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Carlos Andres Gallegos-Riofrio
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WASHINGTON UNIVERSITY IN ST. LOUIS

Brown School

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Sustainable Diets for Planetary Health: A study of Indigenous Based Agri-food Systems in a Community of the Central Highlands of Ecuador
by
Carlos Andres Gallegos Riofrío

A dissertation presented to
The Graduate School
of Washington University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Aug 2020
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Dedicated to Mother Nature; to the memory of Luchi, Luis Antonio, Chochi and Francisco; and to María Luisa, Amaya, Nico and Malu, living examples of unconditional love.
ABSTRACT OF THE DISSERTATION

In order to explore the psychosocial and agroecological dimensions of sustainable diets and their roles in the rural Andean community of Caliata in the Ecuadorian highlands, I conducted a community-centered participatory mixed-methods study. Thirty-nine focus groups and ten key informant interviews were conducted, recorded, translated, transcribed, and analyzed using three-stage coding. The information was triangulated using participant observation, local records, and descriptive statistics from a survey of 57 female household heads, which included a modified 48-hour dietary recall module. Rural appraisal research assessed agroecological dimensions. Ten purposively selected sites were studied alongside local informants in order to obtain diversity indexes and a subset of five sites were analyzed for agroecological parameters using MO-DIRT protocols for soil health and laboratory analysis. A crossover analysis was conducted for agrobiodiversity, parcel size, and dietary diversity using the NOVA food classification to categorize the diet according to levels of processing. Four community-based system dynamics sessions were carried out to elucidate cause-effect relationships.

Caliata has experienced processes of acculturation and the effects of poverty. While gendered agriculture and population aging represent demographic challenges that are directly associated to outmigration. Modern agriculture, based in extensive monocultures and mechanized plowing, represents a potential alternative to labor shortages and to earn additional income. But this form of agriculture represents a threat to Caliata’s traditional landscape. Moreover, Caliata to date has managed to retain its identity, culture, language, and agroecological space, including native crops and a system of knowledge. Hence, people in Caliata refer to themselves as Kichwa-Puruwá indigenous people.
The results of this study reveal a psychosocial dimension defined by a heterarchical mode of organization and government that is reinforced by indigeneity and customary institutions. Hierarchy in Caliata is expressed by distributed and shared intelligence through a diversity of organizational units with specialized functions, which are in constant negotiation in order to reach consensus and procure optimal responses to collective decisions in the face of uncertainty and limited resources. Identity is grounded in a cosmovision that defines a relationship with Mother Nature (Pachamama). Customary institutions reinforce trust and reciprocity and are key to mobilize labor-intensive tasks. An agroecological dimension is characterized by a pre-Columbian system of terraces, ditches, and contention walls, as well as ecological richness and evenness that are managed with ancestral ecological knowledge. Their knowledge includes agrarian calendars that follow natural cycles, pest control, seed selection, and soil restoration measures, which complement the terracing system that creates heterogeneity and acts as energy traps of sunlight, water, and nutrients.

The combined analysis of both dimensions reveal that the community represents a case of positive deviance in that it is a space where sustainable diets are viable and food sovereignty provides an ecocentric way of living based on production, exchange, consumption of local produce, and knowledge of how Pachamama should be treated. In this sense, consistency was found in dietary patterns; all respondents reported intelligent hydration strategies as well as strategies to balance intakes with energy requirements, fruits being the most popular snack. Additionally, two-thirds of households consume unprocessed or minimally processed foods. Meanwhile, chronic health problems remain relatively infrequent compared to the general population.
In conclusion, this study suggests the sustainability of a reinforced loop in Andean agri-food systems, in which sustainable diets support a stable agroecological space and where the dynamic interaction between psychosocial and agroecological factors assure food security. Thus, Caliata provides insights that can be scaled-up from a local experience to programs and policy aligned to planetary health, thereby representing an opportunity to elucidate ideas for sustainability and food security challenges.
Introduction

Recognizing our planetary home as highly dynamic, diverse, complex, and interconnected, a top priority for the survival of our species is defining viable global food systems within the boundaries of the planet capacity (Jackson, 2009; Meadows, Randers & Meadows, 2004; Willett et al., 2019). The UN System Standing Committee on Nutrition (UNSSCN), in a recent discussion paper, titled “Sustainable Diets for Healthy People and a Healthy Planet,” reports: “Food systems and dietary patterns are key determinants of nutrition and health. At the same time, they play a significant role in environmental degradation and climate change” (Tirado-von, 2017: 9).

Anthropogenic induced climate change, ecosystems and biodiversity loss, soil erosion and nutrient loading represent an undeniable rationale to pursue a “Great Food Transformation” – advocated by the EAT-Lancet Commission on Food, Planet and Health (Willett et al. 2019). As stressed by the EAT-Lancet Commission and the UNSSCN, the need is to define and promote sustainable food systems and diets and, overall, a relationship with the planet that is sustainable in terms of environment, economy and society (Rockström, Stordalen & Horton, 2016; Tirado-von, 2017). However, a planetary-level transformation requires answers to questions across scales (e.g. local, provincial, national, regional, global), particularly: how to assure [1996 World Food Summit] food security for the present and future generation? And, in consequence, how to make food security sustainable?
Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996 as cited in Patel, 2009).

Local food systems – under labels like family farming systems, agricultural systems, agri-food systems; agroecosystems; and traditional [e.g. indigenous-based, campesino] systems—play a key role in global food security (FAO & IFAD, 2019). Yet, to effectively accomplish a sustainable global food system that assures food security within the planet regenerative capacity, it is fundamental to consider the conservation, enhancement and replication of resilient systems that cooperate with ecosystems, such as those centered in agrodiversity and energy efficient small-scale intensive food production (e.g. Holt-Giménez & Altieri, 2013; Parraguez-Vergara et al. 2018; Zimmerer, Carney & Vanek, 2015).

In the context of local food systems, the concept sustainable diets has two important dimensions. One well known dimension is food security supported by viable ecosystems (see. e.g., FAO, 2010; Fischer & Garnett, 2016; Tirado-von, 2017), while the other, also based in human behavior, is about how the relationship with nature is established. Sustainable diets are typically characterized by diversity (variety of foods), balance between energy needs and intake, abundance of non-processed and minimally processed foods, and hydration strategies (Fischer & Garnett, 2016).

Consequently, a key task is to characterize sustainable food systems, including the convergent psychosocial factors like sustainable diets, social institutions and norms, and the symbolic elements that prompt agency and community organization; systems that use ecological services such as pest control and nutrient cycling, while keeping ecosystems healthy. Recognizing the planet cultural diversity, the implications of characterizing local
sustainable food systems are vast within social, health and ecological spheres (see. e.g. Fischer & Garnett, 2016; Jones, 2017; Willet et al., 2019).

Specific to the local level (particularly for the indigenous-based systems), there are critical questions that remain for a “Great Food Transformation:” What are the structural and functional factors involved in the sustainability of a diet? What valid, reliable and culturally appropriate methods are available to assess and understand these factors and its potentials within the agri-food system? Specifically, what are the factors that make the system resilient? What characterizes the indigenous’ self-reflection? Hence, what characterizes an indigenous based agri-food system? Are indigenous based agri-food systems traditionally sustainable? What is happening with [nominally] indigenous communities that have experienced acculturation and/or those that are experiencing a transition towards urban standards? Is it possible to revitalize an indigenous based agri-food system that has lost some or most of the factors that otherwise would make it resilient? What are the considerations to revitalize an indigenous based agri-food system to transform potential into effective sustainable healthy diets?

As much as solving these questions is paramount to face the twofold sustainability and food security challenges, answers are contingent to unique social realities as well as to a universe of ways to operate in these realities; Aimé Césaire’s “universal rich with all that is particular, rich with all particulars, the deepening and coexistence of all particulars” (as cited in Grosfoguel, 2012: 95). The need is, consequently, to pursue research questions on case-to-case basis. While ontological plurality, coexistence, and the purpose to learn from “other” social realities should be fundamental premises to work at the local level, Bruno Latur provides a rationale:
Strength does not come from concentration, purity and unity, but from dissemination, heterogeneity and the careful plaiting of weak ties […] instead of starting from universal laws –socials or natural– and taking local contingencies as so many queer particularities that should be either eliminated or protected, it starts from irreducible, incommensurable, unconnected localities which then, at a great price, sometimes end into provisionally commensurable connections (Latour, 1996: 360).

Research founded on a localized approach of the food system (under exchangeable terms like agri-food systems or agroecosystem) deals with ecological and behavioral aspects that can be measured. It also does this with numerous social constructs (e.g. indigeneity) that have to be defined by each community. Furthermore, given the diversity of rural and indigenous communities, each case has to be assessed bearing in mind complexity, like historical processes and the present conditions (e.g. geography, political situation, experience of conquest, migration). Considering the concepts of Choi and Pak (2006), to best address such complexity the research goal should be pursued with a trans- and-inter-disciplinary perspective.

The advantage of this approach lays in gaining a deep understanding, for example, of the cultural attributes and environmental constraints that supports or hinder the system. It also provides the knowledge to improve the health of a population, while creating tools for the preservation of local systems of knowledge, for instance by delineating foods and practices that are both key to nutrition and sustainability. The approach represents an opportunity to contribute learnings that can support other communities that share similar conditions.

This dissertation aims to characterize key factors in an indigenous based agroecosystem that can promote sustainable diets and resiliency. This contribution looks at an indigenous based agroecosystem in the context of the Ecuadorian Andes:
Caliata (Lat 1.813°S | Lon 78.632°W). The community is localized in the province of Chimborazo, which is part of the country’s central highlands. To study Caliata I combined culturally validated qualitative methods, including participatory rural appraisal and community-based system dynamics, agroecology-based site analysis (e.g. agrodiversity and soil health assessments), and household surveys, including a modified 48-hour recall.

The present work is transdisciplinary as it integrates social, biological and health sciences, transcending traditional disciplinary boundaries, and interdisciplinary as the case study links, harmonizes and integrates different disciplines into a coherent whole. Theories and methods are combined across disciplines of sociology, anthropology and archeology, human and political ecology, systems science, agroecology and public health nutrition to present a case study of an indigenous sustainable food system.

Ontological plurality embedded in a trans-and-inter-disciplinary in-depth approach represented the opportunity to explore, describe and explain the case of Caliata as an ecological community; a system composed of intertwined factors at multiple dimensions (e.g. biological, social, individual, symbolic), like the cause-effects relationships of anthropogenic action in the agroecological landscape, and addressing complexity at different levels, such as the dynamics between rural and urban or traditional and modern. Overall, this work was pursued believing that this approach can illuminate on solutions to work towards planetary health.

1.1 Systems system: Ecosphere–Ethnosphere

By observing nature, it is possible to note borders, interactions, patterns, cycles, and energy stocks and flows; this is the observation of systems (e.g. Bush, 1997; Meadows,
The ecosphere (or biosphere) is a complex and adaptive system resulting from the aggregated interaction of ecosystems (Lovelock & Margulis, 1974; Rees & Wackernagel, 2008), each ecosystem autonomous, fragile, self-regulated and quite unique (Montoya, Pimm, & Richard, 2006; Ricklefs & Relyea, 2014).

The planet’s biodiversity reflects the unique geological processes that have taken place during millennia (Bowen & Roman, 2005; Connell, 1978; Schellnhuber & Wenzel 2012), but also in an important manner of anthropogenic intervention (Schellnhuber & Wenzel 2012; Steffen et al., 2020). The Anthropocene marks a geological epoch where humans have become the largest force shaping the planet (Zalasiewicz, Williams, Haywood & Ellis, 2011).

From our hominid ancestors to the present urban citizens, there are undeniable commonalities intrinsic to the human experience. One commonality is that we all share the ecosphere with limits derived from the planet regenerative capacity, the cycles involving energy, matter and organisms that create system stability (Steffen et al., 2020); a capacity also referred to as planet boundaries or safe operating space (Springman et al., 2018; Willett et al. 2019). Another commonality is that our anthropoid biology is subject to the nurture of nature and the nature of nurture (Bassin, 2009; Grove, 1996; Gumilev, 1993), where food represents the intimate link between these two inseparable dimensions (Brooke & Larsen, 2014). Food is, moreover, the “ultimate energy source for every human endeavor” (DeFries, 2014: 7-8).

To our knowledge, biochemical processes present in food are linked to social and psychological factors throughout human history (e.g. domestication, seeds selection,
grafting). Our psychosocial relationship with food reflects an agency that has made our species largely different from others (see, e.g., DeFries, 2014; Wrangham, 2009). Particularly, our capacity to create a realm of the intangible (i.e. the social brain), the symbolic, which is associated to language development and complex social organization (Dunbar, 2003). Language and social organization, foundational to culture, are perhaps the basis of our species agency, including cooking and processing foods, particularly those that are animal-based, which has been hypothesized as key in our species brain evolution (Wrangham, 2009).

In complex societies, food surplus is linked to theories of state creation, while the quality of the diet to the invention of tools and technologies (Erlandson, 1988; Feder, 2004; Hastorf & Foxhall, 2017). In addition, food is linked to a sense of belonging, identity, community cohesion and collaborative work (e.g. Caplan, 1997; Mintz & Du Bois, 2002). Indeed, “food is good to think with,” as Levi-Strauss’ (1966) pointed out. Overall, among societies, the connections in which each community develops systems perspectives (i.e. food-system, health-system, cultural-system, socioecological-system) greatly vary. The deep cosmological, sociocultural, and practical differences in the middle of undeniable commonalities are what constitutes the ethnosphere:

[…] the sum total of all thoughts and intuitions, myths and beliefs, ideas and inspirations brought into being by the human imagination since the dawn of consciousness […] humanity’s greatest legacy. It is the product of our dreams, the embodiment of our hopes, the symbol of all we are and all that we, as a wildly inquisitive and astonishingly adaptive species, have created (Davis, 2009: 2).

In the context of the Anthropocene, the invention of agriculture represents a remarkable example of how humans have been able to shape environmental conditions to the benefit of our species (Bassin, 2009; DeFries, 2014; Gumilev, 1993); humanity’s
imprint (ethnosphere) in the ecosphere has led to a unified system (Figure 1). A system that when disaggregated derives in a multitude of cultures and autonomous ecosystems converging into resource niches, and those that have managed to keep a balance between stocks and flows of energy, while are capable to absorbing disturbances, can be seeing as sustainable. In this context, the agroecosystem (e.g. Altieri, 2018) or the agri-food system (e.g. Thompson & Scoones, 2009) represent pertinent conceptual frameworks; analytical devices that naturally integrate other systems (health, food & cultural systems).

**Figure 1:** Illustrates the inseparable convergence of our species and the planet

Human health is dependent on the health of ecosystems across the scales. In that, the notion of the planet as an integrated system is becoming increasingly evident in public discourses and policy arenas, and hence in local and global efforts. In the international platform, this awareness is represented in the “2015-2030 Agenda for Sustainable
Development Goals (SDGs)” and the agreements achieved at the “Second International Conference on Nutrition (ICN2).” As a result of ICN2, the society of nations committed to the “United Nations (UN) Decade of Action of Nutrition 2016-2025.” The expectation of this new agenda is to put nutrition as a high priority, and to achieve “sustainable food systems and food and nutrition security for all.” SDG’s goals 2, 13, 14 & 15 reflect that the ecosphere is a complex system and that food, agriculture, and environment are key global challenges:

- Goal 2: Zero Hunger: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- Goal 13: Climate Change: Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy
- Goal 14: Life Below Water: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Goal 15: Life on Land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

### 1.2 Planetary-level challenges and opportunities

The planet is home of 7.8 billion people in 2020, and demographers expect 10 billion by 2056 (Chamie, 2020). Approximately 11% of our species population is experiencing hunger, by the indicator of prevalence of undernourishment (FAO, IFAD, UNICEF, WFP & WHO, 2019). Although suffering is incommensurable, this percentage is remarkable for humanity in a historical perspective, considering that just thirty years ago the percentage of hungry people was almost double (FAO, IFAD & WFP, 2015). However, after decades of a steady decline, in 2015 the trend reverted and currently hunger is on the rise (FAO et al., 2019).
Along with hunger, over a quarter of today’s world population is facing some form of food insecurity, which is being at risk of malnutrition and poor health as a result of suboptimal access to nutritious, safe and sufficient food; a reality from which wealthy nations are not exempt (FAO et al., 2019). Other rampant manifestations suggesting a subjacent structural problem are overweight and obesity, hidden hunger (micronutrients deficiency), and urban food deserts defined by limited access to healthy and affordable foods (Ghosh-Dastidar et al., 2014; Willett et al. 2019). Setbacks and incidence of nutrition problems are symptomatic of the behavior and pitfalls of the global food system—all the social structures, knowledge, technologies and ecological functions involved in food production, processing, distribution, consumption and waste around the planet (see. e.g., Fischer & Garnett, 2016; Willet et al., 2019).

In the age of super-fast telecommunications and a globalized economy, it is evident that the 2019 novel coronavirus (COVID-19) pandemic is testing the global food system at many levels. For example, production and distribution chains have been affected for virus related events like closure of food industries and borders, and limited transportation, as well as people’s access to food as a result of shortages, lockdowns and price increases (affordability) (Emmad & Peña, 2020; Moseley, 2020). On the other hand, communities are showing resiliency in creating alternative solutions through local food production and distribution and in creatively overcoming challenges to food access, particularly to support the vulnerable segments of the population (Blay-Palmer, Carey, R., Valette & Sanderson, 2020; Emmad & Peña, 2020; Raja, 2020).

The COVID-19 outbreak is not experienced homogenously across the globe, but ubiquitously a microscopic agent has made more evident the inequalities within cities,
between urban and rural, within countries and even between countries (e.g. Emmad & Peña, 2020; Fernandes, 2020; Power, Doherty, Pybus & Pickett, 2020; Raja, 2020). COVID-19 is having important effects in the world economy (Fernandes, 2020), exacerbating poverty levels, and likely will lead to a deeper reverse in the fight against hunger and different forms of malnutrition. Nevertheless, in some regions a reverse urban-rural migration has been observed (Moseley, 2020). This demographic phenomenon speaks of the central importance of cohesive communities and people’s capacity to produce their own food.

While the pandemic has received extraordinary media attention, “social media panic travels faster than the COVID-19 outbreak” (Depoux et al., 2020, web), there are intertwined threats to the global food system, which could reach cataclysmic proportions. COVID-19 is, however, linked to wildlife trade, and should be a reminder of the accelerated human pressures on the ecosphere (Ceballos, Ehrlich, & Raven, 2020).

The ecosphere is experiencing a rapid environmental degradation (e.g. fertile soils, habitats, fresh water) and biodiversity loss (e.g. insects and vertebrate pollinators), and this is compromising ecological functions in a way that directly affects humanity’s food systems (Díaz et al. 2020). Environmental degradation is concurrent and interrelated to a climate change emergency (Ripple et al., 2019), characterized by more frequent and severe weather events like intense rains causing landslides and floods, prolonged periods of drought and hailstorms capable of destroying the harvest (Carrasco-Torrontegui, Gallegos-Riofrío, Delgado-Espinoza, & Swanson, 2020).
The current situation is paradoxical. On one hand, while the above anthropogenic induced environmental phenomena are increasingly compromising the global food system in its capacity to feed (and feed-well) humanity. On the other hand, the prevailing global food system, particularly large-scale food industry bounded to international supply chains, is one of the main causes of greenhouse emissions, and the most important cause of destruction of natural habitats and loss of species (Díaz et al., 2020; Springman et al., 2018; Tirado-von, 2017).

In response to this paradox the world community is calling for a profound redesign of the current food systems –discourses and intellectual platforms like (i) the “Great Food Transformation” (Willett et al., 2019) and, alternatively, (ii) the sustainable intensification of food production and (iii) the ecological intensification of agriculture (see. e.g., Tittonell, 2014; Zimmerer, Carney & Vanek, 2015). Beyond the differences and convergences of these discourses, what is sought is that a transformation of the global food system should achieve food security and nutrition for all and for the next generations without compromising the health of the planet (Fischer & Garnett, 2016; Springman et al., 2018; Willett et al. 2019). Nonetheless, to mobilize such a profound change, collective action has to be inclusive, engaging key actors that have been typically marginalized, like indigenous people and other rural populations (UN, 2015).

Globally, about 33% of the rural poor are indigenous people and, not surprisingly, this percentage represents the great majority of indigenous people in the world (World Bank, 2017; FAO, 2017). *La Via Campesina* (1996) [The Peasant Way] proposes food sovereignty as a means to achieve genuine food security. Food sovereignty is “the right of people to determine their own food and agricultural systems and their right to produce and
consume healthy and culturally appropriate food” (Kim & Pokharel, 2020, web). Food sovereignty, as political proposal, imply community involvement, the end of food waste, assuring land tenure rights, to stop coercive food policies and respect for life, nature and genetic diversities (Patel, 2009).

Ecologically intensive and sustainable family-smallholding agriculture, represents the backbone of healthy and sustainable diets consumed around the globe (FAO & IFAD, 2019; Holt-Giménez & Altieri, 2013; Parraguez-Vergara et al. 2018; Zimmerer et al. 2015); a stark contrast to the industrial forms of agriculture that by the contrary are co-responsible of the overweight and obesity pandemic, associated chronic diseases, the incremental expansion of agricultural borders and a large portion of greenhouse emissions (Nestle, 2013; Springman et al., 2018). In particular, indigenous peoples have been recognized as key actors in climate change measures and biodiversity conservation by international forums like the Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Consequently, the rural indigenous people are key actors in planetary health.

1.3 Caliata a case study for the Andes and beyond

The Andes is a construct with multidimensional connotations. As ecoregion, the central highlands of Ecuador are considered part of the Northern Andes (Ramos et al., 2020). Politically, economically and culturally Ecuador is considered an Andean country (Andean Community of Nations, 2020). Foremost, “Andean” here refers to a historical-cultural-and-geographical space of regional influence, where the Kichwa (ethnic group with a distinctive language) has a marked influence. The Andean cosmovision is an irreducible
holistic concept, it can hardly be fully defined in rational terms; it integrates a diversity of systems of knowledge, biocultural (or ecocultural) spaces, ancient technologies, language, social institutions and customary norms.

In this sense, from the Andean perspective, food, health and nutrition are viewed as inseparable aspects of the confluence, function, and transformation of other aspects (e.g. medicine, institutions, ecosystems, language and culture) (Gallegos & Jara, 2007; Waters & Gallegos, 2014). This means, in simpler words that for Andean communities the agri-food system is about everything else. Consistently, the Andean region leads an alternative proposal that radically contrast with ideas of “development” (Khotari et al., 2014) known as the Sumak Kawsay (the Good Way of Living or Living Well). This proposal, promoted by indigenous people, has become nowadays explicit in legal frameworks in Ecuador and Bolivia:

In synthesis, we believe that, to have a real harmonious social change that lead us to a dynamic stability, what we need is not more economic wealth, but consciousness and cultural wealth. Only with more integrative and sacred consciousness that emulates natural laws a world in harmony and balance will be possible (Oviedo, 2011:311[trans.])

This dissertation, recognizes the vision of many indigenous communities, and hence represents a shift of perspective; switching the imperative question of “How are we going to feed 10 billion people by 2050” (EAT-Lancet, 2019) to: how the current 8 billion will work cooperatively to regenerate Mother Nature?

Caliata was selected as case of study because: (i) the community fits established dimensions of an indigenous based agri-food system (as detailed in Chapter 1, p. 41-42); and (ii) fieldwork was feasible due to community interest combined with local capacities.
Surrounded by a pre-Columbian terracing system, Caliata relies on subsistence agriculture characterized by a variety of traditional crops, like maize, beans, squash, lupines, quinoa, oca, mashua and potato. The community situation represents one in which customary institutions and traditional agri-food system is intertwined with modern processes of social transformation, including demographic phenomena like outmigration, feminization of agriculture and population aging, which have direct effects on the community’s way of living.

Caliata has also experienced some acculturation, particularly from evangelic missions, and the effects of marginalization and poverty. Demographic phenomena have made modern agriculture, based in extensive monocultures and mechanized plowing, an alternative to labor shortages and source of income. This form of agriculture represents a threat to Caliata’s terracing system, which is still functional and prevalent in the community landscape. Overall, these pressures may compromise their food security, traditional knowledge and, ultimately, their future. However, Caliata to date has managed to retain its identity, culture and agroecological space, including their system of knowledge. Caliata is part of the Kichwa nation and of the Puruwá pueblo (SISSE, 2010), hence they refer to themselves as Kichwa-Puruwá indigenous people.

In Chapter 1, I apply the concept heterarchy as analytical framework to understand social organization in Caliata and its psychosocial dimensions, like a local cosmovision (worldview, ethos and behavior), identity, customary institutions and agency. This framework is applied based on the well documented existence of pre-Columbian communities in Andes that functioned as organized small-scale egalitarian and resource-specialized agri-food systems. This communities had the capacity to create and maintain
intensive productive systems and to absorb disturbance (e.g. severe weather conditions like flooding). Current rural indigenous communities in Andes are not necessarily less complex than their predecessors. Heterarchy, as encountered in Caliata, is expressed in Caliata by distributed and shared intelligence through diverse, specialization and constant negotiation among organization unites (families and agencies) in order to reach consensus and procure optimal responses to collective decisions in the face of uncertainty and limited resources. This form of social organization is an important factor to understand the mechanics and effectiveness of the agroecosystem in procuring sustainable diets.

In Chapter 2, I characterize the physical landscape, including their pre-Columbian system of cultivation terraces, and explore the way it is managed with the local ecological knowledge. The terracing system represents the architecture of the agroecosystem, consisting of the cultivation terraces themselves as well as ditches, contention walls, traditional paths and the anthropogenic biomes it supports (e.g. croplands, rangelands). The Kichwa-Puruwá ancestral knowledge (or ancestral wisdom) is an Andean system of knowledge, centered in Mother Nature (Pachamama). This form of knowledge, which I discuss in the chapter, is in the indigenous discourse and international forums, including Climate Summits. In Caliata their ancestral knowledge is deeply integrated into terracing system, agrodiversity, ecological associations, native crops, and knowledge of natural cycles, which combine to shape a viable agroecosystem. The agroecosystem structure and its functions are the backbone of Caliata’s agri-food system, and it is central to understand why Caliata has remained to present a resilient community, despite internal problems, like population aging, and external pressures such as mechanized-based agriculture.
Finally, in Chapter 3, I show the inexorable connection between food sovereignty and sustainable diets for the context of Ecuador, and applicable to the Andean region. It also integrates the two previous chapters, following the narrative that to achieve a healthy sustainable food system globally, it is imperative to understand how local food systems can provide healthy and sustainable conditions. For the purpose we used the NOVA food classification to categorize the diet according to levels of processing and analyzed categorical and numeric data to understand the interplay of parcel size, agrodiversity, and diet diversity. People in Caliata have a consistent dietary pattern based on diversity of non-processed and minimally processed foods, balance between intake and vigorous lifestyles, and an effective hydration strategy. While, food sovereignty is an ecocentric concept based on production, exchanges of seeds and produce, consumption of produce, and knowledge of how agroecological space is treated. Caliata provides important perspectives on linkages between diet, biodiversity, use of agroecological space, and rural-urban dynamics.

This small indigenous community offers lessons for achieving both healthy ecosystems and food security. In the case of Caliata, the terms agroecosystem and agri-food system are exchangeable used; both indicate the structural and functional elements in place to mobilize food around the community, from soil to plate and back to soil, which includes key cultural elements and its political implications. Moreover, because Caliata is an ancient society, long term interaction of ethnoses and ecosystem, potentially has led to the emergence of ecocultural space, which can be seen as a stable, efficient and resilient system (e.g. Sterling et al., 2017). Whether or not Caliata is an ecocultural space yet remains to be tested, for example dating the age of the terraces with current methods in archaeology and systematically studying the behavior of terraces to different environmental events. Upon
results from follow up research it would be possible to determine the degree of replicability of the factors that make Caliata a stable, efficient and resilient system.

