Caliata: An Indigenous Community in Ecuador Offers Lessons on Food Sovereignty and Sustainable Diets

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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-h recall. We used the NOVA food classification system 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-h period, 70% reported an average of 2.2 servings), and two-thirds of households' consumption represent unprocessed or minimally processed foods. Third, gendered agriculture and population aging represent demographic challenges, while chronic health problems remain relatively infrequent compared with 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.

Conclusions: 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. *Curr Dev Nutr* 2021;5:nzab009.

Keywords: sustainable diets, food sovereignty, indigenous people, ecocentric, Andes, Ecuador, NOVA

Manuscript received December 12, 2019. Initial review completed June 2, 2020. Revision accepted February 4, 2021. Published online May 13, 2021.
This paper was made possible by the generous support of the Shakopee Mdewakanton Sioux Community and of Mindy Kurzer and her team at the Healthy Foods, Healthy Lives Institute. Fieldwork, including travel of the principal investigator (CAG-R), was carried out with funding from the Brown School's International Dissertation Award.

Author disclosures: The authors report no conflicts of interest.

This article appears as part of the supplement "Proceedings of the Fourth Annual Conference on Native American Nutrition," sponsored by the Shakopee Mdewakanton Sioux Community's Seeds of Native Health campaign through a gift to the University of Minnesota. The guest editor of the supplement is Mindy S Kurzer. MSK is supported by the Shakopee Mdewakanton Sioux Community for her role as chair of the conference planning committee and editing the proceedings. The opinions expressed in this publication are those of the authors and are not attributable to the sponsors or the publisher, Editor, or Editorial Board of *Current Developments in Nutrition*.

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Abbreviations used: IRB, institutional review board; MPH, Ministry of Public Health/*Ministerio de Salud Pública* (Spanish); NOVA, NOVA food classification system.

Introduction

The profound restructuring of food systems is essential to assure food security and good nutrition worldwide (1, 2). 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 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).

TABLE 1 Relevant articles from Ecuador's 2008 Constitution

	Constitutional definition
Food security *Article 13*	Access to healthy, sufficient, and nutritional food, preferably produced locally and in keeping with their various identities and cultural traditions
Food sovereignty *Chapter 3: Article 281, subsection 6*	Promoting the conservation and recovery of agricultural biodiversity and related ancestral wisdom, along with the use, conservation, and free exchange of seeds
Sumak kawsay *Preamble (a) and Article 14 (b)*	(a) A new form of public coexistence, in diversity and in harmony with nature, to achieve the good way of living, the *sumak kawsay*; (b) healthy and ecologically balanced environment that guarantees sustainability and the good way of living
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

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 well-being 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 3 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 whom 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 1** (25).

Ecuador's indigenous movement represents a source of cultural and political influence, and its cosmovision infused in a national constitution (Table 1) 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 on economic growth. The good way of living is contingent on the rights of nature, as expressed by 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.

Despite 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 remain 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 <5 y 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 5 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

TABLE 2 Sociodemographic information reported by the head of the household[1]

Variable	Values
Number of people living in this home	2.5 (1.5) [1–8] individuals
Number of years of school completed	3.4 (5.0) [0–16] y
Literacy, *n*	
Able to read a whole sentence	31
No, cannot read at all	23
Able to read only parts of a sentence	3
Blind/visually impaired	0
Household receives a conditional cash transfer,[2] *n*	
Yes	21
No	36
The family receives money from another family member living at the city or abroad regularly, *n*	
Yes	44
No	13

[1]Values are means (SDs); ranges in brackets, unless otherwise indicated.
[2]Conditional cash transfer is a poverty indicator; remittances offer perspective on migration and support network.

plant species and for improving the quality of diets of indigenous families.

Ecuador has drawn an inclusive road map (Table 1) 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.

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 reincorporation 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, a 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 the 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.

