheduling deliveries. Expecting farmers to cover the entire

value chain is somewhat exploitative. This is the other side of the coin that isn't frequently discussed". (Interview with Miski Papa representative, February 24, 2023)

According to the Miskipapa representatives, if farmers decide to take on commercialization as their own venture, that will present risks for them. Generally, costs are offset by sales, which are insufficient given Miski papa current sales. Based on these experiences, the Miskipapa representatives question the prevalent idea of cutting out the middleman in the wholesale and retail phases. Miski Papa's goal was to create demand for Andean potatoes, enabling farmers to receive higher prices for products that previously lacked demand. Addressing current challenges could enable the continued sale of potatoes and inclusion of other crops, provided efficient and appealing delivery costs are achieved. Effective storage and distribution methods and a user-friendly website for quick and easy orders are essential for this goal.

The integration of Wikipapa and Miski Papa is seen as a "highly intelligent and efficient synergy" by Miski Papa representatives. They believe it could address AGUAPAN farmers' commercial and technological needs while promoting intercultural education and engaging consumers as citizen scientists. However, for the integration to be successful, the application must be significant enough for consistent use, aligning incentives for different actors to achieve a powerful convergence:

"Wikipapa could engage consumers who, at the same time, contribute as citizen scientists by identifying local potato varieties through Varscout. Thus, Wikipapa could function as a repository accessible to producers, scientists, and the public, particularly MISKIPAPA

customers and consumers”. (Interview with Miski Papa representative, February 24, 2023)

Another experience similar to Miskipapa is Kusikuy, an application that aims to bring rural farmers products closer to the city, without the intervention of intermediaries. This app is advertised at food and biodiversity fairs and offers various Andean products from several localities of the Andes, such as grains and tubers (Infobae 2022, Guevara 2022, Andina 2022). The Miskipapa team has met with them and started conversations to incorporate AGUAPAN farmers to Kusikuy as an alternative to Miskipapa. However, challenges such as regional distribution and drop-off points proved challenging as potatoes could remain in transit from region to region to finally arrive at their destination. Kusikuy didn't allow the Miski Papa brand to be part of their operations, rather, they preferred to engage individual farmers. This will complicate the logistics, increase the risks and costs, and ultimately would not be a viable option since commercialization costs will be compensated by production costs.

Ultimately, the integration of Wikipapa and Miski Papa could enhance Miski Papa's prestige as a collective brand, adding value to AGUAPAN members' work. Ensuring a positive user experience on the Wikipapa website is crucial for increasing consumer engagement and sales. The experience with Kusikuy, an application similar to Miski Papa, underscores the importance of effective logistics and the challenges of regional distribution, highlighting the need for a well-coordinated and sustainable approach to potato commercialization. The potential integration between Wikipapa and Miski Papa signals the challenges the incorporating e-commerce features

to citizen science platforms, such as implementing traceability and sustaining online delivery service with reduced capacity and distribution organization.

3.6.2 Urban Lens on Technology Adoption and Commercialization

The discussions around market access for potato farmers suggest that economic interests play a significant role in shaping the evolution of Wikipapa. Experts' perspectives on these topics provide valuable insights into technology adoption, economic motivations, and conservation practices within the context of potato agrobiodiversity. Understanding these perspectives is essential for assessing the potential impacts of integrating Miski Papa's e-commerce features into Wikipapa and how it might influence the original conservation goals envisioned by Wikipapa developers. Additionally, it sheds light on the complexities surrounding farmers' decision-making processes and their interactions with technology, markets, and conservation efforts. This understanding is vital for designing effective strategies for integrating Miski Papa and Wikipapa while ensuring the sustainability of agrobiodiversity conservation initiatives.