With these considerations in mind, Caliata is notably, a positive deviance (Marsh, Schroeder, Dearden, Sternin & Sternin, 2004) as demonstrated across the three chapters of the present dissertation. The concept positive deviance is based in uncommon advantageous behaviors practiced by certain individuals with better outcome than their peers or, alternatively, the behavior of an entire community in comparison to another, which is the case of Caliata. The lessons attained provide insights that can be scaled-up from local levels to programs and policies aligned with planetary health.

Positive deviant behavior […] is an uncommon practice that confers advantage to the people who practice it compared with the rest of the community. Such behaviors are likely to be affordable, acceptable, and sustainable because they are already practiced by at risk people, they do not conflict with local culture, and they work (Marsh et al., 2004: 1177).
1.4 References


Kim, J. & Pokharel, P. (April, 2020). The solution to food insecurity is food sovereignty. Food Sovereignty, in the media. La Via Campesina. accessed on 20 June 2020


Parraguez-Vergara, E., Contreras, B., Clavijo, N., Villegas, V., Paucar, N., & Ther, F. (2018). Does indigenous and campesino traditional agriculture have anything to contribute to food sovereignty in Latin America? Evidence from Chile, Peru, Ecuador, Colombia, Guatemala and Mexico. International journal of agricultural sustainability, 16(4-5), 326-341.


Raja, S. (2020). Planning and pandemics COVID 19 illuminates why urban planners should have listened to food advocates all along. Agriculture and Human Values, 1.


Chapter 1:

Ecological community: heterarchical organization in a contemporary agri-food system in Northern Andes

Abstract: Archeological evidence in the Andes supports the existence of heterarchical pre-Columbian societies organized as small-scale egalitarian and resource-specialized communities with the capacity to create and maintain intensive productive systems. Using David Stark’s analytical framework, we explore heterarchical organization in Caliata, an indigenous community in Ecuador’s central highlands in the context of local cosmovision, identity, and customary institutions. Heterarchical organization and governance in Caliata is expressed by distributed and shared intelligence through a diversity of organization units with specialized functions, in constant negotiation in order to reach consensus and procure optimal responses to collective decisions in the face of uncertainty and limited resources. Understanding these psychosocial and organizational factors at play in mobilizing agri-food systems is key to understanding the contemporary expression of ancestral technologies used to achieve sustainable food security.

1 Formatted for a peasant and agricultural studies journal
2.1 Introduction: Heterarchical Organization

The concept of heterarchy refers to a multidimensional system characterized by diversity of unranked factors in spatial, temporal, and cognitive domains (Crumley 2015). Applied to behavioral, social, and environmental sciences, heterarchy is an analytical framework that can be used to examine human organization (Crumley 2015; Stark 2011). As posited in collective action theory, heterarchy is defined by “lateral, horizontal, or network linkages among people and institutions” (DeMarrais & Earle 2017: 193). In that sense, heterarchy is a function or mode of organization in a cognitive matrix modelled by social structures.

We subscribe to a definition of social structure as a “causal mechanism constituted by relationships among social positions that accounts for social phenomena in terms of tendencies, strains and forces inherent in the nexus of those relationships” (Porpora 1989: 340). Social structures are behaviorally based, institutions. Giddens (1981: 26) distinguishes between structure and system by observing that social systems are composed of patterns of relationships between actors or collectivities reproduced across time and space, whereas structures are circumstantial, being “recursively involved in the production of social systems,” which “have only a virtual existence.” In contrast to heterarchies, hierarchically organized social organizations are based on ranked social positions according to status and different levels of power and authority.

Vygotsky noted that social phenomena are, basically, psychological phenomena that differ regarding their historic roles and nature (Cole et al. 1978). A ruler’s psychology is

\[ \text{Note: The we pronoun indicates that for the submission of the manuscript there will be other co-authors; the three chapters were prepared with this orientation.} \]
entangled in the social environment, and both interact as traits in the exercise of authority (Foucault 1995; Reicher & Haslam 2006). Conversely, in a continuum, heterarchy is a dialectic of psychosocial phenomena. This view is consistent with both Weber and Geertz, who recognized humans as social and psychological beings circumscribed by culture. Thus, mental states are expressed at the individual level in the form of motives, needs, preferences, beliefs, desires, emotions, and sensations (Porpora 1989), while at the social level they are expressed as discourses, norms, ideology, and rituals (Mintz & Du Bois 2002). Hence, social action cannot be separated from individual purpose and meanings because the human being is an “animal suspended in webs of significance he himself has spun” (Geertz 2000: 311). As a mode orchestrating individual and collective action, the features of a heterarchy are bound to the culture in which it operates.

In the context of Andean indigeneity, understood from the perspective of cultural, and agricultural and food systems studies, there is a curious gap between the treatment of heterarchy in pre-Columbian indigenous societies and of contemporary indigenous communities. Regarding the former, heterarchy is well established in Andean archaeological literature (Bray 2008; DeMarrais 2007; Hastorf 2002). For example, in the Titicaca basin plains, Arkush (2011) studied a site around a pukara (a hilltop fortification built for purposes of defense, observation, and communication) and observed a pattern of organizational decentralization and segmentation that suggests the existence of heterarchical social organization rather than a hierarchy characterized by political centralization and the unequal distribution of power.

On the other hand, discussions of contemporary indigenous communities use thick descriptions to analyze social organization in terms of gender roles, distribution of labor,
household dynamics, access to credit and markets, food security strategies, mobilization, land tenure regimes, and legal pluralism (Altieri & Toledo 2011; Brass 1990; Korovkin 2001; Mayer 2018; Weismantel 1989). Because of the versatility of the concept “heterarchy,” it is part of a community-centered training model for agriculture and natural resource management in Ecuador (Sherwood, Schut & Leeuwis 2012), whereas in Peru it explains local folk taxonomy for potatoes (Zimmerer 1991).

We found one study outside the scope of the field of anthropology that addresses heterarchy in contemporary rural communities. Rivera-Muñoz et al. (2018: 92) analyze small-scale production and irrigation systems, and suggest that the Cañaris, a pre-Columbian confederation located in the contemporary Ecuadorian provinces of Azuay and Cañar, were heterarchical in that it was based on an autonomous network of horizontally-related ethnic lordships. They explain the concept of in-between territories, which are dispersed heterogenous settlements that manage resources by combining social organization and diverse ecological floors. Nevertheless, heterarchy has not been systematically explored or formally hypothesized as an analytical framework for understanding contemporary agrarian indigenous societies in the Andes.

One reason for this gap is the assumption that the Spanish rule implanted in the Americas extinguished these heterarchical modes of organization and governance (Rivera-Muñoz, Meulder & Proaño 2018). Along with regime change, sedentary populations were affected by the introduction of European diseases and by technologies that dramatically altered land management strategies (Scarborough & Lucero 2010). Another, explanation comes in the form of a cognitive bias that Clark L. Erickson (2006: 334) eloquently articulates:
Few of us grew up on farms […]. Although we are often surrounded by living farming traditions where we excavate and do settlement survey, we rarely pay attention to the farm life going on around us and ignore the relevant local historical and ethnographic literature.

In this paper, we ask whether heterarchical forms of organization are still used to govern social organization in agrarian indigenous societies in Andes. The analysis of contemporary communities requires an analytical framework capable of abstracting from the experience of rural peoples and psychosocial phenomena that define local social structure, which allow for heterarchy as a viable mode of governance.

An ethnographic study conducted by David Stark (2011) of a Wall Street trading room is a case of theoretical and methodological relevance for the present study. Stark (2011: 16) explains that the trading room is “organized as a cognitive ecology in which the friction between multiple, incompatible principles of arbitrage generates new ways of recognizing opportunities.” Inspired by the work of neurologist Warren McCulloch, which established the basis for the concept of self-organization, Stark (2011:25) observes that “heterarchies flatten hierarchy. But they are not simply nonhierarchical.”

Stark (2011: 30) recognizes the ecological nature of organizations: “life is organization.” In that sense the diversity of highly adaptable social, biochemical, and psychosocial factors represents an ecological community, borrowing the concept from biology (Ricklefs & Relyea 2014), which is the interplay of all living and non-living elements in a specific territory. This definition includes the conventional social science definition of community as it relates to human society. In the context of organized human behavior, agri-food systems are heterogeneous and dynamic systems (Thompson & Scoones 2009), which function through complex structures and processes that are
intertwined over time and space with non-linear and multidimensional feedbacks rather than as simple chains of processes and events that link production to consumption through the functions of processing, distribution, storage, and waste.

Heterarchy meets three criteria for robust social theory: (i) consistency between micro (individual) and macro (social) levels; (ii) social actors who exercise conscious agency to alter the structures within which they are circumscribed; and (iii) an explanation of change in the social system (Crumley 2015). For Stark (2011), a heterarchical mode of governance typically has several characteristics. First, it incorporates distributed intelligence and multi-sided accountability between organization units. Second, it contains cross-cutting network structures. Third, it is composed of units that are independently organized and which engage in complex forms of collaboration. Fourth, there is no order on the evaluative principles, i.e. each organization unit has its own parameters to assess their performance. Fifth, organizational diversity results from adaptation upon the constant friction within the network.

Stark’s (2011) heterarchy framework is consistent with approaches to understanding resiliency (Crumley 2012; Stark 2014) and agency (DeMarrais & Earle 2017; Erikson 2006). Resiliency is the capacity of the system to “absorb disturbance without shifting into a qualitatively different and less desirable state” (Crumley 2012: 310). We define agency using its etymology (the Latin agentia that means "quality of the doer"); a key lexical component is agere (move, do, act, carry on), and –nt– like in “agent” (the one who does the action). This assertion of agency is “framed as collective action, collaboration, or cooperation” (DeMarrais & Earle 2017: 184). Concurring with Stark (2011; 2014), agency is based on organizational reflexivity regarding endeavors that are worthy of pursuing.
We note other usages of “agency,” as reflected in Merriam-Webster’s dictionary definitions: “an establishment engaged in doing business for another” and “an administrative division— as of a government.” Despite of the popularity of these assertions, we invite the reader to follow the systems’ rationale. Agency is the function of the agent, and importance of the agent lays in the cause-effect relationship; agent as “an active or efficient cause” (Merriam-Webster Dictionary). This is the same implicit logic in popularized agent definitions: “a representative, emissary, or official of a government” and “a business representative (as of an athlete or entertainer)” (Merrian-Webster). These conceptual nuances are relevant for heterarchy as analytical framework. The agent is the one who carries out the action, agency the function of the agent, similarly an organizational unit [with a function] engaged in doing things (e.g. committee, cooperative, association) could well be called “agency” (in plural agencies).

Based on heterarchy as analytical framework, we explore how Caliata, a rural indigenous community in the central Ecuadorian highlands, is organized to optimize agricultural production and food consumption and how forms of local organization are linked to customary and hybrid institutions consistent with psychosocial factors—including Andean cosmovision, which is a central component of indigenous identity. As expected, the general characteristics identified by Stark (2011) acquire nuances as this framework is applied to a very different setting.

Addressing the “heterarchy inquiry” in the study of Andean agri-food systems is relevant to food security and environmental conservation. Heterarchical societies have been effective in building and maintaining agroecologically-efficient architectures like raised fields (waru-waru or camellones), sunken gardens (qochas), and cultivation terraces
(andenes) (Erikson 2006; Scarborough & Lucero 2010). This is that small groups organized at the family and community levels had the agency to develop these intensive agricultural systems (Erikson 2006). These remarkable ancestral technologies are seeing nowadays as strategies to tackle convergent issues of severe weather events, food insecurity and loss of ecological services in rural areas (Carrasco-Torrentegui et al. 2020).

Overall, the role of organization and psychosocial aspects of agri-food systems have been generally overlooked (Thompson & Scoones 2009). More precisely, in the context of current indigenous communities in Andes; knowing the role of modes governance that have direct implications in the usage of traditional spaces in agricultural and food systems is fundamental. Particularly as environmental challenges push us to understand critical questions: how do individuals organize themselves in order to mobilize local agri-food systems while, at the same time, responding to endogenous and exogenous needs and shocks? Moreover, how do social institutions contribute to community organization, while also adapting to new circumstances?

2.2 Methods

The analysis of heterarchy in Caliata is based on data that was gathered from participant observations, interviews, surveys, and local archives. Most of the data collection took place between April and December 2018, with subsequent participatory evaluation and member checking throughout 2019.

Study design, fieldwork, and data analysis were carried out by an interdisciplinary research team (Tebes & Thai 2018). We designed a comprehensive cross-sectional mixed-methods study of the community of Caliata. Field notes from interviews, focus group
discussions (FGDs), and participant observations were analyzed on a regular basis during fieldwork. Additionally, we conducted member checking (Creswell & Miller 2000) and, based on previous research in the Ecuadorian highlands (Gallegos, Waters & Sebert-Kuhlmann 2017), we conducted a participatory evaluation of initial findings and subsequent iterations.

Caliata is home to 166 residents in 57 households according to a local census, but the study team identified 144 individuals. The difference may be explained by the fact that Caliata is experiencing outmigration, associated to living conditions (Table 1), which had resulted in a shrinking and aging population, as well as the feminization of agriculture. A salient feature of the community is a preserved pre-Columbian system of cultivation terraces that leads to a heterogeneous space, microclimates and high biodiversity (see. Chapter 2).³

³ Note: I am citing the chapter for the purpose of the dissertation, however in the submission to the journal I am expecting to cite the corresponding manuscript; the three manuscripts were written as complementary bodies of evidence.
Ecuador is divided into 24 provinces, each of which has several cantons (counties) and parroquías (parishes). Chimborazo province has ten cantons. Riobamba canton, which has as its administrative center the provincial capital of Riobamba, has eleven parishes. The rural parish of Flores is located in Riobamba canton and the community of Caliata is one of the 29 in the parish.

We selected Caliata for study based on purposive or theoretical sampling (Patton 2002) according to three dimensions present in indigenous food systems (e.g. Kuhnlein et al. 2006):

<table>
<thead>
<tr>
<th>Table 1. Satisfaction of basic needs in Caliata</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicator</strong></td>
</tr>
<tr>
<td>Access to Safe Water</td>
</tr>
<tr>
<td>Spring piped into dwelling</td>
</tr>
<tr>
<td>Unprotected spring</td>
</tr>
<tr>
<td>Rainwater collection</td>
</tr>
<tr>
<td>Access to Sanitation</td>
</tr>
<tr>
<td>Flush to septic tank</td>
</tr>
<tr>
<td>Latrine to pit</td>
</tr>
<tr>
<td>No facility, bush, field</td>
</tr>
<tr>
<td>Access to Waste Disposal</td>
</tr>
<tr>
<td>Garbage collection center</td>
</tr>
<tr>
<td>Waste incineration</td>
</tr>
<tr>
<td>Open air dumps, creeks or rivers</td>
</tr>
<tr>
<td>Education of the head of household</td>
</tr>
<tr>
<td>More than high school</td>
</tr>
<tr>
<td>Middle school/high school</td>
</tr>
<tr>
<td>Up to elementary</td>
</tr>
<tr>
<td>No school</td>
</tr>
<tr>
<td>Crowding (people sharing a bedroom)</td>
</tr>
<tr>
<td>1–2</td>
</tr>
<tr>
<td>3–4</td>
</tr>
<tr>
<td>5 and more</td>
</tr>
</tbody>
</table>
(i) Rurality: Flores is a rural parish (Organic Law of Territorial Planning, Use and Management of the Land of Ecuador 2016).

(ii) Ascription to historical, cultural and geographical entities, in this case an indigenous nation and people. Caliata belongs to the Kichwa nation and the Puruwá people (Integrated System of Social Indicators of Ecuador 2011);

(iii) Self-identification based on cultural and social markers such as residence, language, clothing, and diet. By this definition, 99% of the residents of Flores are indigenous, mostly speaking the Kichwa language as well as Spanish (INEC 2010).

We conducted nine FGDs with a total of 39 participants (Table 2) and 10 key informant interviews with community leaders, traditional health practitioners, personnel from the ministries of health and agriculture, and representatives of NGOs that work with indigenous communities in Chimborazo. Based on previous research (Waters & Gallegos 2014), we provided secure spaces where community members felt free to decide whether to participate and to express themselves in their own terms. The FGDs were conducted separately with men and women in order to avoid potential gender-based influences (Waters & Gallegos 2014; Weismantel 1989).

<table>
<thead>
<tr>
<th>Age group</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥65 yrs.</td>
<td>1 (6)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>40- 64 yrs.</td>
<td>2 (9)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>30- 39 yrs.</td>
<td>1 (4)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>18- 29 yrs.</td>
<td>1 (4)</td>
<td>1 (3)</td>
</tr>
</tbody>
</table>

**Total: 9 (39)**
Age groups were determined based on the proportion of residents in those age groups according to the most recent national census (INEC 2011), adjusted according to demographic characteristics encountered in Caliata. For example, the larger number of female participants (n=23) in the FGDs was a product of male migration and the consequent feminization of agriculture (Waters 1997). At the same time, this gender-based proportion reflects how heterarchy is expressed in the community because women are often the functional heads of households and caregivers in rural Ecuador (Iannotti et al. 2020; Weismantel 1989).

FGDs and individual interviews were audio recorded, and field notes were taken. Recordings were then transcribed. Five FGDs were conducted in Kichwa and translated into Spanish by a proficient bilingual Kichwa speaker, and the audio recordings in Kichwa and the Spanish transcription were reviewed by a second independent bilingual speaker. The ten key-informant interviews were conducted in Spanish and transcribed accordingly. We use numeric identifiers in data in order to maintain confidentiality during analysis. Transcribed information was analyzed separately using three-stage open, axial, and selective coding by two native Spanish speakers (Strauss & Corbin 1990). Coded information was triangulated (Creswell 2014) with participant observations, a desk study of local records, and descriptive statistics from a survey of female heads of household (N=57). Observations took place in a wide variety of settings, including farmland, households, community meetings, and during customary activities. The household survey was validated for linguistic and cultural nuances in an adjacent community in Flores parish.

The desk study included a report from the parish government of Flores; three undergraduate theses presented in a local university; two thesis written for high school
graduation, authored by residents enrolled in Flores’ adult education programs; two booklets published by a local NGO; a study written by a resident for an international NGO and a Swedish university; and the recently updated community Rules of Procedure. Information derived from these sources were used to contextualize the qualitative field-based data described above.

2.3 Results

2.3.1 Institutional landscape

Formally, Caliata is a legally recognized administrative entity by virtue of the laws of Organization and Regime of Communes (1937), Indigenous Justice (in Constitution 2008), and Rural Lands and Ancestral Territories (2016). Internally, community organization is based on mutually agreed-upon and formal rules of procedure and three distinct types of organization. The first type is the ayllu (family nucleus), the principal customary institution. Ayllus are repositories for the practice of cultural dimensions of collective life based on historical past, biological and emotional family ties (compadrazgo), language, clothing, knowledge, and traditions, which has led to forms of specialization (e.g. merchants, trades, traditional medicine).

In parallel to the ayllu, in the social network there are two types that we are calling agencies (i.e. community-based organization units) using the systems rationale we described above. Agencies in Caliata are driven primarily by proactive and planned action [agency] that entails human purpose, and which incorporate gender equity and that are inclusive for older adults and youths. These organization units facilitate community members to participate in communal activities including collective labor (minga), regular
meetings, and financial contributions that cover community expenses such as festivities and improvements.

The second type are the agencies that operate locally but that are organized in a way that link the community with counterparts outside Caliata, such as the water users’ committee and the board of locally-elected representatives (cabildo). Whereas the third type represents collective action entirely within the community, specialized activities are organized through festival committees, a sports club, and three commissions with specific functions. The cabildo is elected annually by adult community members and is registered with the Ministry of Agriculture, which represents an implicit link between national authorities and the community.

The cabildo and water users’ committee have the responsibility to resolve controversies and conflicts. Particularly, the cabildo does arbitrage in minor crimes through the indigenous system of justice, which is based on culturally-based norms and values as well as with specific procedures and practices with the aim of regulating collective behavior in the community and providing for restitution in most cases rather than punishment for damages. When punishment is called, for it is carried out using social pressure; for example, depending on the severity of the crime, an offender may get a haircut, outer clothing may be removed, and cold water baths and lashes with nettles may be applied, for which any resident may participate.

Additionally, according to local records, Caliata is part of a network of local organizations affiliated with local, provincial, and national indigenous organizations and has participated in mobilizations since it was officially recognized in 1930, most recently in
October 2019. The structure of the indigenous movement is bottom-up from the grassroots (Gallegos-Riofrío et al. *under review*). This form of active political participation has been effective in providing substantial gains to indigenous people including the end of indentured servitude in the 1960s and recognition of property rights in the 1990s (Altman 2017).

Caliata is also represented by the parish council in the nearby town of Flores and the county council, headquartered in the provincial capital of Riobamba; this represents organizational overlapping. According to the 2008 Ecuadorian Constitution, parishes, counties, and provinces are organized as decentralized and autonomous governments, which distribute responsibilities and attend to the needs of member communities. In the Flores town there are also organizations (agencies) of the central government, particularly the school that belongs to the Ministry of Education and the health facility, which is part of the network of the Ministry of Health. Both agencies serve Caliata’s residents.

The introduction of evangelical Protestantism has influenced on customary norms in Caliata. For example, traditional practices have been modified during festivals like Carnival. Nevertheless, this organizational inclusion into the network has added diversity, and more complexity in relationships, for example, some residents now refer to elders as “brother” or “sister,” which suggests equality of prestige. Evangelical Protestantism caused some tension, but it has not drastically transformed cultural ties that continue to bind Caliata’s families together, and many customary institutions like the *minga* and indigenous restorative justice remain.
In sum, this institutional landscape is characterized by a diverse array of structures and relationships that are defined by the agency, which provides for different forms of participation and representation (Figure 2).

**Figure 2**: Types of social organization emphasizing the diversity of agencies and interconnections

2.3.2 Psychosocial factors and the symbolic force of cosmovision

Being an inherent part of any culture, language expresses collective norms, values, and behaviors and establishes boundaries between the community and the outside world. The Kichwa language represents a living link that ties members of the community together
and links them with others who are identified as indigenous. In this context, Spanish is the language of commerce and communication with the larger society, including formal institutions in areas of health and education. In Caliata, Kichwa is still the primary identifier because it is the mother tongue. Our survey showed that all heads of households self-identified with indigenous ethnicity but while formally, Caliata might be regarded as a bilingual community, everyday conversation is invariably in Kichwa, even with younger people, and it is how residents speak with elders, who are addressed with terms of respect such as “uncle” and “aunty” regardless of blood ties (as mentioned in tension with the “brother” and “sister” logic of Protestantism).

Caliata’s residents enjoy lifetime affiliation to the community and through the community to the Kichwa nation, represented by ECUARUNARI (Figure 2), its historic ties to the Incan empire, and further back to the pre-Incan Puruwá peoples. The collective memory of a resistant and resilient warrior people is superimposed on concepts of Pachamama (Mother Nature) and of other areas of ancestral knowledge.

These aspects of Caliata’s collective identity are inseparably linked to Andean cosmovision. The symbiosis of psychosocial factors reinforces social cohesion and trust while providing meaning and purpose to daily life and collective action. Indigenous identity exerts an influence on individual and household-level perceptions and decision-making processes in all areas of daily life, including health, nutrition, and agricultural practices. The indigenous self is centered on multidimensional identity expressed by layers of self-identification (Caliata-Puruwá-Kichwa-Indigenous Ecuadorian-Andean) as well as a constant dialogue between local identity and is constituent body of traditional knowledge, attitudes and practices (see Chapter 2), and a modern, in an increasingly globalized world.
In Andean cosmovision, space has both symbolic and physical meanings associated with the agrarian identity of the peasant farmer. Pachamama, a central element of Andean cosmovision is a polysemic concept, referring to Mother Nature as the engineer of life, time in a spiral in which the natural and the supernatural are intertwined, a link between the living and their ancestors, and a connection with the cosmos (Gallegos-Riofrío et al. under review). Pachamama also embodies alli kawsay (harmony between all the elements of life), which provides for health and wellbeing (Gallegos & Jara 2007). Alli kawsay is related to the principle of the Sumak Kawsay or Good Way of Living, which is defined in the preamble of Ecuador’s 2008 Constitution as “a new form of public coexistence, in diversity and in harmony with nature.”

Indigenous identity in Caliata incorporates an emotional connection to Pachamama, which is represented symbolically in the community’s land, the fields of ayllu members, and in the soil itself. These symbolic interconnections are the motor force behind the imperative to take care of fields, prepare the soil, ask for permission from the earth itself, and to eat fresh, diverse, nutritious and safe foods (from “soil to table”). As experienced in Caliata, an indigenous person is one who cultivates the land, and when they are asked what is cultivated, the answer is “life.” Thus, the ability to work the land and to understand the agroecosystem are also essential components of self-identity.

Cultivating life requires having access to land that can be cultivated whether it is owned, rented, or borrowed. As one key informant stated, not having a plot of land is equivalent to urban poverty or indigence. Physical space is also linked to traditional medical practices because plants used for healing are part of the ecosystem and of cultivation practices. Land is also symbolic in that it represents community belonging and
a connection to *Pachamama*. People who migrate to urban centers can remain connected to the community if they retain access to the land, and they will be admired if they can work the land even though they reside in a city—by working during weekends, by hiring workers, or through sharecropping.

*Pachamama* in this sense sustains the *ayllu* and families sustain the community, thereby promoting health and wellbeing in an ecological community that integrates people, animals, plants, and land while maintaining a stable agricultural and food system. The disruption of this system is regarded as a direct assault on *Pachamama*, its healing space, the system of knowledge, the *ayllu* itself, and consequently to the wellbeing of the community. In this sense, the *ayllu* is autarkical and resilient. Resilience, a psychosocial factor, becomes a response expressed as individual or social action within the ecological community and beyond.

These essential elements are all is interconnected in the indigenous *cosmovision*, reflecting cognitions, emotions, aesthetics, behaviors, and lifestyles. Its symbolic power also harmonizes collective action such as *randy-randy* (mutual giving) and *minga*, the collective and reciprocal labor institution.

### 2.3.3 Heterarchy

The parish, county, and provincial councils operate hierarchically; they are accountable to the community, to each other, and to the central government (Organic Code of Territorial Organization Autonomy and Decentralization, 2010). For example, the parish council is governed vertically, being based on bottom-up accountability, while but evaluations reach down from the central government to the parish and the parish council
prepares an annual operating plan and budget after which funds are allocated from the central level.

In contrast, Caliata is internally governed by distributed intelligence, which is an overlapping form of organization when compared with central government and regional bodies. Community autonomy is provided for by the Law of Rural Lands and Ancestral Territories (2016), which considers community lands in ancestral possession as imprescriptible, inalienable, indivisible, and exempt from fees and taxes.

As in Stark’s Wall Street trading room, in Caliata we observe distributed intelligence through the interaction of families and agencies, lateral accountability, independence in organization, and complex forms of collaboration. Key to the function of these factors is the ability to reach consensus among community members.

However, like in the trading room, there are frictions between agencies, particularly due to hybridization dynamics resulting from a dialectic between traditional and modern elements. This dynamic is part of a learning process constantly reshaping the structures in place (ayllus and agencies), for example, the festivities committee has accommodated several customs to Protestant rules like a more moderate consumption of chicha (a corn fermented alcoholic beverage) during feasts. Thus, hybridization dynamics contributes to the diverse network of organizations.

*Distributed intelligence, multi-sided accountability, consensus, organizational independence and complex collaboration.*

The parish council manages a government-allocated budget to respond to responsibilities provided for in the 2008 Constitution. For example, the council is
responsible for promoting productive activities, community organization, food security, and environmental conservation (Ecuador’s 2008 Constitution). The constitutionally defined responsibilities of the parish council and those that customarily correspond to local agencies may overlap, which contributes to the climate of organizational and legal pluralism experienced in Caliata. Nevertheless, the parish council is nominally an endogenous organization, and it is generally perceived to be absent in daily life, so that local agents are responsible for getting the things done with available resources.