Methods

Population

Selection of the study population was theoretical (36) in the sense of meeting 2 criteria: *1*) finding a food system that can be characterized as "indigenous-based" (37) and *2*) 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, ∼210 km south of the country's capital. Ninety percent 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 2** presents household-level sociodemographic data.

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 2 consultative meetings and a formal document of support signed by the 5 elected community leaders and every landowner. The study was submitted for institutional review board (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).

Procedures

We applied a participatory mixed-methods design. Following previous experiences (27, 38), a qualitative component consisted of 9 focus groups with a total of 39 participants and 10 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 of 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 5 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 y of age, the survey was previously validated for cohesiveness and linguistic nuances and modified accordingly. Agroecology-based site analysis was conducted in 10 selected parcels that were studied with local informants in order to approach agroecological richness with reference to diet (30, 31).

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 combines 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 an a priori list of foods) 48-h 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 a unifying information-processing category (for ingredients and portions), because memory operates better when information is grouped: chunking (43). Finally, because diet represents episodic memory (44), which is contextual, a meal is associated with places and times, making it easier to remember. We used household head as the proxy for the diet of the entire family, particularly since female household heads customarily prepare meals, as noted elsewhere (45).

The 48-h recall added nuance into our exploration of the diet because we treated data as both categorical and numerical, which was useful to understand in a greater dimension the consumption of unprocessed and processed foods. Dietary information was sorted using the NOVA food classification system (NOVA) adapted for Ecuador (46). NOVA considers 4 different groups of foods according to levels of processing: group 1 includes unprocessed or minimally processed foods, 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, legumes 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 20 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.

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 3-stage coding process (49), which produced a brief description of the ethnographic landscape and 3 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 3-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 version 9.4; SAS Institute). 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.

Results

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, 2 churches, a volleyball court, and 4 abandoned classrooms. All residents of Caliata are smallholders: 1.8% own ~50 m^2, 21% own <1000 m^2, 52% own <1 hectare, and 8.8% own ≥1 hectare, although are still considered smallholders according to Ecuador´s Agricultural Census (owning <5 hectares).

In Caliata, crop production is divided into that which is stored, sold, or exchanged, as shown in **Figure 1**. Amounts that correspond to each category are measured in sacks, which is understood to be synonymous with a hundredweight, although other products are measured in terms of *arrobas*, which have an average weight of 400 ounces.

Thirty-five different plant species represent the major crops produced in Caliata (range: 3–25 crops/family; mean of 9 crops). Only 10% of families produce ≤4 crop species. 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 1, however, does not show the variety of within-crop species. For example, we identified 8 different varieties of corn as well as 8 different varieties of 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 2 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 crops, including those that have medicinal properties or are 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 2**), including cows, sheep, goats, pigs, llamas, guinea pigs, and rabbits, as well as chickens, ducks, geese, and donkeys, all of which have at least 2 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 reflects traditional agroecological space.

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.

Dietary patterns

All respondents (100%) stated that they consume the food they produce, which is consistent with the finding regarding the 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 with 14% of 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, on average, 5 portions of liquids (averaging 8 ounces each) per 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 1 fruit in 1 of the last 2 snacks, with an average of 2.2 servings. Together with fruits, other sources of energy commonly consumed 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. In addition, bread, noodles, and rice are also consumed. All are seen as a means to sustain the demands of vigorous lifestyles derived from agrarian-based work.

Based on the NOVA classification adapted for Ecuador, we collated data in the 48-h recall survey for each of household heads [$n = 57 \times$ 5 meals (breakfast, morning snack, lunch, afternoon snack, and dinner) $\times$ 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 3**) showed that the diet in Caliata is based principally on foods in group 1, representing 66% of the total,