The UTEC consulting team was assigned as facilitators of Wikipapa and Varscout citizen science workshops. Usually dominated by economists and agronomists, the UTEC team felt somehow new to agriculture and conservation. Funded in 2011 by Hochschild Mining, (Lira & Castro 2013) UTEC is an engineering university with a focus on innovation. UTEC's faculty is encouraged to be entrepreneurial or commercialize their research fostering technology transfer and university-industry interactions (University Innovation.org). For the Wikipapa and Varscout citizen science project, the UTEC consulting team adopted a technological acceptance approach, focusing on how technology is socially appropriated in different contexts, with a special

emphasis on farmers' economic interactions within the potato value chain. Their approach to understanding data platforms and farmer engagement with technology is based on the Technological Acceptance Model (Davis, 1989) as well as its revised version: Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003). These frameworks examine how technology is socially appropriated in different contexts.

However, those frameworks tend to conceptualize users' attitudes and motivations toward technology adoption based on cost benefit and self-efficacy principles (Davis 1989). As the UTEC team mentioned in their report about the workshops, those frameworks seek to model user acceptance of information technology broadly, focusing on examining behavioral predictors. The first model examines perceived usefulness and perceived ease of use of information technology (Davis 1989), while the 2003 model (Venkatesh et al 2003) focuses on factors such as performance expectancy, effort expectancy, social influence and facilitating conditions. The UTAUT2 model of 2012, which inspires UTEC team approach to technology adoption, incorporates three additional constructs: hedonic motivation, price value, and habit. Hedonic motivation is defined as the “fun or pleasure derived from using a technology” (Venkatesh et al 2012), while price value is defined as “consumers' cognitive tradeoff between the perceived benefits of the application and the monetary cost for using them” (Venkatesh et al 2012). At this stage, users are conceptualized as consumers.

Based on these frameworks, it's no wonder that the UTEC team focused their attention on Varscout users' choices and economic interactions such as their connection to the potato value chain. This also explains why they were startled during the workshops when they discovered that

for some farmers, conservation holds more value than commercialization. In their report, the UTEC team explained their hypothesis, prior to the workshops. Their hypothesis proposes that Varscout users are mainly motivated by a digital tool that allows them to be incorporated into the market and improve their financial situation. During the workshops, the UTEC team included a hypothesis that proposes that Varscout users are mainly motivated by a digital tool that allows them to strengthen their sense of identity. However, when I asked them about these topics after the workshops, they struggled to explain the interplay between economic and cultural interests behind agrobiodiversity conservation.

The UTEC team rationalizes farmers' attitudes toward conservation through economic terminology, emphasizing that the viability of sustainable conservation efforts hinges on considering the marginal costs borne by farmers. They suggest that understanding the economic implications for farmers is crucial in promoting sustainable conservation efforts. The words they use to explain farmers' attitudes, motivations and the value of potato agrobiodiversity reflect their preference to rely on economic terminology. For example, to explain why farmers prioritize conservation, the UTEC team relies on the term marginal cost: “perhaps what is happening is that sometimes that marginal cost is very small, and that's why he does it” (Interview with UTEC team member 1, March 31, 2023). According to them, if the marginal cost is high, then the cost of conservation could become unbearable for rural farmers. The marginal cost is associated with the time and resources that farmers allocate to conservation. From their perspective, the team considers that overly promoting agrobiodiversity consumption becomes ideological if one opts to “maximize it just for the sake of maximizing it”. According to them, if conservation is encouraged, marginal costs of farmers should also need to be considered.

During the interviews with the UTEC team, farmers were portrayed as constantly evaluating the risks and benefits of their commercial activities. The team is aware of the complexity of farmers' interactions with intermediaries and highlights the varying perspectives among farmers – some being more "pro-market" while others prioritize conservation. However, even though rural farmers engage in commercial activities, they are not always assessing the costs and the benefits of all their activities. The consulting team understood this; however, they were not able to explain how farmers allocate resources if their work is not always profitable. Nevertheless, this does not imply that most of their agricultural work is not commercial, or that farmers are not aware of potential abuses from intermediaries such as wholesalers and collectors. In contrast, based on UTEC's team previous research, "producers" may have close ties to intermediaries: "a trader told me, my client is my potato producer or my onion producer". This shows the complexity of farmers-intermediaries' interactions.