The existence of plural legalism in Caliata, based on community autonomy to solve controversies and minor offenses, is fundamental to understand overlapping modes of governance. Legal pluralism may be seeing as a divide between organization in public life, specifically in the relationship to government institutions (hierarchical), and in the customary sphere: the intricate matrix of cognitive processes and behavior of laterally accountable ayllus and agencies (i.e. heterarchy). Coexistence of hierarchy and heterarchy in pre-Columbian Andes has been documented (Hastorf 2002), which gives grounds to our finding.

Considering the three different types of social organization (Figure 2), ayllus and two types of agencies, organization units are systematically reinforced by tradition, indigenous institutions like the minga and restorative justice. The symbolic effect of the cosmovision creates a collective sense of system, connecting factors from different dimensions (physical, emotional, spiritual and social). While the combination of the resiliency of ayllus and agency (as function) contribute to an ecosystem that is governed as effectively and efficiently as possible.
In Caliata, agency is observed in the capacity to serve the community in order to get things done for mutual benefit, solve problems, identify and mobilize resources, and negotiate with external actors. Agents (a community member operating on the behalf of an agency) are involved in what are referred to as “errands,” for example, meeting with the president of the adjacent community to solve a solid waste disposal problem or bring technicians to analyze irrigation alternatives.

Even seemingly simple tasks such as printing documents for a meeting, collecting signatures from community members, or buying food for workshop attendees require time, effort, and cost as well as organizational capacity. Consequently, organizing and conducting errands must be negotiated among members and the agent then negotiates within the ayllu to determine who, when, and how a task is to be carried out because personal time (for example to carry out agricultural tasks) must be given up for the community’s benefit.

Lateral accountability is part of customary organization, based on the constant pursuit of consensus. There is no subordination of one agency to the other. The needs of the ayllu are addressed through self-management and each family responds creatively to external shocks. However, beyond the ayllu, community needs are addressed by the agencies, with the purpose and capacity to get the things done. Within the community, ayllus and agencies are constantly engaged in negotiations, which as noted above, produces the intricate matrix of cognitive processes and behaviors (diverse organization network) that characterizes heterarchies.
Within the *ayllu*, households are free to make decisions and develop practices in order to achieve individual goals and to provide for their own subsistence. Nevertheless, there is a cohesion between families, which allows agencies (i.e. organization units) to maneuver. Agents are important components of the agricultural and food system because they connect the *ayllus* beyond kinship, harmonizing the flow of physical energy (labor allocation beyond family arrangements), while agencies fill gaps between household obligations and capacities. For example, arrangements can be made through agencies, like the water users’ committee, the *cabildo* or the special commissions (Figure 2), for managing and maintain common areas such as footpaths and roads and natural resources, such as creeks and springs.

Negotiations among the different types of organizations (family-family; agency-family; agency-agency) represents lateral accountability, which further leads to different forms of performance evaluation and is the key to this diverse, multifunctional structure that sustains the ecological community that values consensus, which is the landmark of heterarchy in Caliata. The need to reach consensus can produce friction but not subordination. Between *ayllus*, where agencies operate, consensus is the central customary norm for decision making. That is, decisions are made collectively but are not determined by a majority, while assuring participation of all community members, who deliberate until consensus is reached.

In general, rural life requires the ability to manage risk in the face of uncertainty with respect to, for example, extreme weather events, insect infestation, or volatility in crop prices. Uncertainty, in turn, means that environmental conditions can change quickly
There is an extraordinary efficiency in heterarchical organization, so it is possible to reach rapid, effective, and efficient consensual solutions.

*Learning and hybridization dynamics leading to diversity and specialization.*

Since agents periodically rotate in their functions (a resident can move after a period serving in the *cabildo* to serve in the water users’ committee), learning opportunities frequently present themselves, which in turn contributes to accountability.

For example, community members have undertaken a process of recovering and promoting traditional norms and practices based on new rules of procedure that promote *Sumak Kawsay* (Good Way of Living), a holistic post-development model (e.g. Kothari et al. 2014). Caliata’s collective decision and capacity to respond to change by developing new structures keeps leading to diversity and specialization. In this sense, agencies are hybrid organizations in constant evolution that combine elements that may be perceived as “indigenous” or “traditional” on one hand or “modern” on the other. This process can be seen in Caliata’s new rules of procedure that have specialized commissions in areas of (i) solidarity, health and nutrition; (ii) culture and language; and (iii) agroecology, [cultivation] terraces and productive entrepreneurships. According to these rules of procedure, commissions should pursue technical and credit assistance from national and foreign institutions in order to development programs and projects in their areas.

As noted above, Caliata’s pre-Columbian system of terraces shows that traditional forms of local organization have acquired modern elements. Similarly, the water users’ committee and the *cabildo* are based on ancient organizational structures, but which are now recognized by the central government. On the other hand, modern organizations have
acquired traditional elements. For example, the festivities committee promotes the use of
the Kichwa language and traditional clothing, and the sports committee promotes
traditional norms such as offering symbolic gifts (*kamary*), and other community activities
are scheduled to be aligned with the Andean agrarian calendar.

Hence, along the same lines, the nuclear family units (*ayllus*) have also undergone
hybridization in that while they retain their traditional functions and cultural basis, their
members acquire formal education but also immerse themselves in traditional knowledge.
They consume traditional foods largely produced by the household but may also purchase
food products in the market, modify traditional dwelling design, and purchase “modern”
technology such as cellular telephones. In short, notions of the “traditional” and the
“indigenous” are increasingly articulated with in contemporary representations, for
example, a more positive indigenous indemnity (Gallegos-Riofrío et al. *under review*).
These are non-structured processes that constantly redesign and recreate the community’s
social organization.

Family-and agency-based arrays of social structure function side by side, in some
cases as specialized activities. For example, there are families of healers who transmit
ancestral knowledge and practice from one generation to the next. Other family-level
specializations include the threshers of cereals and the herders of oxen trained for plowing
(Figure 2). Similarly, some agencies have specialized functions. For example, the water
users committee manages creeks and springs and the sports committee organizes an annual
soccer championship in addition to traditional games.
In the interplay between “traditional/indigenous” and “modern,” there are also overlapping categories of “sacred” and “profane.” Even Caliata residents who practice evangelical Protestantism and regard traditional observations of Inti Raymi (feast of the sun) as barbaric, describe harvest feasts (jahuay) with reverence. Thus, discourse is shaped by dissonance; for example, regard for Pachamama among evangelical Protestants is believed to be consistent with adoration of an omnipotent creator in the Judeo-Christian tradition.

In that sense, cognitive categories are not strictly binary since the pace of life continues to be governed by traditional concepts of cycles that correspond to the changing seasons and the traditional agricultural calendar (see Chapter 2). This complex web of concepts is expressed, moreover, in an environment that is, as discussed above, by changing conditions, risk, and uncertainty. For example, the individual decision to stay in the community versus moving to the city implies taking responsibility for the family’s lands, not pursuing secondary education outside the community, working the land using labor-intensive traditional methods rather than renting a tractor for mechanical plowing, using traditional seeds rather than modern hybrids, and practicing organic agriculture rather than using agrochemicals.

This kind of decisions involve interactions within the family and with agencies like the water users committee and the cabildo. Furthermore, decisions affecting the agri-food system involve formal interactions under the aegis of Caliata’s rules of procedure, which promote health, nutrition, and agroecology. The community as a whole faces similar dilemmas, such as maintaining traditional forms of collective action versus modern alternatives as well as maintaining and promoting indigenous identity.
2.4. Discussion

In ecology, an ecosystem represents an autonomous, fragile, and self-regulating system within geographical boundaries (Montoya, Pimm, & Richard 2006). In political ecology, the social-ecological system (SES) framework represents analytical models that addresses the convergence of societies and ecosystems at the local level (Poteete, Janssen & Ostrom 2010). On the other hand, the work of Stark (2011), using an innovative sociological analytical framework in the field of organizational ecology, has not been widely applied to the rural communities or agricultural and food systems.

Our interpretation of Stark’s concept of heterarchy views human organization in ecological communities as based on distributed intelligence. In that context, Caliata exemplifies a vibrant ecological community that integrates people and the landscape as a product of psychosocial dimensions in the form of customary institutions and symbolic forces—such as Andean cosmovision that focuses on Pachamama. The ecocentric Andean cosmovision integrates human beings into nature (Gallegos & Jara, 2007; Zaffroni 2011) which, while creating social cohesion, provides purpose and meaning for individuals, families, and agencies. The psychosocial dimensions of heterarchy are as complex as the biological characteristics described elsewhere (see. Chapter 2).

For Stark a key element in understanding organization is considering “what counts,” which depends on “incommensurable frameworks” (Stark 2011: 9). The case of Caliata contrasts to the ethnography described by Stark (2011), which sees heterarchy as a mechanism for innovation and the creation of value, which is, however, limited to an economic sociology perspective in an urban-centered setting. In the present case study, the
conditions are not less turbulent than in Stark’s Wall Street trading room, so that in Caliata, the constant response of *ayllus* and agents to the changing conditions and to uncertainty reflects what counts; particularly as agency is directly related to interests, expectations and purpose (DeMarrais & Earle 2017).

While Stark’s (2011) analytical framework has not been applied to the understanding of indigenous people’s organization in contemporary rural Andean communities, it has been used in studies that tangentially involve indigenous people involving issues as varied as food sovereignty (Micarelli 2018), environmental conflicts within the scope of pragmatic sociology (Centemeri 2015), decision-making,(Parasecoli 2017); governance accountability (Dormer & Ward 2020), and food production and resource management (Rickson et al. 2015). These cases reflect the matrix of cognitive processes involved in social organization in the form of uncertainty or “what counts” (value, worth), even following John Dewey’s view of cultural naturalism, which reinforces an eco-systemic way of thinking. Yet even in these studies, heterarchy is not considered in theoretical and empirical engagement widely noted in archaeology.

This gap is also present in Andean research, in which the concept of heterarchy has been relegated to the study of societies in the past. This gap limits our interpretation of contemporary agri-food systems. For example, the central role of the *ayllu* in mobilizing the agricultural and food system has been widely analyzed in the Andes (Argumedo & Wong 2010; Choque & Mamani 2001), including the highlands of Ecuador (Gallegos-Riofrío et al. *under review*; Rhoades 2006; Weismantel 1989). However, the role of agencies is not that well understood, perhaps because the analytical framework for heterarchy has not been employed.
In addition, while we concur with Stark (2011) and Crumley (2015) in the paramount importance of diversity in a heterarchy, however Stark’s idea of competing performance represents an extraneous paradigm to the Andean cosmovision and customary communalism. For example, the *alli kawsay* instills a sense of cooperation (Gallegos & Jara 2007). In pre-Columbian societies it was mutualism rather than competition (Scarborough & Lucero 2010). It is in that sense that we describe the ecological community: diversity of highly adaptable social, biochemical, and psychosocial factors.

In this context, we concur with Stark (2011) in that specialization is a determinant factor in the management of information and resources. This characteristic of a heterarchy has been noted in small-scale complex egalitarian societies (i.e. resource-specialized communities) (Crumley 1995; Scarborough & Lucero 2010). Stark’s concept of ecology is consistent with the field of organizational ecology in that a human setting with psychosocial attributes is characterized by diversity, functionality, adaptability, and productivity. The concept is applicable at the population, community and organization levels. We extend the concept of ecology to one that, along with human organization, includes biological and political aspects, and that is consistent with the indigenous identity that we described above.

To translate Stark’s analytical framework to the context of indigenous-based agricultural and food systems, we incorporate concepts of structure, systems, and culture. The SES framework and the Durkheimian tradition converge here with regard to the role of social structure in shaping individual and collective behavior. The ability of social structure to mobilize the agriculture and food system lays in its capacity to keep members accountable and to apply justice when needed (Ostrom & Schlager 1996). The behavior of
organizations often results in the creation of formal and customary institutions that operate alike according to Durkheim’s “law-like regularities,” which are social facts that govern behaviors (Greenwood 2003).

For example, indigenous law, which is recognized in the 2008 Ecuadorian Constitution, is relevant to social structure because it promotes restorative justice that reincorporates offenders into the community. This system not only provides for correcting wrongs but also for reinforcing basic community values. This form of legal pluralism, which is embraced in Ecuador’s legal and constitutional framework, is based on multiple and intersecting bodies of law in that customary rights and obligations based on tradition are included (Simon-Thomas 2012).

The premise that “the viability of trust, cooperation, and collective action depends decisively on the social embeddedness of interaction” (Macy & Willer 2002: 148) applies to the case of Caliata, where the agricultural and food system is defined by organizational structures and processes, forms of governance, customary institutions, and shared norms and values, which are all brought to bear in agricultural production, distribution, and exchange as well as in traditional practices like the minga (reciprocity-based communal work) randy-randy (reciprocity as giving and receiving), and camary (gift giving). Caliata’s social structure is also based on representation and on checks and balances. For example, it is possible to remove agents from their positions through collective action.

The merging of customary institutions and contemporary legal bodies has resulted in the legal pluralism that characterizes Caliata and other indigenous communities in the Ecuadorian highlands (Simon-Thomas 2012). In this sense, social structure is not simply
objective or material, but cultural as well (Porpora 1989). Furthermore, social structures are contained in dynamic systems that undergo constant change, including stages or emergent structures in a continuum of social transformations and semiotic relationships (e.g. Macy & Willer 2002).

The cognitive challenges that define the behavior and ecology of organizations are observed in urban settings, as exemplified by the trading room (Stark, 2011) where the volatility of the market and the expectations of stock traders. These challenges are also observed in rural settings as discussed here, which face entirely different dilemmas, such as embracing modernity at the expense of the ecological community or finding alternatives that allow for solving persistent problems of poverty, migration, and malnutrition, while at the same time maintaining the integrity of the ecological community, including its culture and historical memory.

In our application of Stark’s framework, we explain how a heterarchical local organization allows for consensus, which is a cornerstone of indigenous societies throughout the Andean region and which allows for constant discussion and negotiation. The archeological literature (Crumley 1995; Erikson 2006; DeMarrais & Earle 2017) also shows that heterarchy facilitates the sharing of knowledge and practices in order to optimize food production and consumption in limited resource settings. Moreover, this perspective incorporates cognitive, emotional, and social resources that are present in human behavior.

Stark’s (2011) concept of heterarchies is also important in the consideration of adaptability, diversity, constant negotiation, and coevolving specialization because these
are defining traits of ayllus, agencies, and the community as a whole. Agency as problem solving mechanism requires creativity and effective and efficient negotiation to overcome limited financial resources and time constraints. Adaptability is, then, a function of the effectiveness and efficiency of the mode of organizational governance and at the aggregate level, of the ecological community.

Negotiation and consensus, individual and social action, resilience, and agency are factors that affect the ecological community. The agricultural and food system, then, represents a feedback loop that functions in heterarchical fashion. Thus, Andean cosmovision (seen as worldview, ethos and behavior) operates as a symbolic force that promotes interactions and mobilizes the social system, thereby affecting not only local organization, but through the bottom-up structure of the indigenous movement has impacted public spheres. It is not a coincidence that Ecuador's national development plan has been defined as the National Plan of the Good Way of Living (Sumak Kawsay) (Kothari et al. 2014; Radcliffe 2012).

Andean cosmovision is an irreducible holistic entity as well as a complex construct that integrates a diversity of systems of knowledge, agroecosystems, technologies, language, social institutions, norms, and language (see. Chapter 2). It is therefore central to indigenous identity, but it also shapes how the agricultural and food system works, so that food sovereignty (see. Chapter 3) and biodiversity (see. Chapter 2) are in constant interaction within ayllus, between agents, and with other components of the ecological community, such as crops, wild plants, animals, soil, and water).
Individuals as well as groups have the agency to creatively respond to external events that affect them, even to the extent of altering the environment that surrounds them (Elder 1995; Gallimore et al. 1993). This model is consistent with the concept of the social-ecological system (SES) framework that recognizes that human agents can make conscious choices in order to conduct motivated action either individually or collectively, and that decisions have an impact on the system in which individuals or groups are imbedded (McGinnis & Ostrom 2014). Perspectives of human ecology (Hannan, & Freeman 1977) and agent-based modelling (Macy & Willer 2002) also assert that depending on the factors that affect agents, the environment can be either relatively homogeneous or heterogeneous.

In this work, we have discussed psychosocial factors like agency and resilience because we recognize individuals as agents in systems because they who have the capacity to affect the structures in which they are embedded (Elder 1995; Gallegos-Riofrío et al. under review; Gallimore et al. 1993; Macy & Willer 2002; Scott 2008). In the field of human ecology (Hannan, & Freeman 1977), responses to both endogenous and exogenous factors are seen to produce patterns, such as norms/rules, institutions, beliefs, innovations, and individual meaning and purpose that can be aggregated into clusters.

Psychosocial forms, including cognitions and emotions, are complementary and intricately connected (Porpora 1989:340). According to the SES framework, collective action represents individual decision-making and rational choice as the basis for communal arrangements that arise, change, and evolve in many areas of collective behavior, such as property ownership (Ostrom & Schlager 1996). As noted by Porpora (1989: 346), Giddens regards the agent as distinct from the structure, meaning that factors such as organization and rules “depend for their existence on their at least tacit acknowledgement by the
participating agents.” This factor is essentially psychosocial; indeed, the “dialectical causal path that leads from structure to interests to motives to action and finally back to structure” (Porpora 1989: 344).

In this context, resiliency has been widely recognized as a key feature of small-scale agricultural producers worldwide (Zimmerer et al. 2015) and specifically in the Andean region (Gallegos-Riofrío et al. under review; Sherwood et al. 2013). Resiliency entails both reactance and resistance. Social psychology understands reactance as the capacity to recognize threats, abuses, encroachment, or impositions that may limit freedom (Brehm & Brehm 2013). In the Andes, resistance connotes not only lost control over choices but also the preservation of the indigenous self (Gallegos-Riofrío et al. under review) and is instilled in indigenous mobilization (Altieri & Toledo 2014).

According to Stark (2011), the cognitive process within an organization that leads to certain decisions depends on accountability, evaluative principles, dependence, network structure, and collaboration within a particular landscape. In the present case, resiliency (reaction) and agency (action) are mobilizing and creative forces that are comparable to innovation. That is, agency is human action that has purpose and meaning while being shaped by culture. As creative forces, resiliency and agency have the capacity to create value.

This analysis of the institutional landscape in Caliata reveals that the anthropogenic side of the ecological community is like the biological side in the sense that both are ever-changing and are established through dynamic interactions that enhance diversity and drive specialization. In particular, the psychosocial dimension of an agricultural and food system
refers to anthropogenic aspects of the ecological community. Dissecting the ethnographic landscape from an ecological and organizational perspective is fundamental to understanding the biological side (e.g. biodiversity, soil health, water management), in contemporary rural communities in Ecuador, the Andes and, potentially anywhere where rural-urban linkages exist.

In Caliata, the interaction of psychosocial and biological dimensions contextualizes the functioning of the agri-food system (see. Chapter 3), in that the community represents a case of positive deviance (Marsh et al. 2004) in the case of, for example, unhealthy dietary patterns and chronic diseases (see. Chapter 3), which are considered major problems of accelerated urbanization, dietary transition, and modern lifestyles (Gallegos-Riofrío et al. under review). In sum, the concept of heterarchy can contribute to understanding complex phenomena like the agri-food system because it helps to explain the anthropogenic footprint on the landscape (Erikson 2006; Scarborough & Lucero 2010). For instance, this perspective contributes to an understanding of the past, present, and future of the terracing system in Caliata.

Our present contribution represents a community-centered effort to reveal a system and its dimensions. In that we concur with Carole Crumley (2012: 305) in that systems research is both “foundation of resilience thinking” and that the heterarchy framework is a powerful tool to understand small-scale complex, resource-specialized and egalitarian societies, like Caliata. The case of Caliata is particularly interesting because it adds consensus to Stark’s (2011) organization theory. In a planet facing environmental challenges, our contribution may fuel discussions in proposals that directly involve rural
societies, like *La Via Campesina’s* food sovereignty, agroecology and ecological intensification of agriculture (Altieri & Toledo 2014; Parraguez-Vergara et al. 2018).
2.5 References


Centemerí, Laura. "Reframing problems of incommensurability in environmental conflicts through pragmatic sociology: From value pluralism to the plurality of modes of engagement with the environment." Environmental values 24, no. 3 (2015): 299-320.


Ecuador:


Erickson, Clark L. "Intensification, political economy, and the farming community; in defense of a bottom-up perspective of the past." In Agricultural Strategies, pp. 233-265. Los Angeles: Cotsen Institute, 2006


Gallegos, Carlos Andres, William F. Waters, and Anne Sebert Kuhlmann. "Discourse versus practice: are traditional practices and beliefs in pregnancy and childbirth included or excluded in the Ecuadorian health care system?." International health 9, no. 2 (2017): 105-111.


Kuhnlein, Harriet V., Suttilak Smitasiri, Salome Yesudas, Lalita Bhattcharjee, Li Dan, and Salek Ahmed. "Documenting traditional food systems of indigenous peoples: international case studies." Centre for Indigenous Peoples’ Nutrition and


Parraguez-Vergara, Elvis, Beatriz Contreras, Neidy Clavijo, Vivian Villegas, Nelly Paucar, and Francisco Ther. "Does indigenous and campesino traditional agriculture have anything to contribute to food sovereignty in Latin America? Evidence from Chile, Peru, Ecuador, Colombia, Guatemala and Mexico." International journal of agricultural sustainability 16, no. 4-5 (2018): 326-341.


Simon-Thomas, Marc. "Legal pluralism and the continuing quest for legal certainty in Ecuador: A case study from the Andean Highlands." Oñati Socio-Legal Series 2, no. 7 (2012).


Chapter 2:

Agroecosystem in Kichwa-Puruwá’s terraced cultivation: cues for sustainability and community inclusiveness in planetary health action

Abstract: Ancestral wisdom, centered in Mother Nature, is in the indigenous discourse and international forums. Caliata, a resilient community in Ecuador’s central highlands faces internal structural problems and external pressures. Nevertheless, it has retained an ancestral wisdom deeply integrated into a pre-Columbian system of cultivation terraces, agrodiversity, native crops, and natural cycles, which combine to shape a viable agroecosystem. We describe the Caliata’s agroecological landscape and community views to explore the sustainability cues that have assured food security, seemingly from ancient times. Our research provides insights that can be scaled-up from local to programs and policy aligned to planetary health.

4 Formatted for a sustainability and agroecology journal
3.1 Introduction

Indigenous people advocate for the recognition of their “ancestral wisdom” or “ancestral knowledge” in order to tackle sustainability, conservation, food security and climate change challenges. Their voices have been heard in global forums like the Climate Summit–COP23 (Bonn: 2017) and the 18th session of the United Nations Permanent Forum on Indigenous Issues (New York: 2019). Ancestral wisdom instills discourses of resistance and resilience, a patent of systems of knowledge and skills that have survived and adapted to historical forms of colonization. Countries of the Andean Community of Nations (CAN), comprised of Colombia, Ecuador, Peru and Bolivia, recognize the importance of ancestral wisdom in their regulatory and legal frameworks, often as complementary to science (e.g. Cevallos, 2013; Ecuador, 2016; Zamudio, 2012). The Andes is home 30 million indigenous people, half are in the CAN area, mostly living in rural communities at altitudes greater than 2,500 meters above sea level [MASL] (FAO, 2014).

Ancestral wisdom is articulated rationally, emotionally, and spiritually in Andean cosmovision, an ecocentric ontological stance that places Pachamama or Mother Nature as a central interconnected whole (see. Chapter 3; Tituña-Males, 2006). In that sense, this knowledge originates in a multidimensional relationship with nature, which Andean societies have developed from pre-Columbian times (e.g. Guerrero-Ureña, 2015; Peñaherrera, Costales-Samaniego & Costales-Peñaherrera, 1996). Thereof, the ancestral wisdom in Andes includes agrarian and hydraulic technologies that are still effective today, such as raised beds (warus-warus), water recharge systems from micro-basins (qochas) or terracing cultivation, as well as robust native crops and genetic variability, which help to
ensure food security, the vitality of ecosystems, and as strategies to address climate change (Carrasco-Torrontegui, Gallegos-Riofrío, Delgado-Espinoza, & Swanson, 2020).

The ecocentric ontology implicit in ancestral wisdom is expressed through the creation of agroecosystems that result from heterogeneous spaces, like family-based polycultures, i.e., the biodiverse *chakra* with its regional variations (e.g. Gallegos-Riofrío et al., under review; Perreault, 2005; Rhoades, 2006). Agroecosystems may be viewed as landscapes with identifiable borders shaped by agency, architectural knowledge (e.g. cultivation and irrigation systems), and close links between geographical, biochemical, social and individual factors (Altieri, 2018). Andean agroecological space is also epistemological, a learning space where children interrelate with elders (Nieto-Gomez, Valencia & Giraldo, 2013). Consistently, it is the backbone of the traditional health system, which is preventive, reciprocity-based, and centered in balance with *Pachamama*, in order to procure access to food and medicinal plants (Gallegos & Jara, 2007).

Andean agroecosystems are characterized by verticality and climatic interactions of ocean currents, mountainous winds, and rainforest humidity, forming microclimates and a variety of habitats (Murra, 2002). Colombia, Ecuador, and Peru are among the world’s seventeen most megadiverse countries (Mittermeier, Robles-Gil, Mittermeier, 1999). The Andean region is, consequently, central to planetary health—representing exceptional biological and cultural richness, both of which are critical for securing ecological functions like climate regulation, soil health, providing water and humidity, and CO2 sequestration, furthermore, the Andean mountains are inexorably linked to the Amazon jungle and its ecological services (FAO, 2014; Mathez-Stiefel, 2017).
Planetary Health (or Biosphere’s Homeostasis from geophysical theory) can be viewed as the self-stabilizing physical and biochemical conditions that generate favorable conditions for life. The concept is, as a matter of fact, a constitutive element of indigenous’ cosmovisions, like the Andean Pachamama (Gallegos & Jara, 2007), while in scientific discourses it has been broadly defined from Lovelock and Margulis’ Gaia Hypothesis (1974) and in Earth System Analysis (Schellnhuber & Wenzel, 2012). More recently it has gained attention in global health through the reports of two collaborations substantiating how human health and food-systems depend on nature’s health: Rockefeller-Lancet (Whitmee et al., 2015) & EAT-Lancet (Willett et al., 2019).

### 3.2 Case study

Seven percent of Ecuador’s population self-identifies as indigenous, representing 14 different nations with distinctive languages and customs (INEC, 2010). The Kichwa nation, composed of Kichwa speakers, is the largest indigenous group in Ecuador; it is concentrated mainly in the highland provinces of Chimborazo (38%), Pichincha (30%), Imbabura (22%), and Cotopaxi (20%) (INEC, 2010). This exploratory study describes and analyzes the Andean agroecological space of the indigenous community of Caliata located at an average altitude of 3,150 MASL in the rural parish of Flores (Riobamba canton, Chimborazo province), near the city of Riobamba, the provincial capital (Figure 3).
Caliata is home to 57 families and 144 residents who are dedicated principally to subsistence agriculture. While crop production is largely rainfed, it also interacts with surrounding forests, creeks, and nearby high montane forest and high Andean meadows (*paramo*) habitats. For example, *paramos*, located above 3,500 MASL, are fundamental for high-altitude agroecosystem because the *pajonal (calamagrostis effuse)* captures moisture from the environment and acts as a water retention mechanism (Sarmiento, 2012). Caliata has retained its indigenous Kichwa-Puruwá identity and Kichwa is the common language. Using historical narratives, people in Caliata recognize a mixed heritage as descendants of the Puruwá people (500-1480 AD) (Freire, 2005) and the Incas (1438-1533 AD) (Costales, 1963). They often wear their traditional clothing and many customary institutions are still in place, such as the *minga* (reciprocal communal work) and *raymis* (feasts). Moreover, the community is affiliated to local, regional, and national indigenous organizations (see Chapter 1).