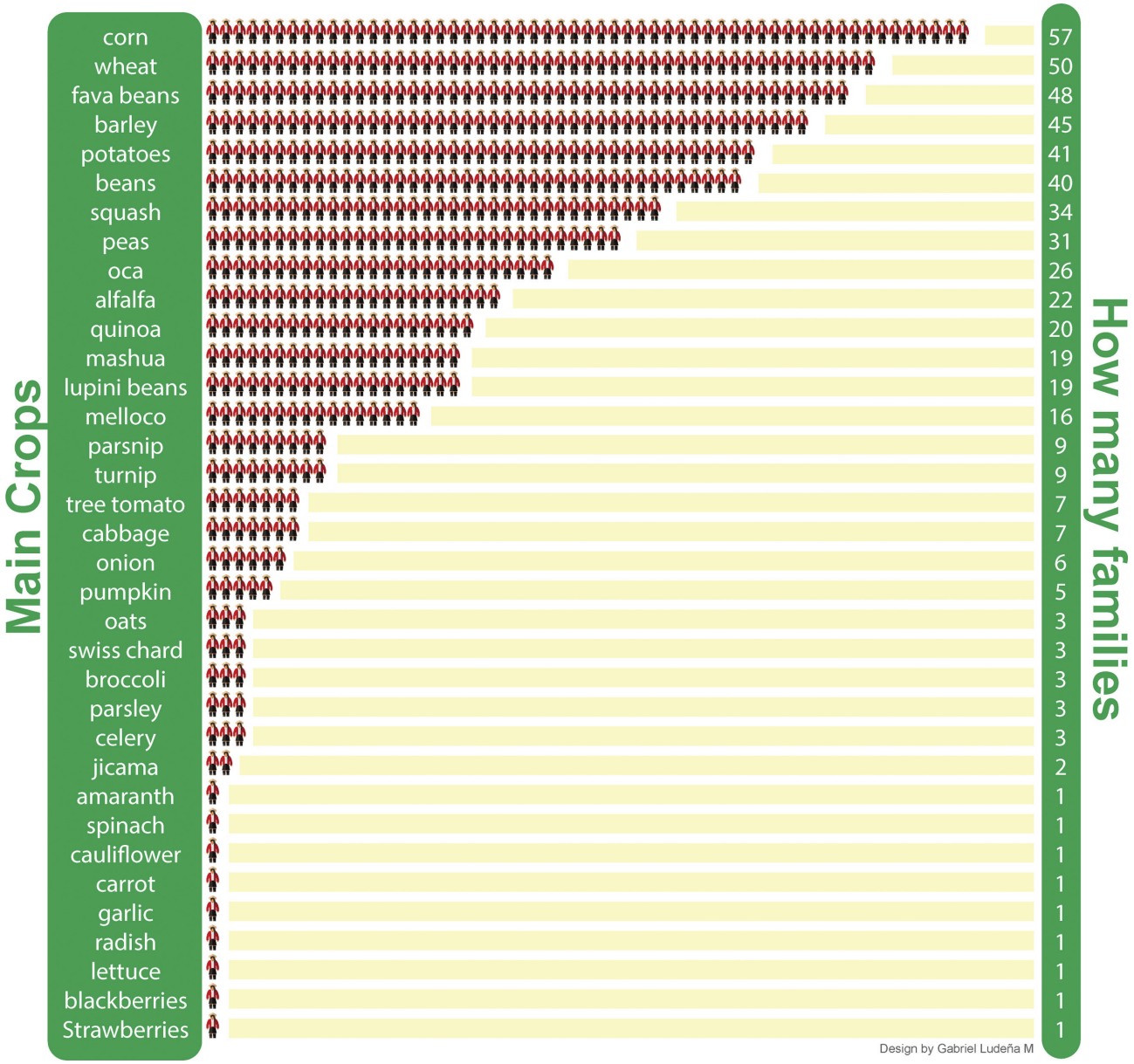

FIGURE 1 Number of families who produce each crop.