The potential introduction of e-commerce features to Wikipapa raises questions about how these changes might impact the conservation goals and practices originally envisioned by Wikipapa developers. The UTEC team acknowledges the prioritization of potato conservation over commercialization by farmers, even in situations where economic ends might not meet. This highlights the complex motivations and considerations involved in farmers' decision-making. According to the team, there are "pro-market farmers" and others who would be "satisfied with conservation". The team became intrigued by the heterogeneity of Andean potato conservation. After the workshops, they felt astounded by how heritage interest plays a fundamental role in conservation:

“It seemed to me in these workshops that, indeed, they are not very concerned about their poverty, which surprised me a lot ... We said, "Wow, this has been a cold shower because we didn't expect this." It's nice that it is this way, but it opens up many questions. I think we need to look at less biased samples of farmers” (Interview with UTEC team member 2, March 22, 2023).

The UTEC team advocates for a "balance" between agrobiodiversity commercialization and conservation activities. They see technology, particularly e-commerce, as a tool to connect farmers with the market, but emphasize the importance of preserving agrobiodiversity. This balance is related to the rural farmers' capacity to commercialize agrobiodiversity. Farmers would need to meet the demand for Andean potatoes, through e-commerce technologies: “technology can connect them with the market and can make them learn ". As risk takers and cost benefit analysts, according to the team, farmers should be able to assess if they are able to supply larger volumes of native potatoes and anticipating its valuation: “these things are sometimes detrimental to agrobiodiversity because they ask for three types of potatoes, and instead of cultivating 300, you end up cultivating three because that's what will pay for the food” (Interview with UTEC team member 2, March 22, 2023) . Higher demand could lead to a reduction of local agrobiodiversity, and ultimately harm farmers' economies. The consulting team inferred that demand is not necessarily the same for all potato varieties, and farmers with large plots cultivate fewer varieties than small-scale farmers with higher agrobiodiversity.

The UTEC team is aware of farmers' changing relationship with "modernity," linking it to increased connectivity and access to markets. However, they caution against assuming farmers'

motivations to commercialize their products. The team is aware of recent changes in the lifestyles of rural farmers: “there is less attachment to land because there is also greater connectivity”. The metaphor of connectivity is used to indicate that farmers now have more alternatives to connect to the “modern world” by actively participating in the market. However, the team considers that it is important to not take farmers' motivations to commercialize their products for granted. If value chain actors recognize that farmers are already motivated to grow their crops, there is a possibility that they will take advantage of that. The team identifies there is a risk of abusing farmers if stakeholders believe that “they will grow potatoes anyway”.

Given the limited knowledge that the UTEC team possesses about what extensionists call the farmer's "reality," they made conjectures about the main challenges in conservation. These conjectures are based on predictions that have not yet incorporated the farmer's perspective, resorting to explanations that rationalize conservation. The team is aware that their conjectures are based on limited knowledge and would prefer to have a better grasp on the farmer's “reality”. This challenge resonates with the idea that the division between rural and urban realities is a product of social constructs, particularly conceptualized by urban scholars (Rochabrun, 1994). By questioning this division, it is possible to critique the idea that the internet, technology, and media literacy “will somehow save or educate rural people” (Wang 2020). Instead, as Wang suggests, it is valuable to pay attention to how the urban rural dynamic forces us to think beyond “remote as disengaged vs metropolitan as connected” (Wang 2020).