The inhabitants of Caliata experience various structural problems like material poverty, acculturation, outmigration and population aging (see Chapter 3). While the
agroecosystem is threatened by modern agriculture in the form of mechanized plowing, agrochemicals, and monocultures, as well as the structural social problems, land is still managed mostly using ancestral wisdom. Caliata is notably resilient and a positive deviance (see. Chapter 3), providing an opportunity for this case study. The case offers insights into approaches of ecological intensification of agriculture (Tittonell, 2014) while contributing to a narrative that inclusiveness with self-determination is fundamental for the major transformation required to stay within the planet’s generative capacity and ecological boundaries (Rhoades, 2006).

3.3 Methods

We conducted participatory agroecology-based site analysis, qualitative techniques and community-based system dynamics (CBSD). This mixed methods design allowed us to combine insights from both local ancestral wisdom and empirical science, and participatively understand the agroecosystem. The research team included two indigenous colleagues from Caliata with applied research experience and a community elder who provided advice. Fieldwork was conducted between April and December 2018. Preliminary findings and refined findings were assessed with community members using a participatory evaluation method, following an experience in an intercultural study with Kichwa speakers in Ecuador’s highlands (Gallegos, Waters & Kuhlmann, 2017). Finally, we employed systematic member checking, including in the making of this manuscript, in order to maximize validity (Creswell & Miller, 2000). Results are presented interspersing the voice of community actors, codified to keep confidentiality (Table 3).

This study was approved by two institutional review boards (IRBs) in Universidad San Francisco de Quito (Ecuador) and Washington University in St. Louis (United States).
3.3.1 Agroecology-based site analysis

We designed a structured observation tool with three modules. Module 1 collected data on seasonality, site characteristics such as access to irrigation water, land management, borders, site architecture, and GPS parameters measured with a Garmin (64sx), including geographical coordinates, plot size, altitude, and angle of the slope. Module 2 consisted of a biodiversity assessment in parcels and at borders, including the common names of natives and introduced plants, varieties, use, and estimated abundance with quadrats at random locations. Module 3 was a training for soil health analysis in terms of physical and biochemical parameters, using MO-DIRI protocols; a user-friendly method that allows community members to obtain on-site test results (Arango-Caro & Woodford-Thomas, 2015).

Using modules 1 and 2, we assessed ten sites following a purposive selection rationale (Patton, 2014) that responded to community perspectives about variability. We assessed parcels, traditional pedestrian paths, and borders or edges. Variability criteria included different heights of terrace systems (high, medium, or low), cultivation practices (e.g. monoculture, polyculture, plowed), presence or absence of irrigation systems, and anthropogenic biomes (cropland, woodland, mixed cropland-woodland, rangelands).

These criteria were attained by applying the talking map technique (Catley, Burn, Abede & Suji, 2007) with four groups of community members (n=48) in order to understand members’ notions of space. Participants were asked to describe their maps, characteristics of different terrains, and rationales for its perceived importance. Descriptions were note recorded, systematized, and discussed with the elder and two local collaborators to select the sites. Landscapes assessment was carried out with the two collaborators and with local key informants (IFK4, IFK6 & IMK1 codes in Table 3), who
identified horticultural and agricultural, trees, medicinal plants, and edible fungi. Afterwards, we developed a comprehensive biodiversity list in the first participatory evaluation meeting (n=25).

Data from site biodiversity assessment served to calculate ecological richness using Margelef’s index (DMg), with the formula proposed in Moreno (2001), where $S$ is the total number of different species on site, $Ln$ is the natural logarithm, and $N$ the total number of individuals of each species. Similarly to a study in five rural indigenous communities in Chimborazo (Oyarzun, Borja, Sherwood & Parra, 2013), we included agroecological diversity and evenness using Shannon’s index ($H^1$); considering $ni =$ abundance, where $pi$ is proportional abundance of species ($pi = ni / N$).

Margelef’s index:

$$ DMg = \frac{(S - 1)}{Ln (N)} $$

Shannon’s index:

$$ H^1 = \sum_{n=1}^{s} (p_i \ln p_i) $$

Margelef’s index formula was also used by Oyarzun et al. (2013), with the difference they considered “$Ln N$” as natural logarithm of the farm area ($m^2$). We corroborated results with a Menhinick’s index (DMn) because “like the Margalef index, it is based on the relationship between the number of species and the total number of individuals observed, which grows when increasing sample size” ([trans.] Moreno 2001: 27). Incorporating the methodology of a relevant study in rural indigenous communities in Chimborazo allowed us to better understand agrodiversity in Caliata.
Menhinick's index:

\[ DMn = \frac{S}{\sqrt{N}} \]

Module 3 tested soil health in a subset of five of the ten sites due to the limited number of portable tests (Luster Leaf’s Rapitest Soil Test Kit \(^\text{TM}\)) that are not available in Ecuador. We conducted several trials and were successful in conducting four full tests with MO-DIRT protocols. One sample was re-tested in the laboratory along with a sample not tested with MO-DIRT, both at Agrocalidad (Ecuadorian Agency for Phytosanitary and Animal Health Regulation and Control), mainly in response to the request of community members that wanted to see laboratory results of a polyculture and a monoculture in similar geographic conditions. Results were contextualized with data from the area. Recognizing major limitations, the primary purpose in applying this module was to promote local collaborators’ capacities and participation in order to conduct a larger study in the future.

3.3.2 Qualitative techniques

As represented in Table 3, using previously tested protocols (Waters & Gallegos, 2014), we conducted nine focus groups (n=39) proportionally distributed in different age groups and ten individual key informant interviews (females=5/ males=5) with six additional follow-ups. The interviews gathered insights from four external informants (etic or exogenous view) who work in relevant areas in indigenous communities in Chimborazo. The other six informants live in the community and together represent knowledge based on leadership, status as elders, detailed knowledge of agrarian practices, and traditional and intercultural health.
Table 3. Testimonials’ Coding Schema

<table>
<thead>
<tr>
<th>Code</th>
<th>Research Activity</th>
<th>Code</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Focus group</td>
<td>I</td>
<td>Interview</td>
</tr>
<tr>
<td>F/M</td>
<td>Biological sex</td>
<td>F/M</td>
<td>Biological sex</td>
</tr>
<tr>
<td>T</td>
<td>Focus groups’ age cluster</td>
<td>Y</td>
<td>Interviewed position</td>
</tr>
<tr>
<td>T</td>
<td>18-29 yrs.</td>
<td>Y</td>
<td>Endogenous perspective/key informer</td>
</tr>
<tr>
<td>T</td>
<td>30-39 yrs.</td>
<td>E</td>
<td>Exogenous perspective/external informant</td>
</tr>
<tr>
<td>A</td>
<td>40-64 yrs.</td>
<td></td>
<td>Order of the interview</td>
</tr>
<tr>
<td>O</td>
<td>≥ 65 yrs.</td>
<td></td>
<td>1-10</td>
</tr>
<tr>
<td>A-Z</td>
<td>Participants’ initial</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. Examples of coding mechanism: (a) “Victoria” [fictional name] has 31 years is a focus group participant, her code is “GFYV.” (b) “Juan” [fictional name] was the third informer interviewed, his code is “IMK3.”
2. The six additional follow-up interviews were aggregated in a single achieve, as an extended interview, for the following codes: IFK2 (x2); IFK4 (x1); IMK1 (x3).

We triangulated the information gathered in focus groups and interviews (Creswell, 2014) with a desk study of records found in the community. As reported in greater detail elsewhere (see Chapter 3) and based on previous research in rural Ecuadorian highlands (Gallegos, Waters & Sebert-Kuhlmann, 201), we conducted qualitative analysis simultaneously conducted by two researchers. Categories obtained separately were compared before and after participatory assessment and the unified categories received systematic input through member checking.

3.3.3 Community-based system dynamics

In addition, we conducted four workshops using CBSD with sixteen participants (females=9/ males=7), considering two principles (see: Hovmand, 2014; Richardson 2011). First, systems thinking requires defined boundaries; Caliata is an ecological community. Second, group model-building (GMB) conducted with an endogenous perspective [or
emic], assuring that a potential intervention will be implemented from a community perspective. CBSD conventions allow for transferring perceptions in the form of mental representations of interconnected variables (cause-effect relationships) and for identifying leverage points or areas of intervention (Meadows, 1999).

In a previous experience using CBSD, twelve Ecuadorian indigenous students participated in five workshops at Universidad San Francisco de Quito, to tailor a culturally appropriate GMB manual, which included the scripts (procedures) applied in Caliata (detail about System Dynamics’ scripts in: https://en.wikibooks.org/wiki/Scriptapedia).

3.4 Results

The most salient feature of the community’s landscape is that houses are located on a system of cultivation terraces (Figure 4). This system is described by residents as pre-Columbian, which speaks to the historical memory of both the Incan period of colonization in the early 15th century and the prior Puruwá epoch. As can be seeing in the satellite image, each segment of the terracing system corresponds to individual smallholdings. It is the architecture of the agroecosystem, consisting of the cultivation terraces themselves as well as ditches, contention walls, traditional paths, agrodiversity and ecological associations; structure and its functions are the backbone of Caliata’s agri-food system.
3.4.1 Sites’ characterization

With local informants, we assessed a total of ten sites. Table 4. presents information on six parcels (T) and two edges or borders (B). We include geographic coordinates in order to make our work accessible. We use local names, recognizing meanings and Kichwa-Puruwá customs for labelling land characteristics. The table includes *Hucu Wayco* (T03) which is a parcel belonging to a Caliata resident that is located in an adjacent community. It was included to present a contrast with agricultural practices not present in Caliata (blackberry monoculture), while having comparable geographical conditions.
We assessed two traditional pedestrian paths (Table 5.), typically referred to as *chaquiñan* (*“chaqui”* foot and *“ñan”* path/road). These paths function as circuits that connect various points within Caliata. Paths are lined with trees and bushes, so they also act as wind barriers that protect fields and pedestrians and also provide materials, food and medicine. In Figure 4 it is possible to note the network of roads and traditional paths intersecting the terrace system.

The characterization of selected sites reflects the agroecological space heterogeneity (Table 6). A key element of variability was the categorization of areas “inside” the terrace
system and those “outside.” The two pedestrian paths cross the terrace system and extend beyond its limits (“interspersed”). The other key characteristic of areas inside the terrace system was whether these were considered high, middle or low grounds; the “top edge” (B01) represents the highest point we measured.

Table 6. On site characterization

<table>
<thead>
<tr>
<th>Code</th>
<th>Terraces system</th>
<th>Terraces system location</th>
<th>Principal land use</th>
<th>Water access for cultivation</th>
<th>Anthropogenic biomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO1</td>
<td>Inside</td>
<td>High ground</td>
<td>Plowed</td>
<td>Rainwater</td>
<td>Cropland</td>
</tr>
<tr>
<td>TO2</td>
<td>Outside</td>
<td>Alongside</td>
<td>Polyculture, timber</td>
<td>Irrigation</td>
<td>Mixed cropland-woodland</td>
</tr>
<tr>
<td>TO4</td>
<td>Outside</td>
<td>Alongside</td>
<td>Timber</td>
<td></td>
<td>Woodland</td>
</tr>
<tr>
<td>TO5</td>
<td>Inside</td>
<td>Middle ground</td>
<td>Polyculture</td>
<td>Rainwater</td>
<td>Cropland</td>
</tr>
<tr>
<td>TO6</td>
<td>Inside</td>
<td>Low ground</td>
<td>Polyculture, grasses</td>
<td>Rainwater</td>
<td>Mixed cropland-rangeland</td>
</tr>
<tr>
<td>BO1</td>
<td>Inside</td>
<td>Top edge</td>
<td>Grasses</td>
<td>Rainwater</td>
<td>Rangeland</td>
</tr>
<tr>
<td>BO6</td>
<td>Outside</td>
<td>Alongside</td>
<td>Polyculture</td>
<td>Rainwater</td>
<td>Cropland</td>
</tr>
<tr>
<td>C04</td>
<td>Interspersed</td>
<td>Middle to low path</td>
<td>Path</td>
<td></td>
<td>Hedgerow</td>
</tr>
<tr>
<td>C07</td>
<td>Interspersed</td>
<td>Middle to low path</td>
<td>Path</td>
<td></td>
<td>Hedgerow</td>
</tr>
<tr>
<td>*TO3</td>
<td>Outside</td>
<td>Not in proximity</td>
<td>Monoculture</td>
<td>Irrigation</td>
<td>Cropland</td>
</tr>
</tbody>
</table>

*Represents “intended” for monoculture, however reality showed otherwise (see: Table 6).

Land use is an important factor in the characterization of land. For example, *Jahua Huichi* (TO1), a freshly plowed terrain occupies former terrace segments that were purposively destroyed to get a larger and even parcel, but it is adjacent to terraced plots where polyculture cultivation is practiced.

Most fields are rainfed. In contrast, *Chuglin* (T02), a mixed biome, is one of the few parcels that has access to a small irrigation system that takes water from an underground source from which it takes its name. Parcels T02 and TO4 (*Bosque Pata*) are eucalyptus forests (an introduced species to Ecuador), combined with native fruit trees like *tocte*
(Juglans neotropica), a walnut, and capuli (Prunus serotina), a native cherry. There are also native bushes such as chilca (Phlebodium aureum).

Chimba Pamba (B06) takes its name from the sector; it is one of many patches of land that are scattered around the community, especially next to the roads. An essential function of these patches is household food production, which supports dietary diversity. Finally, Hucu Wayco (T03*) is a parcel dedicated to irrigated production of blackberries.

3.4.2 Pachamama’s symbolic space

Ancestral wisdom is transmitted through the “doing” (rurai), from the elders to the rest of the family, learning takes place in the field. The Kichwa-Puruwá language supports Caliata’s ancestral wisdom because it defines the landscape, how people relate to elders, and how land is managed. For example, a Puruwá word is tzacmana (to move soil with a tool), which is a decompaction technique that causes minimal soil disturbance. Most parcels are referred as chuzafundio or wachifundio (small parcel), which shows that people in Caliata are smallholders who rely on subsistence agriculture.

IFK2A: I am a Kichwa-Puruwá woman… Our roots are ancestral, so to speak; there was a Puruwá language that was older than Kichwa. The Incas brought the Kichwa language but before, there was the Puruwá language. Here, we have words that come from Puruwá. An anthropological researcher found that, for example, the word Punin [a neighboring parish] is not Kichwa; it means “seed of fire.” Tulabug, the big mountain in front of Caliata, is another Puruwá word. When you go to the top, there is a large esplanade, a sort of stadium.

IMK5: [It is different] if one lives in the city. Despite being indigenous, Puruwá blood, if one does not have the tradition, knowing the culture, the value of our land, the knowledge transmitted by our grandparents, even though they may say that they are indigenous, that does not count at all… I am proud to be Puruwá from here, especially because Caliata is a blessed land […] If I am in the city, I use the Spanish language and likewise with my people, when I go to visit the elders, I use my own mother tongue.

Paths acquire further relevance when using the lenses of the symbolic. Both local records and testimonials mentioned that Caliata has several ancient paths, potentially connected to the Alausi segment, which is known as part the Capacñan or Qhapaq Ñan
(which literately means “main roads” of the network that constituted the Inca Trail). These ancient paths have spiritual and customary dimensions, particularly as a part of Caliata’s historical memory, as detailed in a tourism degree thesis:

In addition to the terraces, there are sacred places such as the crosses. A cross is the space where two ancient roads intersect. It is said that these are transverse paths of the Inca Trail. People come to these points considered since ancient times as places of power, where energy accumulates, in order to ask for health, abundance of crops and animals, and for wisdom, knowledge, patience, and harmony.

Land, field, parcel, and soil are all referred using the same word, both in Spanish (tierra) and Kichwa (allpa or ashpa). However, Kichwa language is highly contextual, for example in referring to “yapuna allpa” (plowing or preparing soil) or “saywa allpapak” (boundary between two fields). Used alone, the word Pacha refers to the landscape, while ashpamama and pachamama are interchangeably used. Pachamama (Mother Nature or Mother Earth) is polysemic: it refers to the parcel (particularly the chakra), which provides conditions for life and also to the cosmos, time, and all existence.

GMTA: The chakra is the Pachamama ... The chakra itself is the mother; we say the Mother Nature or Mother Earth, and Pachamama in Kichwa because she feeds us. We grow food from Pachamama. We live and we have where to stand and walk.

A community member defined her parcel (T06) as “ashpamama tukuiman karaj;” ashpamama refers to field or soil, while Tukuiman signifies all, including plants, animals, people, and spirits, while karaj means “that feeds.” The direct translation then is “field that feeds all,” but the semantic meaning is “sustainable integrated farm.” This example, although may seem as particular, illustrates how a symbolic force, the cosmovision, is instilled through language, defining life as interconnected and relational, with Pachamama at the center. It is an expression of an ecocentric view, in which the symbolic has direct implications in the way people participate in the agroecosystem.
3.4.3 Agrodiversity

Each family has a chakra that produces much of what is needed. The chakra represents agrodiversity, food variety, access, and freshness, local production, and minimal dependence on cities. The chakra provides resources other than food, including medicines and materials. For example, the thorns of the fique plant (Furcraea andina) are used to secure the harvest load on a donkey's back. The chakra is also connected to public spaces like roads and the community meeting hall, and in the event of illness become, along with the chakra, nature’s pharmacy, however accessible and available for all.

GMAC: The chakra is a source of life: it, is like a mother who cares, who puts the mind at peace, that bears fruit, and serves for all, the ecosystem. It not only provides food, but sustains the plant and animal realms, like the birds. Without this diversity, one cannot say that the field is beautiful. This also affects both the body and the mind, and that is all... along with the ecosystem, it is the water, the air.

Starting from the chakra, agroecologically useful species in Caliata include domestic animals and plants that are edible, medicinal, or useful for construction or other household needs. Native species include fique, sigse or siksi (Cortadeira nitida), and chilca. We excluded pollinators, wildlife, and those species locally considered “weeds” (hierba mala). Like Oyarzun et al. (2013), we used a single taxonomical category for species included in the analysis while acknowledging intra-species diversity that is the basis for saving seeds of native varieties—part of Caliata’s ancestral wisdom. Table 8 provides an overview of some of the varieties of main crops found in the community.
Table 7. Crop varieties

<table>
<thead>
<tr>
<th>Crop</th>
<th>Local use names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>Puña; uvilla; papafri; puka chauchá; killu chauchá; gabriela; maría; chuco</td>
</tr>
<tr>
<td>Beans</td>
<td>Canario; muru huagra; cholo; chilli puka</td>
</tr>
<tr>
<td>Corn</td>
<td>Igchug sara; puka sara; yana sara; morocho; chaso; moro; shushi; urubaca</td>
</tr>
<tr>
<td>Barley</td>
<td>Cuchi chupa; fransciscana; common; runa</td>
</tr>
<tr>
<td>Wheat</td>
<td>Turco; apricano; morocho; trigo 150</td>
</tr>
<tr>
<td>Oca i</td>
<td>Candonga; yurak oca</td>
</tr>
<tr>
<td>Melloco j</td>
<td>Puka; killu</td>
</tr>
<tr>
<td>Quinoa</td>
<td>Ancient purple; common</td>
</tr>
</tbody>
</table>

Cross pollination: morocho-puka & Igchug-yana | Oxalis tuberosa | Ullucus tuberosus

In the ten assessed parcels, with a total area of (17,140 m²) we counted on-site 108 different agroecologically useful species (Table 8). The number of agroecologically useful species per parcel ranged from 11 (T01) to 67 (T06) species (Mean= 29.6; Mdn= 23.5). For example, Jahua Huichi (T01) was freshly plowed at the moment of the assessment: different species were found in its margins, while Ashpamama Tukuiman Karaj (T06) represents the chakra—as biodiverse space. Hucu Wayco (T03), was intended for monoculture, so that one species (blackberries) dominated; nonetheless other edible plants, medicinal herbs, and other useful species were also present. Our biodiversity list was expanded during participatory evaluation and monitoring to 165 useful species.

Table 8. Ecological richness, relative abundance, and evenness for site

<table>
<thead>
<tr>
<th></th>
<th>B01</th>
<th>B04</th>
<th>B06</th>
<th>B07</th>
<th>T01</th>
<th>T02</th>
<th>T03</th>
<th>T04</th>
<th>T05</th>
<th>T06</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (m²)</td>
<td>260</td>
<td>1620</td>
<td>6</td>
<td>900</td>
<td>1934</td>
<td>877</td>
<td>789</td>
<td>1200</td>
<td>3395</td>
<td>6158</td>
<td>17140</td>
</tr>
<tr>
<td>N</td>
<td>2432</td>
<td>29300</td>
<td>375</td>
<td>7820</td>
<td>8560</td>
<td>4309</td>
<td>1060</td>
<td>6415</td>
<td>20575</td>
<td>53357</td>
<td>134203</td>
</tr>
<tr>
<td>S</td>
<td>18</td>
<td>26</td>
<td>42</td>
<td>11</td>
<td>43</td>
<td>13</td>
<td>21</td>
<td>36</td>
<td>68</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>pi (average)</td>
<td>0.06</td>
<td>0.04</td>
<td>0.06</td>
<td>0.02</td>
<td>0.09</td>
<td>0.02</td>
<td>0.08</td>
<td>0.05</td>
<td>0.03</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>H1</td>
<td>2.12</td>
<td>2.84</td>
<td>2.54</td>
<td>3.15</td>
<td>1.63</td>
<td>3.30</td>
<td>2.29</td>
<td>2.32</td>
<td>3.00</td>
<td>1.97</td>
<td>2.52</td>
</tr>
<tr>
<td>DMg</td>
<td>2.18</td>
<td>2.43</td>
<td>2.87</td>
<td>4.57</td>
<td>1.10</td>
<td>5.02</td>
<td>1.72</td>
<td>2.28</td>
<td>3.52</td>
<td>6.06</td>
<td>9.06</td>
</tr>
<tr>
<td>DMn</td>
<td>0.36</td>
<td>0.15</td>
<td>0.93</td>
<td>0.47</td>
<td>0.12</td>
<td>0.66</td>
<td>0.40</td>
<td>0.26</td>
<td>0.25</td>
<td>0.29</td>
<td>0.29</td>
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</tbody>
</table>
Table 9 contrasts Caliata with the five communities, in the altitude range between 2,800 and 3,400 MASL, studied by Oyarzun et al. (2013). Differences in ecological richness and species evenness may be due to methodological nuances in selecting sites and identifying and including species, but also reflect unique characteristics of each agroecological space. We address some of the nuances in the discussion section.

<table>
<thead>
<tr>
<th>Community</th>
<th>No. sites</th>
<th>Mean site size (m²)</th>
<th>No. sp/site</th>
<th>No. sp/community</th>
<th>Ecological richness (DMg)</th>
<th>Evenness (H₁)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paquibug</td>
<td>12</td>
<td>2,959</td>
<td>23</td>
<td>58</td>
<td>2.72</td>
<td>2.03</td>
</tr>
<tr>
<td>Vaquería</td>
<td>13</td>
<td>18,197</td>
<td>26</td>
<td>62</td>
<td>2.68</td>
<td>1.64</td>
</tr>
<tr>
<td>Tzimbuto</td>
<td>14</td>
<td>3,675</td>
<td>21</td>
<td>37</td>
<td>1.95</td>
<td>1.45</td>
</tr>
<tr>
<td>Monjas</td>
<td>6</td>
<td>18,567</td>
<td>12</td>
<td>28</td>
<td>1.23</td>
<td>1.26</td>
</tr>
<tr>
<td>Guangopud</td>
<td>6</td>
<td>5,880</td>
<td>14</td>
<td>32</td>
<td>1.49</td>
<td>1.37</td>
</tr>
<tr>
<td>Caliata</td>
<td>10</td>
<td>1,714</td>
<td>108</td>
<td>165</td>
<td>9.06</td>
<td>2.52</td>
</tr>
</tbody>
</table>

The table shows the five communities studied by Oyarzun et al. 2013 (p. 522) and Caliata. No. sites is the number of areas assessed. No. sp/site is the number of species found during the site analysis. No. sp/community is the number of species found at each community. DMg is Margelef’s index for ecological richness for assessed sites. H₁ is Shannon’s index for agrodiversity and evenness.

### 3.4.4 Cycles in customary life

Information from the parish indicates that annual rainfall is between 400 to 500 mm, while median temperatures fluctuate from 8 to 16°C (averaging 12.4°C). We registered temperatures that fluctuated from 7 to 15°C (averaging 10.8°C). Combining testimonials and local records, we deducted an overall picture of variation across the year. Frosts are most common during the months of May, August, and December, while strong winds are experienced in August, fog in April, and droughts from June to December. Lower temperatures are experienced during hailstorms or when frost takes place. The first rains generally begin in November or December.
The *minga* (cooperative group labor) and *raymis* (feasts) are two customary institutions relevant to the agroecosystem. Seasons are intertwined to crops rotation systems, and each system represents a cycle from soil preparation to planting and harvesting. Seasons define the agrarian calendar. Conversely *raymis*, synchronic with the Gregorian calendar, are associated to seasons. The feast pays respect to elders and ancestors and, most importantly, are a ritual of gratitude for *Pachamama*. For example, the Harvest *(raymi)* takes place throughout August to collect the corn, a laborious task that relies on multiple *mingas*. While soil preparation starts in September, in anticipation to the first rains, and this agrarian phase is marked by the Day of the Death (2nd November); fundamental in the indigenous tradition because it is a treat unifying the living and the ancestors, food and seeds are shared.

GMJC: The *minga* [collective work party] here, my colleagues know, the purpose of the *minga* is to mediate conflicts because not everything in the community is a honeymoon. There are ups and downs. With a *minga*–how nice it is when it happens–it is based on human relationships. Here you make friends, you play; we share food, we go out and form a group... We build deep and strong, lasting relationships.

IME1: Religious holidays are synchronized with the *raymis* in the indigenous tradition […]. Here it is still important; festivities are a big thing. They are what bind people together, even those who have migrated come back for the festivities.

The rationale of cycles is also related to female essence. The concepts of *Ashpamama* and *Pachamama* convey the sense of an entity; the termination “mama” refers to mother, who is capable of experiencing emotions, which are related to productivity. Hence, unproductive or abandoned parcels are said to be sad. Smallholders ask permission to work the land, and parcels are often adorned with flowers, and offerings to the land symbolize attaining a healthy soil, so that fertilization strategies are literally expressed as “feeding the parcel” and “rejuvenating the topsoil.”
GMTK: The chakra is Mother Earth. To sow, first you must ask permission from Mother Earth. Can I sow you? And if she accepts, we sow. Because she has life, we communicate. If we sow without saying anything, she feels pain when we shove in the hoe. You must ask permission to sow; otherwise she gets angry. She doesn't produce as she should produce; the corn will grow small.

IFK4: Our Ashpamamita is the land. The Pachamama is all the environment that surrounds us; heaven and earth is included. … We use the plants, but to get the plants we also have to make offerings to the land. In this case, such offerings become fertilizer. Also, we were taught that, for example, we should make the offering with fruits and flowers in a corner of the land, because there the Ashpamama feels happy for the rich things received.

IMK2: This is the first requirement: to give a good diet to our Mother Earth, so that she is well fed, fertile, and fruitful, and to provide the best fruit to feed all living beings.

A community Yachag (healer or wise person) explained that Andean cosmovision sees existence as cycles, which are manifested in many ways, including, management of the agroecosystem in that everything begins and ends in land, the fields, and the soil.

Fundamentally, for people in Caliata being indigenous means in a large extent knowing about how to treat the land, this person is then a “chacarero” (one who knows about the chakra).

IMK1: A good farmer knows at what time of the year his land asks to feed her with organic fertilizer. When the he/she moves the soil, the farmer knows; you can see a whitish soil that indicates that the plot needs to be fertilized.