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 2 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 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,

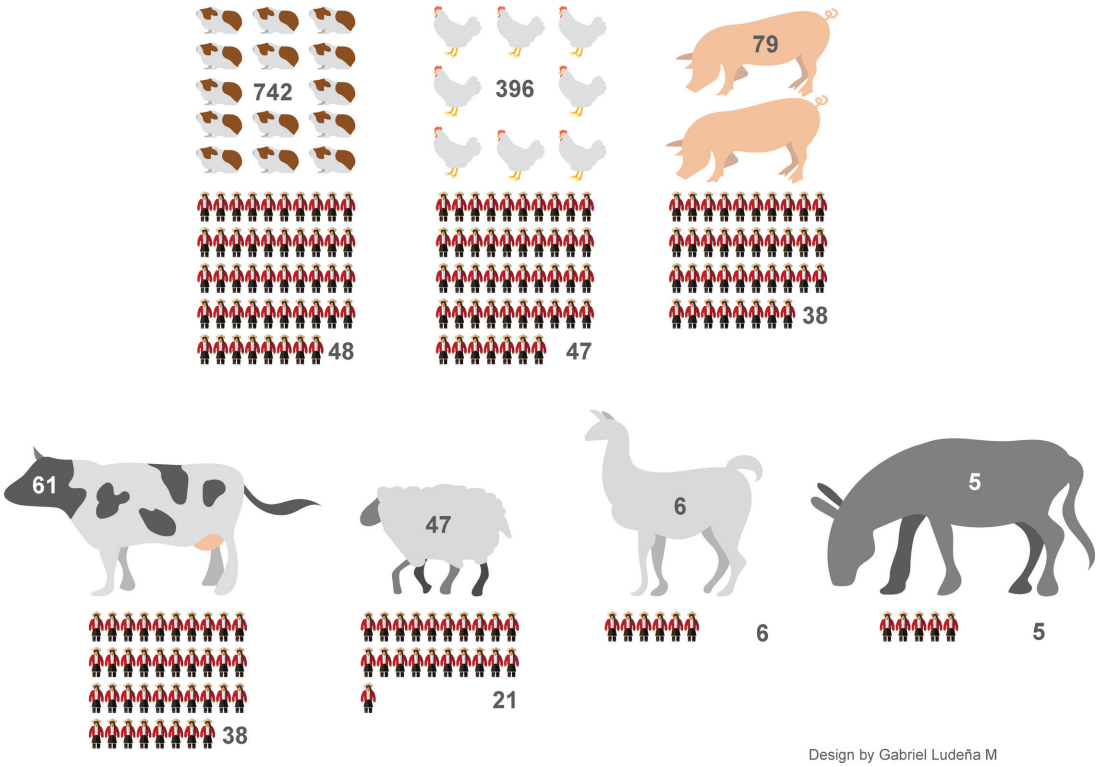

FIGURE 2 Number of animals and families who own each species.

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, the 24-h recall showed 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 vegetables, red or orange vegetables, other vegetables) as well as vegetable oil and fats. In contrast, consumption of foods in group 4 ranged from 0 to 3 ultra-processed food items (average of 0.7), indicating that 42% of respondents did not consume any ultra-processed foods in the past 24 h, whereas 49% consumed 1 ultra-processed food (almost always instant coffee), and only 4% reported consuming 2 or 3 ultra-processed foods. Our statistical models are consistent with these patterns; there are statistically significant correlations between adjusted agroecological richness with land size and the healthy diet index (**Table 3**).

A statistically significant inverse correlation was found between an individual's age and the average amount of fruit consumed in the past 24 h ($P < 0.01$, $r = -0.36$). That is, the older an individual is, the less fruit he/she consumes 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 the 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 increase the diversity of the diet (~1.01 units of adjusted agroecological richness increases by 1 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 1 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. Although 3.5% of respondents believe that their household diet is inferior compared with that of 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.