3.7 Conclusions

The incorporation of FAIR principles into Wikipapa and Varscout has influenced the accessibility and findability of potato biodiversity data. Stated commitments to open and accessible biodiversity data are evident in the effort to understand and curate data from previous agrobiodiversity monitoring projects. This aligns with FAIR principles, emphasizing the importance of making data Findable, Accessible, Interoperable, and Reusable. The rigorous process of data curation, often referred to as "cleaning," underscores the commitment to ensuring the accuracy and reliability of the information provided, a fundamental aspect of FAIR principles. By curating data and incorporating synonyms for potato varieties used in regional catalogs, the platforms enhance accessibility for rural farmers, aiding in the findability of relevant information. However, challenges persist in ensuring fairness, particularly in terms of respecting indigenous self-determination and addressing potential negative impacts on those contributing data. Despite efforts to acknowledge and incorporate local knowledge, there is a continued risk of prioritizing western science over indigenous perspectives, highlighting the ongoing tensions between FAIR and CARE principles in data curation processes.

Wikipapa's initial goal was to develop a citizen science app to showcase information from diverse farmers dedicated to preserving their crop varieties. However, as the project progressed, there was a shift towards integrating Miski Papa, AGUAPAN's brand, into the platform to facilitate online commercialization. This integration poses challenges and opportunities for data curation, particularly regarding the traceability and transparency of Andean potato varieties. The addition of e-commerce features to Wikipapa signifies a potential shift to commercialization and marketization of knowledge within the data chain. This integration aims to provide tangible

incentives for farmers to participate by offering opportunities to reach new markets and potentially improve their livelihoods. Wikipapa developers argue that farmers should be confident about uploading their data to Wikipapa to benefit from e-commerce features and online commercialization. However, it's essential to consider how these changes might impact data curation within the Wikipapa platform and ensure that fairness and equity are maintained.

Wikipapa and Varscout focus on FAIR potato agrobiodiversity data reflects a commitment to fostering collaborative knowledge production and sharing among different stakeholders. By integrating diverse sources of knowledge and incorporating indigenous classification principles, the platforms aim to promote inclusivity and transparency in sharing potato agrobiodiversity data. Efforts to recognize and value the contributions of all stakeholders, including indigenous communities, demonstrate a commitment to fairness and equity. However, addressing the CARE principles remains challenging. Bridging the gap between formal and farmer-led conservation approaches and ensuring that the platforms meet the diverse needs of local stakeholders should be considered. Practical considerations, such as estimating potato production and focusing on cultural uses, highlight the importance of understanding the needs of users and ensuring that both platforms are responsive to their requirements.

The integration of Miski Papa into Wikipapa represents an opportunity to promote openness in agrobiodiversity knowledge infrastructures. By sharing information about potato varieties, farmers bios, and their cultivation practices, Wikipapa can serve as a repository accessible to producers, scientists, and urban consumers. Opening Andean potato data to diverse audiences aligns with the conservation goals originally envisioned by Wikipapa developers, emphasizing

the importance of preserving Andean products and local knowledge. Furthermore, initiatives like Miski Papa play essential roles in showcasing Andean products and providing income opportunities for potato farmers. However, it's crucial to ensure that the integration of Miski Papa into Wikipapa enhances data sharing and promotes transparency throughout the value chain. This can empower consumers to make informed choices and support sustainable agricultural practices.

To scale up potato agrobiodiversity sales, Miski Papa requires Wikipapa infrastructure to provide a contextualized understanding of the origins of their potatoes. According to the Miski Papa team, their model of online delivery service worked well during the pandemic. However, that model struggles to be sustainable on its own as online potato sales fluctuate or decrease. While Miski Papa and Wikipapa integration aim to promote conservation efforts and increase awareness of potato agrobiodiversity, challenges persist in ensuring that both platforms effectively engage and empower rural farmers. Issues such as interface design, accessibility, and usability highlight the importance of inclusive design and equitable technology access. The platforms' reliance on expert curators and data scientists raises questions about the balance between formal and farmer-led conservation approaches and the potential for exclusionary practices. Addressing these challenges requires ongoing dialogue and collaboration among developers, extension workers, and rural farmers to ensure that the platforms reflect the values and priorities of local communities.