GMTK: To be indigenous is to know how to respect what I have learned here: the Kichwa language, ancestral clothing, and ancestral knowledge such as the terraces. What is the terrace for? Why the black soil? Why do the soil layers have different colors? What is the best soil? Being indigenous is knowing the ancestral and practicing, not losing... Knowing how to really sow and the best days to sow; to maintain the soil using an ancient celestial calendar, to see which days crops can be sown, the day that is good for the roots, the day that is bad for sowing. See the moon, as in the past, the day to sow, and likewise, the day to harvest.

3.4.5 Land management

People in Caliata closely monitor lunar phases and cues from nature. For example, residents report that the arrival of certain bird, between September and December, determines the beginning of an agrarian season, which starts preparing the soil. Informants
describe this bird as of grey color, known in Kichwa-Puruwá as *tulig* (or *lig-lig* in Incan-Kichwa); during member checking we identify that it may be the Stout-billed cincloides (*Cinclodes excelsior*). The news about the appearance of this bird are spread among families mobilizing the work necessary for planting.

Land management practices aligned to natural cycles also reflect community values such as interpersonal relationships, reciprocity, and redistribution, which lead to nutrient feedback loops: land-plants-animals-people-land. In this sense, a cycle starts with the preparation of the field because as expressed by a community member: “the soil must be well fertilized so that nutrients are not lacking.” People in Caliata employ different techniques of soil fertilization, including a variety of mixtures of compost and bio-fertilizer (*biol*). Soil preparation measures can be seeing as anthropogenically induced bottom-up trophic processes, an important element to understand the viability of the agroecosystem.

**IMK1**: First, love the land or parcel, we say: How to use organic fertilizer? Precisely from the animals, including cattle, donkeys, guinea pigs, chickens, rabbits, sheep, ducks, and turkeys. For what reason? The fertilizer of each animal serves according to the land, according to the need. This organic fertilizer is processed, dried in the sun and piled up for a certain time. When it is seen that the fertilizer has decomposed, then it is taken to the parcel. We never use raw compost.

**GMTM**: The *biol* [bio-fertilizer] is made with the waste of the animals. It is mixed with molasses and natural plants such as alfalfa and clover, mixed all together, and left to sit for about fifteen days.

Along with fertilization strategies, people in Caliata practice crop rotation systems, periods of fallow, associated cropping schemes, and the use of hedgerows between parcels and along roads. The association of crops, in principle ecological mutualism, also has symbolic elements; as a community elder commented, “corn is sad when there is no quinoa.” The two principal crop association schemes practiced in Caliata are: corn scheme, which corresponds to corn-beans-squash-quinoa-lentejilla (*Lepidium virginicum*)-vicia.
(Vicia sativa)-and-lupini beans (see Figure 5); followed by one of potatoes, which is potatoes-ocas-melloco-fava beans-and-lupini beans. The lupini beans is present in both systems as a food, and also as a wind break, nitrogen fixation and to prevent the growth of unwanted species.

**Figure 5: Illustration of corn cycle**

The figure shows the traditional crop association of corn-bean-squash with the lupini beans acting as wind break.

During the potato scheme, people in Caliata have an ancestral technique to “cure” the potato, consisting in using guinea pig bones nailed to the seed. This is, the family and sharecroppers once in the cultivation area, would eat roasted guinea pigs, separating the bones, which would be pinned to the potato seed (like a “toothpick appetizers”) during sowing. The idea of “cure,” a remedy, speaks to well established notions of preventive health from the Andean cosmovision—this is “cure in healthy” so that the plague does not enter and so that the plant grows strong. A testimonial from a community elder indicated that he consulted once about this technique with an agricultural specialist, who speculated that this may have to do with the nitrogen cycle.
GFOR: Our parents knew that potatoes produce best when one takes the roasted guinea pig to the planting... When they sat down for lunch, they said that they should keep the guinea pig bones... Grabbing a handful [of bones], my mother would stick each tiny bone into a seed potato... It was true; this way, the harvest would be plentiful. Up on the hill, my late would take the donkey to spread the straw from high pasture in order to keep the moisture and the (organic) fertilizer in the soil... They prepared the field so that they could eat during Carnival. Now things have changed; we sow in the months of May or June...

GFOBe: On the day potatoes were sown, my mother would roast the guinea pig… She knew how to send the tonga (lunchbox) to those participating in the planting… To sow the potatoes, one must keep the bones so the potatoes will grow to the size of a guinea pig.

Other crop associations in Caliata are the combination of peas-vicia-and-lentejilla, and also of peas-barley-and-wheat, both are planted throughout the year in scattered patches in parcels. In addition, hedgerows, which serve as barriers to wind and pests, also have combinations of useful plants. One combination provides both medicinal plants and species used for a variety of household uses: chilca, valeriana (Valeriana pilosa), calaguala (Campyloneurum angustifolium), and fique. Another combination found in hedgerows consists of taxo (fruit vine, genus Passiflor) that climbs the capuli tree (an Andean cherry); two native species that enrich the diet and also have medicinal properties.

IMK1A: Back then, the elders said that in associated cropping, the plants have a minga in defense of the harmful predators and plagues: the plants take care of each other.

Fallow periods should follow a full crop rotation of corn and potatoes schemes so that, as a community elder explained, “the land is fertilized and does not tire of producing.” However, for smallholders this is a challenge. Depending on land that the family has available, the fallow period can last up to three years, which corresponds to the maximum length seeds of legumes and cereals can be stored. During the fallow periods, cover crops are typically planted with a twofold purpose. First, they protect the topsoil from wind and water erosion. Second, animals are allowed to temporally graze in parcels, which provides fertilizer.
In addition, clothing is an integral part of Caliata’s identity and the traditional health system, and is also relevant to the agroecosystem management because it combines the symbolic with practical elements of everyday life. The traditional woven belt women wear, for example, is said to help carry heavy loads by protecting the hip and back during the physically demanding tasks. Similarly, the thick wool poncho protects the body from the cold and rain and the traditional broad-brimmed hat protects the wearer from intense UV radiation experienced at high altitude and protects from the rain.

IMK3: The cushma is something like a poncho; it is not very long and made here. They wear the cushma with a white sash. This is special, from our ancestors. So, when it rained, they would stand along the wall where it was dripping, and with that hat she would sit there and she would squat when it rained, and when the rain fell on her hat, she did not get wet. The water fell behind her. These are things that our ancestors left to us.

GFA2M: I believe in improving self-esteem; I liked the anaco (wrap-around skirt) but when I understood, when the elders explained to me the meaning of what our anaco, our bayeta (shawl), our sash, and our hat means. Then I accepted this with much more joy. The natural materials protect us from diseases.

3.4.6 Installed capacity on soil health

An outcome of agroecological assessment was that two local collaborators were familiarized with MO-DIRT protocols and language about physical and biochemical factors, and in doing so, we gained a sense of soil health in Caliata.

Data on nutrients present in soil (Table 10), were obtained with the Rapitest Soil Test Kit and validated with results from the government Agrocalidad laboratory for TO6, our reference lot tested by both methodologies. Testing revealed that the soil had a neutral pH of 6.5 and levels that were low for nitrogen (N0), mid-low for potassium (K1), and high for phosphorous (P3). Laboratory results provided comparable values: pH 7.26; N = 0.14%; K= 0.73 cmol/kg and P= 40.3 mg/kg, which according to lab reference tables are considered Ph neutral (6.5-7.5); N low level (0-0.15); K high level (>0.4) and P high level.
(>21). With the exception of potassium, all other results were similar using the two methods. This finding suggests the potential of MO-DIRT as a feasible on-site methodology.

**Table 10. Soil health factors**

<table>
<thead>
<tr>
<th>Code</th>
<th>pH</th>
<th>Nitrogen</th>
<th>Potassium</th>
<th>Phosphorus</th>
<th>Soil texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO5</td>
<td>7.2</td>
<td>N 0</td>
<td>K 3</td>
<td>P 4</td>
<td>Clay</td>
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<tr>
<td>TO1</td>
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<td>K 2</td>
<td>P 4</td>
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<tr>
<td>TO2</td>
<td>6.2</td>
<td>N 0</td>
<td>K 2</td>
<td>P 2</td>
<td>Silty Clay Loam</td>
</tr>
<tr>
<td>TO6</td>
<td>6.5</td>
<td>N 0</td>
<td>K 1</td>
<td>P 3</td>
<td>Silty Clay</td>
</tr>
</tbody>
</table>

Rapitest values: 0= depleted; 1= deficient; 2= adequate; 3= sufficient; 4= surplus

The soil test of two samples in the *Agrocalidad* lab revealed adequate organic matter levels but with important differences. Although more research is required, the sample from T06 (in terracing system) was in the high range with 2.86 of volumetric content compared to T03 (located outside Caliata, and intended blackberry monoculture that received agrochemical inputs), which was in the mid-level range of 1.97 for the lab reference (protocol: PEE/SFA/09).

Compared to reference values found in local records for five local communities (Baaquitay Quillincocha; Guantul Central; Shungubug Chico; Flores Centro; & Tumbug Lliushirun), it was notable that land in Caliata has generally higher organic matter values, lower nitrogen, and similar pH levels. Also, from local records, it was derived that in the Flores Parish approximately 20.16% of the total soils are *cangahuas* (indurated borizoiis, sedimentary rock) and also that approximately half of cultivable soils need to be recovered.

In addition, we used systems dynamics to explore with community members (n=16) the agri-food system. Figure 6 shows a causal loop diagram (CLD) pertinent to soil health; this model building was preceded by two other Community-Based System Dynamics’ (CBSD) experiences: Variable Elucidation with Rankings and Connection Circles. A CLD
uses the conventions described in the box under the figure. During a workshop, participants rationalized causal relationships that, through our team facilitation (including the two local collaborators), were conveyed in an agreed-upon model.

**Figure 6:** CLD for a soil health view in Caliata

\(+\) / \(\pm\)

Positive causal relationship

\(-\) / \(\pm\)

Negative causal relationship

A decrease (-) in soil disturbance leads to increase (+) of microbes, likewise, the increase (+) in agrodiversity leads to increase (+) in soil health. The model is expressed in both “reinforcing” (R) and “balancing” (B) loops.
CBSD’s workshop participants unanimously concurred that healthy soils assure a sustained production of food for the community. In the same fashion, participants expressed consistently that polyculture agriculture have kept soils in Caliata fairly healthy, acknowledging that this practice has been preserved from generations ago. The maintenance of the *chakra*, representing intense small-scale agriculture, assures agrodiversity. If these elements are maintained, the system is seen as resilient. Furthermore, people in Caliata have a good sense of the micro-ecosystem present in soil, and they know well that the system resilience depends substantially on these organisms.

However, participants also recognized that modern practices, particularly mechanized plowing, are a threat to this resilience because of the disturbance on the soil, which directly affect the populations of microbes, compromising the resilience of the system. In this rationale, unhealthy soils cannot sustain food production nor the biodiverse environment that secure the traditional diet.

### 3.4.7 An ancient architecture

Whereas a satellite image of the terracing system shows individual smallholdings (Figure 4), on the ground it becomes more evident a variety of ecological niches and microclimates that support largely the richness of species found in Caliata. Terrace segments vary in area and the height of the walls; however, it seems that each represent a piece of a purposive design. Figure 7 is an overly simplified representation of a terrace segment in Caliata to describe structure and functions.
Terraces are aligned with sun patterns procuring maximum sunlight exposure throughout the year. This structural element is fundamental for the growth of C4 plants like corn. Moreover, if not for this design, including the microclimates promoted by the terraces, it will not be possible grow corn with yields in the high-altitude cold weather of the area. Walls are covered with moss, and the presence of different plants absorb water. Ditches at the foot of each terrace wall are also important because they retain energy within the system, particularly as nutrient traps: water runoff drags nutrients from higher parcels. In that sense, another ancestral technique practiced in Caliata is “soil harvesting,” which consists of collecting the sediments deposited in the ditches after each rainy season and spreading it in adjacent parcels. The ditches also have an additional traditional function.
Upon observing where toads lay their eggs, smallholders predict how much water will be available in the rainy season.

GFA2M: I am a Puruwá woman who is very happy to be from Caliata [...] In October, everyone plants corn. In other places, there is always frost, and they hardly have any corn production like us. Here, there is never frost: that's nice, it's a blessing

An important function of terracing in Caliata is that it reduces the degree of slope. For example, in three sites (T05; T06; B01), the average slope was 7%, whereas where land was no longer terraced (Jahua Huichi; T01) the average slope was 40%. In contrast, in two terraced parcels adjacent to T01, the average slope was 8%. An agricultural engineering thesis from our local records presented similar findings about slopes in the Flores Parish, showing that the slope in terraces range from 5 to 9%, compared to 40–60% in non-terraced areas. A report of the council of the Flores parish, analyzed in our desk study, confirms these results in that slopes range from 5% to a pronounced 40%, again reflecting the difference between terraced and non-terraced areas.

Considering that a few segments of the terrace system have been destroyed, because a contradictory development is that larger plots provide for more efficient production because they require less labor and more intensive agricultural practices such as mechanized plowing and monoculture of commercial crops with the use of agrochemicals. The case of Jahua Huichi is striking as it becomes a natural experiment that allows to have a sense not only of variation between terraced and non-terraced but also of change when segments of the terrace system are modified/destroyed.

Despite some deterioration, community members report that the terrace system keeps sustaining a steady biodiverse agri-food system that ensures crop survival and protection against pests and frequent strong weather fluctuations (e.g. frost, hailstorms, and heavy rainfall). In the desk study a local record reported: “The presence of the pre-Incan
terraces has been essential for agriculture since this ancient technique has allowed the inhabitants of Caliata to never suffer losses in their crops.” This is plausible in the light of the structural and functional factors evidenced, such as wind and pest barriers, heterogeneous segments with microclimates, ecological associations, reduced slope and soils systematically fertilized, and the overall effectiveness of the system as energy traps (i.e. agrodiversity, sun, water, nutrients).

IMK5: when you work in plots [in the terraces] you can take advantage of irrigation ditches for soil harvesting. Also, [working in terraces] is not like a large area of land where you cannot work by yourself. Instead, in the terraces, you go parcel by parcel. This makes the work easier, from my point of view, while also working carefully to avoid erosion and the influences of the weather. For example, the terraces protect the land from excessive wind and frost, because I have analyzed the terraces in this sector, the frost does not affect them from eroding and on the other hand, in other places further back where there are no terraces, there is land that are just exposed. They do not have terraces; that is why the frost kills the crops. It hits them and the plants are burned. The terrace has something—some kind of protection—that inhibits certain climatic problems. I believe that the ancestors worked with a strategy while also thinking about the future: in the future I think, thinking about us....

3.4.8 Challenge and opportunities

While the beliefs and practices discussed above suggest that community members are dedicated to taking care of Pachamama, there is also a sense of loss and depletion (including the soil itself), perceived as threatening for the community. The sense of loss is related in part to developments around Caliata. Along the highway from Caliata to the provincial capital of Riobamba. The parish of Punin, located only eight kilometers away, one observes dozens of agrobusinesses. The presence of agrobusinesses indicate their dependence on the use of pesticides to produce cash crops like tomatoes and broccoli, which have raised health concerns in Caliata: in particular, residents worry about their neighbors related to rumors about high rates of stomach and lung cancers.

GMTA: A comparison: down here in Punin, the people spray the tomatoes, onions, carrots; all that is infected. We can make biol; we can fumigate with natural [ingredients]. Instead, down there, they use chemicals that kill themselves and other people ... I have some
colleagues who work there; they say that through infection and by fumigation they contaminate the body and cause cancer of the intestine and lungs.

GFA2B: Because we are eating our grains, it seems that we are still holding on. Those deadly diseases still do not affect us, we still do not hear, in what is below [in Punin and other places with irrigation and fumigation] people are decaying.

To better appreciate challenges and opportunities from the endogenous perspective in Caliata, like with soil health, CBSD allowed us to explore causal-effect relationships in the agroecosystem—these relationships were created from variables that workshop participants previously proposed and ranked according to importance (Variable Elucidation with Rankings). For the purpose we use a culturally validated script (procedure) for building a Connection Circles models, which is effective to define initial cause-effect relationships. Figure 8 shows the results of this workshop, participants were divided in two groups of eight people, we facilitated separate model building with each group (the model the rationale and conventions described in the textbox below Figure 6).

**Figure 8: Connection Circles in the agroecosystem: groups A (right) and B (left)**

Results from the Connection Circles are self-explanatory. For example, in model A, agricultural ancestral knowledge was related to less use of agrochemicals and in model B terrace damage means less healthy foods. Interestingly, and despite the activity was
conducted with two separated groups, the resulting models are remarkably similar in the messages they convey, for instance, the variable “lack of irrigation water.” In model A it is connected to less “organic production” and also less “diversity of crops,” whereas in model B to “unhealthy diets” and “outmigration.” In both models, “lack of irrigation” is also connected to agrochemicals. However, counterintuitively, this situation is an important issue that has allowed Caliata to preserve their ancestral agroecological space, along with their land management strategies and an associated cosmovision that integrates space, indigenous identity, language and culture. This unexpected element is reasoned by an exogenous key informer:

IME1: In productive terms, there is a trend by which the market defines what needs to be produced. It’s not the family with its autonomy … that defines what should be produced. This market orientation means links with wholesalers or circuits of intermediaries, which determine food distribution, obviously speculating with information on where the demands are. For example, we are here in Riobamba, and you will that see all the nearby areas are very productive, Chambo, from San Luis to Punin, which all have irrigation; everything is tied into the circuit defined by monocultures, especially tomatoes, and some vegetables that are very intensively produced. These farmers are totally at the whim of the intermediation of wholesalers, and they can’t have any influence. This implies giving up your land to the service of the market, so if you used to have land available for your own food for household production and supply, it is now very limited because most of the space is allocated to produce for the market.

Despite a generalized lack of irrigation to water the crops, among other internal and external pressures to the system, including a growing presence of crop pests and marginal participation in capital economy, it is clear that Caliata has remained a resilient community; a positive deviance in terms of the health of both people and ecosystem, which contrasts with neighboring communities. Figure 9 (a CLD model like in Figure 6) could be seen as the final outcome towards the end of the forth workshop (n=16); here community participants identified in CBSD language the “leverage points,” which are the variables with the greater potential to produce the greater change in the community, in other words,
areas of intervention. In sum, the model below shows that the ancestral wisdom interconnects biological, physical and psychosocial factors, acting as a central factor for the agroecosystem. Fundamental to understand this model is that the rescue of the ancestral wisdom is rather than a future plan an ongoing process of resistance, it is Caliata's strategy to face current challenges.

Through the above CLD participants expressed their rationale. A reinvigoration of the ancestral knowledge is seeing as the mechanism to strengthening of the current agriculture system, fundamentally to preserve the fertility of the soils, which in turn leads to secure an adequate nutrition and therefore to maintain the community health. Ancestral wisdom also represents to produce organic, healthy products through agroecological technology. The pre-Inca terracing system achieves crops for a healthier diet while
preserving soil fertility. Ancestral medicine is part of agrobiodiversity, they are also plants that protect the system, while maintaining people's health. Health is also part of the virtuous circle, of the relationship between people and life, because health for the Andean optics is based more on prevention than on the cure of the disease.

GMYV: The chakra, the field, and the soil are the fundamental parts for life. Without our soil we would not have life. It is where we can plant our crops. It gives us food; it is where we receive everything in order to survive, in order to exist. In short, to develop ourselves as indigenous people, as peasants. It is essential; so, we must take care of the land, our Mother Earth, and, in this way, treat her well.

GFAIRM: For a fever, I ask someone to bring tipo flowers (minhostachys mollis/Kunth), also the taxo (Passiflora tarminiana). “Please bring me,” I say. After peeling the taxo, I crush it the with the seeds with a small stone. With that, if you have a cold fever, with a little piece of panela (raw sugar), they give (the sick person) the liquid in a cup.

3.5 Discussion

Based on a system view, we have analyzed a space where nature and human agency represent an integrated whole. In that sense, the agroecosystem is physically and conceptually circumscribed within the community territorial borders. Biochemical factors in the form of agrobiodiversity and soil health parameters are paramount for Caliata’s ecological agriculture. Caliata’s agri-food system represents a contrast with neighboring communities, which do not have the benefit of the terrace system, which, among other things, is an efficient architecture in to reduce the slope, create segmentation and respond to environmental shocks (Carrasco et al. 2020). These factors interact with psychosocial factors, like the customary institutions (mingas and raymis) and the symbolic and pragmatic elements of the cosmovision along ancestral wisdom, working as a virtuous circle that strengthens the system, maintaining its resilience.

Elsewhere, we reported that Caliata’s residents are smallholders; 74.8% have less than one hectare (see Chapter 3), this is the chuzafundio or wachifundio. We also reported
that the 57 families grow an average of 18 main crops that besides consumption serve for exchange and sale. They produce a variety of Andean crops, including corn, beans, squash, lupini beans, quinoa, oca, mashua, and potatoes, as well as crops introduced by the Spanish, which are now regarded as traditional, including barley, wheat, broad beans, and peas. In addition, animal husbandry is practiced by 82% of families in Caliata. An adjusted agrodiversity metric was significantly associated to variety of healthy foods consumed within the household (p<.05; β=1.01) (see Chapter 3). Here we observed 108 different agroecologically useful species in the field, and with input from community members, the list grew to 165 species. With the Kichwa-Puruwá ancestral wisdom merged with the landscape, a sense of diversity is coherently reflected in what we encountered in the field, what families reported (crops produced and diet), social organization and how space is conceptualized and managed.

Biodiversity in Caliata is relatively high in comparison to the communities studied by Oyarzun et al. (2013) in Chimborazo –who were participating from 2008 in an action-research project concerning agrodiversity intensification and local management. Also, when compared to communities involved in on-farm diversity conservation projects in highlands of Peru and Bolivia and at lower altitudes in the northern inter-Andean valleys of Ecuador (Cotacachi canton, Imbabura province) (Bellon, Gotor & Caracciolo, 2015). In the Cotacachi project, Bellon et al. (2015) accounted 137 species of crops, fruit trees, herbs, and collected wild species; these are communities located in altitudes between 2,300 to 2,800 MASL, with a reported precipitation of 625 mm/year and mean temperature of 15 °C. Authors caution, however, “problems of endogeneity and selection bias due the fact that the projects built on the farmers’ interests and motivations to maintain crop diversity” (Bellon et al. 2015: 173).
The examples above contrast with Caliata, a non-intervened community, and also in the exploratory nature of our study, conducted without *a priori* categories, hypothesis and expectations for what we found in the field. However, in our view, absolute comparisons between Caliata and other communities risks several potential biases because in participatory agroecological assessment, informants’ perceptions play a key role and are clearly subject to different interpretations. For example, the definition and understanding of what a weed is can vary between communities and individuals; what is considered a weed (*mala hierba*) in one place may be a medicinal herb, food or household material in another. Considering long-standing anthropogenic imprint in Andean mountainous ecosystems (Sarmiento, 2012), cultural dimensions and that Caliata is an ancient human settlement (Costales, 1963), what is wild and what is (or was) disseminated by people may not be easy to discern. The category of wild vegetation should be considered along with ethnobotanical and archeological records.

Another limitation of strict comparisons is related to the inclusion of different kinds of spaces in a study. For example, Oyarzun et al. (2013) were interested in farms, whereas in this study the agroecosystem includes other land uses and margins. Finally, there is an array issues in methodological differences, scope of interventions and lack of enough information—like knowing the interaction between preexistent and/or implemented practices [through action-research/conservation projects] in agrodiversity outcomes, and the contribution of each type. In the same manner, we are unaware if these communities are determined by a complex agroecological architecture, associated to long modeled human behaviors, like the system of terraces and Kichwa-Puruwá wisdom described here. These considerations are fundamental in the light of recognizing the benefits other systems of knowledge, prompting the need of further research.
In the context of ecological efficiency, soil health parameters—we started to
explore—suggests that Caliata functions as a viable ecosystem (Arango-Caro & Woodford-
Thomson, 2015). Because of high levels of organic material and minerals, reflecting the
effectiveness of land management practices combined with the agroecological architecture;
a pre-Columbian system of terraces, which through the generations have continued to be a
pillar of the agri-food system. Caliata’s system is reflected in consideration to experiences
in other latitudes in Andes involving pre-Hispanic terraces in active use, soil quality and
system resiliency (Goodman-Elgar, 2008) and also to those long abandoned but that
nonetheless offer insights about erosion patterns (Londoño et al., 2017). Low nitrogen
levels as actually reflect the benefits of agricultural techniques used in Caliata, because
higher levels usually represent usage of chemical fertilizers, typically intended for
monocultures to maximize crop yields (Fonte et al., 2012; Edwards, 2001). In this context,
the true importance of agrodiversity is its long-term result in achieving a system that is
constantly replenishing soil nutrients and maintaining soil microorganisms, while
increasing the resilience of the entire system (Swan & Kominoski, 2012).

The terracing system is also part of a long collective memory, a cosmovision
instilled in the web of meanings that is culture (Geertz, 2008). Cultural expressions are
linked to the localized indigenous identity, including language, clothing, health system,
customary governance, respect to tradition and elders, attachment and reciprocity. In the
cosmovision, Pachamama is a multidimensional feminine entity, a mother, each family’s
chakra, fields, fertile soil, everything above and below, an inclusive and inseparable whole.
Meaning resides in functions to sustain the community physically, emotionally and
spiritually. Consequently, this ecocentric ontological stance, a way of living that
incorporates people into an ecological community, prompts an epistemology that provides
the means to ends. Ancestral wisdom is a foundation of contemporary practices that align the agrarian calendar with natural cycles, including lunar phases and ecological signs. These elements provide the basis for nutrient loops in that Caliata smallholders are facilitators of biochemical processes and trophic chains.

During the four CBSD workshops, it was possible to integrate from an endogenous perspective (community view), learnings from psychosocial and agroecological dimensions. The agroecosystem’s salient elements were the cultivation terraces, irrigation channels, contention walls, and paths. But that includes functional elements such as an agrodiversity characterized by richness, evenness, ecological associations, native crops, and healthy soils. This agroecosystem is the signature of the Kichwa-Puruwá’s ancestral wisdom; an efficient energy trap to retain solar radiation, water, and nutrients, and also divides the landscape into many small parcels providing microenvironments were species are thriving, and effective mechanism against the impact of pests and environmental events like frosts and hailstorms. Together, this system permits the persistence of an intensive yet ecological form of agriculture that promotes food security.

This agroecosystem is, however, increasingly confronted by internal and external pressures, including encroaching urbanization, changes in land use, and environmental challenges. Intensive farming based not on traditional practices, but the use of agrochemicals, mechanized plowing, and erosion of terraces threaten the agroecosystem in physical, biological, and cultural terms. As noted elsewhere (see Chapter 3), these threats are accompanied by population aging, the feminization of agriculture, acculturation and intergenerational breaches, which also affect the stability of the system.

Nevertheless, evidence from the field along with testimonials suggest that the community and the agroecosystem are still very resilient. Paramount reasons are that their
heterarchical social organization has the ability to respond to pressing needs with very limited resources and their particular behavior, for example, the residents’ preference for healthy diet and corresponding limited consumption of ultra-processed, industrialized foods, a positive deviance comparatively (see Chapter 3)—the concept has also been noted in the context of agrobiodiversity, diet, and smallholder family farming in Chimborazo (Oyarzun et al. 2013). Considering the climatic conditions experienced by many Andean communities living above the 3,000 MASL and that in Ecuador the range for high-altitude corn is 2,200 to 2,800 MALS (Yanez et al., 2010), annual corn yields in Caliata already represent a notable agroecological feature (note: crop yields were appraised in a participatory ranking and scoring activity [see: Catley et al., 2007] not reported here).

As a globalized awareness about sustainability reaches Caliata, there is a growing recognition among community members of the importance of their ancestral wisdom, which they well understand should be preserved, promoted and, used as a tool for confronting global challenges.