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 7 d, which is indicative of the role of

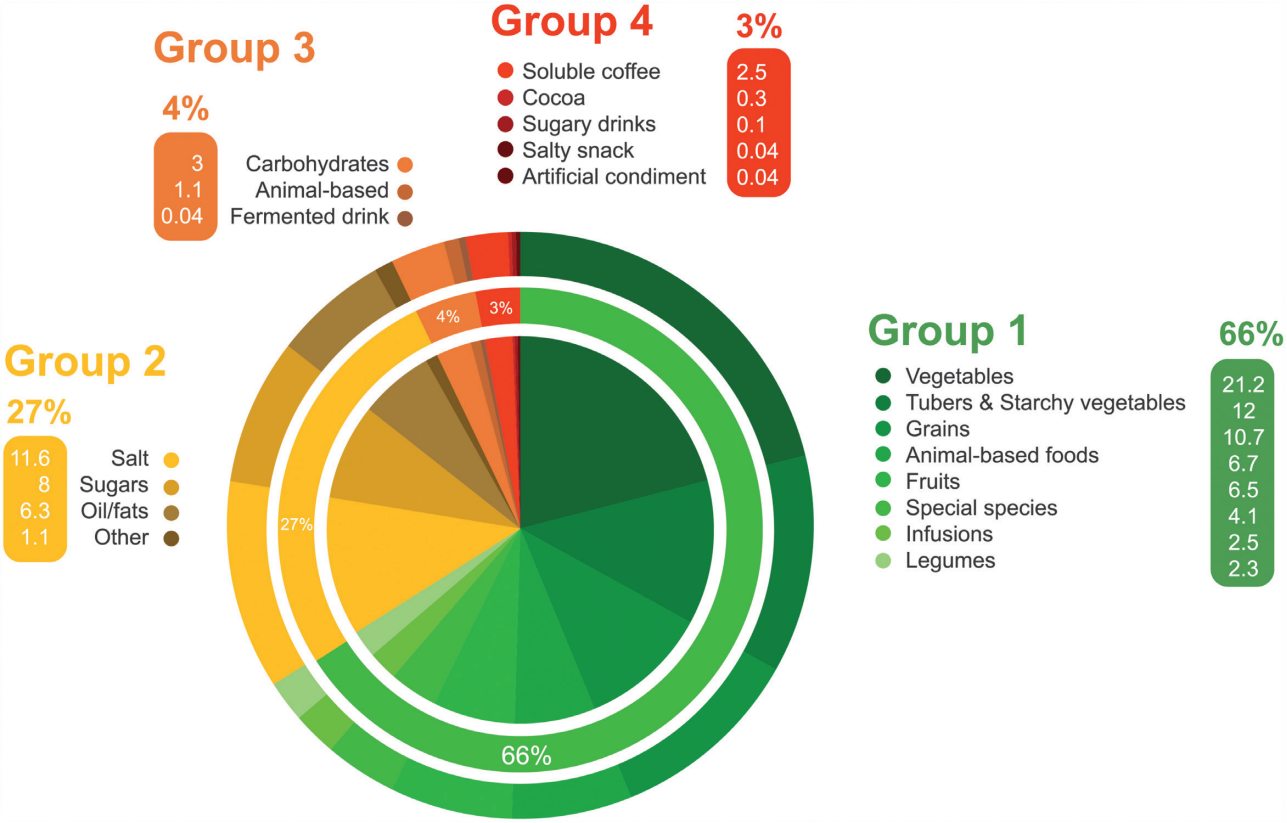

FIGURE 3 NOVA food classification system adapted for Ecuador (46) in the household 48-h recall survey.

subsistence agriculture. Moreover, as in Ecuador as a whole, Caliata's population is aging.

The survey revealed that there were no infants from 6 to 18 mo of age and no pregnant women. We encountered only 6 families with children from 2 to 9.9 y of age and only 10 children in all; 11 families had children from 10 to 18 y of age (15 in all), and only 3 families had children in both age groups. In contrast, 52% of survey respondents were older adults (≥65 y; mean: 73.66 y). Life expectancy at birth in Chimborazo province is 70.0 y for males and 76.7 y for females (50), although the rural sector lags behind the urban population in this respect (51). Twenty-six percent of people who participated in the survey had surpassed average life expectancy, and we found 4 residents aged ≥100 y.