The interpretation of conservation activities within the Wikipapa data chain requires a nuanced understanding of the motivations and incentives driving farmers' participation. While economic

interests play a significant role in shaping the evolution of Wikipapa, it's essential to recognize the complex interplay between commercialization and conservation efforts. Farmers may prioritize conservation over commercialization, particularly when heritage interests and cultural identity are at stake. The UTEC team's exploration of farmers' attitudes and motivations reveals their own limitations to grasp the everyday reality of potato farming. The heterogeneity of potato conservation practices in the Andes highlights the importance of balancing economic considerations with local environmental stewardship. The introduction of e-commerce features to Wikipapa raises questions about how these changes might impact potato conservation. While technology can connect rural farmers with markets, there is a need to ensure that potato commercialization efforts do not compromise agrobiodiversity conservation. While the citizen science workshops that I attended focused on measuring the impact of digital platforms in conservation, my focus is on FAIR and CARE implementation. Compromising conservation and local knowledge will certainly avoid CARE implementation, thus turning Wikipapa to a farm to table startup.

CONCLUSION

The comprehensive examination of ex situ conservation practices, socio-economic dynamics, and digital platform integration underscores the multifaceted nature of Andean potato agrobiodiversity conservation in Peru. This study highlights the interplay of care, security, sustainability, fairness, labor, niche cultural markets and community-based conservation revealing pressing challenges as well as tensions across geographies, communities and knowledge infrastructures.

Chapter 1 establishes the importance of cleaning as a critical institutional mandate at CIP. This process is essential for maintaining the phytosanitary status and reputation of CIP, underpinning the broader care-security work crucial for preventing contamination. The chapter emphasizes the challenges curators face in integrating diverse scientific disciplines and indigenous knowledge, highlighting the docility and resistance of plant materials in standardization practices. CIP's interactions with informal seed systems reveal significant limitations in addressing local needs, underscoring the necessity for culturally sensitive engagement.

Chapter 2 explores the dichotomy between everyday conservation by rural farmers and the institutionalized promotion of agrobiodiversity. The chapter sheds light on the socio-economic divides, where urban consumers and value chain dynamics often overlook the labor and low returns of rural farmers. Public venues and fairs emerge as discursive arenas rather than substantial improvements in farmer benefits, perpetuating systemic issues. AGUAPAN's advocacy for fair prices and autonomy reflects broader aspirations but faces internal governance challenges and the paradox of scalability, threatening agrobiodiversity while aiming to improve farmer benefits.

Chapter 3 focuses on the integration of FAIR principles into digital platforms like Wikipapa and Varscout, enhancing data accessibility and findability. The chapter highlights the challenges in balancing FAIR and CARE principles, particularly in respecting indigenous knowledge and ensuring fairness. The integration of e-commerce features into Wikipapa offers potential economic benefits for farmers but raises questions about data curation and conservation efforts. The collaboration between formal and farmer-led conservation approaches requires ongoing dialogue, inclusive design, and a careful balance between economic and heritage motivations to ensure sustainable practices.

In summary, this project underscores the intricate and multifaceted nature of Andean potato agrobiodiversity conservation in Peru. It highlights the critical role of ex situ conservation practices, the socio-economic dynamics at play, and the integration of digital platforms in promoting agrobiodiversity. Through an in-depth examination, it reveals the essential interplay of care, security, sustainability, and fairness, alongside the challenges faced by curators and farmers in navigating cultural sensitivities, labor disparities, and market dynamics. The analysis sheds light on the socio-economic divides and systemic issues that impede rural farmers' benefits and emphasizes the importance of culturally sensitive engagement and balanced integration of diverse knowledge systems. This project ultimately advocates for ongoing collaboration, inclusive design, and a commitment to balancing economic and heritage motivations to ensure sustainable and fair agrobiodiversity conservation practices.

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