Looking forward, Caliata deserves support in a systematic-participatory study of their terracing system, combining archeology and ecology—so it is possible to effectively determine the behavior of the system and for how long it has assured food security. Moreover, there are other elements of the ancestral wisdom worth of future consideration. For instance, it would be illuminating to study the use of guinea pig bones in the potato seeds and their potential to promote the growth of bacteria that transforms atmospheric nitrogen into fixed nitrogen, as well as the use of Caliata’s natural cues (e.g. bird arrival and where toads lay their eggs), and to gain more information about ecological associations known in Caliata. Similarly, after a capacity building experience for soil health, our time has gained local capacity to conduct a longer study.
For many indigenous populations that are economically, politically, and physically marginalized, the adoption of “modern” forms of agriculture have failed to lift up communities out of a vicious circle of chronic malnutrition, poverty, and environmental degradation (Montenegro & Stephens, 2006; Tittonell, 2013). Caliata, in contrast, has retained successfully their traditional agroecosystems characterized by ecological richness and evenness, the presence of native crops, and interspecies variety, the efficient usage of environmental niches, energy traps, and nutrient loops, soil health, ecological interactions, effective pest control, and mechanisms for mitigating adverse environmental events. Altogether, it is evident that the agroecological system of Caliata offers a view to rethink and redesign farming lands in indigenous communities in the Andean mountainous territories, particularly as the current landscape is increasingly defined by modern agriculture.

More broadly, in the Andean region, agroecosystems also represent political space, which through peasant and indigenous organizations, has implications beyond the borders of communities (Altieri & Toledo, 2010). The local level is the foundation of indigenous mobilization (Gallegos-Riofrío et al., under review), that has impacted public policy. For example, indigenous communities and organizations in the Andean region champion proposals voiced at the international level, such as the recognition of the rights of nature and sumak kawsay or the “good way of living” (see Chapter 3). Consequently, planetary health is Pachamama’s health. The convergence of mobilization capacity, ecocentric views and ancestral wisdom represent a social force that can be pivotal to global actions needed to redesign the food system within the carrying capacity of the biosphere.
3.6 References


Cevallos, M. M. (2013). Documento descriptivo, analítico y comparativo de las políticas públicas sobre cambio climático en Colombia, Ecuador, Perú y Bolivia y su relación con el conocimiento tradicional. Quito: UCIN.


cultural geography reader (pp. 41-51). Routledge.

pre-Columbian terraces from the Paca Valley, Peru. Journal of Archaeological
Science, 35(12), 3072-3086.

https://www.google.com/maps/place/Parroquia+Flores/@-1.8147201,-78.6397248,937a,35y,90h/data=!3m1!1e3!4m5!3m4!1s0x91d25542b6d0c6f3:0x972b640eba8fdb29!8m2!3d-1.8142011!4d-78.6450414

Historia de las ciencias y el pensamiento científico en el Ecuador (pp. 189-215).
Quito: Academia Nacional de Historia

process. In Community Based System Dynamics (pp. 17-30). Springer, New York,
NY.

INEC [Ecuador’s National Institute of Statistics and Census]. Censo Nacional de Población
y Vivienda. Retrieved June 5, 2020 from
https://www.ecuadorencifras.gob.ec/censo-de-poblacion-y-vivienda/

learned from abandonment of ancient Wari agricultural terraces in Southern

Lovelock, J. E., & Margulis, L. (1974). Atmospheric homeostasis by and for the biosphere:
the Gaia hypothesis. Tellus, 26(1-2), 2-10.


Swan, C. M., & Kominoski, J. S. (2012). Biodiversity and ecosystem function of decomposition. eLS. https://doi.org/10.1002/9780470015902.a0023601


Chapter 3:

Caliata: an indigenous community in Ecuador offers lessons on food sovereignty and sustainable diets

Abstract

Background: To achieve a healthy sustainable food system globally, it is imperative to understand how local food systems can provide healthy and sustainable conditions.

Objective: To explore, through the indigenous community of Caliata in the Ecuadorian highlands, the factors that support or hinder sustainable Andean food systems.

Methods: We designed a participatory mixed-methods study in Caliata (Chimborazo, Ecuador), and an inclusive and transdisciplinary research process with constant member checking. The study combined culturally validated qualitative methods (n=49), agroecology-based site analysis, and household surveys (N=57), including a modified 48-hour recall. We used the NOVA food classification to categorize the diet according to levels of processing and analyzed categorical and numeric data to understand the interplay of parcel size, agrodiversity, and diet diversity.

Results: First, the agroecological space is defined by the stewardship of Pachamama (Mother Nature), a central role in Andean cosmovision, leading to trophic interactions and
cycles characterized by a diversity of heterarchical social organizations and agroecologically useful species. Second, consistency was found in dietary patterns; all respondents consume their produce, fruits being the most popular snack (in a 24-hour period 70% reported an average of 2.2 servings), and two-thirds of households consume unprocessed or minimally processed foods. Third, gendered agriculture and population aging represent demographic challenges, while chronic health problems remain relatively infrequent compared to the general population. Fourth, food sovereignty is an ecocentric concept based on production, exchanges of seeds and produce, consumption of produce, and knowledge of how agroecological space is treated. This system represents a nutrient loop tied to a system of knowledge about how to care for soil, land, and the ecological community.

Conclusion: Caliata provides important perspectives on linkages between diet, biodiversity, use of agroecological space, and rural-urban dynamics. This small indigenous community offers lessons for achieving both healthy ecosystems and food security.
4.1 Introduction

The profound restructuring of food systems is essential to assure food security and good nutrition worldwide (1,2). While during the Second International Conference on Nutrition the consensus was that food security and nutrition are pivotal to face global sustainability challenges. Following recommendations of the UN System Standing Committee on Nutrition (UNSSCN) and the EAT-Lancet Commission on Food, Planet and Health and (2,3), it is essential to characterize and promote sustainable food systems, which can only be attained through sustainable diets and a harmonious relationship with the biosphere. Food is a symbolic, material, and spiritual link between human beings and the biosphere (4,5). In that context, sustainable diets connote local food security based on constant, equitable, and culturally acceptable access to safe and nutritious foods to meet the dietary requirements for a healthy life, without compromising ecosystems (3).

In order to mobilize a profound change in the global food system, collective action must be inclusive, engaging key actors who are typically marginalized—particularly indigenous peoples (6,7). Indigenous-based food and agroecological systems are resilient and are also critical for climate stability, conservation of ecological functions, and enhancement of biodiversity (8–10). In many indigenous societies, food, health, and nutrition are inseparable aspects of the confluence, function, and transformation of other components of social organization, such as medicine, institutions, agroecosystems, language, and culture (11,12). Furthermore, daily behavior, symbolic meanings, and customary institutions place the relationship with the biosphere as a core principle that is inseparable from human wellbeing in all its dimensions (13,14). This ecocentric
perspective, noted in the literature (13,15), is illustrated in the preamble of Ecuador’s 2008 constitution:

We women and men, the sovereign people of Ecuador
RECOGNIZING our age-old roots, wrought by women and men from various peoples,
CELEBRATING nature, the Pachamama (Mother Nature), of which we are a part, and
which is vital to our existence […]

In the past three decades, Ecuador has experienced rapid social and demographic change (16), including dramatic processes of urbanization, such that less than one-third of the population now lives in rural areas, of which 79% are indigenous people (17). This change is related to the emergence of the dual burden of malnutrition along with epidemiological and demographic transitions (18–20). At the same time, new forms of social organization and action have emerged, particularly a reinvigorated indigenous movement, whose philosophy, structure, and mobilizing capacity is linked to many social gains (21,22). Examples that have crossed international borders are the indigenous proposal for sustainable post-development known as the sumak kawsay (or the good way of living) and the constitutional recognition of the rights of nature (23,24) as shown in Table 11 (25).

Table 11. Relevant articles from Ecuador’s 2008 Constitution

<table>
<thead>
<tr>
<th>Constitutional Definition</th>
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<tbody>
<tr>
<td><strong>Food security</strong></td>
</tr>
<tr>
<td>Article 13</td>
</tr>
<tr>
<td><strong>Food sovereignty</strong></td>
</tr>
<tr>
<td>Chapter 3: Article 281, subsection 6</td>
</tr>
<tr>
<td><strong>Sumak-kawsay</strong></td>
</tr>
<tr>
<td>Preamble (a) &amp; Article 14 (b)</td>
</tr>
</tbody>
</table>
Rights of nature

Article 71

Nature, or Pachamama, where life is reproduced and occurs, has the right to integral respect for its existence and for the maintenance and regeneration of its life cycles, structure, functions and evolutionary processes.

Ecuador’s indigenous movement represents a source of cultural and political influence, and its cosmovision infused in a national constitution (Table 11) has been inspirational for environmental movements internationally (23,24). Andean cosmovision is more than worldview; it encompasses the whole existential experience. According to Andean cosmovision, food sovereignty inexorably connects food security to the good way of living, representing a post-development model that focuses on planetary health rather than in economic growth. The good way of living is contingent on the rights of nature, as expressed by the Article 14 of the 2008 Constitution.

Article 14. Environmental conservation, the protection of ecosystems, biodiversity and the integrity of the country's genetic assets, the prevention of environmental damage, and the recovery of degraded natural spaces are declared matters of public interest.

In spite of these advances, indigenous communities in the central Ecuadorian highlands are experiencing converging challenges to nutrition and health and more broadly, to well-being (26,27). Chimborazo province, in particular, is highly vulnerable because of high levels of poverty (28). Concurrently, Chimborazo has a high prevalence of stunting and micronutrient deficiencies, concentrated in indigenous rural communities. This is a long-standing, intergenerational problem that arises from multiple factors. Despite having access to locally produced food, there remains gaps in the diets of many indigenous communities particularly during vulnerable periods, in early childhood for example. A recent national household survey on health and nutrition (29) found that chronic malnutrition (stunting) affects 48.8% of children less than five years of age, while the province has the second highest proportion of adolescents with impaired growth (42.2%).
In general, indigenous people in Chimborazo live in a vicious cycle of poverty, and poor health and nutritional conditions.

In contrast, the revitalization of ancestral agroecological spaces and renewed value of traditional foods entails diversification of space and diets. A study with smallholder family farmers in the five indigenous communities in Chimborazo province showed the relationship between land management, crop diversity, and local diets (30). This is consistent with evidence from a meta-analysis in low-and middle-income countries including Ecuador and Bolivia, which suggests that agricultural diversification may contribute to diversified diets through cultural identities and customary ways of living (31). These studies reveal promising opportunities for sustaining nutritious plant species and for improving the quality of diets of indigenous families.

Ecuador has drawn an inclusive road map (Table 11) that is deeply infused in indigenous Andean concepts in order to analytically approach nutrition and sustainability challenges. Changes in discourses at the national level, as those reflected in the national constitution, have been possible because of the mobilization capacity, cultural resistance, customary social structures, language, cosmovision, and political positions of indigenous people in Ecuador (13,21–24). More broadly, these phenomena are consistent with the global intensification of smallholder agriculture, gendered livelihoods, and agrodiversity (32). But a gap in the literature remains in understanding the nutritional potential of Andean food systems and current nutritional conditions in indigenous communities. We address this gap in the case of the indigenous community of Caliata (Chimborazo, Ecuador).

The study was conducted with a community-based orientation and in the spirit of exploring the confluence of localized nutritional and agroecological circumstances using a transdisciplinary approach. The research questions that guided our observational study
revolved around the factors that support or hinder Andean food systems as exemplified in the case of an indigenous community in the Ecuadorian highlands. The case reflects processes of acculturation and the effects of marginalization and poverty, as well as resilience anchored in indigenous identity, culture, customary institutions, and agroecological spaces. In the process, we achieved unexpected gains, specifically, how diet, biodiversity, the use of agroecological space, and rural-urban dynamics in Caliata offer lessons that may help indigenous populations in the highlands to improve their health and nutrition without compromising the ecosystems, and while supporting local knowledge.

4.2 Ethnohistorical Background

Indigenous identity is particularly strong in Caliata, where Kichwa is the principal language used on a daily basis, although most residents also speak Spanish. Indigenous identity is tied to collective memory, traditional clothing and diet, and farming activities that are specific to Caliata’s agroecosystem. In addition, customary institutions continue to promote cohesion, trust, and cooperation; these include festivities associated with the agricultural calendar, the *minga* or reciprocal communal work, bartering (typically involving produce, seeds, and labor) and indigenous law, which is based on restitutive principles and re-incorporation of offenders. The customary regime operates through consensus, based on a continuous process of negotiation among individuals, families, and organizations; Caliata is a society governed by distributed intelligence, an heterarchy using David Stark’s (33) usage of the concept.

Residents of Caliata identify themselves as members of the Kichwa nation and of the Puruwá people (a category similar to “tribe”). The concept of indigeneity in Caliata exemplifies concentric layers of meaning ranging from local to regional (community–
people–nation–Ecuador–Andes). The Puruwás inhabited what is now Chimborazo Province at the time of the arrival of the Incas around 1480 (34). The Incas introduced new agricultural practices, promoted the use of Kichwa as common language, and built a complex road system (34,35). The vestiges of the ancient roads are still found in Caliata, whose strategic location places the community at a crossroad leading west toward the Pacific coast and east toward the Amazon basin. This strategic location has given people in Caliata access to foods from different altitudinal levels (particularly fruits, cassava, and rice) and likewise has driven temporary migration waves to the coastal area for rice and plantain harvests.

4.3 Methods

4.3.1 Population

Selection of the study population was theoretical (36) in the sense of meeting two criteria: (i) finding a food system that can be characterized as “indigenous-based” (37) and (ii) the existence of community collaborators and local contacts in order to establish an ongoing, long-term relationship. Ethnicity is defined in Ecuador by self-identification; this dimension tends to be based on cultural ties, language spoken at home and having been born in communities historically considered as indigenous (27). Caliata belongs to the rural parish of Flores, about 210 kilometers south of the country’s capital. A 90% of people in Flores are dedicated to agriculture and animal husbandry. The study covers the entire universe of Caliata residents, including 144 individuals in 57 smallholder families; Table 12 presents household-level sociodemographic data.
Table 12. Sociodemographic information reported by the head of the household

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of people living in this home</td>
<td>2.5 (1.5)</td>
<td>1 – 8 individuals</td>
</tr>
<tr>
<td>Number of years of school completed</td>
<td>3.4 (5.0)</td>
<td>0 – 16 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Literacy</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Able to read a whole sentence</td>
<td>31</td>
</tr>
<tr>
<td>No, cannot read at all</td>
<td>23</td>
</tr>
<tr>
<td>Able to read only parts of a sentence</td>
<td>3</td>
</tr>
<tr>
<td>Blind/visually impaired</td>
<td>0</td>
</tr>
</tbody>
</table>

Household receives a conditional cash transfer

<table>
<thead>
<tr>
<th></th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>21</td>
</tr>
<tr>
<td>No</td>
<td>36</td>
</tr>
</tbody>
</table>

The family receives money from another family member living at the city or abroad regularly

<table>
<thead>
<tr>
<th></th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>44</td>
</tr>
<tr>
<td>No</td>
<td>13</td>
</tr>
</tbody>
</table>

Notes. Conditional cash transfer is a poverty indicator; remittances offer perspective on migration and support network

4.3.2 Fieldwork and inclusion

Most of the fieldwork was conducted between April and December 2018, but this study is also the product of an ongoing process that included participatory assessment of findings (June 2018 and May 2019), which allowed for testing and expanding information and analytical categories (38). The research also included member checking (39).

Conceptually, the study was designed to provide Caliata with information that can be utilized by community members in their present and future endeavors. Findings of the study are provided to the community as a reflection of a partnership and commitment to design applied research aligned with the needs, aspirations, and philosophical stance of the community.

The community reached formal consensus with regard to participating in the present study through two consultative meetings and a formal document of support signed by the five elected community leaders and every landowner. The study was submitted for IRB
approval as an expedited observational study with low risk to participants. As such, oral individual consent was provided, witnessed, and documented. Confidentiality was assured by omitting identifying information from surveys, recordings, notes, and manuscript preparation.

The study was approved by the IRB of Washington University in St. Louis, and a review of cultural appropriateness provided by the IRB of the Universidad San Francisco de Quito, which is recognized by Ecuador’s Ministry of Public Health (MPH).

4.3.3 Procedure

We applied a participatory mixed-methods design. Following previous experiences (27,38), a qualitative component consisted of nine focus groups with a total of 39 participants and ten key informant interviews (women=5; men=5), combined with participant observations, photo and video documentation, and a desk study of local records. Semi-structured questions were previously validated for linguistic nuances. Focus groups and interviews were recorded, transcribed and, when necessary, translated from Kichwa to Spanish by a translator and an independent reviewer.

The quantitative component consisted in a survey (N=57), mostly conducted with female household heads (women=54). The instrument was based on the Lulun Project’s survey that was applied in five rural parishes in the central highlands (40), incorporating items related to land and agriculture, and a module adapted from the Mexican National Health and Nutrition Survey “ENSANUT-Mexico 2016” (41) for chronic diseases. Applied to respondents ≥ 20 years of age, the survey was previously validated for cohesiveness and linguistic nuances and modified accordingly. Agroecology-based site analysis was
conducted in ten selected parcels that were studied with local informants in order to approach agroecological richness with reference to diet (30,31).

4.3.4 Operationalization

The survey provided information on crops cultivated by each family, which contrasted with species diversity from the agroecology-based site visits. We inquired about this distinction during member checking and found that residents measure cultivation in terms of volume and weight, but also in terms of the relative importance of different crops in the diet and their market value. Considering these community-based parameters, we defined the category “diversity of main crops produced in a parcel.” Furthermore, purposively selected sites offered evidence for defining the category “adjusted agroecological [species] richness” as an adjusted measure that combine main crops cultivated and a modest estimate of endemic species observed across prospected sites (e.g. vicia, lentejilla, paico, lemon verbena, and coriander) during agroecology-based analysis.

We used a modified (without a priori list of foods) 48-hours recall questionnaire to analyze meals, ingredients, and portions for “yesterday” and the “day before” consumed by the household head; using “meal” as the cue to prompt complete answers: cued recall (42). Meal acts as unifying information-processing category (for ingredients and portions), because memory operates better when information in grouped: chunking (43). Finally, because diet represents episodic memory (44), which is contextual; a meal is associated with places and times, making easier to remember. We use household head as proxy for the diet of the entire family, particularly since female household heads customarily prepare meals, as noted elsewhere (45).
The 48-hours recall added nuance into our exploration of the diet because we treated data as both categoric and numeric, which was useful to understand in a greater dimension the consumption of unprocessed and processed foods. Dietary information was sorted using the NOVA classification adapted for Ecuador (46). NOVA considers four different groups of foods according to levels of processing: Group 1 includes unprocessed or minimally processed; Group 2 includes culinary ingredients; Group 3 includes processed foods; and Group 4 includes ultra-processed products.

We obtained a healthy diet index (47) using a simplified method (48), based on the NOVA classification of Group 1 items, as well as reference food groups (www.choosemyplate.gov): grains, dairy, animal protein, legume and nuts, fruit, dark green vegetables, red or orange vegetables, other vegetables, and oils. In our simplified method we counted the number of food groups consumed daily (1 point for each group consumed in NOVA “Group 1,” where the maximum score is 10).

In addition, we calculated the variety of foods purchased based on a list of twenty food items (plus an open-ended “other”), based on the Lulun Project survey that included the purchase of rice, noodles, bread, canned tuna, canned sardines, sugar, oil, salt, red meat, poultry, eggs, fruit, vegetables, coffee, sweetened beverages, commercial condiments, yogurt, milk, candies and other sweets or chocolate, wheat flour, and cornstarch.

4.3.5 Analysis

Focus groups and key informant interviews were triangulated with participant observations, local records, field-based documentation, and descriptive statistics from the household survey. The resulting coded information was analyzed using a three-staged coding process (49), which produced a brief description of the ethnographic landscape and
three analytical categories. The combination of research methods, particularly of participatory evaluation and member checking, allowed us to reach the point of saturation, which is the point at which additional research does not add new information (49). Descriptive analysis was conducted for production, consumption, diet, parcel size, diversity of crops and livestock, and reported chronic health conditions.

The three-stage coding consisted, first, of open analysis that treated information as a whole, identified key words, and produced dispersion plots and other graphical representations. Second, the diet was compared by day of the week and type of meal (breakfast, morning snack, lunch, afternoon snack, and dinner). Third, a categorical analysis created clusters according to the NOVA classification as a whole, groups of meals and preparations, and NOVA classification by case and according to food groups.

Data from the household survey were analyzed using the SAS statistical package (SAS Analytics V. 9.4). We considered household as the unit of analysis; consequently, the universe of subjects was included in the study. We calculated Pearson correlations and linear regressions and checked for multicollinearity.

4.4 Results

4.4.1 Agri-food system

Caliata covers an area of 77 hectares, including roads, walking paths, streams, forests, and other common areas, including infrastructure such as a meeting hall, kitchen, two churches, a volleyball court, and four abandoned classrooms. All residents of Caliata are smallholders: 1.8% own about 50 square meters; 21% own less than 1000 square meters; 52% own less than 1 hectare; and 8.8% own 1 hectare or more, although still
considered smallholders according to Ecuador’s Agricultural Census, owning less than 5 hectares.

In Caliata, crop production is divided into that which is stored, sold, or exchanged, as shown in Figure 10. Amounts that correspond to each category are measured in sacks, which is understood to be synonymous to a hundredweight, although other products are measured in terms of *arrobas*, which have an average weight of 400 ounces.

**Figure 10:** Number of families that produce each crop

Thirty-five different plant species represent the major crops produced in Caliata (range 3-25 crops per family; mean of 9 crops). Only 10% of families produce four crop species or fewer. The variation depends largely on family size and age; in particular, older adults produce fewer varieties. The major crops are corn, wheat, fava beans, barley, beans,
squash, peas, alfalfa, quinoa, lupini beans and several Andean tubers: potatoes, oca (*Oxalis tuberosa*), mashua (*Tropaeolum tuberosum*), mellocos (*Ullucus tuberosus*) and jicama or yacon (*Polymnia sonchifolia*).

Figure 10, however, does not show the variety of within-crop species. For example, we identified eight different varieties of corn and potatoes, some of which residents claim are unique to Caliata. Another fundamental aspect of crop production is companion planting. Every family in Caliata grows corn, generally in association with beans, squash and lupini beans, and typically with two plants that are used for traditional home remedies and as animal feed: vicia (*Vicia sativa*) and lentejilla (*Lepidium virginicum*).

In addition to the main crops, a rich variety of herbs are produced, including lemongrass, lemon verbena, parsley, coriander, oregano, and paico or epazote (*Dysphania ambrosioides*). Smallholders also produce other edible including those that have, medicinal properties or used to make things. Among the most common are llanten (*Plantago linearis Kunth*), fique/pita (*Furcraea andina*), calaguala/samambaia (*Campyloneurum angustifolium*), and chilca (*Phlebodium aureum*). Caliata’s agroecosystem also includes fruit trees, particularly the capuli (Black American Cherry), brambles (genus *Rubus*) and Ecuadorian curuba or taxo (*Passiflora tarminiana*).

There were 91% of families reporting that they keep livestock (Figure 11), including cows, sheep, goats, pigs, llamas, guinea pigs, and rabbits, as well as chickens, ducks, geese, and donkeys, all of which have at least two functions (meat, milk, eggs, fertilizer, work, hair, or hides). The guinea pig is particularly common; being reported by 84% of households, with an average of 15 per household. This finding reflects the cultural importance of the guinea pig in Andean tradition, being used in the diet, feasts, traditional
medicine, and as an asset for future sale. The presence of Andean camelids (llamas and alpacas) also reflect traditional agroecological space.

**Figure 11:** Number of animals and families that own each species.

The poultry category (ducks, geese and, most commonly, chickens), was reported by 82% of the households. As is the case of guinea pigs, chickens have several culturally relevant functions, including diet (meat and eggs), feasts, and in traditional medicine. Chickens are less economically and culturally valued than guinea pigs, however. Caliata’s agroecological space also includes cows (which are valued for their meat and milk), sheep, and pigs. Oxen are still used in the traditional plowing while sheep have symbolic meaning because in the colonial Spanish system, the community was a center for wool and textile
production. Donkeys are fundamental for agrarian tasks. Only guinea pigs, llamas, and alpacas are, nonetheless, native to the Andes.

4.4.2 Dietary patterns

All respondents (100%) stated that they consume the food they produce, which is consistent with the finding regarding origin of the majority of food consumed by the family: an average of 86% of food comes from the parcel while only 14% is purchased. Gender roles represent a critical element in understanding how food is obtained, selected, prepared, and distributed. In Caliata, decision-making for household food consumed is mostly in the hands of women (68% of households as compared to 14% men, and shared responsibility in 18% of households). Notably, similar proportions were found with regard to decision-making in health (women, 63%; men, 14%; shared responsibility, 23%).

In general terms, dietary habits are consistent across families, as well as the ingredients and preparation. To start the day, families eat a combination of machica (ground barley), in black coffee, and a watery vegetable soup, usually made with potatoes, Swiss chard, green onions, and carrots. Tubers are cooked first to thicken the soup and vegetables are added later to provide a crunchy texture. Meals are often prepared with parsley, coriander, or paico, averaging 0.7 ounces per individual. Respondents reported consuming in average five portions of liquids (averaging eight ounces each) a day in the form of black coffee, herbal teas, soup, or other homemade drinks.

The most common snack is a fruit; 70% of household heads reported having eaten at least one fruit in one of the last two snacks, with an average of 2.2 servings. Along fruits, other sources of energy commonly eaten in Caliata represent local foods such as machica, toasted corn, mote (boiled corn), timbo (a mix of different Andean tubers), quinoa, oatmeal
and flours made from wheat, corn, or fava. Additionally, bread, noodles and rice are also consumed. All as seeing as means to sustain demands of vigorous lifestyles derived from agrarian-based work. Based on the NOVA classification adapted for Ecuador, we collated data in the 48-hour recall survey for each of household heads (n=57 x 5 meals [breakfast, morning snack, lunch, afternoon snack & dinner] x 2 days = 570 slots, equivalent to 2513 itemized entries). Each itemized entry represents a food item/ingredient (e.g. apple, potato, salt, coffee). This analysis (Figure 12) showed that the diet in Caliata is based principally on foods in Group 1, representing 66% of the total, and being dominated by vegetables (21.2%), tubers and starchy vegetables (12%), grains (10.7%), and fruit (6.5%). Other foods from Group 1 include two special spices (4.1%) and legumes (2.3%). Special species are achiote or annatto seeds (Bixa orellana) (89%) and cinnamon (11%), which NOVA-Ecuador classifies for this group.

At the other end, of the NOVA spectrum, respondents reported using very few ultra-processed items (Group 4) being limited mostly to instant coffee (2.5% of households). If this item is removed, the consumption of ultra-processed foods is minimal. Consumption of processed foods (Group 3) included bread (90% of respondents), plantain chips, popcorn, French fries, and granola, and animal-based foods included cheese, canned tuna, and canned sardines. Condiments (Group 2) consumed in Caliata include vegetable oil (canola, palm, or corn), shortening as well as a local mixture (aliño) made of garlic, coriander, parsley, paico, oregano, and salt.
With regard to foods purchased in the store or market, respondents reported buying foods rice, noodles, bread, and oil; moreover, 98% of households purchase sugar and salt, followed by fruit (96%), canned tuna (96%), vegetables (90%), canned sardines (86%), red meat (68%), coffee (56%), poultry (54%), eggs (51%), and milk (47%). To a lesser degree, households purchase sweetened beverages (39%), yogurt (26%), industrialized condiments (25%), snacks (19%), and wheat flour and cornstarch (11%). Finally, a small proportion of families (2%), reported buying rolled oats, cocoa, mustard, tapioca, and fish.