The feminization of agriculture and aging of the population are simultaneous demographic factors and are related to migration, including of women of childbearing 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 on infant morbidity because of the absence of individuals in that category. However, 32% of respondents reported chronic conditions, representing a total of 18 cases, of whom 89% were 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%), 1 had heart failure (4%), and another had heart disease (4%). In addition, 1 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 20 other communities. An analysis of publicly available records of the MPH revealed that the facility attended

TABLE 3 Pearson correlations among adjusted agroecological richness, land size, and healthy diet index

Measure	Mean	SD	1	2	3
1. Adjusted agroecological richness	18.2	5.9			
2. Land size	2.7	0.7	0.26*		
3. Healthy diet index	7.1	1.6	0.31*	0.14	

*Correlation is statistically significant at the 0.05 level (2-tailed).

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 ($n = 4546$). Among adults from 20 to 64 y of age and older adults (≥65 y) the records for 2018 indicated 4 - cases of diabetes and 20 cases of high blood pressure; none of the other chronic conditions were reported.

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), as shown in the following quotation:

> 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 an 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 with 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 4**).

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 represent 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 not 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. Despite these challenges, Caliata is able to resist external and global influences, in large part thanks to the 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 of sustainability is expressed in pragmatic terms as "*guagua guaguapi*" (caring for the next generations).

The traditional indigenous knowledge base is reflected in the 6 ways that the residents of Caliata care for their agroecological space: *1*) care taken in preparing the parcel; *2*) safeguarding native seed varieties; *3*) protecting the parcel from wind erosion; *4*) protecting the topsoil from water erosion; *5*) practicing crop rotation, fallow, and crop associations; and *6*) "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 acts 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 2 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.

Discussion

Notably, 90% of families produce >5 different crops in their parcels that are accompanied by at least 5 other agroecologically edible plant species. Associated crops produced by all the families in Caliata, including 5 endemic edible plants, averaged 18 species per family. In addition, 82% of the families keep different species of poultry and 84% have guinea pigs. 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

FIGURE 4 Participatory evaluation exercise with the community after preliminary findings.

households' consumption represent unprocessed or minimally processed foods, whereas 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 4 NOVA food groups at the national level (29), household heads (and presumably their families) in Caliata consume relatively fewer grains (NOVA groups 1 and 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-h period, 70% of household heads' consumption of fruit alone averaged 2.2 servings. Furthermore, in a period of 48 h, fruit and vegetables (excluding tubers and starchy vegetables, grains, 2 spices, and legumes) represented 27% of the diet of household heads in terms of food groups (see Figure 1). Caliata is located only 11 km 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 <60 y of age. Among older adults, the results are consistent with national figures in that the most prevalent chronic condition is high blood pressure, whereas the prevalence of high blood pressure, heart disease, and diabetes is relatively lower compared with 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 requires 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 nonfood 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 was 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 sovereignty: 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, however; 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 living" has been expressed by granting constitutional rights to nature. This policy reflects the 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 well-being 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 heterarchical 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 is 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 study 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 to 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 pre-established categories (27, 49).

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 used 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 systems. The situation of Caliata resembles well the lifestyles of communities living in world regions with higher than average proportions of long lived people, 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.

Acknowledgments

The authors gratefully acknowledge the support of Gabriel Ludeña Maruri for his outstanding collaboration in the design of the infographics presented in this manuscript. We also acknowledge Wilma Freire and her team for making accessible the list of foods, preparations, and beverages that are consumed in Ecuador according to NOVA classification 2017. The authors' responsibilities were as follows—CAG-R: was responsible for conceptualizing and writing the manuscript with substantial input from WFW, AC, LAR, MP, MC, JC, AAB, and LLI; WFW, AC, LAR, and LLI: participated in data analysis and reviewed and suggested modifications in the final version; CAG-R: had primary responsibility for final content; and all authors: read and approved the final manuscript.

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