Respondents also reported purchasing 21 different fruits, especially apples, bananas, grapes, oranges, tangerines, pears, and pineapples as well as 18 varieties of vegetables, especially Swiss chard, cabbages, cauliflower, broccoli, onions, and lettuce. Here again, we find a preponderance of foods in the NOVA Group 1.
With respect to food consumption, based on the NOVA classification during the 24-hours recall show a range of 3 to 10 (average of 7) in our “healthy diet index” of consumption of foods in Group 1 (grains, dairy products, animal protein, legumes and nuts, fruit; dark green vegetable, red or orange vegetables, other vegetables) as well as vegetable oil and fats. In contrast, consumption of foods in Group 4 ranged of 0 to 3 ultra-processed food items (averaging 0.7), indicating that 42% of respondents did not consume any ultra-processed foods in the past 24 hours, while a 49% consumed one ultra-processed food (almost always instant coffee), and only a 4% reported consuming two or three ultra-processed foods. Our statistical models are consistent to these patterns, there are statistically significant correlations between adjusted agroecological richness with land size and healthy diet index (Table 13).

Table 13. Pearson Correlations among adjusted agroecological richness, land size, and healthy diet index

<table>
<thead>
<tr>
<th>Measure</th>
<th>M</th>
<th>SD</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adjusted agroecological richness</td>
<td>18.2</td>
<td>5.9</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Land size</td>
<td>2.7</td>
<td>0.7</td>
<td>0.26*</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>3. Healthy diet index</td>
<td>7.1</td>
<td>1.6</td>
<td>0.31*</td>
<td>0.14</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: M indicates mean; SD indicates standard deviation.
* correlation is statistically significant at 0.05 level (two-tailed).

A statistically significant inverse correlation was found between individual’s age and the average amount of fruit consumed in the past 24-hours (p < 0.01; r = -0.36). That is, the older an individual is, the less fruit they consume on average. Parcel size was not statistically significantly associated with variety of food purchased (p=0.64).
The linear regression model of parcel size and species richness was statistically significantly associated with the outcome of healthy diet index \( (p<.05, r^2 = 0.14) \). Parcel size approached statistical significance \( (p = 0.08) \). Healthy diet index was significantly associated with adjusted agroecological richness \( (p<.05; \beta=1.01) \), suggesting that increases in adjusted agroecological richness increases the diversity of the diet (roughly 1.01 units of adjusted agroecological richness increases by one the diversity of the diet).

A linear model including parcel size, species richness, and variety of food purchased was regressed on healthy diet as the outcome. The overall model was statistically significant \( (p<.05; r^2 = 0.1475) \), indicating that parcel size, healthy diet index, and food variety explain 14.75\% of the variance in adjusted agroecological richness. The healthy diet index was significantly associated with adjusted agroecological richness \( (p<.05; \beta=1.088) \), confirming that as adjusted agroecological richness increases by 1.088 units, the healthy diet index increases by one unit.

These findings are consistent with community perceptions regarding their diet quality; 100\% of survey respondents stated that they consume what they produce, this being the main source of food, as shown above. While 3.5\% of respondents believe that the household diet is inferior compared to other communities, and 21\% believe that it is about the same, three quarters believe that their food is better because of the diversity and the nutritious quality of foods produced and consumed, and the fact that their crops are organic produce.

4.4.3 Demographic challenges and diseases

The feminization of agriculture is an important aspect of rural life in Ecuador, as it is elsewhere. The survey revealed that 53\% of families have a woman as head of the
household without an adult male present. Of the 54 female respondents, 77% reported that they had not received financial support within the past seven days; an indicative of the role of subsistence agriculture. Moreover, as in Ecuador as a whole, Caliata’s population is aging.

The survey revealed that there are no infants from 6 to 18 months of age and no pregnant women. We encountered only six families with children from 2 to 9.9 years of age and only 10 children in all; eleven families had children from 10 to 18 years of age (15 in all), and only three families have children in both age groups. In contrast, 52% of survey respondents were older adults (≥ 65 yrs.; mean 73.66 years.). Life expectancy at birth in Chimborazo province is 70.0 for males and 76.7 for females (50), although the rural sector lags behind the urban population in this respect (51). A 26% of people that participated in the survey had surpassed average life expectancy, and we found four residents of 100 years of age or more.

The feminization of agriculture and population aging are simultaneous demographic factors and are related to migration, including of women in fertile age. The youth of Caliata are the most prone to migrate in order to receive formal education, earn better incomes, and to access goods and services found in cities. These demographic trends represent a challenge to the very survival of the community as a cultural entity with a local identity, collective memory, use of the Kichwa language, social institutions, and agroecological practices.

With regard to health conditions, the survey has no data of infant morbidity because of the absence of individuals in that category. But 32% of respondents reported chronic conditions, representing a total of 18 cases, of which an 89% are older adults. The most prevalent chronic condition reported was high blood pressure (35%), followed by kidney
stones (19%), kidney failure (19%) and heart attack (11%). Two respondents reported that they were diabetic (8%), one had heart failure (4%), and another had heart disease (4%). In addition, one person reported high blood pressure during pregnancy, but no cases of diagnosis of preeclampsia or eclampsia were found.

A small semi-urban center in the parish of Flores has a public health facility that serves Caliata and twenty other communities. An analysis of publicly available records of the MPH revealed that the facility attended an average of 183 patients per month from January to December 2018 (ranging from 71 patients in December to 250 in May). Infectious diseases (diarrhea, urogenital tract infection), respiratory diseases, and injuries resulting from accidents represent the most common health problems in the population of Flores (N= 4 546). Among adults from 20 to 64 years of age and older adults (≥65 yrs.) the records for 2018 indicated four cases of diabetes and twenty cases of high blood pressure; none of the other chronic conditions were reported.

4.4.4 Food sovereignty (Ecuador’s concept)

Caliata is characterized by a diversity of heterarchical organizational arrays in the form of family units (ayllus) and formal and informal groups (agencies), including the community irrigation organization and special committees that deal with issues related to solidarity, health and nutrition; culture and language; and agroecology. The agri-food system represents overlapping of biological, social, and cognitive processes within a physical and symbolic space. Through their cosmovision the agroecological space is expressed as the production cycle and the central role of stewardship of Pachamama (Mother Nature, soil, land, and territory).
The ancients even said that it is not worth having a lot of clothing, one change of clothes is sufficient. Mother Nature is the only thing that matters, take care of the soil; if we work with our own hands, we eat well, no matter that we don't have enough clothes to dress. (A participant in a focus group with women in Caliata, June 2018)

The integration of anthropogenic and biochemical factors, bonded by indigenous cosmovision, forms an ecological community, which is affected by and evolves through endogenous forces, such as agricultural change and bidirectional migration waves as well as exogenous forces, such as market conditions, public policy, and urbanization. In the contemporary collective memory, the residents of Caliata are proud heirs of an ancient civilization, which is the foundation of their ecological community and of a knowledge that includes agrarian calendars and methods of pest control, seed selection, soil restoration, nitrogen fixation, and observation of natural occurrences (e.g. birds, insects) that signal the beginning of phases in the production cycle.

The most outstanding representation of this ancient past is a pre-Columbian system of terraces, trenches, and contention walls found throughout Caliata. This system has agroecological functions based on a diversity of plants and animals that are strategically and efficiently allocated and used, including ecological interactions (e.g. companion planting), cover crops, and organic fertilizers, which have provided the community, a reliable food supply. The significant relationship between diversity in the agroecological space and diversity in the diet parallels a community-based model developed in a participatory evaluation exercise conducted in May 2019 (Figure 13).
Four concepts (health, exchange, diversity, and resilience) combine to represent the ecological community from an endogenous perspective that is consistent with findings presented above. Exchanges, diversity, health, and resilience are dynamic, interconnected, and overlapping factors. Their interrelationships in the agri-food model represents a facet of the system as well as the perceptions of the residents of Caliata, who view the ecological community in relational, reciprocal, and respectful terms. For example, a prayer is offered before working the land and permission from Mother Nature is asked before proceeding.

The survey also addressed assets (land, house, and other property). We assumed that in most cases, the appraisal of the respondent would reflect the size of the parcel owned, but we did not find a relationship between reported assets and parcel size. Most residents do value their land based on its market value. Rather, access to land gives people
a sense of place in Caliata and in that sense, land is central to identity and a sense of belonging. Land is so precious that it is seldom bought or sold, except in exceptional circumstances, and often the community would have a say in any formal land transaction. Even those who have migrated to the city retain property ownership and travel to the community during festivities.

Caliata’s historical memory also includes experiences of conquest and racism, which are combined with a present-day awareness of contemporary external threats, particularly environmental pollution and the decay of the terracing system. In spite of these challenges, Caliata is able to resist external and global influences, in large part thanks to indigenous cosmovision that keeps the system operating – because it is based on shared principles, which are connected to a rich system of agroecological knowledge and to a sense of purpose. In this context, the concept sustainability is expressed in pragmatic terms as “guagua guaguapi” (caring for the next generations).

The traditional indigenous knowledge base is reflected in six ways that the residents of Caliata care for their agroecological space: (i) care taken in preparing the parcel; (ii) safeguarding native seeds varieties; (iii) protecting the parcel from wind erosion; (iv) protecting the topsoil from water erosion; (v) practicing crop rotation, fallow, and crop associations; and (vi) “feeding” the parcel by rejuvenating soil and other resources. These practices contribute to a nutrient loop between people and agroecosystem, while responding to the core principle of respecting Pachamama, including the individual parcel. This involves rejuvenating the soil with different organic fertilizers and complex interactions between plant species and livestock and poultry.

Finally, the study is acting as a platform for sumak kawsay-oriented projects (www.caliatainitiative.org). Hence, the research team has already delivered a capacity-
building outcome as a local collaborator was invited to participate in a school of agroecology and nutrition sponsored by two international organizations. After training, our collaborator used data from this study to write a project profile with the aim of creating a group of local women to gather traditional food recipes in order to promote good nutrition and the conservation of native crops.

4.5 Discussion

Notably, 90% of families produce more than five different crops in their parcels that are accompanied by at least five other agroecologically edible plant species. Associated crops produced by all the families in Caliata, including five endemic edible plants, averaged 18 species per family. In addition, 82% of the families keep different species of poultry and 84% have guinea pig. Taking into account these circumstances, Caliata falls in the high agrobiodiversity spectrum for smallholders globally (10,30,31).

Agrobiodiversity seemed to align with dietary diversity among the Caliata families. Although there was minimal variability across households, dietary diversity was high across days. Notably, two-thirds of households consume unprocessed and minimally processed foods, while minimal consumption of ultra-processed foods contrasts with global tendencies (52), and emerging dietary habits and preferences (53). A recent publication of the American Heart Association states that evidence from observational studies shows that “greater dietary diversity is associated with suboptimal eating patterns, that is, higher intakes of processed foods, refined grains, and sugar-sweetened beverages and lower intakes of minimally processed foods” (54: e160).

In comparison to consumption of items in the four NOVA food groups at the national level (29), household heads (and presumably their families) in Caliata consume
relatively fewer grains (NOVA Group 1 & 2 combined) and legumes (Group 1) and more tubers, vegetables, and fruit. For example, Ecuadorians consume a daily average of 2.29 servings (183 g/d) of fruit and vegetables (29), while in Caliata in a 24-hour period 70% of household heads consumption of fruit alone averaged 2.2 servings. While in a period of 48-hours, fruit and vegetables (excluding tubers and starchy vegetables, grains, two spices, and legumes) represented in proportion a 27% of the diet of household heads in terms of food groups (see Figure 1). Caliata is located only eleven kilometers from the provincial capital city of Riobamba, but our systems approach reveals a stark contrast between Caliata and urban environments, particularly in that Caliata’s residents express a strong preference for a healthy diet composed of unprocessed foods produced on their own land.

The Caliata community showed a low prevalence of chronic disease which may emerge from its high fruit and vegetable consumption and levels of physical activity (29,54). Furthermore, information provided by heads of household shows that only 2 of 18 cases of chronic conditions reported corresponded to people under 60 years of age. Among older adults, the results are consistent with national figures in that the most prevalent chronic condition is high blood pressure, while the prevalence of high blood pressure, heart disease, and diabetes is relatively lower compared to the general population (55). While the Caliata case suggests that chronic diseases may be mitigated by fruit and vegetable consumption and diets largely absent of ultra-processed foods, considering the persistence of stunting at the provincial level (29), access to other food types such as animal source foods for young children require more attention.

Caliata’s agroecological space is both physical and symbolic, in which biochemical interactions and cycles are mobilized through a diversity of heterarchical organizational arrays combining extended family units (ayllus) and specialized agencies (e.g. irrigation
organizations and special committees that organize issues such as solidarity, health, and nutrition). Physical space is characterized by a complex pre-Columbian system of terraces that has consistently provided food to the residents of Caliata for generations. In contrast, symbolic space is defined by the stewardship of *Pachamama* (Mother Nature), a central role in traditional local cosmovision.

Caliata is a historical, ethnic, cultural, and agroecological entity that has retained many traditional sociocultural features. The community has resisted conquest, marginalization, racism, economic disparities, rural-urban tensions, disenfranchisement, and epistemological dominance. While Caliata has endured by responding creatively to challenges, it is still subject to the same structural transformations found elsewhere in the country and region, including demographic and epidemiological transitions, the feminization of agriculture, and outmigration (18–20). As elsewhere in Ecuador, males frequently participate in different forms of cyclical, temporary, and even semi-permanent wage migration because while Caliata’s households provide for many of their needs through agricultural production and animal and poultry husbandry, they live in a monetized economy. Both components—cash income and household production—represent strategies for household survival, particularly to access non-food items and foods from other altitudinal levels.

Food sovereignty is an ecocentric decision-making concept based on production, exchanges of produce, seed and companion planting, and the manner in which agroecological space is treated. These relationships represent a nutrient loop tied to a system of knowledge related to care for soil, land, and the ecological community. This conclusion is consistent with studies that recognize the role of rural communities that have been articulated in Ecuador by the indigenous movement, which bases its discourse on
agroecological production, healthy diets, and the consumption of natural and fresh foods (56).

The Andean cosmovision, as expressed in Caliata, incorporates a cognitive domain or worldview based on a rationalization of the living experience. It explains how the cosmos and its mechanics function; the indigenous ecological knowledge is tied to phenomenology and covering laws. The cosmovision also has an ethos that is expressed in an emotional domain reflected in symbols, stories, and rituals. This domain interacts with the worldview in shaping behavior. Finally, there is a cosmovision’s spiritual domain that in essence connects people, animals, ancestors, land (chakra), and Pachamama (biosphere–Mother Nature), causing a sense of purpose around the generation of life: cultivation.

The indigenous view of the complex interrelationships between land management, agriculture, animal husbandry, and food security were articulated in a letter written by a Caliata community elder in 2018.

*Harmony with nature is real:*

[…] soil, water, sun, wind, human being and every living being live in harmony, connected to each other. When the human being alters this order of nature, there comes hunger, famine, diseases, and therefore, malnutrition and displacement of populations from one place to another […] When the wind blows suddenly, one takes off one’s hat and says a prayer to the wind. That is why we communicate, greet, respect, and talk with nature.

*Civilization views:*

Here is an example: our ancestors endured all kinds of invasion after invasion, exploitation, humiliation, racial segregation. Finally, pollution; that is, we are currently supporting the poisoning of humans, animals, and plants. For the large transnational companies with the so-called fertilizers and chemical fertilizers.

*Food Sovereignly:*

Having to eat (food) is sovereign to us; above all things, you can have cars, buildings, companies, airplanes, cruises, (but) if you don't have anything to eat "you die," that is our conception of life. This is the first requirement: to give our Mother Nature a good diet so that she is well fed, fertile, and fecund to offer the best fruit to feed every living being. Every seed you sow with your hands in the row of our Mother Nature, you are cultivating to generate more years of life.
As food systems evolve, societies and individuals change the meaning of food, production patterns, institutions, and preferences (4,5). While global in scope, these changes are particularly evident in small communities. Small-scale and subsistence agriculture is increasingly in conflict with worldwide international food chains that provide global consumers with commodities such as coffee, cocoa, soy, corn, and cotton. The globalization of food is not unilinear, though; important countercurrents can be seen including resilience at the local level (10,24,32). Furthermore, understanding rural dynamics is a fundamental aspect of urbanization—entropic by design and functions (57), and they rely on their peripheries. Rural communities, in turn, are affected by their ties to cities (57).

In Ecuador, sumak kawsay or good way of has been expressed by granting constitutional rights to nature. This policy reflects Andean cosmovision and also speaks to the role of small communities in countries like Ecuador, which lie in the periphery of the world-system (58). Nevertheless, the relationship between “Pachamama” and the “good way of living” provides a local alternative to understanding nutrition, health, and wellbeing as lived in many rural communities (17,27). As a Yachag (an elder or traditional health practitioner) stated in a panel of experts in 2013: “food is not only to feed the body, but also to feed the spirit and to create empathy.” This concept is put into action in every aspect of daily life such that food has cultural, emotional, and spiritual meaning that links people, the land, and the biosphere.

As an alternative to globalized transitions, agrarian and environmental movements have presented new alternatives of food systems worldwide (59,60). Caliata is an example of resilience, which can be viewed as a critical feature of sustainable food systems, which is the basis of sustainable diets. This resilience is explained by an array of factors, such as an
hierarchical regime defined by a diversity of specialized organizations, an efficient search for the common good, and the value of consensus. In this context, a landscape defined by an ancient system of terraces and other structures and by agrodiversity stewardship of natural resources, and continued reliance on the relationship between traditional cosmovision and agricultural cycles and calendars.

This study has some limitations that merit mention here. As a cross-sectional study, we are unable to clearly observe or measure changes. Potential biases that can affect essentially all research are readily acknowledged. Nevertheless, while we worked from within the community, we attempted to confront and address biases as they presented themselves, in each stage of planning, data collection, and analysis. Another potential limitation was the age structure of the community. We were not able to assess dietary patterns among young children for example as a subgroup vulnerable to stunting and undernutrition.

In our opinion, one of the strengths of this student was its community orientation. We included community members not only as subjects, but as members of the field team and as coauthors. Moreover, this study is part of a decade-long relationship with the community, so that the research project was part of a commitment meaningful and long-lasting changes in the community. We approached Caliata from an inductive perspective without formulating a hypothesis for confirmation and without constructing a priori categories, the idea being to explore the food system in its full dimension as described by community members. Similarly, the analysis of qualitative data involved a sequence of coding that was designed to reveal underlying patterns of response that did not reflect preestablished categories.
All data gathering instruments were subjected to a process of cultural and linguistic validation. Much of the work was conducted in the Kichwa language by local collaborators and then translated and assessed independently by several local collaborators. Furthermore, we included participatory assessment and member checking of findings with community members. Finally, we triangulated information from several sources and employed the principle of saturation, reflecting the point at which additional research does not add new information.

In sum, Caliata may illustrate a positive deviance (61) in the context of food system. The situation of Caliata resembles well lifestyles of communities living in the blue zones, like Okinawa in Japan, Nicoya in Costa Rica or Sardinia in Italy (62), in terms of contact with nature, physical activity, social cohesion and diets based on fresh, diverse and minimally processed foods. The case of Caliata illustrates the importance of understanding sustainable diets in the context of agri-food systems and a multitude of interconnected individual and social phenomena, including food preferences, production, processing, rituals, and meals (4,5). Caliata also exemplifies the concept of ecological community, as conventionally used in biology (63), but which should also include the human factor. This concept resonates with alternative socioecological frameworks (9,23,24,56,59), especially, in this case taking Andean cosmovision –ecocentric– into account.
4.6 References


   doi:10.1016/j.cosust.2015.03.004


2009. doi:034378

doi:10.3945/ajcn.114.083766


doi:10.1177/0094582X10384209


Regist Of 449. 2015. doi:10.1017/CBO9781107415324.004


27. Waters WF, Gallegos CA. Aging, Health, and Identity in Ecuador’s Indigenous


50. INEC. Compendio de Resultados Encuesta de Vida ECV, Sexta Ronda 2015. doi:10.1007/s13398-014-0173-7.2


doi:10.1177/1559827616637066

Conclusions

Described in three chapters, the case shows that the agroecosystem has a variety of intertwined factors within and across dimensions. For example, in a dimension of psychosocial factors a mode of social organization and governance [heterarchy] is connected to customary institutions (like the reciprocity-based minga, feasts, and indigenous justice) and to the local identity around a relationship with Mother Nature (Pachamama), the landscape and the realm of the living. In contrast, from a biochemical perspective of the agroecosystem, an efficient agroecological architecture, agrodiversity, ecological associations, and soil fertilization and pest control strategies are among the central factors. These factors are all interconnected to the food production and dietary patterns encountered in Caliata.

In Chapter 1, I focused on the psychosocial dimension using David Stark’s (2011) framework for heterarchy. In Chapter 2, I focused on the agroecological dimension, where salient features are an active to date pre-Colombian system of terraces managed with a well preserved Kichwa-Puruwa ancestral knowledge. In Chapter 3, it was possible to combine psychosocial and agroecological dimensions. In doing so, the emphasis of the chapter was placed on the link between food sovereignty and sustainable diets. For example, the NOVA food classification (Monteiro et al., 2016) allowed the categorization of the diet, and then the comparison of the diet with size of the parcel and food production; all consistent with a local definition of food sovereignty.

[Sustainable diets are] those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources (as cited in Fischer & Garnett, 2016: 10).
Considering the above definition for sustainable diets, which reached consensus during the 2010 International Scientific Symposium “Biodiversity and Sustainable Diets: United Against Hunger” (organized by FAO and Biodiversity International), in Caliata is possible to recognize that sustainable diets meet criteria for food security supported by viable ecosystems (Fischer & Garnett, 2016; Tirado-von, 2017). This is mobilized by human behavior, in which the relationship with nature is central. It is also possible to advert the elements that typically characterize a sustainable diet, like the diversity of healthy foods consumed by households (Fischer & Garnett, 2016).

Following Marsh et al. (2004: 1177) rationale that “the most efficient way to improve health is to use locally available, sustainable, and effective approaches, the Caliata case features two issues. First, the promotion of a localized reality representing a positive deviance, an unanticipated gain, which has the potential to serve as a model for healthy agroecosystems with healthy people in the central highlands of Ecuador and beyond. Second, a systems’ view (e.g. Meadows, 1999; Richardson, 2011) based on the dynamic interaction of psychosocial and biochemical dimensions, deeply interconnected as a whole (Gallegos-Riofrío et al., 2019). This holistic perspective is the outcome of a cosmovision (worldview-ethos-behavior) that is ecocentric, the relationship with nature is essential as noted above. This is consistent with the experience of other indigenous communities in Ecuador (Gallegos & Jara, 2007), and similar to other indigenous societies elsewhere (Kirmayer, Brass & Tait, 2000).

Moreover, through the analysis of psychosocial and agroecological dimensions, separated and combined, it is possible to identify limits and possibilities of food sovereignty and sustainable diets in indigenous communities, particularly in the Andean
region. For example, it was noted that in Caliata, food sovereignty and sustainable diets are contingent on organization, exchange, diversity, resilience, and health on multiple levels. In addition, the methodological approach undertaken facilitated that community self-reflections could be examined in the context of national and international discourses –like the *Sumak Kawsay* (or Good Way of Living), a post-development proposal (Kothari et al., 2014), *La Via Campesina*’s food sovereignty (Patel, 2009), and planetary health as a conceptual lens to face humanity’s challenges (e.g. Steffen et al., 2011; Willett et al., 2019).

Each chapter has been presented as a stand-alone manuscript, so a discussion section was provided that interprets findings, offers limitations, and presents implications. In this concluding chapter, I present the case overview in dialogue with its methodological innovations. I also place the lessons from Caliata in the context of current debates around planetary health (e.g. EAT-Lancet Commission), with attention to the role of indigenous people. Toward the end of this final chapter, I present insights to the applied implications of this work, including future research plans.

### 5.1 An in-depth view of Caliata

Throughout time, cities have risen at the expense of ancestral traditions, and eventually fallen. Some have even recognized a correlation between the slow and increasing distance from natural resources… [if the collapse of civilization is inevitable] Many would contend not, and further that a large part of the solution is Biocultural Conservation. Biodiversity and conservation are not ‘lifestyle choices’ – they are the measure of civilization or, in their absence, its decline.

–David Maxwell Braun (Sept 2014) in *Changing Planet*, National Geographic

As a research experience, the case can be summarized in terms of unanticipated gains, which are interconnected in a narrative about a remarkable living system. Caliata represents a resilient space for maintaining cultural identity, where an ecocentric society
and ancestral knowledge and practices catalyze the efficiency and integrity of the ecosystem. In a scale with *pro et con*, we may be witnessing a plausible example of sustainability where culture and ecological functions are effectively combined (see. e.g., Sterling et al., 2017).

Caliata represents a case of positive deviance, an unanticipated gain as already emphasized, in that it is a space where sustainable diets are taking place and food sovereignty provides an ecocentric way of living based on production, exchange, consumption of local produce, and knowledge of how *Pachamama* should be treated. The key element in the positive deviance concept is to advert the advantages that lead to healthy outcomes, which in the logic of a system may represent factors operating on cause-effect relationships. In this regard, the concept of positive deviance operates based in a context (Caliata compared to indigenous communities in Chimborazo), in a similar fashion to resilience that is also in relation to something (e.g. resilience to stress or inclement weather).

As noted in Chapter 2, the agroecosystem has several factors of contrast, like Caliata’s remarkably high agrodiversity and their soil health compared to indigenous communities in Chimborazo. Based on the analysis of the agroecological dimension, it is possible to speculate that the salient advantage of Caliata is their pre-Columbian system of terraces. However, there is an important conjoint of factors that are behavior-based. Particularly, considering findings in Chapter 3, consistency was found in dietary patterns characteristics of sustainable diets; all respondents reported intelligent hydration strategies as well as strategies to balance intakes with energy requirements, fruits being the most popular snack. Additionally, two-thirds of households consume unprocessed or minimally
processed foods. Meanwhile, chronic health problems remain relatively infrequent compared to the general population. This represents a stark contrast to global trends (Springman et al., 2018).

The cosmovision construct is relevant to understand the concept positive deviance, which is a behavior-based concept. In this context, the importance of the cosmovision lays in its effects in people, as psychosocial factor, it is an example that shows how the symbolic has tangible effects, particularly in the way soil, plants, animals, land, and planet as a whole are treated. In this sense, the notion of Pachamama is not essentially different to other depictions of Mother Nature elsewhere. The cosmovision is a part in the rationale for the shift of questions posed in the introduction:

Moving from “How are we going to feed 10 billion people by 2050” (EAT-Lancet, 2019) to: how the current 8 billion will work cooperatively to regenerate Mother Nature?

Results showed that the agroecological space is defined by the stewardship of Pachamama, essential in the Andean cosmovision as articulated in the constitutional and legal framework of Ecuador and Bolivia (Zaffaroni, 2011). The cosmovision gives purpose to feasts celebrated during the agrarian calendar and explains natural cycles. The sense of diversity in Caliata is present in social organization in specialized structures like families and committees (a defining trait of heterarchy [see. Crumley, 2015]), and in the landscape; Caliata has a high agrodiversity by comparative measures (see. Oyarzun et al., 2013) as well as by total number of species (see. Bellon, Gotor & Caracciolo, 2015).

In Caliata, diversity was consistently found in dietary patterns, as reported by heads of households. Thus, residents consume their produce and local fruit and others brought
from the lowlands are the most popular snack. Two-thirds of households consume unprocessed or minimally processed foods and consumption of highly processed and industrialized food items is minimal. Residents have smart hydration strategies as well as strategies to balance intakes with energy requirements. Both are effective for meeting the physical demands of lives dedicated to the chakra. This suggest that Caliata has sustainable diets (Fischer & Garnett, 2016). Gendered agriculture and population aging represent demographic challenges, however chronic health problems remain relatively infrequent compared to the general population (Guevara & Andrade, 2015).

These results represent a hopeful contrast to the prevailing notion of the nutrition transition that assumes the inevitable change of diets and lifestyles with the emergence of chronic diseases (Popkin 2001; 2004). In the nutrition transition framework, rural and indigenous communities move into hyper caloric diets based on industrialized and ultra-processed foods and sedentary lifestyles in detriment to their traditional food ways and the vigorous lifestyles associated to agrarian activity (e.g. Azcorra et al. 2013; Beard et al., 2007).

Caliata has retained a strong cultural identity, including language and ancestral knowledge; for instance, the chacarero is the one that knows how to take care of the chakra. In Caliata, notions of health are not limited to people, but also expressed in the health of the agroecosystem through factors like soil quality and biodiversity. Caliata’s agroecosystem operates as a nutrient loop tied to ecological principles of caring for the soil and land, including crop-association schemes (e.g. corn-beans-squash-quinoa-lentejilla-vicia-and-lupini beans –as detailed in Chapter 2).
As mentioned above, resources are efficiently managed by a heterarchical mode of organization and governance: an ecosystem (e.g. Stark, 2011). Archeological evidence in the Andes supports the existence of heterarchical pre-Columbian societies organized as small-scale egalitarian and resource-specialized communities with the capacity to create and maintain intensive productive systems that may persist to the present day (see. e.g. Bray 2008; DeMarrais 2007; Hastorf 2002). Heterarchies are effective and efficient ways to manage agroecosystems, including the fertilization of parcels, creation and maintenance of agrarian infrastructure, and the exchange of seeds (Erickson, 2006; Rivera-Muñoz, Meulder & Proaño, 2018; Scarborough & Lucero, 2010).

Heterarchical organization and governance is expressed in Caliata by distributed and shared intelligence through the application of diverse, specialized functions that are constantly negotiated in order to reach consensus and procure optimal responses to collective decisions in the face of uncertainty and limited resources. A local indigenous identity infused by the symbolic force of the cosmovision and practiced through customary institutions that promote trust and cohesion are the foundations of this mode of organization and governance. Understanding these psychosocial and organizational factors at play in mobilizing agri-food systems (i.e. labor-intensive tasks and food production, exchange, and processing) is key to understanding the contemporary expression of ancestral technologies used to achieve sustainable diets (e.g. Carrasco-Torrontegui et al., 2020).

The heterarchical organization in Caliata should be thought of in the context of its ancient agroecosystem architecture. The pre-Columbian system of terraces (including ditches and contention walls) is also efficient and effective as energy traps (e.g. maximum exposure to sunlight, water, and nutrient retention), and includes factors like ecological
richness, evenness, and ecological mutualism (such as association crops schemes). The terracing system shapes a heterogenous landscape with a variety of ecological niches and microclimates that support the richness of species found in Caliata. This is essential to the diet, which is largely explained by local production and food exchanges from other altitudinal floors, which is a strategy practiced in Caliata from remote times.

Similar features in both ecological functions and in the capacity to sustain healthy diets have been observed in traditional agroecosystems around the world (Altieri, 2009). A body of literature often refers to these spaces as ecocultural or biocultural space because of a remarkable carrying capacity and resiliency (Sterling et al., 2017; Winter & Lucas, 2017). Relevant examples of biocultural landscapes are the traditional satoyama rice fields (Fukamachi, 2017) and the Hawaiian Limahuli gardens (Winter & Lucas, 2017); both landscapes operate using terracing systems that integrate agrodiversity and infrastructure such as ditches and ponds for irrigation.

A combination of structures, functions, and culture creates an efficient whole. This array of psychosocial and agroecological dimensions represents unexpected findings because, like most people involved in public health and working with rural communities in Ecuador, I expected to uncover the bitter faces of poverty; chronic malnutrition, hopelessness, eroded land, and seriously affected ecosystems. Caliata is not exempt from problems and challenges, but it presents contrasts not only in nutrition and health parameters, particularly in the context of the province of Chimborazo (Freire, Ramirez, Belmont & Mendieta, 2014), but also in the health of the ecosystem, even when compared to communities that have been externally supported to promote better diets through the agroecological intensification of agriculture (e.g. Oyarzun et al., 2013; Bellon et al. 2015).
Both dimensions (psychosocial and agroecological) prompt resiliency in terms of capacity to respond to endogenous and exogenous shocks through specialization, diversity, and the capacity to adapt (e.g. Crumley, 2012; Zimmerer, 2015). By the same logic, food sovereignty (Patel, 2009) is structurally and functionally assured, reflecting psychosocial phenomena such as a preference for healthy and diverse diets and emotional attachment to the traditional diet and to land. Ecosystem functions, including carrying capacity of the local food system and resilience are fundamental to respond to major global forces that are caused or accelerated by anthropogenic actions such as climate change and ocean acidification (e.g. Ripple et al., 2019; Schlüter et al., 2014).

As mentioned above, Caliata represents a case of positive deviance. This concept, as noted in Chapter 2, was proposed in Oyarzum et al. (2013), in the context of Chimborazo province, as a mechanism for observing what is working well in indigenous communities that are historically poor, marginalized, and chronically malnourished (Freire et al. 2014; Ramirez et al. 2019). This view does not contradict the many challenges and threats that Caliata is experiencing, particularly population aging and increased pressure to modernize agriculture. Outmigration rural to urban and the modernization of agriculture define the physical and demographic landscape of the Ecuador’s highlands as a result, for example, of land use changes and policies like the agrarian reforms (De Zaldívar, 2008; Dufour & Piperata, 2004; Waters, 1997).

5.2 Methodological contribution

The systems perspective allows for observation of cause-effect interrelations in an integrated whole, while it favors acquiring a twofold structural and functional explanation
of complex phenomena (Bunge, 2004; Meadows, 1999). The system perspective also implies setting or defining the boundaries of the system (Richardson, 2011), Caliata is observed as a historical and cultural entity as well as an ecological community—where people are participating in (and are emotionally engaged) in actions to mobilize trophic processes at different levels, from soil fertilization to the creation of anthropogenic biomes (e.g. rangelands, croplands).

This perspective also incorporates endogenous views of those embedded in the system (Hovmand, 2014), including distinctive ways of knowing and understanding the system. The endogenous view is expressed in the context of community-centered research that responds to community expectations. In consequence, fieldwork was conducted participatively, and this facilitated an inclusive environment. As a result, the exploration of psychosocial and agroecological dimensions (the integrated agroecosystem) encompasses the voice of local actors, bringing nuance to intangible domains; e.g. their historical memory and the behavioral-cognitive matrix that is present in a heterarchy (see. Stark, 2011).

The systems view is accompanied by other methodological aspects that are central to the philosophy infused in this dissertation, such as the trans-and-interdisciplinary strategy (Choi & Pak, 2006), which allowed for incorporating different methods and bodies of knowledge. The strategy included biodiversity assessment of richness and evenness (Moreno 2001; Oyarzun et al. 2013); MO-Dirt protocols for soil health (Arango-Caro & Woodford-Thomas, 2015); the NOVA food classification for Ecuador (Freire et al. 2018); 48-hour dietary recall using cognitive theory (e.g. Gobet et al., 2001; Rugg et al. 1998); and Stark’s (2011) analytical framework for heterarchy.
An in-depth study of a local food system contributes to a “deeper understanding of diverse ‘rural worlds’ and their potential pathways to sustainability through agriculture” (Thompson & Scoones, 2009: 386). This approach views agro-food system as heterogeneous and dynamic (Rivera-Muñoz et al. 2018; Thompson & Scoones 2009), as well as mobilized by complex social structures and functions (DeMarrais & Earle, 2017) and intertwined over time and space with non-linear and multidimensional factors (Sterling et al. 2017). This view contrasts to an interpretation of food systems as linear chains of events that link production to consumption through processing, marketing, storage, consumption, and waste (see. e.g., Heller & Keoleian, 2003; Lang & Barling, 2012).

This localized approach emphasizes a conceptual construction of all the particularities found in indigenous identity and cosmovision. This stance aligns with an understanding of a food system that is consistent with the field of human ecology (Hannan & Freeman 1977; Hawley 1944) and other intersections between natural and social sciences that are implicitly committed to integrating ethnosphere and biosphere in a healthy planet (see. e.g., Altieri 2004; Erickson 2006; Roué & Nakashima, 2002).

The cosmovision renders life as holistic experience that is consistent with Darwin's definition of ecosystems as entangled banks. Consequently, in Caliata, as also happens in the field of ecology (e.g. Ricklefs & Relyea, 2014), each dimension (i.e. psychosocial and agroecological), is fundamental for understanding causal relationships like food preferences that favor a healthy and diverse diet or consensus that is made possible through a constant exercise of negotiation between families and other organization units. It is, therefore, impossible to distinguish the boundaries of dimensions; a pragmatic position is to make distinctions only as purposive to the end pursued.
The end result of these efforts, including incorporating an ontology inherent to Caliata, is a dissertation with an ecocentric stance, which places human organization as a part of nature and not as an exogenous force operating on it, thereby differing from analytical frameworks based on a resource management perspective—without discounting the enormous value of these contributions (e.g. Rammel, Stagl & Wilfing, 2007; Schlager & Ostrom, 1992). This divergence is not necessarily noted in other literatures, however the ontological differences and the importance of a “dialogue of wisdoms” has been well recognized and promoted (Altieri, 2004; Kuhnlein & Receveur, 1996; Roué & Nakashima, 2002).

5.3 The state of things

Two decade ago, earth systems analysts Schellnhuber and colleagues (1997: 19) stated that: “[the health of] patient Earth has considerably declined.” We should all ask the inevitable question: How did we get here? There is no easy answer, but if we are intending to have a future, we should have the awareness that the past two hundred years, an infinitesimal part of our existence as a species has been greatly responsible for the state of things.

Following the narrative of planetary health, *Homo sapiens* have been inhabitants of the ecosphere for at least 200,000 years, while our most essential connection to the planet has been food (DeFries, 2014) that nourishes our bodies, cultures (the medicine of the Hippocratic axiom). Our ancestors expanded the geographic range of the species, enhancing biodiversity. Including, for instance, the neotropical fruits that have contributed to diversify past and present human diets (Van Zonneveld et al., 2018). From historical and
evolutionary perspectives, an important portion of the planet’s genetic diversity as well as the ecological functions that support humanity’s food systems are the result of interactions between ethnoses – in reference to Davis’s (2002) ethnosphere concept – and their environments (Haberl et al., 2007; Schellnhuber, 2012; Van Zonneveld et al., 2018).

From only a “one digit fraction” of our time on the planet (the past 12,000 years), our relationship with Mother Nature has become more complex, primarily because the domestication of plants and animal species; i.e., the invention of agriculture as we know it – the “complex system of mutual secondary energy traps for the species involved” (Beardsworth & Keil, 1997: 25). At this critical moment, the beginning of the Holocene, the planet experienced the improvement and rapid spread of agriculture, propelling the beginning of a 10,000 years period of accommodating environment for humans (DeFries, 2014; Steffen et al., 2011).

This array of overlapping events (a warmer climate, agriculture occurring in different parts of globe, and settlement) also marks the beginning an accelerated period of development of human societies (Feder, 2004; Zalasiewicz, Williams, Haywood & Ellis, 2011). Nowadays, humanity has become a global actor in the planet’s health; our species’ agency has shaped ecosystems functions and enhanced biodiversity, while agriculture is our undeniable landmark. Humanity controls “more than 50% of the net primary terrestrial production caused by green plants” (Schellnhuber, 2012: 17) – human appropriation of net primary production (HANPP).

[HANPP] the aggregate impact of land use on biomass available each year in ecosystems, is a prominent measure of the human domination of the biosphere. (Haberl et al., 2007: 12942)
During the last two centuries, humanity has become the causal planetary-scale factor in a new geological epoch, the Anthropocene (Schellnhuber et al., 1997; Steffen et al., 2011; Zalasiewicz et al., 2011). However, during this recent period, we also crossed the boundaries in terms of the regenerative capacity of the planet (Haberl et al., 2007; Steffen et al., 2011). Our global food system is a primary cause of the decline (Díaz et al. 2020; Springman et al., 2018; Willett et al. 2019). Since the Second Green Revolution of the mid-20th century, about “30% of fertile soil have been lost” due to anthropogenic erosion (Schellnhuber, 2012: 19).

If the current trend is maintained (e.g. Ceballos, Ehrlich & Raven, 2020; Díaz et al. 2020; Ripple et al., 2019), Mother Nature will enter in the state of entropy: a downward spiral for both ethnosphere and ecosphere as we know them. In observing the state of things, I adhere to a change of perspective from “how are we going to feed 10 billion people by 2050” (EAT-Lancet, 2019) to how the current 8 billion will work cooperatively to regenerate Mother Nature.

5.4 Planetary healing: challenges and hopes

Is it possible to understand a biosphere without incommensurable and irreducible cultural diversities? If a dominant society colonizes the world, homogenizing every village on the planet, would it be the equivalent to reducing the 14,000 edible plant species to the five crops mostly consumed by contemporary humans?6

In the context of the 2015-2030 Agenda for Sustainable Development Goals (SDGs) and the Second International Conference on Nutrition (ICN2), the EAT-Lancet

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6 The relationship between known edible plant species and those that are mostly consumed by current humans comes from Willett et al., 2019.
Commission on Food, Planet, Health represents a relatively recent transdisciplinary convergence (e.g. Rockström, Stordalen & Horton, 2016; Willet et al. 2019) that promotes two overarching concepts for responding to the most pressing challenges of humanity: planetary healthy diets and the Great Food Transformation. There are, nonetheless, important roadblocks to meeting these critical challenges.

Agricultural and food systems are defined by power asymmetries that are both symbolic and physically coercive. Power is exercised from centers to peripheries (Foucault, 2007), including from cities to rural and indigenous communities. As noted in rural studies (Cloke, 2006; Halfacree, 2006; Williams 1975), views of the periphery that are dependent on the center have caused a symptomatic distortion of rural life, which is reflected in urban-rural relationships. For example, modern cities are entropic by design and to meet their needs in terms of food and ecological services, urbanization imposes constant pressure (footprint) on rural societies and ecosystems (Rees & Wackernagel, 2008). With regard to agricultural policies, for example, the “urban bias” represents reducing incentives for food producers for the benefit of urban consumers (Dethier & Effenberger, 2012; Thompson & Scoones 2009).

Similarly, hegemonic powers have historically imposed coercive and symbolic power from the core to periphery (Boswell & Sweat, 1991). The “modern world,” irradiated from core to periphery through globalization, symbolizes a dominant interpretation of civilization and progress (De Sousa 2008; Escobar 2004). In this interpretation, indigenous people are classified using “colonial epistemic borders and hierarchies” (Luisetti, 2012: 51) seen, for example, in the “ecologically noble savage” debate (Raymond, 2007). This exercise of power is also reflected in the configuration of historical narratives (Dunbar-
Ortiz, 2014; Mendieta, 2012) and in the creation of authorized epistemologies to comprehend social realities (Bourdieu, 2003). Consequently, homogenization becomes a byproduct of the expansion of the hegemon (De Sousa 2008).

The hegemon sets the rules of international politics, economics, and trade (Boswell & Sweat, 1991); this power is exercised from the city, the supposedly ideal of civilization (see. Baudrillard, 1987). The core-to-periphery rationale for administering life on the planet gives a more robust context for the aggressive expansion of the agricultural frontier, the fossil fuel-dependent industrial-scale food system, and effects on the health of people and ecosystems (see. e.g., Altieri, 2009; Figueroa-Helland, Thomas & Aguilera, 2018; Nestle, 2013; Pfeiffer, 2006; Weis, 2010).

In the Anthropocene epoch, when human beings are global actors of planetary health, planetary healthy diets and the “Great Food Transformation” will not be achieved without addressing these power dynamics. This is a challenge that requires more and better renewable energy sources, habitats with low ecological impact, and sustainable food production, thereby embracing a paradigm that improves at the planet-scale our species’ conception of and relationship with the planet.

For example, in the Andes, the concept of balance or harmony is interchangeable with health (Gallegos & Jara, 2007), and likewise health (including sustainability, resistance, and resilience) with the Good Way of Living (Sumak Kawsay) – without assuming a faultless translation to realities through the associated ethnopolitics in countries like Ecuador and Bolivia (Acosta et al., 2011; Zimmerer, 2015). However, at the philosophical and experiential levels, these conceptions are positive because they
emphasize at the macro-level (the ecosphere) that human health depends on the health of Mother Nature/\textit{Pachamama}, whereas at the micro-level, health (homeostasis) is relational and based on reciprocities among the land, the living, and ancestors (Gallegos & Jara, 2007). These conceptions are coherently articulated in World Health Organization’s (WHO) Declaration on the Health and Survival of Indigenous Peoples:

Indigenous peoples’ concept of health and survival is both a collective and an individual intergenerational continuum encompassing a holistic perspective incorporating four distinct shared dimensions of life. These dimensions are the spiritual, the intellectual, physical, and emotional. Linking these four fundamental dimensions, health and survival manifests itself on multiple levels where the past, present, and future co-exist simultaneously (WHO, 1999).

A planetary-scale sustainable food system will not be feasible if it is not pursued inclusively (UN, 2015). This precondition is not only about social justice but is also substantiated in the effectiveness and efficiency of traditional, indigenous and/or biocultural agroecological spaces. Moreover, inclusiveness requires working in diversity, including a plurality of ontological stances (Agrawal, 1995; Altieri 2004; Roué & Nakashima, 2002).

The diversity of cultures (the universe of particular epistemologies developed around the relationship with nature) is the strength of indigenous peoples and what is voiced in their discourses in international forums like IPCC and IPBES. Human survival depends on a diverse planet (Booy et al., 2000; Dobson & Carper, 1993; Lovelock & Margulis, 1974; Reed & Frankham, 2003; Zimmerman, 2015). As pointed out by Tirado-von (2017) in her UNSSCN report, the more diverse the system, the higher its resilience in the face of climate change and other stressors. Indigenous people are keepers and enhancers of ecosystems, and they embody diversity.
The strength of cases like Caliata lies in consolidating planetary level efforts into “dissemination, heterogeneity and the careful plaiting of weak ties” rather than in “concentration, purity and unity” (Latour, 1996, p. 360). Considering a different route for planetary health, Caliata represents an illuminating case of the indigenous perspective. In particular, it is an opportunity to understand from a systems’ view the factors that hinder and support the twofold challenge of achieving agroecological stability while assuring food security.

The case also illuminates how the community has been able to resist modern processes that would transform the community in different directions, as has happened in neighboring communities and across the central highlands, including biodiversity loss, accelerated desertification, and reliance and dependence of agrochemical fertilizers and pesticides (Barrera, Escudero, Alwang & Andrade, 2012; Harden, 2001; Partridge, 2016).

In the big picture, this dissertation adds perspective to the planetary health debate in two ways. First, fit acknowledges indigenous peoples’ ecocentric perspective in international agendas that are calling for a great food system transformation. Since such a transformation can only be accomplished on the basis of an inclusiveness that cannot ignore an estimated 33% of the rural poor (World Bank, 2017; FAO, 2017). Five areas are crucial in this respect: (i) techniques and technologies suitable for adaptation and mitigation of climate change; (ii) enhancement of ecological functions; (iii) native foods and traditional diets that can support healthy diverse diets; (iv) keepers of traditional seed varieties that are resilient to extreme weather events; and (v) biodiversity conservation (see. e.g. Holt-Giménez & Altieri, 2013; Carrasco-Torrontegui et al., 2020; Kuhnlein, Erasmus & Spigelski, 2009; Walker et al., 2014).
Second, the dissertation contributes to community-driven approaches to the endeavor of achieving planetary health because the functions of the ecosphere are influenced by macro-dynamics of the ethnosphere, which in a way represent the aggregated effects of ethnoses-ecosystem dynamics, including customary organization, culture, language, symbolism, rituals, feasts, and social norms. At the expense of falling into excessive generalizations, it has been broadly noted that indigenous social organizations, cultural food systems, and their systems of knowledge are in convergence with the agroecological space (e.g. Altieri, 2004; Erickson, 2006; Kuhnlein & Receveur, 1996; Roué & Nakashima, 2002).

By appreciating the singularities of Caliata, as well as the lessons that have applicability in indigenous communities in the Andes and beyond, it is also evident that the community cannot be thought of as a closed system. Caliata, despite its relative autonomy through Ecuadorian regulations, is also part of the decentralized system of governance in the country, part of the grassroots organizations of the indigenous movement, and people in Caliata are citizens subject to rights and obligations. In the same way, the community participates—marginally—in the national economy and there are a series of external factors that are altering their landscape and social fabric, such as the urban sprawl and outmigration—as detailed across the three chapters and recapitulated above.

In considering Caliata as a historical, cultural and political entity, there are two important avenues to support the community survival: (i) To link the community with the national agroecological movement, aligned to La Via Campesina (Holt-Giménez & Altieri, 2013); and (ii) adding the Caliata case, in a peasant-to-peasant approach (Altieri, 2009), to strengthen the application and validity of existing regulations both at conjoint cultural and

5.5 The future is in the past and the present is now

The bottom line of this dissertation as well as the vital lesson provided by this small community is that food sovereignty is about a relationship with Mother Nature. In that regard, three lessons are draw for future research and applied work with indigenous communities:

1. Work with and about indigenous communities should consider as a principle the localized system’s perspective. An intervention in indigenous Andean communities should consider activities focused on the traditional diet and the rehabilitation of agroecosystem; however, both aspects have to be related to local social organization and culture (Gallegos et al. 2019).

2. Collaborations should be consistent with paradigms discussed in nutrition and public health that promote food sovereignty and ecosystem health to ensure food security (e.g. Altieri, 2009; Figueroa-Helland et al., 2018; Kothari et al, 2014; Tittonell, 2014). This approach considers access to fresh, nutritious, safe, and culturally accepted and affordable diets in amounts and quality that are required for a life in plentitude, supported by nutrient loops that maintain soil health and agrodiversity. The Caliata case confirms that the traditional diet plays a role in increasing indigenous resilience, partly because of underlying factors that range from the nutritional properties of traditional food, the diversity they represent (in both the plate and in the field), and their role in the indigenous health system (e.g. Altieri, 2004; Reyes-García, 2010).
3. A traditional diet represents an expression of identity (see, e.g., Caplan, 1997; Mintz & Du Bois, 2002; Weismantel, 1989). Consequently, applied research oriented around food security in indigenous populations should aim to increase the consumption of diversified versions of the traditional diet as assessed in Caliata, using indigenous’ identity as a central mechanism to reinvigorate agroecological spaces, protect genetic and cultural resources, and strengthen the overall agency of individuals and communities.

These three lessons, emerging from the Caliata case, have applications to the Andean region; particularly Colombia, Perú and Bolivia, which share with Ecuador many political, historical, cultural, and geographical conditions. Such application would not represent an easy task but can be achieved through a community-to-community approach as promoted by agroecology and *La Via Campesina’s* food sovereignly movement (Altieri, 2004; 2009; Patel, 2009). Symbolic elements play a paramount role in the adoption, for example, of ancient techniques and technologies like the terracing system; as shown by the failure of the rehabilitation programs in the Titicaca basin (Swartley, 2018). In that sense, careful attention to the cosmovision is imperative.

In Caliata, there is also important work to be done and which will be key for the replicability of lessons learned. In regard to the factors supporting the agri-food system, stratigraphic layers of the terracing walls show evidence of use preceding the modern plow zone. This finding is consistent with testimonials by community members, who claim that Caliata’s terraces have sustained a steady biodiverse agro-food system for generations (possibly dating from the pre-Incan era), providing for survival of crops against pests and frequent strong climate fluctuations (e.g. frost), suggesting that the terraces are a potentially valuable biocultural space. However, to gaze into the future, it is paramount to understand the past and the present, as intended in a future project.
Using the trans-and-interdisciplinary approach, a suggested next step is combining ecology and archaeology to better understand the past and present behavior of the community’s pre-Columbian terracing system. This future research could have a profound effect on applied projects in the rural sector in the northern Andes (Colombia and Ecuador). This interdisciplinary work might represent an opportunity to explore how a historically-based society shaped their ecosystem to construct a productive space, and how ancient people designed an agroecosystem architecture that continues to support the food systems of the community today. This research is highly needed to move forward.

Cultural ecology (e.g. Sterling et al., 2017; Winter & Lucas, 2017) could provide insights into interrelations among human societies and living organisms and their environments, which gives place to biodiversity within the scope of geographies, such as observed in Caliata, as well as the fragile and self-regulating ecosystems that support it. The archaeology of food and ecology (e.g. Butzer, 1982; Hastorf & Wright, 1998) provides an historical perspective of the social processes that mobilized ancient food systems in each context.

Archaeological and ecological work in Caliata is important because of the variations of geography, weather, and historical processes in the central highlands of Ecuador compared to other ecoregions in Peru, such as those sites in altitudinal zones at the average of 10,000 ft., where there is abundant research (e.g. Chepstow-Lusty et al., 1998; Guillet, 1987; Kendall, 2013; Treacy, 1989). Consequently, there is knowledge and even an agroecological potential to uncover the latent variation in terrace systems between places and time periods.
The fact that the terraces in Caliata are an active system that currently provides food for 144 people, represents an important example of Pan-American indigenous technologies: others include the Albarradas in Ecuador’s coast (Delgado, 2017), Aztec floating gardens (Armillas, 1971), and the Lari’s terraces in the Colca Valley of Peru (Guillet, 1987). While they are active, there are many parts of the system that are inactive, or in decay, and have the possibility of being rehabilitated for future production for the entire community and beyond.

In the Andes, this potential study will provide a contrast with research in other rehabilitated areas, such as the raised beds around the Titicaca basin in Bolivia and Peru (Kolata & Ortloff, 1996; Swartley, 2018) and irrigation channels and terraces in Peru’s Urubamba Valley (Kendall & Drew, 2016), and with other sites long abandoned, found in several other Peruvian valleys (Goodman-Elgar, 2008; Londoño, 2008).

Integrating pre-Columbian landscape practices (e.g. Erickson, 2006; Goodman-Elgar, 2008; Scarborough & Lucero, 2010), as in the present research, may help to frame how communities such as Caliata have thrived in their agroecological space. Combined archaeological and ecological studies are concerned with sustainable practices conducted by ancient and contemporary indigenous communities. The evidence derived from a study like this will be instrumental to rehabilitation, conservation, and replication strategies for terracing architecture in rural Andes. However, these findings should complement to behavior-based interventions based on the factors that characterize Caliata as a positive deviance; an important lesson from the Caliata experience is that the agroecological dimension operates in coordination to the psychosocial dimension. Consequently, the success of future work depends in a full comprehension of the system as a whole.
Finally, the proposed dissertation project constitutes an essential piece of a long-term initiative to pair research with positive impacts on local communities, which contrasts with research models where little remains for the community after data collection. That is, this research was designed to empower. Below I briefly describe the current efforts.

At present, a group of researchers from different academic institutions and disciplines as well as professionals in the visual arts, publicity, and marketing, are engaged in a long-term partnership with the rural indigenous community of Caliata. The goal to positively transform the community by empowering community members to become agents of change and examples for other communities in the Ecuadorian highlands and by; operating using a “one community at the time” logic. We named this partnership, an umbrella for diverse community-centered projects, the Caliata Initiative (www.caliatainitiative.org). This transformation, infused by the vision and aspirations of community members, starts by halting the disruption of communal organization, language, culture, and agroecosystems. At this moment, the Caliata Initiative has a portfolio of six project profiles. As closing statement, there is no better way to express it other than in the voice of Caliata:

The resilient and free ancient Kichwa-Puruwá people of Caliata feel obliged to protect and promote their historical, cultural and biological heritage. The heritage that the ancestors, Taitas and Mamas Yachags (wise men, educators and healers), have managed to preserve, despite conquests and transgressions; a heritage for us and for the future generations.
5.6 References


Braun, D. M., (Sept, 2014). Biocultural Conservation: the Antidote to Nihilism?. Changing Planet,


Ceballos, G., Ehrlich, P. R., & Raven, P. H. (2020). Vertebrates on the brink as indicators of biological annihilation and the sixth mass extinction. *Proceedings of the National Academy of Sciences*.


ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.


Ecuador:


