Université de Montréal

Diversity from Farm to Plate:
Nutrition and Food Relationships among Agroecological Farmers in Ecuador

Ana Laura Deaconu

A thesis submitted to Université de Montréal, Faculty of Medicine, Nutrition Department in partial fulfillment of the requirements of the degree of Doctor of Philosophy (PhD).

March 15, 2021

Université de Montréal

Département de Nutrition, Faculté de Médecine

This thesis titled:

Diversity from Farm to Plate:

Nutrition and Food Relationships among Agroecological Farmers in Ecuador

Presented by:

Ana Laura Deaconu

Has been evaluated by a jury composed of the following individuals:

Valérie Marcil

President-rapporteur

Malek Batal

Director

Geneviève Mercille

Co-director

Mira Johri

Jury member

Andrew Jones

External examiner

Geneviève Mailhot

Dean’s representative

Abstract

Concerned with agricultural practices that harm human and environmental health, networks of farmers in Ecuador have organized around agroecology as a more sustainable alternative. This comes at a time in which a nutrition transition has driven Ecuador's rural population to unprecedented levels of overweight and obesity, even while micronutrient deficiencies persist, thus creating a double burden of malnutrition. Through agroecology-based alternative food networks (AFNs), farmers and their allies have increasingly recognized the linkages between healthy agricultural practices and healthy food consumption. A breadth of literature explores how agriculture interventions can improve nutritional outcomes, such as by promoting production diversity, increasing incomes and empowering women. Agroecology has much potential to act on these pathways. However, because agroecology often spreads as a social movement rather than as a systematic intervention, empirical research assessing linkages between agroecology and farmers' dietary practices is lacking.

This thesis explores how the production practices and social capital promoted through agroecological AFNs may be associated with unique dietary practices that hold potential to support nutritional health in the face of both obesity and micronutrient deficiencies. To do so, this research implemented a participatory approach and sequential, exploratory mixed method design including ethnography, key informant interviews, focus group discussions and a cross-sectional survey comparing agroecology AFN participants and their non-participant farming neighbours. Findings show that AFN participants out-performed their neighbours on multiple indicators of dietary nutrient adequacy and moderation. Analyses further suggest that agroecological AFNs support these dietary outcomes by strengthening production diversity and social capital, which in turn promote the consumption of foods from own-production and from the social economy (e.g. barter) as well as promote the consumption of traditional foods.

These results empirically demonstrate how agroecology can act on agriculture-nutrition pathways to enable healthy diets. Given the largely self-spreading nature of the global agroecology movement, agroecology may present an endogenous resource for supporting rural nutritional well-being.

Keywords : agroecology, nutrition, Ecuador, Indigenous populations, agriculture, alternative food networks, health, agrobiodiversity, social capital, dietary diversity

Résumé

Préoccupés par les pratiques agricoles qui nuisent à la santé humaine et environnementale, des réseaux d'agriculteurs équatoriens se sont organisés autour d'une alternative plus durable, l'agroécologie, au moment où une transition nutritionnelle conduit la population rurale à des niveaux sans précédents de surpoids et d'obésité, alors que persistent des carences en micronutriments, créant ainsi un double fardeau de malnutrition. À travers les réseaux d'alimentation alternative (RAA) basés sur l'agroécologie, les agriculteurs et leurs alliés reconnaissent de plus en plus les liens entre les pratiques agricoles saines et la consommation d'aliments sains. De nombreuses publications ont exploré la manière avec laquelle les interventions agricoles peuvent améliorer la nutrition, par exemple, en favorisant la diversité de la production, en augmentant les revenus et en renforçant l'autonomie des femmes. L'agroécologie possède un grand potentiel d'action sur ces mécanismes. Toutefois, comme l'agroécologie se répand souvent en tant que mouvement social plutôt qu'en tant qu'intervention systématique, des recherches empiriques sont encore nécessaires pour évaluer les liens entre l'agroécologie et les pratiques alimentaires des agriculteurs.

Cette thèse explore comment les pratiques de production et le capital social promus par les RAA agroécologiques peuvent être associés à des pratiques alimentaires uniques, avec le potentiel de soutenir la santé nutritionnelle face à l'obésité et aux carences en micronutriments. Suivant une approche participative de recherche, un devis mixte séquentiel exploratoire comprenant l'ethnographie, des entretiens avec des informateurs clés, des discussions de groupe et une enquête transversale comparant des agricultrices appartenant aux RAA agroécologiques à leurs voisines agricultrices non participantes a été appliqué. Les résultats montrent que les participantes aux RAA ont obtenu de meilleurs résultats que leurs voisines à travers de multiples indicateurs d'adéquation et de modération alimentaires. Les analyses suggèrent en outre que les RAA agroécologiques soutiennent ces meilleurs résultats nutritionnels en renforçant la diversité de la production et le capital social qui, à leur tour, favorisent la consommation d'aliments issus de l'auto-production et de l'économie sociale (par exemple le troc), ainsi que la consommation d'aliments traditionnels.

Ces résultats démontrent empiriquement comment l'agroécologie peut agir sur les mécanismes liant l'agriculture à la nutrition pour favoriser une alimentation saine. Étant donné la nature du mouvement agroécologique mondial, largement auto-disséminé, l'agroécologie peut représenter une ressource endogène importante pour soutenir le bien-être nutritionnel des populations rurales.

Mots-clés : agroécologie, nutrition, Équateur, Autochtones, agriculture, réseaux alimentaires alternatifs, santé, agrobiodiversité, capital social, diversité alimentaire

Table of contents

List of tables

List of tables in published or submitted articles

Article 2

Article 3

Article 4

List of boxes and figures

List of figures in published or submitted articles

Article 2

Article 3

Article 4

List of acronyms and abbreviations

AFN : Alternative food network

TF : Traditional food

DDS : Dietary Diversity Score

FVS : Food Variety Score

HEI : Healthy Eating Index

MDD-W: Minimum Dietary Diversity for Women

HDDS: Household Dietary Diversity Score

NAR: Nutrient Adequacy Ratio

MAR: Mean Adequacy Ratio

OW/OB: Overweight and/or obesity; Overweight and/or obese

LMIC: Low- and middle-income country

BMI: Body mass index

masl: meters above sea level

FFQ: food frequency questionnaire

FAO: Food and Agriculture Organization

NGO: non-governmental organization

Dedicated to Ecuador's agroecology movement

Acknowledgements

When I began this doctorate, I did not realize that it would be a process of progressively becoming more and more indebted to a multitude of people that made these past several years possible, most of the time with no benefit to themselves. My partner, José Luis Mosquera, moved to Canada and learned to enjoy the cold, all in the name of my education. My parents spent the past few years wondering when I would grow up, get a job and start a family; even so, they trusted my decisions and mostly just cared that I am happy. My brother did not pose any of those questions, because he went through it himself during his doctorate. One of my greatest debts is to Stephen Sherwood, who saw potential in me and convinced a team of people that I should be worthy of a doctoral scholarship, even though I myself was not certain about going through with it. He has provided steady guidance to me throughout this process, and did not complain when I decided to stay in Canada longer than expected.

Along with Stephen, other members of our Ekomer research team gave me their patience and their wisdom, challenged me when it was necessary, and always treated me with compassion, humor and joy. For this, I am especially grateful to Ross Borja, Pedro Oyarzún, Peter Berti, Donald Cole, Myriam Paredes, Eliana Estrella, Marcelo Aizaga, Gabriel April-Lalonde and Bana Salameh. Gabriel started his PhD at the same time as me, and we soon became close friends and confidantes. I cannot imagine sharing this PhD-adventure with anyone else. I met Bana when she was doing an internship with our project, and since then she has become indispensable in my life as both a part of our team and as one of my closest friends. Peter and Donald were generous in sharing their insights on research matters big and small, and graciously accepted to be co-authors on several articles. Their wisdom, experience and detailed knowledge contributed immensely to my learning experience, and I feel that I made noticeable improvements from one article to the next, largely thanks to their input. My doctorate involved three phases of field work, and I could not have done this alone. For all their advice and support, I thank Michelle O. Fried, Eduar Pinzón, Paula Túquerrez, Rosa Murillo, Luzmila Vásquez, Olga Carlosama, Rolando Cangás, Roberto Tocagón, Lucía Linquinchano, Blanca Obando, and the Vibrant Village and EkoRural teams. I most especially thank my research assistant, Leonardo Velasco, who approached his work with diligence and love, and has recently decided to pursue his own academic interest in agroecology and health through a master's program.

During my time as a student, I became identified with our research group, Transnut. The Transnut office became a home for me, a place of learning, a place of eating, and a place of (constant and loud) laughter. I thank my colleagues and friends, the "Transnuters." One of these Transnuters, Lara Steinhouse, graduated and moved on to other work several years ago, but she has remained a close friend, climbing partner and something of a life advisor. Research took me into the homes and lives of many people who were officially my "participants," but with time, many became friends. I deeply thank all of these people for warmly opening their doors to me, answering my many questions, and teaching me so many lessons. The time I spent in the field created some of the most important moments of personal growth in my life. I learned so much more than can ever be conveyed in a thesis, and I hope to put this knowledge to good use throughout my life.

Lastly, I reserve my deepest acknowledgements to my PhD supervisors. Geneviève Mercille shared her knowledge and graciously offered her time, even before she came on board to be my co-supervisor. I appreciate her sincere, no-nonsense approach, which helped give direction to my sometimes meandering, oftentimes whirlpooling currents of thought. All students under her supervision are very lucky. My words sputter and fail when it comes to thanking my supervisor, Malek Batal. While he has always believed in my writing, I cannot find a way to adequately express how important he has been in this process. Malek always reminded me of the forest when I was tangled in the trees, reminding me of why this research mattered. He gave me liberty to study what I wanted, how I wanted, but also knew how to gently reign me in and make sure I would eventually finish. Malek drives the Transnut ship with a rare empathy and compassion, and leads with his actions. No matter what else he had going on, whenever I sat down in his office it felt like he had nothing more important to do than give me his time. Having him as my supervisor was a unique privilege.

Funding acknowledgement: For this research, I received funding from the International Development Research Centre, the Canadian Institutes of Health Research, the Fonds de Recherche du Québec en Santé, the Quebec Population Health Research Network, the Université de Montréal Nutrition Department, and the Université de Montréal Faculté d'Études Supérieures. Initial funding from IDRC was made possible through EkoRural Foundation. I am grateful to the many funders who supported this research.

1. Introduction

Scholars around the world are coming to terms with the reality that food, which holds potential to nurture human health and environmental sustainability, is largely threatening both the former and the latter (Willett et al. 2019). In lower and middle income countries, chronic micronutrient insufficiency persists and disproportionately affects the rural poor, many of whom are farmers (FAO 2014). Meanwhile, both the urban and rural sectors of these same countries are experiencing a rapidly-spreading pandemic of overweight, obesity and related cardiometabolic chronic diseases (Popkin, Adair, and Ng 2012). Ecuador mirrors this global situation. Agricultural industrialization has drastically degraded the country's natural resources (Fonte et al. 2012; Vandermeer and Perfecto 2013), nominally as a means to support food security (Sherwood et al. 2013). Even so, 25% of children remain stunted due to micronutrient deficiencies, with that figure rising to 42% among the nation's predominantly rural Indigenous populations (Freire et al. 2014). Meanwhile, overweight and obesity affect 63% of adults, with prevalence increasing fastest among rural communities (Freire et al. 2014), and diet-related chronic diseases occupy the top four positions in national causes of death (INEC 2014).

Globally, the staggering health consequences of this double burden of malnutrition coupled with the calamitous environmental impacts of food production are driving calls for systemic transformation concerning food and agriculture (Willett et al. 2019; HLPE 2017; Popkin 2014; Herforth et al. 2019). Within the visions for this transformation, interest is coalescing around the potential of agroecology and similar agrobiodiverse production systems to enhance nutritional security while regenerating the environment (HLPE 2019; Herforth et al. 2019; Frison and IPES-Food 2016; FAO 2018b; Nyéléni 2015). Agroecology is a dynamic, locally-adapted concept (HLPE 2019) that applies regenerative ecological principles to agricultural practices—such as by optimizing production diversity, eliminating harmful inputs, and leveraging beneficial biotic relationships (Altieri and Toledo 2011; Tittonell 2014; HLPE 2019)—and integrates these practices with environmental, social and economic principles that contribute to farmer well-being and sustainable food systems (HLPE 2019; Francis et al. 2003; FAO 2018b).

For rural populations in particular, who are often disproportionately vulnerable to food insecurity and nutritional disparities (FAO, IFAD, and WFP 2015), multiple pathways exist by which agriculture can improve nutrition, such as by providing food for own-consumption, generating income or empowering women (Hawkes and Ruel 2008; Arimond et al. 2011; Herforth and Harris 2014; Kadiyala et al. 2014). An important enabling factor for many of these pathways is agrobiodiversity, which can support production stability, supply diverse nutrients to the diet and provide income for food purchase (Jones 2017; Frison and IPES-Food 2016; Powell et al. 2015). Agroecology is similarly expected to positively impact nutrition, in particular because its production principles are rooted in agrobiodiversity, but also because agroecology is often associated with socioeconomic, cultural and political principles that may support healthy diets (HLPE 2019; Wezel et al. 2020). However, empirical evaluation of the relationship between agroecological participation and farmers' dietary practices is in its infancy (HLPE 2019; Mottet et al. 2020; Anderson et al. 2020). In part, this may be because agroecology spreads in many spaces as a dynamic social movement rather than as a systematic intervention (Wezel et al. 2009), making it more challenging to study. However, the momentum that agroecology has gained among peasant farmers and other local actors (Wezel et al. 2009; Altieri and Toledo 2011) may make it all the more interesting in that it may present an endogenous, self-spreading resource for rural nutrition-related health.

The **goal of this thesis** is to contribute to this knowledge through a deep exploration of the relationship between farmers' participation in agroecology and their dietary practices in Ecuador's Imbabura province. Imbabura is situated in the Ecuadorian highlands, where farmers and other actors concerned with the environmental, economic, cultural and health consequences of agricultural "modernization" began uniting under the banner of agroecology as early as the late 1970s (Gortaire 2016; Sherwood et al. 2013). By the 2000s, agroecology forged strong alliances between farmers' associations, NGOs, and civil society groups oriented toward food activism (Sherwood et al. 2013). Together, these diverse actors created agroecology-based alternative food networks (AFNs)—in the form of farmers' markets, food baskets, solidarity stores, among others—intended to support farmers' agroecological practices and give consumers access to agroecological products (Sherwood et al. 2013; Gortaire 2016). At the time research began for this thesis, Imbabura province had been identified as a hotspot for agroecology in Ecuador, with numerous well-established agroecology-based AFNs as well as several that were newly emerging (Heifer 2014). Through nuanced qualitative inquiry of the participants in these AFNs, as well as quantitative comparison between agroecology-based AFN farmers and their non-AFN farming neighbours, this thesis aims to understand the mechanisms by which agroecology may impact farmer nutrition in the Ecuadorian highland context and draw lessons that are applicable to the broader discussion on linkages between agroecology and nutrition.

2. Literature review: the Ecuadorian highland food system in perspective

2.1 Dueling food systems

Food systems: Food systems include the range of activities and actors involved in getting food from production to consumption, the environmental and socioeconomic drivers that act on these, and finally the outcomes for food security and for societal and environmental welfare (Ericksen 2008).

The FAO and other leading global voices on the food and nutrition stage advocate for a "food systems approach" to advance food security and nutrition imperatives, proposing that this holistic approach is necessary to address the complexities created by demographic transitions, changing consumption patterns, globalization, climate change and the depletion of natural resources (FAO 2018c; HLPE 2017; Swinburn et al. 2019; Willett et al. 2019). The sense that **food systems** (Ericksen 2008) exist on a continuum between two divergent paradigms has increasingly been articulated in Ecuador (Sherwood et al. 2013; Arce, Sherwood, and Paredes 2015) and around the world (HLPE 2017; M. I. Gómez and Ricketts 2013; Goodman and Goodman 2009). On one end, literature describes food systems characterized by industrialization; globalized economies dominated by multinationals; market integration across the value chain; and, the prioritization of economies of scale. In many locations, this system has become predominant, and is often summarized as the "modern" (M. I. Gómez and Ricketts 2013), "industrial" or "conventional" system (Goodman and Goodman 2009). On the other end, literature describes food systems characterized by small-scale, family-based agriculture; short, local food chains; and, the prioritization of synergies between agricultural production and local ecosystems. This system is consistent with traditional practices around food and agriculture that persist in some locations, and has thus been labeled the "traditional" food system (M. I. Gómez and Ricketts 2013). However, a growing interest in re-orienting modern food around these same characteristics has driven the use of the term "alternative" to describe this food system (Goodman and Goodman 2009).

2.1.1 Ecuador's unsustainable agricultural convention

A food system is unsustainable when its components create negative trade-offs or destructive feedback cycles with harmful impacts to food security, societal welfare or the environment (Ericksen 2008; Frison and IPES-Food 2016). Such is the case, for example, when food production causes soil erosion and biodiversity depletion, which in turn propagate a negative cycle by imperiling food production. Conversely, a food system is sustainable when its components regenerate each other, such as when food production replenishes soils and increases biodiversity, thus enabling further food production (Frison and IPES-Food 2016).

In Ecuador, the process of agricultural modernization that began in the 1950s heralded a new approach to the food system that nominally carried with it an altruistic promise of resolving chronic food scarcity by intensifying production (Sherwood et al. 2013). Yet over half a century later, malnutrition not only persists, but has itself modernized to take on new forms offered by a widespread transition toward dietary excesses (Freire et al. 2014; Gross et al. 2016). Alongside nutritional consequences, agricultural and food industrialization in Ecuador has created a series of environmental and social problems in need of critical attention.

Agricultural intensification through mechanized tillage, reduced fallow times and use of chemical fertilizers propel massive soil erosion and loss of the organic matter that forms the basis of soil fertility (Fonte et al. 2012). Meanwhile, the expansion of the agricultural frontier for both internal and export markets threatens Ecuador's watersheds (Fonte et al. 2012) and erodes its biodiversity through deforestation, ecosystem fragmentation and other forms of habitat loss (Vandermeer and Perfecto 2013; Tapia-Armijos et al. 2015). Likewise, seed selection in the interest of economies of scale and market efficiency is implicated in the loss of an immense diversity of Andean seed varieties developed over millennia and their associated cultural knowledge (Zimmerer 1997; Sherwood 2009). While these agricultural practices prioritize short-term gains, in the longer term, they have driven declines in production, defeating their nominal purpose (Sherwood 2009).

Conventional agriculture has also created bleak externalities for farmer health. Many Ecuadorian farmers apply pesticides that have been banned by the United States and European Union, and in one region, deaths from pesticide poisonings rank among the highest documented in the world (Cole, Carpio, and León 2000; Sherwood 2009). Finally, multiple aspects of the modern Ecuadorian food system, including the value chain from production to retail, marketing practices and the advent of ultra-processed foods, have been identified as an affront to food sovereignty, transferring control of the food system from the hands of individuals and families to those of large companies (Rebaï and Vélez 2018; Torres et al. 2016; Arce, Sherwood, and Paredes 2015). This panorama portrays a conventional food system that does not support nutritional, social or environmental health and is in need of upheaval.

2.1.2 The emergence of agroecology as an alternative

Concern with the failures of the modern Ecuadorian food system motivated the emergence of sub-political, counter-movements aiming to practice and promote a more sustainable alternative (Sherwood et al. 2013). Rooted in a long Andean tradition of successfully managing diverse ecosystems, many farmers still maintain a wealth of traditional knowledge that remains relevant to current efforts to achieve agricultural sustainability (Fonte et al. 2012). However, recognizing new political, sociocultural and economic realities, as well as certain advantages to introducing knowledge from around the world, successful traditional agricultural practices have been updated and rebranded. Now, numerous actors advocating for sustainable agriculture in Ecuador—including Indigenous federations, farmers' associations, NGOs and civil society groups—have united around **agroecology** as the preeminent alternative (Gortaire 2016; Sherwood et al. 2013).

Agroecology: Agroecology encompasses a science, a farming strategy and a social movement that generally converge around the use of farming practices that: (i) apply ecological principles to farming, (ii) are locally adapted, (iii) promote biodiversity and leverage ecosystemic interactions, (iv) create a closed cycle to minimize and eventually eliminate dependence on outside inputs such as synthetic pesticides and fertilizers, and (v) are regenerative, rather than toxic. In some, but not all, cases, agroecology can be considered functionally equivalent with traditional farming practices as well as other emergent paradigms such as organic farming or permaculture (HLPE 2019).

Ecuador's experience is part of a greater trend in Latin America and around the world promoting agroecology (HLPE 2019) as the path toward agriculture that regenerates the environment, provides family farmers with a just and dignified livelihood, respects traditional cultures and knowledge (Altieri and Toledo 2011; HLPE 2019), and is able to provide an abundance of food to meet local and global nutritional needs (Pretty et al. 2006; McKay 2012; Force 2008). Agroecology has received emphatic buy-in from a diversity of actors, including researchers, development practitioners, and more recently international organizations such as the FAO (HLPE 2019; FAO 2018b). However, its widespread promotion across farmer networks has earned it a status beyond that of a science or production strategy, but rather of a social movement (Wezel et al. 2009).

The consolidation of Ecuadorian agroecology as a movement, rather than as a disparate collection of people practicing a farming strategy, was largely related to a resounding recognition among farmers of the need to reclaim their food sovereignty—that is, control over what and how to produce and consume—which modern agriculture and food systems had compromised (Gortaire 2016). By the mid-1990s, farmer organizations viewed agroecology as a means to interfere with the logic of industrial agriculture in that it promotes diversity on the farm (rather than crop specialization), it maintains farmer labour autonomy (rather than pushing farmers to work for the agriculture industry), it maintains the value of the farm's products in the hands of the farmer (rather than placing value at the whims of a demand-driven market), and it breaks the cycle of dependence on expensive and often toxic agricultural inputs (Gortaire 2016). These linkages to food sovereignty popularized agroecology among rural networks, including among highly-organized and highly-influential Indigenous organizations (Gortaire 2016).

Box 1: Trajectory of agroecology in Ecuador

The term "agroecology" took hold in the Ecuadorian lexicon in the 1980s, but traditional farming strategies that local agroecological practices are largely based on originated before the arrival of the Spanish and even before that of the Incas. Traditional production paradigms and specific strategies that persist to date include the *chakra andina, wachu rozado, chakra amazonica, aja shuar, finca montubia, huerto palta*, *finca pasto, canoero, colino,* and *cantero*, among others. These practices employ creative adaptations to environments as unique and different as the high-altitude Andean mountains, mangroves, dry forests, and Amazonian river banks (Gortaire 2016).

The *chakra andina*, for example, is a farming paradigm that remains wide-spread across the highland region. Like all traditional farming strategies, the chakra andina holds the objective of providing agrobiodiversity to meet the family's food needs. This agrobiodiversity is supported both through intercropping of domesticated plants that hold mutually beneficial relationships (e.g. grains with legumes, wherein the grain provides structural support and the legume fixes nitrogen) as well as through management of wild or semi-domestic plants that support diets, deter or distract pests, or provide other services (Torres Guevara and Parra Rondinel 2005). Planting calendars are determined by lunar cycles, solar cycles and climatic signals. Synergistic ecological management of the soil, water and the greater natural environment is integrated with spiritual connections to *Allpa Mama* (literally, mother earth or mother soil; refers to the idea of "living soil"), *Yaku Mama* (literally, mother water; refers to the idea of "living water") and *Pacha Mama* (literally, mother universe; refers to the natural environment and the universe's energetic vitality) (Gortaire 2016). In the Northern highlands, where potato production presently dominates the agricultural landscape, some farmers and especially those who manage the steepest slopes continue to apply the traditional *wachu rozado* strategy. This strategy employs a tillage technique that conserves soil from erosion, protects tubers from pests by managing humidity and has been shown to be overall more productive than modern tillage conventions (Sherwood 2009, 38).

In recent decades, a convergence of competing demands resulted in many farming families in the Ecuadorian highlands maintaining their traditional practices by implementing a double-strategy: on part of their land, they produced cash crops for the market using "modernized" approaches including application of agrochemicals; simultaneously, they produced for home consumption, using traditional agroecological practices based on biodiversity and efficient use of natural resources (Gortaire 2016). However, as farming families began to lose revenue on cash crops (Sherwood 2009; Waters 2007) and experience the severe health effects and mortality related to pesticides (Cole et al. 2002; Sherwood and Paredes 2014), some families abandoned the project of modernization and returned to the safer route of traditional agriculture approaches (Gortaire 2016). Simultaneously, certain scientific and academic organizations became concerned with the environmental impacts of agricultural modernization, and began promoting the reintegration of plant and animal agrobiodiversity, soil conservation practices, appropriate water use, native reforestation, and organic fertilizers (Gortaire 2016).

By the 2000s, agroecology became the dominant paradigm for sustainable agriculture in Ecuador, as in much of Latin America, and numerous farmers' organizations, NGOs, and broader networks emerged at a local and national level for its promotion (Gortaire 2016; Sherwood et al. 2013). Simultaneously, agroecology became a way to honor and reconnect with the traditional Indigenous agricultural strategies and related cultural traditions that persisted but had lost prominence (Gortaire 2016). As more and more Indigenous and non-Indigenous farmers appropriated agroecology and began to self-identify as agroecological, the production practice increasingly took the shape of a movement. Now, Ecuador's agroecological farmers are well-connected in farmers' associations that organize farmers' markets or engage in other types of alternative food networks. Agroecological networks also organize education initiatives relating to food production, transformation, commercialization and consumption, and farmers are the co-authors of educational campaigns that bring together consumers and producers around food as an articulating common cause (Sherwood et al. 2013).

The role of alternative food networks

The recognition of agroecology as a means to reclaim food sovereignty played a large role in the creation and promotion of agroecology-based **alternative food networks (AFNs)**, such as farmers' markets and community-supported agriculture food baskets (Gortaire 2016; Goodman and Goodman 2009). AFNs emerged as an integral component for exerting food sovereignty because they allowed farmers to capture monetary value on their agroecological products by selling directly to consumers (Gortaire 2016). This not only allowed them to establish more equitable prices, but also to sell a diversity of products in smaller quantities, rather than in the bulk quantities expected by intermediaries in conventional commercial networks (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017; Deaconu, Borja, and Oyarzún 2015). Moreover, they created

Alternative food networks (AFNs): Providing an "alternative" to conventional agriculture and supply chains that are frequently harmful to farmers, these networks typically consist of short commercial value chains connecting sustainable family farming to consumers through little or no intermediation (Goodman and Goodman 2009). In Ecuador, the most relevant examples include farmers' markets, food baskets and solidarity stores (Gortaire 2016; Heifer 2014).

affective (i.e. emotional) relationships between producers and consumers that favoured equitable transactions and positive interpersonal experiences (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017; Sherwood, Arce, and Paredes 2018). Agroecology-based AFNs initially took hold in the 1990s, and interest grew rapidly: by 2013, a study documented 210 active AFNs across 17 of Ecuador's 24 provinces, and the authors posited that others existed that they had not yet identified (Heifer 2014). AFNs are now the primary spaces in which agroecological farmers discuss ideas, create a shared identity, initiate new practitioners, and establish norms around production practices (Heifer 2014).

The growth of agroecology-based AFNs brought greater visibility to agroecology, allowing for the creation of larger agroecological networks that included not only farmers' associations but also consumers and other allies (Gortaire 2016). Through these diverse alliances, Ecuador's agroecology movement has expanded to address multiple aspects of the food system that extend beyond agricultural production. An integral component is now the promotion of "responsible consumption" among farmers and non-farmers alike, which advocates for consuming food that is nutritious and healthy for the producer, consumer and environment, that promotes social and economic justice, and that is culturally relevant (Sherwood et al. 2013; Sherwood, Deaconu, and Paredes 2017; April-Lalonde et al. 2020). The shift in the discourse from "agriculture" to the more inclusive "food" gave entry to new interest and opportunities to integrate subjects such as gastronomy and nutrition into the activities of agroecological networks, and gave rise to specific concerns regarding farmers' nutrition-related health (Sherwood et al. 2013; Sherwood, Deaconu, and Paredes 2017).

In summary: The environmental, social and health problems associated with conventional agriculture motivated Ecuadorian farmers to seek a more sustainable alternative, and many united around agroecology. They further implemented alternative food networks such as farmers' markets to exert food sovereignty and sell their agroecological products. These networks opened the door for new alliances that ultimately expanded the priorities of agroecology to include not just agriculture but also food, integrating nutrition into the discourse.

2.2 Nutrition imperatives in Ecuador

Nutritional health is a term used throughout this thesis to encompass dietary practices and health outcomes that directly relate to nutrition, including both food and nutrient intakes, typically measured through dietary assessment methods, as well as physiological outcomes, measured through anthropometric (e.g. height, weight), biochemical (e.g. nutrient levels) and clinical assessment (e.g. disease diagnosis). This summary term is used to simplify discussion on different health concepts within and adjacent to nutrition. Greater specificity is provided when relevant, and particularly to describe the components of nutritional health assessed in this study's research methods (as described in Sections 4 and 5).

In 1986, a nationally representative survey on food, nutrition and health among children under 5 years of age, DANS[1], marked Ecuador's interest in systematically understanding its population's **nutritional health**. This survey identified high prevalence of both acute and chronic malnutrition, characterized by emaciation and stunting, respectively (Freire, Ramírez, and Belmont 2015). Since then, Ecuador has made striking progress in reducing hunger[2], and has slashed its prevalence from 21% to 9% over the past decade (FAO et al. 2020). This progress notwithstanding, the most recent nationally representative nutrition survey, ENSANUT-ECU[3], which gathered data from 2011 to 2013, upheld the importance of prioritizing nutrition in national public health policy. This data underlined that nutritional health imperatives have shifted from addressing hunger to a need for addressing diets marked by chronic nutrient imbalances, including both deficiencies and excesses, and their widespread physiological consequences (Freire, Ramírez, and Belmont 2015).

2.2.1 Malnutrition in Ecuador

A double burden of malnutrition

Like most other countries in Latin America and the Caribbean (FAO et al. 2019), Ecuador is now weighted by a double burden of malnutrition, wherein high rates of micronutrient deficiency coexist

[1] The name of the survey, DANS, is the Spanish acronym for Diagnóstico de la Situación Alimentaria y de Salud de la Población Ecuatoriana Menor de Cinco Años.

[2] Hunger is measured according to undernourishment, referring to the inability to meet daily caloric needs (FAO et al. 2020).

[3] The name of the survey, ENSANUT-ECU, is the Spanish acronym for *Encuesta Nacional de Salud y Nutrición del Ecuador.*

with overweight and obesity (OW/OB) (Freire et al. 2014). As a result, the consequences associated with micronutrient deficiency—which include among others, stunting, cognitive deficiencies and immune system impairment (Branca and Ferrari 2002; M. M. Black 2003; Katona and Katona-Apte 2008)—persist and are now accompanied by increased prevalence of chronic diseases that include but are not limited to heart disease, diabetes mellitus, cerebrovascular disease and hypertensive disease (Freire, Ramírez, and Belmont 2015). Indeed, these diseases rank as the top four causes of death in Ecuador, in the same order (INEC 2014). The double burden of malnutrition is visible at different scales. On a national level, 25% of children under five are stunted, while OW/OB is present in 8.5% of children of the same age range and in 63% of adults. At a household level, over half of stunted children under five have an OW/OB mother, and at an individual level, 20% of stunted children aged 5-11 are themselves OW/OB (Freire, Ramírez, and Belmont 2015).

Although stunting in Ecuador has decreased over the past decade, the prevalence for children under five remains, alarmingly, over three times the South American average of 7.3% (FAO et al. 2020) and trails only Guatemala when compared to other countries in Latin America and the Caribbean (FAO et al. 2019). With respect to OW/OB among adults (63%), Ecuador performs better than the South American average of 81%, and the prevalence for children under five (8.5%) is similar to the South American average of 7.9% (FAO et al. 2020). Both under- and overnutrition come at a cost. The United Nations Economic Commission for Latin America and the Caribbean estimates that, in 2014, undernutrition[4] cost Ecuador $2.6 billion (USD) and overnutrition (OW/OB) cost $1.7 billion, when accounting for costs to health, educational efficiency and productivity. When looking at costs to health alone for that year, overnutrition, at $1.5 billion, cost the country's public health system and private pockets 35 times more than undernutrition (which cost $43.5 million) (Fernández et al. 2017).

Nutrition transition

Ecuador's double burden of malnutrition is the result of its incomplete passage through a nutrition transition from traditional to globalized foods (Freire et al. 2014), making its population simultaneously vulnerable to the nutritional disadvantages of both systems. Thus, while deficiencies associated with

---

[4] The study's indicator includes costs associated with a history of underweight, stunting and wasting (Fernández et al. 2017).

traditional food systems persist, increased consumption of processed foods and higher intakes of simple carbohydrates, sodium and saturated fats lead to dangerous nutrient excesses (Popkin 1993; Popkin, Adair, and Ng 2012). The ENSANUT-ECU survey characterizes how this nutrition transition is manifest in the Ecuadorian diet, estimating that less than three percent of the population meets recommended fiber intake levels, reflecting low consumption of fruit and vegetables. Meanwhile, rice, bread, sugar and other simple carbohydrates are among the top contributors to caloric intake, along with palm oil. The latter is further problematic because of its high saturated fat content. Further, the survey finds that increased consumption of sugar-sweetened beverages, processed and ultra-processed foods are contributing to high intakes of calories, sodium and unhealthy fats (Freire, Ramírez, and Belmont 2015). In 2013, sales per capita of processed foods in Ecuador was 88 kg, representing a 20% increase over merely three years (PAHO 2015). While this was lower than the Latin America regional average of 130 kg per capita and paled in comparison to the United States (307 kg) and Canada (230 kg) (PAHO 2015), the rapid increase is cause for deep concern. Even in parts of rural Ecuador where processed and ultra-processed foods are not yet as prevalent, high intake of culinary ingredients including oils, sugar and salt contribute to the excesses and imbalances characteristic of the nutrition transition (Gross et al. 2016).

The ENSANUT-ECU identified the most pressing micronutrient deficiencies to be those in iron, vitamin A and zinc, with inadequate dietary intake among 83%, 77% and 42% of the population for each nutrient respectively (Freire, Ramírez, and Belmont 2015). Despite national supplementation programs, prevalence of deficiency for each was higher in 2012 than in 1986-1988 national data (Freire, Ramírez, and Belmont 2015)). ENSANUT-ECU also identified calcium, B12 and vitamin C as other micronutrients of concern, with inadequate intake estimated for 96%, 12% and 27% of the population, respectively. Iodine deficiency is no longer a problem thanks to successful salt iodization policies; instead, there now appear to be harmful iodine excesses caused by high salt intake. The ENSANUT-ECU authors highlighted zinc as the most important micronutrient to prioritize, given the role of zinc deficiency in stunting. While zinc is common in animal-source foods, at a national level the primary source of protein is rice, which inhibits zinc absorption due to its high phytic acid content (Freire, Ramírez, and Belmont 2015). This further underlines the unique complexity of the nutrition transition, given rice's status as a recently-introduced food associated with modernity in much of Ecuador (Gross et al. 2016).

2.2.2 Social inequalities and malnutrition

Rural and Indigenous populations

The prevalence of different forms of malnutrition in Ecuador is enmeshed with deeply-rooted and self-perpetuating inequalities, with certain populations more vulnerable to malnutrition than others. Poverty, which affects 26% of the total Ecuadorian population[5] (INEC 2016), is intricately linked to stunting and micronutrient deficiency, as are low education and ethnic identity (Larrea and Kawachi 2005; Freire, Ramírez, and Belmont 2015; Ramírez-Luzuriaga et al. 2020). Notably, rural people are three times more likely to live in poverty than urban people, with poverty prevalences of 47% and 16%, respectively. Among rural people, those who depend on agriculture for their livelihoods are even more susceptible to poverty (INEC 2016). In turn, the nation's rural population has consistently higher prevalence of different forms of undernutrition among both children and adults, including underweight, stunting and key nutrient deficiencies (Freire et al. 2014).

Indigneous people, who are more likely to live in rural areas[6] and depend on farming as a livelihood (INEC 2006), are also at the highest risk for poverty and undernutrition. Indeed, Indigenous identity is the strongest predictor of poverty at a national level, with poverty affecting an alarming 65% of the Indigenous population (INEC 2016). Among Indigenous women, 52% have short stature, which is indicative of a history of stunting, compared to 27% of mestizo (i.e. non-ethinic minority) women, and 42% of Indigenous children are stunted, compared to 24% of mestizo children (Ramírez-Luzuriaga et al. 2020). Indigenous populations also fare worse on other specific nutritional indicators; for example, they are less likely to meet their protein needs, and Indigenous children are more likely to be anemic (Freire, Ramírez, and Belmont 2015).

At first glance, OW/OB appears to be a somewhat more democratic player in that the nation's wealthiest fare only slightly better than do others, with an OW/OB prevalence of 60% among the

---

[5] The 2014 income-based poverty line is established at $84.32 USD per capita monthly and the extreme poverty line is established at $47.56 USD per capita monthly (INEC 2016).

[6] 81% of Indigenous men and 83% of Indigenous women live in the country's rural sectors (INEC 2006).

wealthiest income tertile, compared to 66% in the lowest and middle tertiles (Ramírez-Luzuriaga et al. 2020). Although OW/OB remains a larger problem among urban adults, the burden is shifting quickly toward rural sectors. The annual increase in prevalence of OW/OB is higher in rural areas than it is in urban areas, and children in rural areas have higher prevalence of OW/OB than children in urban areas (Freire et al. 2014). Indigenous adult women currently have lower prevalence of OW/OB than their mestizo counterparts (55%, compared to 64%), but no such difference appears when comparing children or adolescent girls, suggesting that Indigenous populations may, unfortunately, be catching up on this health problem (Ramírez-Luzuriaga et al. 2020). Similarly, diet-related chronic diseases have made deep inroads into both urban and rural sectors, and across all wealth levels and ethnic groups (Freire, Ramírez, and Belmont 2015).

Cycles of inequality and malnutrition

Not only do socioeconomic factors contribute to malnutrition, but malnutrition also perpetuates the cycle of inequality. This is exemplified by the relationship between childhood undernutrition and education. An analysis by the United Nations Economic Commission for Latin America and the Caribbean and the World Food Programme found that, in Ecuador, stunting is associated with a three-fold lower probability of finishing primary school, and only 11% of people who were stunted as children finish secondary school, compared to 45% of those without a stunting history. In total, chronic undernutrition is estimated to be associated with an education gap of 2.3 years (excluding post-secondary education) (Fernández et al. 2017). In turn, this education gap can contribute to further malnutrition, as shown by a study based on Ecuadorian census data that found that lower maternal education level is associated with children's stunting (Larrea and Kawachi 2005).

Cruelly, malnutrition also begets further malnutrition through physiological mechanisms. A growing understanding of health development throughout the life course posits that factors operating early in life can have long-term health outcomes (Halfon et al. 2014). People who were undernourished as children are not only more likely to become OW/OB later in life, but they are also more likely to experience greater severity of metabolic disorders (Stein, Thompson, and Waters 2005). Moreover, the children of women who experienced nutrient deficiencies during pregnancy are more likely to experience metabolic disease throughout their life course (Godfrey, Gluckman, and Hanson 2010). The ultimate result is that undernutrition catalyses the double burden of malnutrition in individuals and across generations, thus enabling the inequalities that underscore nutritional deficiencies to also be implicated in nutritional excesses.

In summary: In Ecuador, a nutrition transition from traditional to globalized food systems has placed the country in the throes of a double burden of malnutrition, wherein the problems of nutrient excesses are expanding while the problems of nutrient deficiencies have yet to be resolved. Rural and Indigenous people, who are primarily situated in the country's highland region, face multiple, self-perpetuating inequalities that increase their vulnerability to this double burden.

2.3 Focus on highland farmers' food and nutrition

Ecuador is frequently described according to four main regions with distinct biogeographic, historic, economic and cultural characteristics—the highlands, coast, Amazon and Galápagos—and the socioeconomic differences in malnutrition are mirrored by differences across these regions, as well as internal differences between the rural and urban sectors. The rural sector of the highland region ranks the highest in terms of poverty, affecting 46% of the population (compared to 26% nationally) (INEC 2016), as well as stunting, affecting 38% of children (compared to 24% nationally) (Freire, Ramírez, and Belmont 2015). Uncoincidentally, this region is also home to the majority of the country's Indigenous and rural population, as well as population relying directly on farming for their livelihood (INEC 2006; Heifer 2014). Understanding the circumstances that place rural highland populations at disproportionate risk of malnutrition requires attention to the unique challenges that farmers face, the dietary practices in the region, as well as the environmental co-factors that contribute to and aggravate malnutrition in rural areas.

2.3.1 Opportunities and obstacles for nutritional health

Smallholder, family farmers (Berdegué and Fuentealba 2011), who comprise an estimated 85% of Ecuador's farming population (Leporati et al. 2014), rely heavily on consumption of own-production as well as agriculture-based income for food. The biogeographic conditions of the highland region, which belongs to the *páramo* Andes ecosystem stretching between Peru and Venezuela, provides unique opportunities for biodiverse farming. Its inhabitants live at altitudes from about 1,500 to over 3,000 meters above sea level in the inter-Andean valleys and mountainsides that rest between Ecuador's Western and Central cordilleras. This region is characterized by extreme altitudinal variation, meaning that multiple ecosystems exist over short geographic distances. This condition allows farmers to grow a diversity of crops over small distances, from tropical fruits in lower regions to Andean grains (e.g. quinoa, amaranth) and tubers (e.g. potatoes, *melloco*, *oca*) in higher regions, thus contributing tremendous diversity to the local food environment and often even to individual family farms with parcels at different altitudinal levels. Further, a wet climate and diurnal (i.e. from day to night) rather than seasonal temperature variation allow farmers to maintain a diversity of crops throughout the year even with little or no irrigation (Fonte et al. 2012; Prefectura de Imbabura 2017).

Smallholder, family farmers: The terms "smallholder" and "family farmer" generally refer to producers managing farms that are *(i)* small, with respect to local dimensions; *(ii)* family-operated; and, *(iii)* have limited or no non-family hired labor (Berdegué and Fuentealba 2011). **In this thesis any mention of farmers is in reference to smallholder, family farmers, unless explicitly stated otherwise.**

However, the highland region's history of inequality in land access for Indigenous people and the rural poor has relegated many of these farmers to small plots on highly-sloped, high-altitude or otherwise marginal lands. Farmers of Indigenous identity now usually occupy the most challenging environments (Waters 2007; Melby et al. 2020), characterized by steep mountainsides with severe water run-off and soil erosion, poor road infrastructure, high winds and dramatic weather events (e.g. hail, drought, violent rainstorms) made worse by climate change, and extreme difference in day-and-night temperatures (Sherwood 2009). The unique complexities of producing on these lands lead many families to prioritize high energy density foods such as potatoes, corn and simple carbohydrates, thereby paving the way for both micronutrient deficiencies and macronutrient excesses (Oyarzun et al. 2013; Berti, Krasevec, and Cole 2004). Improving this situation is further complicated by additional factors that affect Ecuador's rural sectors and farming populations, including limited access to education, health care, credit, and other services (Torres et al. 2016), neurobehavioral impairment and other consequences of pesticide exposure (Berti, Krasevec, and Cole 2004; Cole, Carpio, and León 2000), production challenges due to soil degradation, climate change, and pesticide resistance (FAO 2015), economic uncertainty due to fluctuating markets for cash crops (Zamosc 1994; Sherwood 2009), gastrointestinal infections from parasites and enteric pathogens (Jacobsen et al. 2007), cultural displacement of traditional foods (King and Gershoff 1987) and traditional knowledge (Gortaire 2016), as well as historic and modern-day discrimination against Indigenous people (Torres et al. 2016).

2.3.2 Dietary practices

Despite the vulnerability of the highland rural sector, the past two decades have seen limited research on the consumption practices of family farmers in the region (Oyarzun et al. 2013; Berti, Fallu, and Cruz Agudo 2014). Existing research shows that the transition from subsistence farming to wage labour and migration has changed the way farming families eat. While Ecuador's rural highland families eat more fruits and vegetables today than they did three decades ago (Soto 2014), access to wages has increased consumption of carbohydrates and processed sugars, and a clear nutrition transition is underway (Soto 2014; Oyarzun et al. 2013). Moreover, factors such as women's increased workload and global market values have resulted in the decision to sell rather than consume highly nutritious Andean crops such as quinoa and lupine beans, and to use the cash to purchase cheaper, but less nutritious industrialized foods (Arce, Sherwood, and Paredes 2015).

Eating practices in the Ecuadorian highlands do not exhibit the intra-household nutritional disparities (typically favouring adult men) that have been reported in other countries; instead, household members tend to eat the same foods in equitable quantities, regardless of sex or age (Berti, Leonard, and Berti 1997; Berti, Krasevec, and Cole 2004). However, gender is important for determining roles in food practice, with women playing a greater role and holding high decision-making power in food-related practices such as preparing food, feeding children and making food purchases (Soto 2014; Peterman et al. 2015).

In the northern highlands, Berti and colleagues found diets to be dominated by potatoes and grains, with adequate vegetable intake, but insufficient intake of animal products. As a result, dietary intake was high in carbohydrates, with potentially inadequate intakes of protein and fat. The study also found high prevalence of inadequate intake of vitamin A, vitamin B12, zinc, folate, riboflavin and calcium. Instead, vitamin C intake was high, and iron intake was mostly adequate, which the authors identified as a likely result of high levels of potato consumption (Berti, Krasevec, and Cole 2004). In a study on children of potato growers in Ecuador's central highlands, Orozco and colleagues reported dietary patterns similarly dominated by excess carbohydrate intake and insufficient protein intake, but also identified widespread excess in caloric intake as well as excess fat intake among a quarter of participating households. Unlike Berti and colleagues, Orozco and colleagues found iron intake to be insufficient among 96% of the study population; findings for other micronutrients were largely similar between the two studies (Orozco et al. 2007). The disparities in fat and iron intake between the two studies may have been as much a reflection of distinct research methods (e.g. Berti and colleagues assessed dietary intake using two 24-hour recalls whereas Orozco and colleagues used food purchases) as that of true nutritional differences between the two populations. However, both highlight problematic macronutrient intakes and micronutrient inadequacies associated with a deficit in animal-source foods.

2.3.3 Environmental co-factors in farmer malnutrition

While poor diet is the most proximate cause of malnutrition, other environmental factors may place Ecuador's farmers at additional risk of malnutrition as well as exacerbate its consequences, with strong evidence for the role of gastrointestinal infections and pesticide exposure[7]. Among rural populations, gastrointestinal infection can be related to lack of potable water, close contact with farm animals, and oral-fecal contamination (World Health Organization 2015). Pesticide exposure on the farm is not limited to people who apply pesticides, but can also occur through inappropriate storage as well as exposure to clothing or to household items that have come into contact with pesticides (Cole et al. 2002).

Gastrointestinal infectious disease

Diarrheal disease, parasitic infections and enteric pathogens play an important role in malnutrition throughout the life cycle. These gastrointestinal infections can impair nutritional status by creating acute symptoms, such as diarrhea, blood loss and loss of appetite, as well as chronic nutrient

[7] Earlier literature also pointed to low oxygen levels, or hypoxia, related to life at high altitudes as a factor that may affect nutritional outcomes in high-altitude populations such as those of Ecuador´s highlands. However, the relationship seems to disappear when controlling for socioeconomic factors, suggesting that hypoxia may not play the role that was previously hypothesized (Leonard et al. 1990).

malabsorption related to gut inflammation or damage known as environmental enteropathy. Particularly among young children, both acute and chronic symptoms can result in stunting and impaired cognitive development (World Health Organization 2015). However, these problems are not unique to children, and can also affect nutrient absorption among adults (Korpe and Petri Jr 2012).

One study in the rural Ecuadorian highlands underlined the pertinence of gastrointestinal infections in this region, finding the prevalence in the study population to be higher than among similar studies in South America (Jacobsen et al. 2007). Of ten parasites and pathogens tested, 86% of children were infected with at least one and 63% were infected with two or more. Additionally, 78% had at least one protozoan infection and 42% had at least one helminth infection (Jacobsen et al. 2007). Children may also suffer the consequences of gastrointestinal diseases indirectly. For example, maternal anemia, which may be caused by nutrient malabsorption (Korpe and Petri Jr 2012), increases the risk of preterm delivery, low birth weight and undernutrition during childhood (R. E. Black et al. 2013). Similarly, a study in Ecuador identified associations between maternal parasitic infection and fetal growth retardation, even when the infection was asymptomatic (Weigel et al. 1996).

Pesticide exposure

Pesticide exposure is of pressing concern in the Ecuadorian highlands, and in one province, mortality due to pesticide poisonings ranked among the highest reported in the world (Cole et al. 2002; Sherwood 2009). Adding to the many consequences of pesticide exposure—which include acute poisoning, skin disorders, neurological effects and cancer—it appears that pesticide exposure also interacts with various forms of malnutrition and their consequences. Although few studies support a direct causal relationship between pesticide exposure and nutritional deficiencies, one study in the United States suggests that such a link exists between organochlorine pesticides and vitamin D deficiencies (J.-H. Yang et al. 2012). Further, a study with Ecuadorian agricultural workers found lower hemoglobin levels in male pesticide appliers as compared to female housewives who had less pesticide exposure, suggesting a potential, though unconfirmed, link between pesticides and anemia (Cole n.d. In (Berti, Krasevec, and Cole 2004)). Instead, more evidence exists to support the link between pesticide exposure and the problems associated with nutrient excesses, particularly to metabolic syndrome (Rosenbaum et al. 2017; D.-H. Lee et al. 2011), cardiovascular disease (Ha, Lee, and Jacobs Jr 2007), obesity, dyslipidemia, insulin resistance and diabetes (D.-H. Lee et al. 2011). In the Ecuadorian highlands, Grandjean and colleagues found prenatal pesticide exposure to be associated with higher systolic blood pressure in children, putting them at higher risk for cardiovascular disease later in life (Grandjean et al. 2006).

Pesticide exposure and malnutrition can also lead to similar cognitive outcomes, thus exacerbating this problem among farmers and other populations that are vulnerable to both factors. For example, deficiencies in many nutrients—including iodine, iron, zinc, vitamin A, vitamin B12, folate, thiamin, vitamin E and essential fatty acids—can lead to similar nervous system effects and neurobehavioural outcomes as exposure to pesticides containing carbamate and organophosphorus (Berti, Krasevec, and Cole 2004; Cole et al. 1997), and use of pesticides containing these compounds is widespread in the Ecuadorian northern highlands (Cole et al. 1997). In their study in the Ecuadorian highlands, Grandjean and colleagues found that both prenatal pesticide exposure and stunting were similarly associated with children's performance on cognitive tasks, even though pesticide exposure and stunting were not themselves causally related (Grandjean et al. 2006). Meanwhile, Berti and colleagues found high neurobehavioural impairment among adults, but determined that their data could not discern the effects of pesticide exposure from those of childhood nutrient deficiencies (Berti, Krasevec, and Cole 2004).

In summary: Farmers in the Ecuadorian highlands confront unique agricultural and social challenges that undermine their ability to produce healthy foods for their own consumption, resulting in diets dominated by energy-dense carbohydrates and low in key nutrients. Many also live in environments where gastrointestinal infections and pesticide exposure further compromise nutritional health and aggravate the consequences of malnutrition.

2.4 Historical overview of Ecuadorian highland food systems

To better understand the consequences of conventional, modern food systems, it is useful to gain perspective by turning to the food systems of the past. Given the particular nutritional inequalities that Indigenous people in Ecuador presently face, this section explores in broad strokes how the food systems and nutritional circumstances of Indigenous people in present-day highland Ecuador have evolved over time, beginning with available evidence from pre-Colombian food and agriculture. It does not pretend to capture either the heterogeneity of experiences around food and agriculture across time and locations, nor does it capture the tremendous atrocities of colonization and subjugation of Indigenous people.

2.4.1 Pre-Colombian food systems

Much of what we know about pre-Colombian agriculture and food in the Ecuadorian highlands is pieced together based on archeological remains and early documentation at the time of colonization. Because evidence from archeological remains is sparsely scattered across millenia, it can only be used to form general hypotheses of how food systems have evolved over time.

Pre-Colombian people in the Ecuadorian highlands are theorized to have taken advantage of the unique biogeographic conditions of the highland region—particularly the rapid altitudinal changes—to employ "micro-verticality" in their land management practices. Micro-verticality allowed people to farm or otherwise utilize land in different climatic niches and return home at the end of each day (Salomon 1980). Early Spanish descriptions of production practices suggest that farmers managed their land by employing inter- and intra-species crop biodiversity, intercropping techniques, crop rotation, fallow periods and the application of manure and other organic amendments (Sherwood 2009; Estrella 1986). Moreover, they utilized creative agricultural strategies to adapt to the rough terrain and extreme weather events of the highlands, including complex irrigation systems, cisterns, terracing and development of resilient varieties of grains and tubers (Estrella 1986).

Early Spanish documents from the 16th century show which Andean foods were utilized in the region at the time of conquest. In the lower, humid valleys dropping away from the Andes, Indigenous people produced coca, cotton, fruit, sweet potato, *yacón* (*Smallanthus sonchifolius*, known in Ecuador as jícama) and *zanahoria blanca* (*Arracacia xanthorrhiza*, which somewhat resembles a parsnip). Higher up, the mild inter-Andean valleys were home to cereals such as maize and quinoa, legumes such as field beans, and certain tubers, notably potato. In the highest cultivated regions of the highlands, where wind, rain, and occasional sub-zero temperatures meant that only the hardiest of crops could survive, people primarily cultivated various Andean roots and tubers, including potato, oca, melloco and mashua (Estrella 1986). While these products receive the lion's share of attention in present-day discussions on traditional Andean foods, historical evidence points to the use of numerous fruits and vegetables in the diet and in medicinal preparations. In Estrella's analysis, the author believes that pre-Colombian Andean people consumed vegetables in greater frequency and diversity than did the Indigenous population of the 1980s. Estrella's conviction is supported by Cabello de Valboa's 1576 journal entry, where he writes in astonishment regarding the diversity of plant foods consumed by Indigenous people of the Andes:

> "No tiene cuento ni número la gran cantidad, y variedad de yerbas que han descubierto, y hallado para comer ansi concidas como crudas, acompañando las unas, y las otras con la sal, y ají (...)" (Estrella 1986).
>
> English translation:
> There is no count or number of the great quantity and varieties of plants that have been discovered and found to eat, both cooked and raw, accompanied by salt and chili."

Among numerous others, vegetables that were documented in the pre-Colombian highland diet include *penco* (an agave species), *lengua de vaca*, the leaves of various quinoa and amaranth species, *verdolaga*, *melloco* leaves, *berro* (watercress), *chulco*, nasturtium leaves and flowers, *achojcha* (slippery gourd), tomato, hot peppers, and *zambo* (a type of squash)[8]. Highland fruits that were documented at the beginning of Spanish arrival include, among others, *mortiño*, *capulí*, cactus fruit, *chichualcán*, *chamburo* (both relatives of the papaya), avocado, *chirimoya*, *pepino*, and several types of passionfruit[9]. Nuts and seeds included the *tocte*[10] nut and squash seeds. Beside these, numerous other plants were used to season food as herbs or spices. Animal products also came from a variety of

---

[8] Penco: *Agave americana L.*; Lengua de vaca: *Rumex crispus L., Rumex longifolius, Rumex acuaticus, Rumex acatus, Rumex grandifolia.*; Quinoa: *Chenopodium abrosioides, Chenopodium quinoa Willd*, *Chenopodium album*; Amaranth: *Amaranthus caudatus, Amaranthus quitensis, Amaranthus blitum*; Verdolaga: *Portulaca oleracea L.*; Melloco: *Ullucus tuberosus*; Berro: *Nasturtium officinale*; Chulco: *Oxalis spp.* Nasturtium: *Tropaeolum majus L.*; Achojcha: *Cyclanthera pedata Shrad*; Zambo: *Curcubita ficifolia Bouche*.

[9] Mortiño: *Vaccinum floribundum*; Capulí: *Prunus salicifolia*; Chihualcán: *Carica candamarcensis Hook*; Chamburo: *Carica chrysopetala Heilborn*; Cherimoya: *Anona cherimolia Mill*; Pepino: *Solanum muricatum Ait*.

[10] Tocte: *Juglans Honorei Dode, Juglans neotropica Diels*.

sources, including domesticated peccaries, guinea pigs, ducks, pigeons and llamas, as well as from hunting of wild animals such as cottontail rabbits, white-tailed deer and other deer species, wild peccaries, fowl and non-domesticated camelids. Highland people also consumed the *catzo* beetle[11], several types of snails all referred to as *churos*, and numerous freshwater fish from rivers and lakes. Domesticated dogs were also likely used for meat (Estrella 1986). Not only was this a formidable variety of nutritious foods, but it was likely accessible in relative abundance. For example, early Spanish descriptions refer in amazement to the ease with which deer and rabbit were hunted by Indigenous people throughout the highlands (Estrella 1986).

Beyond the good fortune of ecological diversity, pre-Colombian food systems were shaped by economic, political and socio-cultural contexts. Societies were organized in such a way that not everyone had to devote their energy to agriculture. Instead, agricultural surpluses opened up human capital for other activities, such as for artisanry, trade, and political and spiritual social functions. Foods and other goods that were not readily available in the local landscape were obtained through barter. Long-distance merchants, termed *mindalaes*, extended bartering networks beyond the highlands, affording a certain degree of access to goods from the coastal and Amazonian regions (Salomon 1980; Estrella 1986). Salt was one such bartered good, and highland mines in present-day Imbabura and Bolívar provinces provided iodine-rich salt. By some accounts, the distribution of salt from these mines was sufficient to shield much of the highland population from iodine deficiency until the 18th century, when colonial preference for sea salt, among other factors, reduced access to iodine-rich montane salt (Pomeroy 1988).

As remains the case today, access to food was also influenced by social hierarchy. Prior to the Incas, some societies established social stratification systems wherein commoners paid tribute, via goods or labour, to higher class society members. Such was the case of the Cara society, who inhabited present-day Imbabura and Pichincha provinces. Modern descriptions of this time period classify the population into two groups: political leaders termed *caciques*, and common labourers. When the Incas arrived in Cara territory—just decades before the Spanish—tributary systems were expanded and social stratification became much more pronounced. Social differences in access to food were visible at the

[11] Catzo: *Euchroma gigantea*

time of Spanish arrival. For example, documents written by Ponce de León in 1582 suggest that, in the region of present-day Imbabura province, llama meat was not accessible to most people, and was rather the purview of the ruling class or of wealthy coca growers. The case of the llama also shows how pre-Colombian political transitions brought ensuing changes to the food environment. It was not until the arrival of the Incas that llama domestication became widespread in the Ecuadorian highlands, despite archaeological remains of camelids in this region from as early as 3000 B.C.E (Estrella 1986).

Notwithstanding social differences (and potentially injustices) in food access, the confluence of favourable conditions in the food environment led early Spanish conquistadors and chroniclers to comment on the robust, healthy-looking, medium-height frame of Indigenous highland people, as well as their intellect and longevity (Estrella 1986). Similarly, paleopathology (the study of disease in bones and teeth) reveals that pre-Conquest Ecuadorian people were likely healthier and better nourished than their contemporaries in other parts of Latin America (Ubelaker and Newson 2002).

2.4.2 Food system transitions from Spanish conquest through agricultural modernization

The arrival of the Spanish upended Indigenous societies. In the central Andes, the arrival of new pathogens, as well as conflict and displacement, decimated the region's population to less than a third of its original size over the span of a single generation (Sherwood 2009). With Andean societies at their knees from a slew of multiple epidemics, it was arguably easy for the Spanish to conquer these well-organized societies and install a new social order (Mann 2005), including changes to the production, distribution and consumption of food.

Lacking major mineral deposits, the Ecuadorian highland region did not immediately attract as much Spanish interest as did modern-day Chile, Peru and Bolivia. When the value of minerals dropped at the end of the sixteenth century, the Spanish turned to agricultural production as a means of wealth accumulation and Ecuador's lands became of increased interest. In a land concession policy known as *encomienda*, the Spanish Crown assigned conquistadors the rights to land and to its inhabitants. In exchange for this concession, the conquistador held the obligation to "protect" the Indigenous inhabitants and convert them to Catholicism. The inhabitants, in turn, were subject to paying tributes and providing labour services in exchange for this protection (Sherwood 2009).

The Spanish encomienda system drastically altered Indigenous people's means of production across Latin America. Land concessions altered access to resources, including to land for agriculture and to hunting grounds, while forced labour and tribute payments reduced the time available for these independent productive activities. The pre-existing social organization systems that permitted collective land management and collective labour during key moments of the cropping cycle were largely dissolved. In places where labour demands forced people to abandon their communities for extended periods of time, crops would fail and seeds—many of which are reproduced by allowing healthy exemplars of living plants to reach the end of their life cycle—would be lost. Just as people's means of production were truncated, they also had to produce enough to meet tribute demands, which commonly reached 25 to 50 percent of their harvest. On the other hand, the food demand that Indigenous people needed to meet their own consumption decreased drastically—owing to the cruel reality of depopulation (Sherwood 2009).

While the forced labour of the encomienda system was abolished in 1812, it gave way to the indentured servitude of the *hacienda* system, known locally as the *huasipungo*, which would predominate Ecuador's highland agriculture until the mid-1900s. While Indigenous people were no longer considered property, in this system, they had to pay landowners for the right to live and farm on their land. Payments were generally made through a portion of their harvest, or through labour (Guerrero 1975). While the hacienda system was nominally a humanitarian improvement over its predecessor, the lived reality depended highly on the personality and management of each landowner. For many Indigenous people, it was still not far from slavery (Zamosc 1994).

By the end of the 17th century, the hacienda system consolidated the importance of agriculture to Ecuador's economy. The Spanish Crown took measures to support agricultural development for growing domestic and regional markets, as well as for export to Europe. This growing attention to agricultural development largely displaced the remaining vestiges of pre-Colombian Andean agricultural management practices, including microverticality and the social structures supporting collective agricultural systems (Sherwood 2009). The Spanish began introducing Old World crops almost immediately upon arrival, such as sugar cane, wheat, barley, and rye. However, with the exception of sugar cane in lower regions, intensive production did not immediately become widespread because these crops were not as adapted and therefore not as productive as native crops. Instead, many such crops were inserted into traditional intercropping strategies, without necessarily displacing traditional crops. However, this would change in many locations by the mid-1800s, when economic drivers promoted intensification of cash crops and undermined the production of the native crops that failed to attract global economic interest (FAO 1994).

Increasingly, agricultural land was consolidated into fewer and fewer hands. By 1954, half of the highland agricultural area was monopolized by 700 large hacienda estates, while primarily Indigenous, smallholder “peasant” farmers controlled less than one-third of the land in about 250,000 small farms (Zamosc 1990). Yet by this time, changing international economies meant that haciendas had to “modernize” in order to maintain profitability, which meant transitioning from their neo-feudal labour system to capitalist economies involving formalized wage labour and integration of new technologies such as mechanized tillage (Sherwood 2009). Meanwhile, internal and international pressure was building to redress the social inequalities of the hacienda system. This process, coupled with the looming economic collapse of haciendas that failed to modernize, led to a series of agrarian reform laws, nominally intended to redistribute land in a more equitable manner and benefit the peasant class (Zamosc 1994).

Agrarian reform ended the servile structure of the hacienda system, but delivered little on the promise of land redistribution, affecting only 3.4% of Ecuador’s agricultural land (Brassel et al. 2008). Hacienda owners typically maintained access to the most fertile lands or exited agriculture in favour of other business strategies, and the peasants who obtained land (Zamosc 1994)—representing only 29% of the intended beneficiaries (Sherwood 2009)—often received steep, higher altitude parcels that were further from urban centres (Zamosc 1994). These marginalized agricultural conditions were coupled with other challenges, such as denied access to resources and debt created through the agrarian reform process, that impeded their possibilities to improve their wellbeing (Zamosc 1994; Sherwood 2009).

Beside land redistribution, agrarian reform laws were also intended to improve productivity and modernize agriculture; policies were enacted to promote crop specialization, distribute seeds and provide loans for synthetic Green Revolution fertilizers and pesticides. Because agricultural subsidies were preferentially distributed to higher yielding farmers, this had the effect that lower yielding smallholders were, to some extent, shielded from the rapid march of agricultural modernization (Abbott 2005). Even so, modernization caught up; several decades of economic policies that continue to date have targeted smallholder farms to improve productivity through specialization and the intensive use of pesticides (Sherwood and Paredes 2014). Owing to economic liberalization, state technicians from the Ministry of Agriculture have reduced their role as brokers of knowledge among smallholders, and pesticide vendors have instead filled this role, heralding a period of hazardous pesticide use that simultaneously undermines environmental and human health (Rebaï and Vélez 2018).

Paradoxically, agricultural modernization did not make farming an easier task. Over time, intensification degraded previously fertile lands, requiring greater investments to keep up in the agricultural economy. Meanwhile, consumer and intermediary demands for unblemished products, and a lack of interest in "clean" pesticide-free products, made traditional, environmentally-sound strategies unmarketable (Rebaï and Vélez 2018). As a result, rural people, and especially men, increasingly sought alternative livelihoods, leaving behind a reduced and "feminized" on-farm labour force (Rebaï and Vélez 2018). The confluence of new sources of income and reduced dedication to agriculture led farmers to increasingly obtain food through market purchase and less so from their own production, as well as to supplant the diversity of crops used for own consumption for those that are more marketable (Rebaï and Vélez 2018; Oyarzun et al. 2013).

The effects of Spanish conquest and agricultural modernization extended into the social and cultural valorization of certain types of food and agriculture. Some American products were embraced in European diets, notably potatoes, maize, tomatoes, and cacao (FAO 1994). Despite the recognition of so many American crops, other food practices that were associated with Indigeneity were subject to social and racial prejudice (Flores 2015). For example, the legume *chocho* (Lupinus mutabilis), is currently recognized for its nutritional value, boasting high calcium content and a protein and lipid profile similar to that of the soybean (Carvajal-Larenas et al. 2016); however, from conquest up until the late 1980s, it was regarded as an unrespectable food (Flores 2015). In turn, the use of Old World products was, and in many cases continues to be, associated with prestige (Gross et al. 2016; Chamorro 2011). Agricultural livelihoods also witnessed these cultural transformations, with some smallholders fearing that farming was no longer a dignified lifestyle (Rebaï and Vélez 2018).

2.4.3 Nutritional changes over time

Lacking nutritional data for most of history, archeological evidence and paleopathology allow for an approximation of the nutritional status of different populations in distinct moments in time[12]. This evidence suggests that historical changes to the food environment brought along demonstrable consequences for people's nutritional health. Specifically, it identifies two key moments of widespread nutritional alterations in the Andean region: the first is the transition from hunting and gathering to agriculture, and the second is the arrival of the Spanish (Ubelaker and Newson 2002).

Bogin and Keep, who combine data on stature spanning 8,000 years from sites across Latin America make the provocative statement that "it is clear that estimates of the statures of pre-Conquest Latin Americans (prior to [AD] 1500) are significantly greater than stature anytime after the Conquest"[13]. The authors find a steady decline in stature from the pre-Colombian data up until 1939, at which point stature begins a steady increase. In Ecuador, the authors detect a stature loss of 10 centimeters from the peak mean stature achieved prior to colonization as compared to the year 1950. This is particularly interesting given that their 1950 population includes all Ecuadorians, not just Indigenous people (Bogin and Keep 1999).

[12] One of the main proxies that bones offer for understanding population-level nutritional health is adult stature. Because nutrition is one of two primary non-genetic factors influencing adult stature, along with childhood disease, changes over time in a population's adult stature allow for making inferences on improvements or declines in nutritional health (Silventoinen 2003). Other measures include analysis of bone porosity, which serves as an indicator of iron-deficiency anemia, and several measures of dental decay.

[13] The authors provide the following supporting data: pre-Conquest mean stature = 163.4 cm for men and 152.9 cm for women; AD 1600 - AD 1989 mean stature = 159.5 cm for men and 148.6 cm for women (Bogin and Keep 1999).

However, Bogin and Keep explain that colonization is not the only process that caused this 10 centimeter decline. In the pre-Colombian Andes, the shift from hunting and gathering to agriculture not only appeared to create a more sedentary lifestyle with decreased dietary diversity, but it also brought with it societal structures that increased inequalities (Bogin and Keep 1999). This is also reported by other scholars who find that, beside reduced stature, the transition to agriculture is associated with increased porous lesions in bones and dental stressors, indicating anemia and generalized decline in nutritional status. Further, they find increased bone markers of infectious disease, which was possibly linked to the population growth afforded by agricultural lifestyles. Notably, these changes related to the transition to agriculture are consistent with findings from around the world (Verano 1997).

Once agriculture was well-established in highland Ecuadorian societies, they nevertheless seemed to fare better than their contemporaries in other agricultural societies, such as the Mayas of present-day Honduras and the societies of present-day central Mexico. A lower prevalence of dental caries suggests that the Ecuadorian highland diet was likely more varied, and not as dependent on starchy staples, particularly maize (Ubelaker and Newson 2002). By the years just before Spanish conquest, population-level variation in stature suggests that dietary inequalities were likely similar to those occurring in the 20th century (Bogin and Keep 1999).

Examination of burial sites suggests that, at the time of Spanish arrival, Ecuador's Indigenous population was likely of a similar stature to that of the European newcomers (Ubelaker and Newson 2002). Although data on Indigenous Ecuadorians is much too limited to draw definitive conclusions on whether the process of colonization produced changes in stature, Ubelaker and Newsom believe it has probably not (Ubelaker and Newson 2002). Other paleopathological indicators (e.g. cribra orbitalia, perotic hypertosis, hypoplasia, dental caries) from burial sites suggest that Spanish conquest may have brought with it a slight increase in iron-deficient anemia, but the evidence does not permit discerning whether this is specific to an Indigenous population, to individuals of European ancestry or both. Overall, evidence is insufficient to argue for, or against, relevant nutritional consequences as a result of Spanish conquest. What is more clear is that, upon arrival to the Ecuadorian highlands, the Spanish found a population whose nutritional status was likely at least as healthy as their own, and likely healthier than that of nearby agricultural societies (Ubelaker and Newson 2002). This marks a stark difference with the nutritional inequalities that Indigenous populations confront today (Ramírez-Luzuriaga et al. 2020).

In summary: Evidence on Pre-Colombian food systems suggests that people in the Ecuadorian highland region employed creative agricultural adaptations as well as wild harvest, hunting and extensive barter networks to secure a diverse and abundant food supply. At the time of Spanish conquest, Indigenous people likely had similar or better nutritional health than European newcomers. Spanish arrival and the ensuing centuries of subjugation and marginalization in agricultural policy unmistakably deteriorated cultural knowledge around food and altered the means of food access for Indigenous people. While it is unclear how the nutritional health of Indigenous people fared during distinct moments in history, evidence suggests that the drastic differences of today between Indigenous and non-Indigenous people's nutritional health were not present at the time of European arrival.

2.5 Promising pathways for healthier farmer food systems

Recognition of the nutritional challenges that many farming communities face, particularly in low- and middle income countries, has driven global interest in improving this situation through a diversity of approaches. This section describes how agriculture-nutrition linkages and traditional foods may impact farmer nutritional health, and explores how agroecology may act on these.

2.5.1 Agriculture-nutrition linkages

Multiple linkages between agriculture and nutrition exist that can enable agricultural interventions or strategies to positively impact farmer nutritional health, particularly by providing access to diverse, nutritious diets. These linkages generally operate on three interrelated pathways: 1) food production for household consumption; 2) agricultural income for food expenditures; and, 3) women's empowerment in agriculture, which affects diverse factors including how income is spent and care practices related to the family's nutritional health (Haddad 2000; Arimond et al. 2011; Herforth and Harris 2014; Kadiyala et al. 2014). Moreover, Herforth and Harris describe how the effectiveness of these pathways depend on enabling environments, including natural resources allowing for differing levels of production diversity as well as knowledge and norms surrounding health and nutrition (Herforth and Harris 2014).

Production diversity

Production diversity of plants and animals on the farm, or agrobiodiversity, has received extensive attention for its potential to moderate agriculture-nutrition pathways (Frison et al. 2006; Toledo and Burlingame 2006; Berti and Jones 2013; Jones 2017; Herforth et al. 2019). Production diversity is intricately linked with the diversity of products that families can consume from their own farms, thereby influencing their ability to obtain the diversity of nutrients needed for supporting nutritional health (Johns and Sthapit 2004; Frison, Cherfas, and Hodgkin 2011; Berti and Jones 2013; Jones 2017). Further, production diversity affects farmers' resilience in the face of environmental or economic shocks, thus enabling a more stable food supply through both consumption of own production and agricultural income (Johns and Sthapit 2004; Frison, Cherfas, and Hodgkin 2011). In some cases, higher production diversity can also provide new economic opportunities, increasing purchasing power to buy food (Frison, Cherfas, and Hodgkin 2011; Jones 2017). Importantly, both inter-species diversity and intra-species diversity (i.e. different varieties of a species) can contribute to nutrient intake diversity, resilient agricultural ecosystems and economic diversification, thereby holding potential to support nutritious diets (Berti and Jones 2013; Johns et al. 2013; Cook 2018; Herforth et al. 2019).

In a review of 21 studies assessing the relationship between production diversity and dietary diversity, the vast majority, 19 studies, reported a positive association (Jones 2017). This is a relevant indicator of the importance of production diversity to nutritional health, given that dietary diversity acts as a proxy for nutrient adequacy (Arimond and Ruel 2004; Ruel 2003). Moreover, some of the studies reviewed were able to provide context-specific insights on how the relationship between production diversity and dietary diversity plays out on different agriculture-nutrition linkage pathways. For example, while a positive relationship was evident in most subsistence contexts (i.e. where people consume more from their own production), when dietary diversity was mediated by income, the magnitude and direction of the effects of production diversity were less consistent (Jones 2017).

Even so, much is left to be understood about successfully operationalizing production diversity for dietary diversity, as reflected in recent debates reflecting on why the magnitude of the association between production diversity and dietary diversity is generally small (i.e. large increases in production diversity are associated with only small increases in dietary diversity) (Jones 2017; Sibhatu and Qaim 2018a; 2018b; Berti 2015). Some scholars argue that, in some contexts, market factors favour agricultural specialization (i.e. lower production diversity) for income generation, thereby effacing the importance of higher production diversity in supporting dietary diversity through an income pathway (Sibhatu and Qaim 2018a). However, this explanation cannot be generalized across all contexts, given the breadth of country-specific evidence that instead supports a positive correlation between higher production diversity and agricultural income (Pellegrini and Tasciotti 2014). Another explanation for the small magnitude of association between production diversity and dietary diversity is that, in some contexts, the relationship may simply not be linear; specifically, farmers with low initial production diversity may benefit substantially from increases and those with greater diversity may experience diminishing returns (Sibhatu, Krishna, and Qaim 2015). Some studies also show that even neighbouring farmers living in the same communities may respond differently to distinct agriculture-nutrition pathways, such as when some farmers obtain food primarily through subsistence means and their neighbours obtain food primarily through agricultural income; in such cases, the aggregate relationship between production diversity and dietary diversity may be attenuated by diverging trends (Oyarzun et al. 2013). These discussions underline the importance of exploring the heterogeneity of unique contexts to understand how, and among whom, production diversity may be mobilized for nutritional health.

Health and nutrition knowledge and norms

Health and nutrition knowledge and norms are also important components to the enabling environment for agriculture to succeed in engendering positive nutrition outcomes, wherein the knowledge of key family and community members affects decisions related to food production, purchase and consumption (Herforth and Harris 2014). One review of 30 nutrition-sensitive agricultural interventions found that programs investing in human capital and particularly nutrition education were more likely to succeed in positively impacting farmer nutritional health (Berti, Krasevec, and FitzGerald 2004). Women's nutritional education appears to be especially important in impacting dietary practices that affect both their own and their children's nutritional health (Ruel, Alderman, and Maternal and Child Nutrition Study Group 2013).

In intervention settings, the importance of locally relevant food and nutrition knowledge also applies to program implementers. For example, programs that promote production diversity for nutritional health are more likely to succeed if the products they encourage are nutrient-rich (Berti and Jones 2013). However, such interventions need to account for local norms and integrate appropriate education strategies. In a telling example from Bangladesh, a vegetable production intervention failed to impact dietary intake because vegetables were not a customary part of the local diet, which was primarily fish-based, and the intervention did not provide sufficient nutritional education to modify this custom (Bouis 2000).

Although nutrition education, including social behaviour change strategies, is recognized to play an important role in affecting dietary outcomes (Herforth and Harris 2014), long-term impacts on people's dietary practices are challenging to achieve, and generally require extensive programming investments (Murimi et al. 2017). A growing body of knowledge rooted in the "diffusion of innovation" literature on the spread of farming practices from farmer to farmer now discusses the importance of people's social networks in influencing their dietary and other health practices (Greenhalgh et al. 2004; Christakis 2007; Smith and Christakis 2008; Valente 2010; Berkman and Glass 2000). The structure and quality of an individual's social environment powerfully influences their decisions to adopt practices, and different network structures can be more efficient at transmitting innovations (Greenhalgh et al. 2004). This is related to the construction of social capital, which includes providing social support, influence, engagement, physical person-to-person contact and access to resources (Berkman and Glass 2000). Understanding how knowledge and norms are situated and spread within farmers' social environments may thus be valuable for leveraging a strong enabling environment for agriculture to impact nutrition.

Agriculture and nutrition linkages in the Ecuadorian highlands

Farmers in the Ecuadorian highlands produce both for subsistence as well as market sale, with the latter taking an increasingly important role in many communities (Orozco et al. 2007; Oyarzun et al. 2013; Melby et al. 2020). Previous studies in Ecuador demonstrate how distinct production patterns can be associated with different dietary outcomes. In a recent study in Imbabura province, farmers with high subsistence orientation, obtaining over half of their food from their own production, exhibited a clear relationship between production diversity and dietary diversity as well as food security (Melby et al. 2020). Meanwhile, both Orozco and colleagues and Oyarzun and colleagues found that higher intensity of cash crop production was associated with lower quantity and diversity of other crops, and reduced reliance on foods from the farm. For these farming families, dietary diversity is supported primarily through agricultural income rather than own-consumption; however, this also propagates higher access to less nutritious foods that may lead to harmful nutrient imbalances, including sugars, oils, sweetened beverages and simple carbohydrates (Orozco et al. 2007; Oyarzun et al. 2013). This was particularly clear in Orozco's study, where the children of higher intensity potato farmers, who primarily obtained foods from markets, were more likely to have protein deficiencies and carbohydrate excesses than children of lower intensity potato farmers, who instead obtained more food from the diversity of their farm's production (Orozco et al. 2007). Oyarzun and colleagues suggest that farmers with greater land access can capitalize on crop specialization to meet nutritional needs through income, but that production diversity may be a particularly important strategy for achieving nutritious diets among farmers with limited resources and income earning capacity (Oyarzun et al. 2013). These findings demonstrate that even among neighbours from the same communities, agriculture can impact farmers' dietary intake in distinct ways.

2.5.2 Traditional foods in agriculture-nutrition pathways

Traditional foods and related food practices have received attention as means to restore sustainable food systems and promote culturally appropriate nutritional health (Johns et al. 2013). Traditional

Traditional foods and traditional food practices: Traditional foods are the products and food-related practices (farming, gathering, hunting, food preparation, diets, etc.) that are defined both socioculturally and bioculturally following a period of historical continuity. These are are often rooted in the traditions of Indigenous communities (Johns et al. 2013).

crops[14], crop varieties[15], and diet patterns may provide nutritional benefits to farmers through a number of mechanisms: (i) adaptation of landraces to local environmental conditions, thus improving resilience in food access for farming communities (Johns and Sthapit 2004; Borron 2006; Stigter et al. 2005); (ii) macronutrient and micronutrient contribution of traditional foods (Batal and Hunter 2007; Burgos et al. 2007; Vorster et al. 2007; Grivetti and Ogle 2000); and, (iii) mitigation of the nutrition transition, which otherwise steers families toward diets characterized by modern food products that are high in sodium, sugars and fats (M.-J. Lee, Popkin, and Kim 2002; Batal and Hunter 2007; Receveur, Boulay, and Kuhnlein 1997). Further, growing traditional products may hedge against pesticide exposure, as their adaptations to local environments frequently facilitate production without agrochemical inputs (Sherwood 2009).

In farming communities, the linkages between production and consumption mean that traditional food promotion can also operate on agriculture-nutrition pathways, and can be particularly relevant for leveraging linkages between production diversity and dietary diversity as well as knowledge and norms around nutritious foods (Johns et al. 2013). Interest in integrating traditional foods into agriculture-nutrition interventions has emphasized the potential of "neglected" and "underutilized" species. The former refers to those commonly grown and utilized in their centres of origin by traditional farmers, but that have received limited attention from the research community. The latter refers to species that were once widely grown, but have fallen into disuse due to a variety of agronomic, genetic, economic and cultural factors (Padulosi et al. 2002). Suggestions for how to mobilize traditional species for nutrition outcomes include both production for own consumption, as well as production of value-added products in order to improve farmer livelihoods. Simultaneously, the very qualities that define many traditional species as neglected and underutilized bring with them a prerequisite mandate to improve research, market opportunities and cultural knowledge in order for these species to successfully support nutritional priorities (Padulosi, Thompson, and Rudebjer 2013).

---

[14] The enduring process of colonization has led to a certain degree of syncretism in the Americas regarding what today's Indigenous populations consider to be the products that are central to their cultural traditions. As a result, products that are considered traditional by many Indigenous communities are in fact of Eurasian origin (FAO 1994). Such is the case for wheat and barley in the Ecuadorian highlands (Karnes 2008).

[15] Traditional crop varieties or cultivars, known as "landraces" are defined as "a dynamic population(s) of a cultivated plant that has historical origin, distinct identity and lacks formal crop improvement, as well as often being genetically diverse, locally adapted and associated with traditional farming systems" (Villa et al. 2005).

However, the growing interest in supporting traditional crops for nutritional outcomes also extends to species with relatively well-established cultural use as well as attention in research and markets. For example, multiple initiatives in Kenya support nutrition through the production and consumption of sweet potato, which they consider to be a traditional crop—in this case, due to cultural history rather than geographic origin; while the use of sweet potatoes may pale in comparison with commodity crops such as maize, it is far from neglected or underutilized in the region (Muthoni and Nyamongo 2010). Efforts to support traditional foods with vastly different trajectories in sociocultural use meet unique challenges and opportunities, but also highlight the broad potential for mobilizing traditional foods for nutrition uses (Padulosi, Thompson, and Rudebjer 2013).

Traditional foods in the Ecuadorian highlands

The Ecuadorian highlands is home to a vast diversity of cultivated and wild traditional foods that remain present, to varying extents, in present-day diets (Estrella 1986; Chamorro 2011; Van den Eynden, Cueva, and Cabrera 2003). Some Andean crops, such as potatoes, maize and beans, are ubiquitous in both Ecuadorian and global diets. Numerous others, such as *mashua, oca, zanahoria blanca* and most wild edibles are in a precipitous decline due to changing cultural preferences, supplantation with more marketable crops, and habitat loss (King and Gershoff 1987; Espinosa et al. 1997; Oyarzun et al. 2013; Chamorro 2011; Van den Eynden, Cueva, and Cabrera 2003). Even the potato has not entirely escaped this fate; diversity of traditional cultivars has dramatically decreased in response to market pressures favouring potatoes that grow fast, large, and in a uniform shape (King and Gershoff 1987). Moreover, in important cultural ceremonies in rural highland communities, organizers are increasingly expected to provide “urban foods” such as canned tuna, rice and soft drinks instead of traditional foods (Chamorro 2011). Still other traditional foods are experiencing a marked revival, particularly *chocho* (Andean lupine) and quinoa, due to renewed national and international interest in their nutritional and culinary value. However, production for own consumption of these products remains marginal on many smallholder farms (Oyarzun et al. 2013).

In agriculture, there are clear benefits to the production of traditional Andean foods, given their unique adaptations to the often harsh conditions of the Ecuadorian highlands. Reflecting this, some otherwise greatly underutilized crops remain relatively common in remote locations where growing conditions are the most extreme (Espinosa et al. 1997). In recent years, increasingly unpredictable weather patterns caused by a changing climate are adding stress to Andean farming (Urrutia and Vuille 2009), intensifying the imperative to grow resilient traditional crops and crop varieties (Oyarzun et al. 2013). Despite some attempts in national agricultural policy to promote traditional foods—such as the successful initiative to promote *chocho* by the National Institute for Agricultural Research (Peralta 2016)—the greater policy environment promoting agricultural specialization, export and other forms of modernization (Rebaï and Vélez 2018) likely abets the decline in production of the majority of traditional foods.

Traditional Andean foods can also make important contributions to nutritious diets. While quinoa and amaranth have gained much international press for their wide range and high content of amino acids, many other underutilized traditional pulses, grains, tubers and roots also provide higher levels of proteins, amino acids and fatty acids than more common starchy-staple commodities (e.g. wheat, beans, potatoes) (Ayala 2004). As with all other crops, nutrient content varies greatly according to variety, environmental conditions and other factors, often with threefold differences in key nutrients across different analysed specimen[16] (Burgos et al. 2007). Although specific nutritional information on many Ecuadorian traditional foods is lacking, the vast diversity of available traditional products and the enduring (albeit declining) cultural relevance may make traditional foods a relevant strategy for promoting nutritional health.

2.5.3 Potential links between agroecology and nutrition

Agroecology may hold potential to positively impact farmer nutrition by acting on recognized agriculture-nutrition linkage pathways and enabling environments for these pathways, as well as by supporting traditional food practices. The production practices of agroecology are intended to create a healthy agricultural ecosystem while also supporting smallholder farmers' ability to generate

[16] For example, protein (reported as grams protein per 100 grams of product), varies from 3.0-8.4 g for oca, 10.8 - 15.7 g for melloco, and 6.9 - 15.7 g for mashua (King 1987). In the case of the potato, a study on 49 native Andean potato varieties found iron content to vary from 0.9 to 2.7 mg (per 100 grams dry, peeled potato) and zinc content to vary from 0.8 - 2 mg (per 100 grams dry, peeled potato) (Burgos et al. 2007).

agricultural income and grow food for their families (Altieri and Toledo 2011; Heifer 2014). Doing so, agroecology has potential to act on the pathways connecting agriculture to nutrition. Longitudinal evidence from Brazil, India and Senegal suggests that agroecology has improved farmers' incomes as well as the quantity of foods available for own consumption (Chappell et al. 2018), both of which can be mobilized for nutritional gains (Herforth and Harris 2014).

Strategic deployment of interspecies and intraspecies agrobiodiversity is fundamental to agroecological farming (Altieri 1999; HLPE 2019), thereby fortifying the natural resource base that enables the success of agriculture-nutrition linkages in many contexts. The movement surrounding agroecology, characterized by agroecological farmers' networks (Wezel et al. 2009) and frequently involving close relationships to urban consumers and other allies (Sherwood et al. 2013; HLPE 2019), may also foster unique social capital (Kansanga et al. 2020; Sherwood, Arce, and Paredes 2018). This social capital may hold potential to strengthen and spread norms and knowledge around food and agriculture that can benefit nutritional outcomes, including through norms related to women's empowerment (Kumar et al. 2018). Finally, traditional food and agriculture practices are closely integrated with the development of agroecology and its application (Altieri and Toledo 2011; HLPE 2019), suggesting that agroecology may support the healthy food environments that are associated with traditional foods. If agroecology indeed mobilizes these pathways toward nutrition, it may be a particularly interesting endogenous resource for health, given agroecology's diffusion throughout farmers' networks as a social movement (Wezel et al. 2009; 2020).

Box 2: Do organic farming paradigms such as agroecology produce more nutrient-rich foods?

Increased global interest in alternative production paradigms based in organic farm management—including agroecology as well as permaculture, certified organic production and several other paradigms—has sparked research on whether or not there exists an innate nutritional benefit to consuming organic products. If so, farmers who consume their own organic products may have a nutritional advantage.

In a review of systematic reviews and meta-analyses, Baranski and colleagues found studies that support significant differences in nutrient contents between organic and non-organic foods. Specifically, organic crops appear to have higher antioxidant content; organic meat, milk and dairy have higher concentrations of omega-3 fatty acids; and, organic milk has higher concentrations of iron, α-tocopherol and higher total conjugated linoleic acids. Meanwhile, non-organic crops appear to have higher content of protein, nitrogen, nitrates, and nitrites; non-organic milk has higher iodine content; and, non-organic meat has higher concentrations of certain saturated fatty acids (Barański et al. 2017). Other reviews obtained similar results (Seufert and Ramankutty 2017; AFSSA 2003). However, Baranski and colleagues provide the critical caveat that the studies they reviewed were of variable quality (Barański et al. 2017). Similarly, AFSSA states that supporting evidence on differences between organic and non-organic products was difficult to find because many confounding factors can only be controlled for in experimental settings, but most studies on the subject were not carried out in those settings (AFSSA 2003). Further, while numerous studies report statistically significant differences in nutrient content, the magnitude of these differences is likely insufficient to have real impacts on health (AFSSA 2003).

Unless more rigorous evidence emerges, it does not appear that the consumption of otherwise equivalent organic or non-organic products would directly impact farmers' nutrient intake.

Agroecology-nutrition linkages in Ecuador

Available evidence from agroecology in Ecuador, though limited, provides clues on whether and how agriculture-nutrition pathways may be relevant in this context. Given that agroecological farming in Ecuador is closely tied to participation in alternative food networks such as farmers' markets (Gortaire 2016; Heifer 2014), it is plausible that it would strengthen agricultural income. However, in studies from Chimborazo and Tungurahua provinces, agroecological farmers did not report gaining a higher income over what they would have earned otherwise. While they did find other benefits in terms of the ease and comfort of economic transactions—for example, selling a lower quantity but at a higher price per-product; avoiding negative interactions with intermediaries; forming positive relationships with clients (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017; Deaconu, Borja, and Oyarzún 2015)—these do not provide strong support for an income pathway to nutritional outcomes in this context. On the other hand, two of the central tenets of the Ecuadorian agroecology movement appear to be the strengthening of agrobiodiversity as well as the farm's ability to provide food for the family (Heifer 2014). Indeed, agroecological farmers from an AFN in Chimborazo province reported that they were able to obtain a greater quantity and diversity of foods for family consumption through their agroecological farming practices (Deaconu, Borja, and Oyarzún 2015). This points to a role for consumption of own-production in generating nutrition outcomes among Ecuadorian agroecological farmers, and positions agrobiodiversity as a likely mediator. Evidence from an AFN in Tungurahua province suggests that agroecological farmers not only consume a greater quantity and diversity of foods from their own production, but from each others' production, as the AFN is an active space for barter between farmers (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017). In Andean culture, social capital enables farmers' participation in the social economy, wherein they engage in reciprocity-based gifting, barter and direct purchase with other farmers to obtain certain goods, including foods (Argumedo and Pimbert 2010; Ferraro 2011). The friendships and other relationships created between farmers within an AFN (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017) may make agroecological AFNs an enabling space for Ecuadorian farmers' access to foods from the social economy. Finally, the role of the Indigenous movement in shaping Ecuadorian agroecology as well as local knowledge on the ecological adaptability of traditional crops (Gortaire 2016) may give traditional food practices unique protagonism among agroecological farmers.

In summary: Agriculture can support farmers' nutritional health by leveraging their ability to grow food for the family, use agricultural income to purchase food and by empowering women, who make many household decisions related to food and care. Agrobiodiversity as well as the norms and knowledge surrounding food practice are key to creating an enabling environment for the pathways linking agriculture and nutrition. In many contexts, supporting traditional foods can also contribute to sustainable food systems and farmers' nutritional health. Agroecology holds important potential to act on agriculture-nutrition pathways and support traditional foods in such a way as to provide positive health outcomes for the farmers in this growing global movement.

3. Objectives and hypotheses

3.1 Knowledge gap

Over the past several decades, agroecology has garnered a strong evidence base establishing it as a means to support sustainable food systems, with particular attention to its possibility to support regenerative, resilient agriculture (S. R. Gliessman 1990; Wezel et al. 2014; Frison and IPES-Food 2016) and equitable social and economic conditions for farmers (Francis et al. 2003; Altieri and Toledo 2011; Timmermann and Félix 2015; FAO 2018b). Yet the last several years have also brought attention to agroecology's potential to support sustainable diets, and particularly the nutritional health of farmers (S. Gliessman and Tittonell 2015; Frison and IPES-Food 2016; HLPE 2019). However, the interest in agroecology for farmer nutrition is largely based on theoretical underpinnings rather than on observed, empirical study (HLPE 2019). Moreover, the majority of the theory supporting agroecology's possible ties to nutrition outcomes focuses on nutrient adequacy but ignores dietary moderation (Herforth et al. 2019), despite the rapid incursion of the double burden of nutrient inadequacies and excesses in rural settings around the world (Popkin, Adair, and Ng 2012). Developing empirical evidence with agroecological farmers is necessary both to contribute to the global understanding of agroecology's potential to support farmer nutritional health as well as to support local knowledge for developing effective programs, policies and practices. In Ecuador and particularly in the Ecuadorian highlands, the double burden of malnutrition that disproportionately affects farming communities (Freire et al. 2014; Ramírez-Luzuriaga et al. 2020) creates a pressing need for research on integrated, health-promoting practices.

3.2 Objectives and hypotheses

The principal objective of this research is to identify promising food-related practices for promoting nutrition and more broadly, the health of individuals, communities, and their natural environment. To do so, this research aims to understand whether the food practices of agroecological farmers in Ecuador promote nutritional health, and if so, what mechanisms support these practices. Three interacting hypotheses are proposed on the relationship between participation in agroecological alternative food networks (AFNs) and nutritional health:

Hypothesis 1: Agroecological AFNs act as incubating spaces for social and agricultural practices with potential to act on the diets of participating ("agroecological") farmers. Specifically, AFNs:

A. Promote production diversity;
B. Create unique social capital that impacts the social spread of food and nutrition norms and knowledge.

Hypothesis 2: Agroecological farmers prioritize food practices that differentiate them from their neighbours who do not participate in agroecological AFNs ("reference" farmers). Agroecological farmers are expected to:

A. Consume more foods from own-production;
B. Consume more foods from the social economy;
C. Consume more traditional foods.

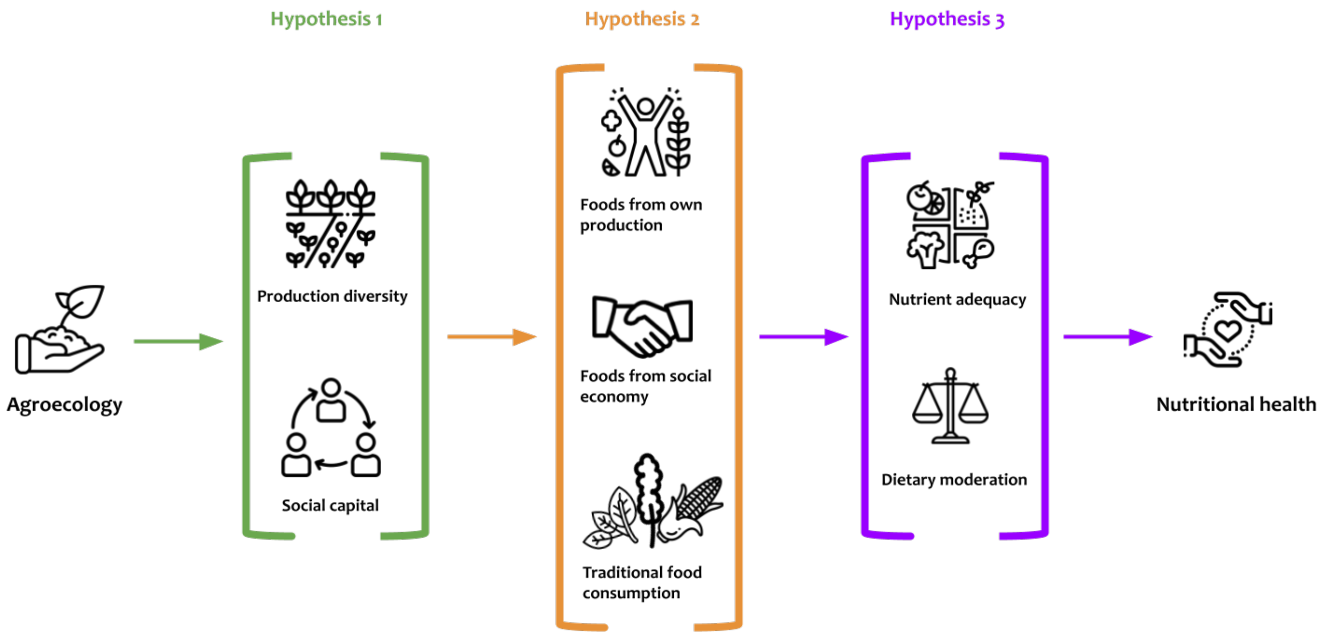
Hypothesis 3: The food practices of agroecological farmers lead them to have healthier nutritional outcomes than reference farmers with respect to:

A. Nutrient adequacy;
B. Dietary moderation.

Figure 1[17] illustrates the interactions between these three hypotheses and how they link participation in agroecological AFNs with nutritional health outcomes.

[17] Icons used in this figure and in Figures 3, 4 and 5 are made by Pixel Perfect, Vitaly Gorbachev, Smashicons, Eucalyp, Freepik, Monkik, Becris, and Mynamepong from www.flaticon.com.

Figure 1: Interacting hypotheses linking participation in agroecological alternative food networks to nutritional health



4. Methodological review

This chapter establishes the basis of the methodological decisions made to address the objectives and hypotheses of this study. It presents a brief literature review of the primary methods considered, including instruments and key analysis variables. *Section 5: Methods* describes in further detail the methods that we ultimately used and how we applied them.

4.1 Production diversity assessment

Data on production diversity can be collected through questionnaires or through field measurements, and several indicators exist to describe and assess this data. One indicator that is commonly applied in interdisciplinary research with farmers is species richness, in the form of a crop count or an aggregate crop and animal count (Jones 2017). Data collection for obtaining species richness is easy to conduct using questionnaires and represents a low burden to participants. However, this measure is limited in the depth of information that it can capture. For example, it does not account for farm size or the proportion devoted to different crops. In this sense, a farm that grows primarily corn but also has a single bean plant and a single chicken would have the same diversity as a farm that intercrops corn and beans and has numerous chickens. Given this limitation, some studies instead quantify production diversity by applying indexes such as the Margalef Richness Index, the Shannon Diversity Index, or the Simpson Diversity Index, which apply algorithms used in ecological diversity studies to account for factors including farm size and evenness of dispersion (Oyarzun et al. 2013; Jones, Shrinivas, and Bezner-Kerr 2014; Morris et al. 2014). While these measures provide a greater depth of information, they can be burdensome to apply because they require obtaining (by inquiry or measurement) the surface area devoted to each crop. In settings with relatively high agrobiodiversity, this can be very time-intensive.

4.2 Nutritional health assessment

Multiple forms of assessment are available for understanding nutritional health, including anthropometric measurement, biochemical assessment, clinical evaluation and dietary intake. This section focuses on instruments and analysis methods for evaluating dietary intake as well as on anthropometric indicators of nutritional health. Discussion on dietary methods is limited to those that are likely the most relevant and appropriate for rural Ecuadorian adults, recognizing that there is a gap in dietary indicators available specifically for low- and middle-income countries (LMICs) (Trijsburg et al. 2019). Given the importance of the double burden of malnutrition in the study region, the indicators described aim to capture both nutrient adequacy and moderation in dietary intake.

4.2.1 Dietary data collection instruments

In LMIC settings, two retrospective dietary data collection instruments are most often applied and considered to be most appropriate for population-level analysis: 24-hour dietary recalls and food frequency questionnaires (FAO 2018a). These retrospective instruments collect data on past consumption. Several prospective instruments also exist, such as estimated or weighted food records, that can collect data in real-time (as people consume meals) rather than depending on people's memory. These are considered more accurate, but are generally much more burdensome and have potential to influence people's diets during data collection (Jayawardena 2016; FAO 2018a).

24-hour dietary recall

The most common instrument for dietary data collection in LMIC settings is the 24-hour recall, which requires participants to list the foods consumed over a 24-hour period (e.g. the previous day) (FAO 2018a). This instrument is commonly used in areas with low education levels, particularly because the cognitive burden is relatively low. It further has the advantage of being adaptable to numerous cultural contexts and research needs (Gibson, Charrondiere, and Bell 2017). For example, it can be qualitative or quantitative, wherein the former is a simple list of foods and drinks consumed and the latter also collects information on the quantities of each item consumed. While qualitative recalls are much easier and quicker, quantitative recalls provide data that can be used for a greater variety of dietary indicators and can also be used to calculate nutrient intakes. To facilitate calculation of portion size, it is common to use props, models or images. The 24-hour recall can also be tailored to include additional information, such as time of food consumption, mode of preparation or other variables (Gibson, Charrondiere, and Bell 2017; FAO 2018a).

Even so, the 24-hour recall has several limitations. For example, it is subject to desirability biases, in which respondents may be selective with which foods they wish to report (FAO 2018a). Further, it has been demonstrated to underestimate energy intake and overestimate micronutrients, does not reflect long-term food intake trends or day-to-day variability for individuals, and does not capture seasonal variability (Poslusna et al. 2009; Gibson, Charrondiere, and Bell 2017). These limitations are especially common when 24-hour recalls are conducted on a single occasion. To mitigate this, it is recommended to conduct the 24-hour recall on multiple occasions (e.g. on different days during different seasons), which then allows for applying appropriate modifications to the dietary indicators assessed or to nutrient intake estimates (Jahns et al. 2005; Souverein et al. 2011). However, conducting multiple recalls comes with the trade off of requiring additional data collection. There is some evidence to suggest that intra-individual variability in LMIC settings is smaller than in higher income settings, thus requiring fewer repeat recalls to obtain a "usual" intake (Gibson, Charrondiere, and Bell 2017).

Food frequency questionnaire

Another common instrument for dietary data collection is the food frequency questionnaire (FFQ) (FAO 2018a). The FFQ queries participants on the frequency of consumption of different items in a list, which may include food groups or specific foods, according to the research objectives and cultural context. FFQs can operate on different time scales (e.g. year, month, week) and can also inquire on additional information, such as usual portion size. With carefully chosen food groups, portion size (also facilitated by props, models or images) can then be used to estimate usual nutrient intake (Willett et al. 1985; FAO 2018a). The FFQ can also be adapted for other types of research objectives. For example, it has been used to assess consumption of traditional foods among Indigneous people (Batal et al. 2005).

To a certain extent, this instrument holds advantages where the 24-hour recall holds limitations, and vice versa. Notably, the FFQ can capture trends over time and is less affected by intra-individual variability as the 24-hour recall. Further, it produces data that is easy to compare and analyze, and depending on the length of the FFQ, it can also be relatively quick (Willett et al. 1985; FAO 2018a). On the other hand, the scope of FFQs is limited by the pre-established food groups or items in the instrument's list, thus sacrificing depth of inquiry in dietary analysis. Choosing which food groups or items to include in order to assess nutrient intake or specific dietary practices can also be very demanding for researchers and may fail to capture the most relevant items, particularly in regions with much diversity in food practice (FAO 2018a). Further, the FFQ is beleaguered by cognitive difficulties; estimates of consumption frequency and portion size over a broad timeframe have been demonstrated to be unreliable, thereby producing grossly inaccurate dietary intake estimates (Kristal, Peters, and Potter 2005).

4.2.2 Nutrient composition

Once data is collected on the food items and quantities that people consume, numerous methods are available to evaluate diets. Some of these methods, which will be discussed in the following sections, require the use of nutrient composition tables to understand each food item's contribution to caloric energy, macronutrients, micronutrients or other food compounds (e.g. polyphenols). Developing these tables has many challenges. Not only do they require laboratory-based nutrient analyses to establish average nutrient values for each food and food variety, but they also require consideration of policies such as fortification. Moreover, developing nutrient composition tables requires consolidating a vast array of nutrient data that was often derived using different, and sometimes outdated, laboratory methods or expressed in incompatible units that are not easily converted (Deharveng et al. 1999).

In Latin America, the majority of nutrient composition tables draw heavily from the table maintained by the United States Development of Agriculture (USDA). The most recent published nutrient composition table for Ecuador obtained most of its data from the USDA, but also draws on tables published in Mexico, Peru and Brazil for certain foods that are more traditional in Latin America and uncommon in the US (Ramírez-Luzuriaga et al. 2014). Unfortunately, there is a global lack of reliable nutrient composition data for certain traditional foods, particularly for neglected and underutilized species and varieties (Padulosi, Thompson, and Rudebjer 2013). Obtaining reliable information requires extensive research to not only capture differences between different varieties, but also within varieties, as nutrient composition can vary substantially depending on factors such as soil conditions, climate and moment of harvest (Burgos et al. 2007).

The variability in nutrient composition across and within varieties as well as the lack of data on certain locally-relevant foods makes obtaining accurate nutrient intakes difficult. In the case of the Ecuadorian database, several substitutions were made as a result of this challenge. For example, the traditional product *Smallanthus sonchifolius*, which is most commonly referred to as jícama in Ecuador, was substituted with the USDA data for the species *Pachyrhizus erosus*, which is also referred to as jícama in Mexico, but not consumed in Ecuador (Ramírez-Luzuriaga et al. 2014). Although the two products have similar taste and texture, the former is a type of daisy, closely related to the sunflower and the Jerusalem artichoke, while the latter is a legume. Presumably, the two may have differing nutrient contents. Further illustrating the challenges of obtaining accurate nutrient data, a closer look at the USDA information for *Pachyrhizus erosus* shows that the majority of the nutrients provided for this product were themselves substituted from other products (USDA 2019). This means that the Ecuadorian table substituted one species for another, the data for which was itself based on substitutions. For lack of a better alternative, the use of nutrient data composition tables is nevertheless ubiquitous for calculating nutrient intakes and for applying dietary indexes that require information on calories or other nutrients.

4.2.3 Nutrient adequacy

A wide array of methods are available for assessing nutrient adequacy in dietary intake, including some that require extensive adaptations to specific countries or food environments as well as others that can be applied more generally across broader contexts. Among these, dietary diversity measurements have emerged as a popular, low-burden proxy for nutritional adequacy in low- and middle-income settings (Ruel 2003; Arimond and Ruel 2004). Dietary diversity can be described either as a number of food items or food groups consumed by an individual or household in a given period, usually over a 24 hour recall (Ruel 2003). Two commonly used methods of assessing dietary diversity are the Food Variety Score (FVS) and various adaptations of the Dietary Diversity Score (DDS). FVS counts individual foods eaten, whereas DDS separates foods into food groups (Steyn et al. 2006), with most adaptations of DDS classifying foods between 9 and 12 food groups[18]. A review of application in multiple country contexts and age groups finds both FVS and DDS to be associated with numerous nutritional status indicators, including energy and micronutrient adequacy (Ruel 2003). For DDS, this association appears for a

[18] Common food group classifications in various DDS schemes include: starchy staples, vitamin A-rich fruits and vegetables, green leafy vegetables, other fruits, other vegetables, meats, eggs, dairy, nuts, and pulses. Some classifications disaggregate different types of meat (e.g. organ meat), and others aggregate pulses with nuts. Still other adaptations also include groups such as oils and fats, sweets, and spices, condiments and beverages.

diversity of categorization schemes, utilizing different numbers of food groups (Ruel 2003; Arimond et al. 2010). In some contexts DDS appears to be a stronger indicator of nutrient adequacy than FVS, which is related to the understanding that foods from the same food group are likely to provide similar nutrients and those from distinct groups are likely to provide a broader diversity of nutrients (Hatløy, Torheim, and Oshaug 1998). However, in contexts where food variety is generally low, both appear to be of equal value as indicators (Steyn et al. 2006).

Numerous validation studies have evaluated DDS and FVS by comparing them to specific nutrients using the Nutrient Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR) (Ruel 2003). NAR is the ratio of the intake of a particular nutrient to the recommended daily allowance, and MAR is the average of individual NARs (Madden, Goodman, and Guthrie 1976). The number of nutrients assessed varies across validation studies, as do the findings regarding associations between higher DDS or FVS and specific nutrient densities in the diet (Ruel 2003). For example, a recent study assessing a 6-group and a 9-group DDS in five resource-poor settings focused on 11 micronutrients considered to be of public health concern (Arimond et al. 2010).

Habte and Krawinkel recently raised concerns regarding whether the correlations between DDS scores and NAR or MAR are sufficiently strong as to constitute true indicators of nutrient adequacy (2016). Indeed, applying NAR and MAR directly is likely more appropriate for in-depth studies on nutrient intake, but holds other trade-offs, beginning with the added complexity of application. Further, NAR and MAR's focus on nutrients rather than foods may overlook the role that different types of foods can play in supporting health beyond their capacity to deliver nutrients. It is therefore not surprising that diversity-based dietary indicators such as DDS and FVS have established deep roots in dietary research as a proxy means for assessing nutrient adequacy (Ruel 2003; Trijsburg et al. 2019; Martin-Prével et al. 2015).

Dietary diversity score

One of the newer and most popular iterations of the DDS is the Minimum Dietary Diversity for Women (MDD-W). A novel strength of MDD-W is that, unlike many other DDS, it provides a validated cutoff for whether a population is likely meeting its minimum needs. Out of 10 food groups, women receiving a score of 5 or above indicates that they likely meet minimum dietary diversity needs, whereas those scoring below 5 likely have low dietary diversity. Whereas its predecessor, the Women's Dietary Diversity Score, only allowed for generating a mean score across a population, MDD-W allows for data to be reported as percentages that meet and do not meet minimum needs within a population (FAO and FHI 360 2016; Ruel 2015). While the cutoff score has only been internationally validated for micronutrient adequacy among women of reproductive age[19], the performance of MDD-W as a proxy for micronutrient adequacy (without applying the cutoff) otherwise performs well across all age groups and gender[20] (Ruel 2015).

MDD-W also diverges from previous indicators, such as the Household Dietary Diversity Score (HDDS), by not analyzing food groups that can contribute to harmful nutrient excesses (specifically: oils and fats; sweets; spices, condiments and beverages). Further, the foods that contribute to each food group exclude certain nutrient-poor processed and ultra-processed foods, as they are not considered to contribute to micronutrient adequacy. The criteria for doing so is left at the discretion of the analysts in accordance with local realities (FAO and FHI 360 2016). Like other scores based on the 24-hour recall instrument, MDD-W does not capture long-term variation in individual diets, and is therefore most useful for assessing dietary adequacy at a population level. Its developers highlight the score's utility for comparing populations, identifying at-risk populations, and monitoring programs or policies (Ruel 2015).

In Ecuador, MDD-W has been used recently to assess the diets of rural populations in both the highland region of Imbabura province (Melby et al. 2020) and the tropical lowland region of Cotopaxi province (Penafiel et al. 2019). It was further applied with representative data for the Ecuadorian urban population in a recent study that established the validity of MDD-W in the Latin American context using data from eight countries (G. Gómez et al. 2020). Other research in Ecuador has also used HDDS

[19] MDD-W has been validated according to the 11 micronutrients of public health concern proposed by Arimond and colleagues (2010): vitamin A, thiamin, riboflavin, niacin, vitamin B-6, folate, vitamin B-12, vitamin C, calcium, iron, and zinc

[20] In fact, the score's developers expect cut-off values to soon be established and validated for other age ranges as well as for men (Ruel 2015).

(Cordero-Ahiman et al. 2021) as well as other food-group based versions of DDS (Pera, Katz, and Bentley 2019).

Food variety score

Numerous studies on dietary diversity in rural areas apply the item-based Food Variety Score (FVS), although not always under this name. Beside its role as an indicator of nutrient adequacy (Ruel 2003), FVS may provide additional information on dietary complexity with respect to the number of ingredients present in the diet. Dietary complexity is relevant to the consumption of beneficial secondary metabolites (Egert and Rimbach 2011) and can further inform understanding of cultural norms surrounding dietary practices (Yates and Warde 2015; Kahma et al. 2014). Some evidence also suggests that higher FVS is associated with overweight (Saibul et al. 2009; J. Lee et al. 2010), although this seems to depend on the types of food contributing to higher variety (McCrory et al. 1999). For example, greater diversity of calorie-rich foods tend to contribute to overweight, whereas a greater diversity of vegetables tends to contribute to healthier weight status (McCrory et al. 1999). In Ecuador, FVS has been used as a measure of dietary diversity in rural highland populations (Oyarzun et al. 2013) as well as in urban populations in both the highlands and lowlands (Hidrobo et al. 2014).

4.2.4 Dietary moderation

Until recently, nutritional research in LMIC settings has been almost exclusively focused on problems of nutrient deficiency. However, the growing prevalence of obesity and diet-related chronic diseases in these settings has highlighted a need to also assess dietary moderation (Popkin, Adair, and Ng 2012; Herforth et al. 2019). Given the relatively recent recognition of this need, not many dietary instruments that assess moderation have been validated in LMIC settings (Trijsburg et al. 2019).

In high income countries, the Healthy Eating Index (HEI) has gained popularity in dietary assessment because it provides component scores for both nutrient adequacy and moderation (Waijers, Feskens, and Ocké 2007; Guenther et al. 2013). However, context-specific adaptations of the HEI are limited among LMICs, and to date none has been validated for the Andean region. For the rural Ecuadorian highlands, we believe existing HEI versions developed in high income countries are likely not suitable.

For example, these versions penalize the consumption of fats and saturated fats in their moderation components (Waijers, Feskens, and Ocké 2007; Guenther et al. 2013; Krebs-Smith et al. 2018). Although fat is also of moderation concern in Ecuador at a national level, there are nevertheless substantial subpopulations where imbalances in fat are still an issue of deficiency rather than excess; nationally, an estimated 23% of the national population have problematically low intakes of fat, and this problem is highest among Indigenous populations and other ethnic minorities as well as in the rural sector (Freire, Ramírez, and Belmont 2015). In the rural highlands, dietary studies have further identified certain nutrient deficiencies that are linked to low consumption of animal-source foods, which are otherwise high in saturated fat (Berti, Krasevec, and Cole 2004; Orozco et al. 2007). Thus, dietary indexes that penalize fat and saturated fat intake may contradict nutritional priorities for certain populations, including for Indigenous people in the rural highlands.

On the other hand, growing global concerns regarding the health impacts of consuming processed and ultra-processed foods have led the World Health Organization, the Panamerican Health Organization and the Food and Agriculture Organization to support application of the NOVA classification system as a means to understand this dietary moderation issue in a diversity of contexts (Moubarac et al. 2014; Monteiro et al. 2019), including in Ecuador (Freire et al. 2018).

NOVA classification

NOVA classifies foods into four categories according to the nature, purpose and extent of processing: (i) unprocessed or minimally processed foods; (ii) processed culinary ingredients; (iii) processed foods; and, (iv) ultra-processed foods. This system characterizes individual diets according to the proportion of caloric intake that belongs to each of the four categories (Monteiro et al. 2018). Although at least six other classification systems exist for assessing level of food processing, NOVA is the most commonly used and has been applied in North America, Latin America, Europe, the Middle East and Australia (Kelly and Jacoby 2018). NOVA has been applied for understanding how food processing relates to socioeconomic and demographic factors, the impact of dietary share of ultra-processed products on dietary nutritional content, and the association of ultra-processed product consumption with obesity and diet-related noncommunicable diseases (Moubarac et al. 2014; Monteiro et al. 2019). In Latin America, application of NOVA has successfully predicted overweight and diet-related chronic diseases

(PAHO 2015). Moreover, studies applying NOVA in multiple country contexts have found an association between ultra-processed food consumption and poorer nutritional intakes, including higher intake of energy and added sugars and lower intakes of fiber, micronutrients and protein (Kelly and Jacoby 2018). Therefore, although NOVA does not provide information on intake of specific nutrients and it has neither been proposed nor systematically tested as a proxy for understanding dietary moderation, it nevertheless appears to provide valuable information on this subject.

Most analysis conducted using NOVA is in relation to the consumption of ultra-processed foods, or NOVA category 4 (Moubarac et al. 2014; Monteiro et al. 2019). However, in regions where ultra-processed foods are still but a minor part of most people's diets, such as has been documented in rural Ecuador (Gross et al. 2016), assessing NOVA category 4 is likely less relevant. Nevertheless, many of these regions have experienced a profound intrusion of cheap sugars and edible oils utilized as culinary ingredients (Gross et al. 2016; Popkin 2015). Excessive consumption of these foods has been implicated in negative physiological outcomes (Popkin 2015; Freire, Ramírez, and Belmont 2015; WHO and FAO 2003), pointing to the utility of assessing consumption of foods belonging to NOVA category 2, processed culinary ingredients, to better understand dietary moderation. Meanwhile, category 1, unprocessed or minimally processed foods, may be interesting because the foods in this group[21] generally coincide with those that are promoted by international and Ecuadorian guidelines as forming part of healthy diets (WHO 2018; MSP and FAO 2020). Because NOVA evaluates individual diets by describing the share of total caloric intake belonging to each of the four categories, greater consumption of foods from category 1 implies lower consumption of foods from the remaining three categories, which are generally foods that dietary guidelines suggest should only be consumed in moderation[22] (WHO 2018; MSP and FAO 2020).

---

[21] Monteiro and colleagues offer the following description of this food group: "Unprocessed (or natural) foods are edible parts of plants (seeds, fruits, leaves, stems, roots) or of animals (muscle, offal, eggs, milk), and also fungi, algae and water, after separation from nature. Minimally processed foods are natural foods altered by processes that include removal of inedible or unwanted parts, and drying, crushing, grinding, fractioning, filtering, roasting, boiling, non-alcoholic fermentation, pasteurization, refrigeration, chilling, freezing, placing in containers and vacuum-packaging" (Monteiro et al. 2018).

[22] However, this is not necessarily the case for all foods in group 3, processed foods. According to Monteiro and colleagues, "Processed foods, such as bottled vegetables, canned fish, fruits in syrup, cheeses and freshly made breads, are made essentially by adding salt, oil, sugar or other substances from Group 2 to Group 1 foods" (Monteiro et al. 2018). Many of these foods can contribute to healthy diets (WHO 2018).

4.2.5 Anthropometric assessment

Anthropometric measurements such as height, weight and waist circumference are commonly used to determine cutoff points for diet-related health risk. The Body Mass Index (BMI), a measure of weight (kg) divided by height-squared (m^2), has been used for decades by the United States National Institute of Health, the World Health Organization and other agencies as a simple means to assess underweight, normal weight and overweight (WHO 2000). BMI has several recognized limitations. For example, it does not differentiate between lean mass and fat mass, nor between different fat mass distributions of subcutaneous and visceral fat, both of which have important implications for health (WHO 2000). Further, there is increased recognition that the existing BMI cut-off points, which were established with primarily Caucasion populations, are not adequate for all ethnicities (Deurenberg, Yap, and Van Staveren 1998). However, efforts to establish new cut-off points have been limited (Hudda et al. 2017; Wong et al. 2016). Even so, the use of BMI remains ubiquitous and can be a useful tool for making comparisons between populations belonging to the same ethnic group.

Waist circumference measurement is also gaining recognition for its use in assessing metabolic health, with sex-specific cutoff points utilized to define cardiometabolic risk (Alberti et al. 2009). Unlike BMI, different cutoff points are proposed for distinct populations, aiming to transcend the Caucasian bias that is pervasive to health indexes (El Mabchour et al. 2015). The harmonized recommendations put forth by the International Diabetes Federation, American Heart Association and other organizations established cut-off values of 90 cm and 80 cm for Latin American men and women, respectively; however these recommendations were based on South Asian populations, and held the important caveat that more research was necessary for Latin American populations (Alberti et al. 2009). Since then, other studies have aimed to establish cut-off points for the Latin American population as a whole (Aschner et al. 2011), as well as for specific country groups, regional groups or ethnic groups. One study in Peru proposed cut-off points for Andean populations as 97 cm for men and 87 cm for women (Medina-Lezama et al. 2010).

Among adult populations, history of stunting is relevant to diet-related health because chronic malnutrition in childhood can impact risk of cardiometabolic disease later in life (Stein, Thompson, and

Waters 2005). History of stunting is therefore defined by very short adult stature. Previous studies concerned with stunting history in LMICs have utilized the cut-off point of 145 cm to establish very short stature in women (Child Health Epidemiology Reference Group Small-for-Gestational-Age/Preterm Birth Working Group 2015), including several studies in Latin America (Hernandez-Diaz et al. 1999; Ramirez-Zea et al. 2014).

4.3 Measuring the relationship between production diversity and nutritional health

A 2017 review identified 23 studies that assessed the relationship between production diversity and nutritional health (Jones 2017), and a steady stream of others has since emerged (Hirvonen and Hoddinott 2017; Lachat et al. 2018; Zanello, Shankar, and Poole 2019; Melby et al. 2020). Of the studies reviewed by Jones, 21 assessed nutritional health using a measure of dietary diversity, employing either a Dietary Diversity Score, a Food Variety Score, or both. Other nutritional indicators included Mean Adequacy Ratio and child anthropometric z-scores (height-for-age, weight-for-age, weight-for-height), which allow for understanding issues of stunting and underweight. To measure production diversity, most studies utilized a species richness measure (a crop count or a crop and animal count). Four studies applied either a Margalef, Shannon or Simpson diversity index in addition to or in lieu of the species richness measures. Furthermore, two counted studies crop food groups, aligned with the same food groups as those used in their dietary diversity score (Jones 2017).

Berti raises the important point that the relationship between production diversity and dietary diversity depends on the scale used for measuring each, particularly if the relationship is expected to be largely driven by consumption of own-production. He provides the useful example that growing rice, corn and barley would increase species richness by three, but would only increase a Dietary Diversity Score by one (i.e. cereals), thereby masking a statistical correlation (Berti 2015). Similarly, to understand the relationship between production diversity and dietary diversity, it is necessary to consider the means by which they are related. For farmers with a primarily subsistence orientation, products grown on the farm are expected to directly relate to those consumed in the diet. However, for farmers with a primarily commercial orientation, the relationship would be mediated by agricultural income, and it may therefore not be as clear. Where both own-consumption and income are important, the situation accordingly becomes more complex (Berti 2015; Jones 2017).

Besides measuring production diversity and dietary diversity, studies that assess the relationship between these two variables also commonly account for seasonality, (Oyarzun et al. 2013; Bellon, Ntandou-Bouzitou, and Caracciolo 2016; Zanello, Shankar, and Poole 2019), regional ecological differences across larger study sites (Jones, Shrinivas, and Bezner-Kerr 2014), origin of foods contributing to dietary diversity to understand which foods come from own production and which come from purchase (Oyarzun et al. 2013; Jones, Shrinivas, and Bezner-Kerr 2014; Bellon, Ntandou-Bouzitou, and Caracciolo 2016), market access (Jones 2017) and socioeconomic correlates (Oyarzun et al. 2013; Jones, Shrinivas, and Bezner-Kerr 2014; Bellon, Ntandou-Bouzitou, and Caracciolo 2016).

5. Methods

5.1 Study overview

5.1.1 Research context: Ekomer consortium

The research presented in this thesis was conducted under the guidance of the Ekomer research consortium. Ekomer is a collaboration between EkoRural Foundation, Université de Montréal, University of Toronto, Healthbridge Canada, *Facultad Latinoamericana de Ciencias Sociales-Ecuador*, and *Pontífica Universidad Católica de Ecuador.* Between 2016 and 2019, Ekomer conducted a study titled "Strengthening impact of the Healthy Food Consumption Campaign: 250,000 Families in Ecuador," which was funded by the International Development Research Centre and administered by EkoRural.

Based in Ecuador, this project had the general objective "to strengthen an innovative, civil society-based marketing strategy for responsible food consumption that enables improved food policy interventions, adoption of healthier, more sustainable diets that curb and prevent food-related chronic illness" (Sherwood 2019). One of its specific objectives was to "assess ways, reasons and purposes of people reached by the campaign in adopting healthier and responsible food consumption practices." In the context of these objectives, Ekomer was also interested in understanding how agroecological farming, which is closely related to and supported by the responsible consumption campaign, may impact nutritional health (Sherwood 2019). This PhD project, "Diversity from Farm to Plate: Nutrition and Food Relationships among Agroecological Farmers in Ecuador," was designed to address this interest.

5.1.2 Role in the study

I was responsible for conducting the Diversity from Farm to Plate study, for which I received critical guidance and support from my supervisor, co-supervisor and numerous members of the Ekomer team. My responsibilities included: formulating study objectives, designing methodology and data collection protocols, obtaining ethical approval, conducting data collection, processing data, conducting analysis, disseminating results and leading resultant publications. I was solely responsible for collecting qualitative data using ethnography, key informant interviews and focus group discussions. For quantitative data collection, I shared survey recruitment and administration responsibilities with a research assistant.

5.1.3 Research location: Imbabura province

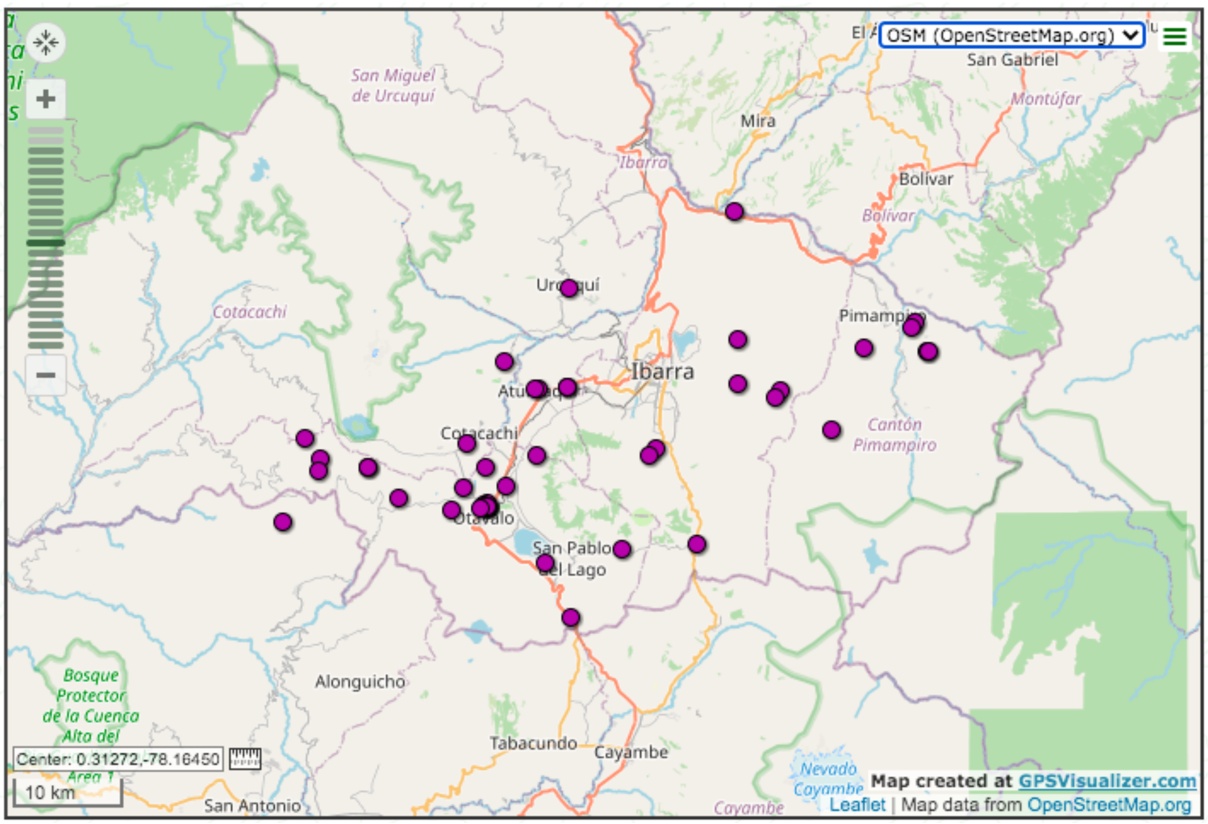
This research is situated in the rural sector of Imbabura, a province in Ecuador's northern highland region. Imbabura province is a recognized hotspot for agroecological associations, with the nation's second highest number of documented farmers participating in associations that promote agroecology (Heifer 2014). We chose this province as our study site given the number and diversity of agroecological experiences, the relationships formed by members of our research consortium with agroecological associations in the area, and the decisive interest expressed by association leaders in contributing to this research.

Imbabura has the third largest Indigenous population of Ecuador's 24 provinces, most of whom identify as *Kichwa* and live primarily in rural areas (INEC 2006; 2010). Rural poverty in Imbabura is estimated at 54%, with some community-level data reporting ubiquitous poverty upward of 99% (INEC 2016, n. Supplementary material). Farmers in the region are primarily smallholder, family farmers, as are all agroecological farmers (Heifer 2014). The documented dietary context in this region is similar as that of the rural highland region more generally (refer to Section 2.3: Focus on highland farmers' food and nutrition), with rural diets predominated by calorie-rich carbohydrates and a nutrition transition that is increasing intake of simple sugars, sodium, edible oils and processed as well as ultra-processed products (Gross et al. 2017). As a result, Imbabura is also experiencing a considerable double burden of malnutrition, with children faring worse than the national average on both stunting and OW/OB, and adult OW/OB on-par with the national average (Freire, Ramírez, and Belmont 2015).

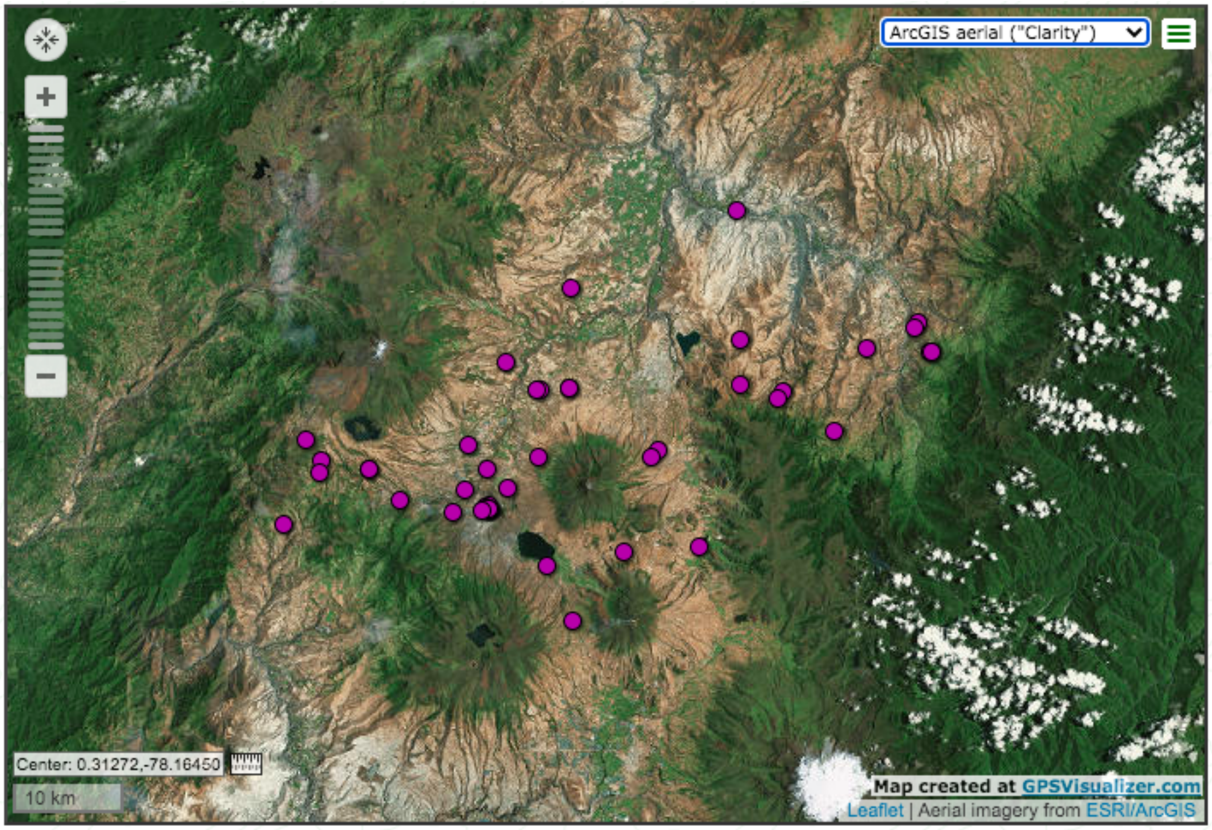
The geographic boundaries of the study site are delimited by the locations of farmers belonging to agroecological associations and who participated in this study (Figure 2). Although the longest distance between farmers in the study site is only 60 km, participants resided as low as 1550 meters above sea level (masl) in hot, humid subtropical valleys and as high as 3570 masl in the wet montane *páramo* ecosystem. People living at all altitudes raise livestock and grow a wide variety of products, with ubiquitous production of maize, beans and potatoes. Lower altitudes support more diverse fruit production, including tropical fruit, as well as production of sugarcane and sweet potato, whereas higher altitudes support production of traditional Andean products such as lupine, melloco, oca and mashua. Temperature and rainfall patterns in the region allow most farmers to harvest a diversity of products throughout the year, even without irrigation (Prefectura de Imbabura 2017). Of Imbabura's farmers, 86% are smallholders, but due to land concentration they only occupy 16% of agricultural land; women and Indigenous farmers disproportionately occupy the smallest parcels (Brassel et al. 2008).

Figure 2, A and B: Locations of participating agroecological farmers in the study site, indicating localities (A) and aerial view of biogeographic features (B).

A:



B:



5.1.4 Ethical review

Ethics approval for the entirety of the Ekomer project was obtained from the Institutional Review Board of the Universidad San Francisco de Quito in Ecuador, certificate number 2016-118E, and the Diversity from Farm to Plate component received additional approval from the Health Research Ethics Committee of the Université de Montréal, certificate number 17-053-CERES-P. Field work for Diversity from Farm to Plate commenced in May 2017 and ended with results triangulation and dissemination activities in May 2019. Ethics certificates are provided in Annex 1.

5.2 Theoretical framework and study design

5.2.1 A salutogenic, strength-based perspective

Antonovsky asserted that the pathways toward health are substantially different from, and not merely the opposite of, the pathways to disease (Antonovsky 1979). While much health research may be interested in understanding the "pathogens," or the drivers of illness, this thesis follows Antonovsky in prioritizing exploration of the "salutogens" that support health. This salutogenic framing is also consistent with strength-based approaches, which prioritize identification of strengths over that of weaknesses (Brough, Bond, and Hunt 2004), and have gained prominence in research with Indigenous communities in many parts of the world (Mataira 2019; Waller 2018; Brough, Bond, and Hunt 2004; Knibbs et al. 2012). Central to the search for salutogenic or strength-based approaches is the understanding of people's self-organization (Sherwood, Leeuwis, and Crane 2012), in which we, as researchers, accept that communities, and especially vulnerable communities, have the capacity to author their own responses to challenges that they face. That is, our role is not to create solutions but to identify and leverage those that already exist and were created through self-organized means.

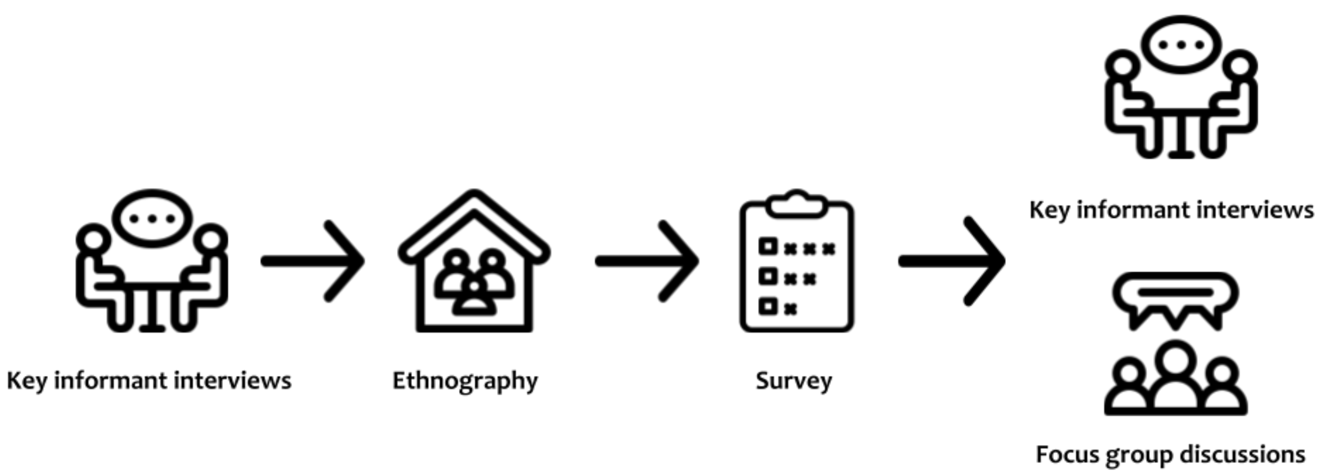
5.2.3 Participatory approach

This study applied a participatory approach in order to give the participating community of farmers voice in the research (Cornwall and Jewkes 1995). In participatory approaches, researchers collaborate with members of the research population to improve study protocols and ultimately produce findings that both benefit the community and provide valid, generalizable knowledge (Macaulay et al. 1999). The objectives guiding this research were developed following years of discussion and close engagement with Ecuador's agroecological farming community. Prior to the start of this research, agroecological association leaders expressed in meetings of the *Colectivo Agroecológico* (a national agroecology network) that it would be pertinent to better understand the relationship between agroecology, farmer diets and nutritional health. In the interest of maintaining a close relationship throughout the project, and to more deeply engage in a participatory process specific to Imbabura province's agroecological community, we developed research methods to ensure multiple moments of community collaboration, as will be further described in the section that follows. Community collaboration was key for refining study instruments and protocols, informing statistical analyses, elaborating on key results and validating study findings. Further, we implemented a deliberative process (Gauvin 2009) to share and interpret results with Imbabura's agroecological farming community as well as other relevant stakeholders.

5.2.3 Mixed methods design

We implemented a sequential, mixed methods design, as illustrated in Figure 3, to allow for greater depth of exploration and triangulation across methods (Creswell 2009, 10-12,208-227). The process began with key informant interviews (May - June 2017) and ethnography (June - July 2017). Preliminary findings from these two exploratory phases informed the development of a cross-sectional survey, conducted from July through November 2017. Finally, we implemented additional key informant interviews as well as focus group discussions (FGDs) (Colucci 2007) in March and April 2019. The latter phase of key informant interviews was intended to share study results with stakeholders and discuss their perceptions of the results. Similarly, FGDs had the objective of exploring the extent to which farmers' lived perceptions converged with quantitative results and to understand farmers' explanations for the drivers behind the results. After discussion of key themes, FGDs were also used for returning study results to local communities. Best local research practices were determined in collaboration with EkoRural Foundation, which has extensive research experience in the Ecuadorian highlands. Research instruments are explained in detail in the sections that follow, and instrument protocols, including questionnaires, are provided in Annexes 2 and 3.

Figure 3: Sequential chronology of mixed methods instruments



5.2.4 Conceptualization of agroecology in this research

Being an agroecological farmer can refer not only to utilizing certain farming practices, but also to forming part of the agroecological social environment (Wezel et al. 2009). Given the importance of social organization in agroecology's trajectory in Ecuador (Sherwood et al. 2013; Gortaire 2016), in this research, we conceptualize agroecology to include only the farmers who both employ agroecological farming practices *and* participate in the agroecological social environment. In a mapping of Ecuadorian agroecology, Heifer Foundation found that agroecology is primarily spread through alternative food networks (AFNs), such as farmers' markets, solidarity stores and food baskets. Of these, farmers' markets organized by agroecological farming associations were the most prominent AFNs providing a social space dedicated to agroecology (Heifer 2014). We therefore use agroecological associations that hold farmers' markets as a proxy to identify "**agroecological farmers**". In contrast, we also refer to "**reference farmers**," who we conceptualize as smallholder, family farmers who are neighbours of agroecological farmers, but who do not participate in agroecological AFNs[23]. Reference farmers act as a point of comparison for the agroecological group, given that they live in the same communities and are likely to experience similar ecological and socioeconomic circumstances; however, they do not form a control group per se, in that this research does not assess the longitudinal effects of a systematic intervention. Rather, the comparison between agroecological and reference farmers is observational and akin to a natural experiment.

Agroecological farmers: For the purposes of this study, this term refers to smallholder, family farmers who participate in agroecological alternative food networks (AFNs), particularly agroecological farmers' associations that hold farmers' markets.

Reference farmers: For the purposes of this study, this term refers to smallholder, family farmers who do not participate in agroecological AFNs. Reference farmers are the neighbours of agroecological farmers.

We do not make *a priori* assumptions on the farming methods employed by either group. Agroecological AFNs usually have internal mechanisms to ensure that members adhere to certain norms in their farming strategies, but these norms can vary from one AFN to the next (Heifer 2014). Meanwhile, some reference farmers may also apply traditional production methods that are otherwise consistent with agroecological farming (Gortaire 2016), even though they do not self-identify as agroecological and are not otherwise organized around agroecology. We do not attempt to assess how "agroecological" each farmer's production strategy is, and are instead interested in the totality of the relationship that agroecological participation may have on nutritional health.

[23] In Section 6.2: Article 1, we used the term "conventional" farmers instead of reference farmers.

5.3 Instruments

This section presents an overview of the instruments utilized in the study. Further detail on implementation of each instrument is provided in the methodological sections of the articles presented in Section 6: Results.

5.3.1 Key informant interviews

Key informant interviews (Creswell 2009) were used at different points in the study to obtain feedback on study instruments, obtain critical information for identifying participants in ethnography and for the survey, assist in local interpretation of results, identify potential implications, and establish appropriate follow-up methods for communicating results locally. Further, key informers facilitated communication with agroecological association members throughout the study, including for convening focus groups and communicating results to study participants, stakeholders and the broader public. Interviews were semi-structured, and tailored to the context of each interviewee.

Selection criteria

We selected key informants for their formal leadership or demonstrated informal leadership in groups or organizations with relevance to agroecology and/or farmer nutrition in Imbabura province. Key informants included: leaders of agroecological associations, NGO representatives, local food movement civil-society actors and state employees from local and national ministries, among others.

5.3.2 Ethnography

Ethnography was used to understand the food practice of families participating in agroecology, with particular interest in the relationship between agriculture and food. We adopted a critical ethnography approach, which recognizes that the ethnographer is not an unobtrusive "fly on the wall" and instead incorporates reflexive inquiry as to the ethnographer's influence on daily practice (Madison 2005). Visser and colleagues propose ethnography as an appropriate method for examining underlying values and needs around daily food practice in context of culture and society, particularly given the complexities of food behaviour and the failures of any single theory in explaining food choice. For example, they highlight that in daily practice, people do not consider diet and other lifestyle habits in terms of rationality or "risk," but instead relate them to meaningful experiences and feelings. Visser and colleagues further specify the utility of participatory tools in ethnography, such as observation and in-depth interviews, to capture participants' perspectives in a way that both explores existing theories on food behaviours and elicits new insights. This approach aims to generate output that can contribute to a culturally sensitive understanding of the factors that drive food choices (Visser, Hutter, and Haisma 2016). We thus deployed ethnography both as a means toward our research objectives, as well as to inform later phases of research with key cultural insights, particularly survey development.

Selection criteria

We followed Visser and colleagues in selecting the family as the unit of ethnographic analysis for understanding power, agency, and ultimately decision-making in food practice (Visser, Hutter, and Haisma 2016). To select families, we adopted an actor-oriented approach, which allows for identifying heterogeneous social practices and discourses as carried out by social actors (Long 2007). Key informants from NGOs operating in Imbabura assisted in identifying and recruiting families with a variety of lengths of participation in agroecological associations, as well as roles within those associations. See Section 6.2: Article 1 for further details on the ethnography instrument, including the data collection protocol and analytical approach.

5.3.3 Cross-sectional survey

A cross-sectional survey was used to provide data for understanding the mediators of healthy food practice. The survey was administered to agroecological and reference farmers in order to draw comparisons between the two groups. This instrument further provided data to enable analysis of relationships between dietary, production, sociodemographic, and health variables.

Survey development and components

Literature review of key variables relevant to agriculture-nutrition pathways informed the development of the initial survey draft, and preliminary results from key informant interviews and ethnography guided development of the final survey. Table 1 describes the survey modules that were used in this study, as well as their application protocols.

Table 1: Summary of survey modules	
Module	**Description and application protocol**
24-hour recall	A single open-ended, quantitative 24 hour recall was used to obtain the following information: all items consumed (including composite ingredients whenever possible), quantities of all items consumed, acquisition source of all items consumed. In a first step, respondents were queried for all foods and drinks consumed the previous day, beginning when they woke up; in a second step, they were queried for snacks, drinks or other forgotten items; in a third step, they were queried for quantities of each item consumed (using props and models to support estimation); in a final step, they were queried for the acquisition source of all items consumed, using open response (acquisition categories were not suggested).
Diet-related noncommunicable disease questionnaire	For each of the following diseases, participants were asked to report if a medical professional had diagnosed them with the disease: diabetes, hypertension, high cholesterol, heart disease, cancer.
Traditional foods food frequency questionnaire (TF-FFQ)	The TF-FFQ queried for consumption of 12 indicator traditional foods, frequency of consumption (accounting for seasonality) and most common acquisition method (conventional markets, harvest, social economy). Because “traditional” foods are locally defined by social, cultural, and biological factors (Johns et al. 2013), the indicator foods selected were based on consultation with local experts, ethnography and key informant interviews, and were chosen to include both common and underutilized traditional foods.
Wild foods consumption questionnaire	Consumption of wild foods was assessed based on a list of common wild foods in the region. Respondents were also probed for "other" wild foods consumed that were not in the questionnaire.
Production diversity questionnaire	Using an exhaustive list developed based on ethnography and key informant interviews, respondents were probed for their production in the past year of distinct products. Respondents were also probed for "other" products not on the list.
Intra-species diversity questionnaire	Respondents were asked to list the different varieties or cultivars that they grow of the following three crops: maize, potatoes, beans.

Productive resources questionnaire	This survey module inquired on access to irrigation and amount of land in production. The latter refers to the amount of land utilized by the respondent, not the amount that they legally own.
Sociodemographic questionnaire	Respondents were probed to respond for themselves for: age, education completed, and time to market (using their most common transportation method). They were probed to respond for their household regarding: household size (number of people who usually spend at least 4 nights a week in the household), household gender and age distribution, monthly household income, livelihood sources and beneficiary status for the Human Development Bonus program (Moreno 2017).
Anthropometric measurement	At the end of the survey, respondents were given the option to have the following measurements taken: height, weight and waist circumference, using a portable stadiometer, portable scale and tape measure.

Selection criteria, sampling methodology and sample size

The survey was administered to adult, female agroecological and reference farmers, with a minimum age of 18 and no maximum age. It included only women, given their central role in food procurement, preparation and feeding, as well as their knowledge of the household's agricultural practices[24] (Soto 2014). Agroecological farmers were recruited at random from eight agroecological associations. Reference farmers were recruited by visiting neighbouring homes geographically near those of participating agroecological farmers, generally at a short walking-distance. One reference farmer was recruited for every second agroecological farmer.

Due to insufficient pre-existing data to predict variance on key variables, it was not possible to determine sample size according to statistical power calculations. Instead, sample size was determined according to an estimated requirement of 20 to 30 participants per sample for comparing dietary outcomes. The reference sample was thus set to include 30 participants, and the agroecological sample was set to include 60 participants in order to allow for additional within-group analyses. Some agroecological associations included participants from multiple communities spread out across the province, while other associations were specifically oriented toward a single, geographically bounded

[24] Frequently, women are in charge of diverse parcels and also provide support for larger cash crops, which are primarily managed by men. Men are more likely to work off-farm.

community. As a result of the latter, many farmers in the sample tended to be clustered in certain localities. However, given the small sample size, we did not attempt to control for clustering effects. See Section 6.4: Article 3 for further details on the survey instrument.

5.3.4 Focus group discussions

The third phase of data collection involved focus group discussions (FGD) with agroecological farmers' associations. FGDs had three objectives: (1) to triangulate findings between quantitative and qualitative results; (2) to explore how farmers explain the drivers behind the results; and, (3) to share results with the associations that participated in research and co-interpret research findings. The FGD protocol followed a sequence that allowed for key study questions to be addressed prior to participants receiving the research results.

Selection criteria and sample size

Separate FGDs were conducted for each of the eight agroecological farmers' associations whose members had participated in the survey. To promote inclusivity and a variety of perspectives, all association members were invited, including men (who were otherwise not sampled in the survey). Colucci suggests restricting FGD size in order to promote full participation (Colucci 2007). However, the size of the associations, most of which do not contain more than 25 active participants, provided a natural limit. See Section 6.4: Article 3 for further details on the FGD instrument.

5.4 Results dissemination with study participants and stakeholders

The project used a deliberative process to support a diligent return of results to study participants and stakeholders, as well as to promote application of research-based knowledge (Gauvin 2009). Focus group discussions were structured in such a way as to promote the co-interpretation of study findings. The second phase of key informant interviews emphasized the interests of each stakeholder and were used to interpret findings, reflect on the research process and consider next steps relevant to the stakeholder. This process included one-on-one or small group meetings with farmers' association leaders, representatives of NGOs active in Imbabura, civil society organization leadership, local authorities and state agencies at different scales (municipal, provincial, national). See Section 6.6: Supplementary results for further details on results dissemination.

5.5 Analysis methods

5.5.1 Quantitative variable construction

As discussed in Section 4: Methodological review, numerous indicators are available for assessing agricultural diversity and nutritional health. Indicators were selected for constructing analysis variables according to: validation and history of previous use, relevance to local context and feasibility. This resulted in the dietary, traditional foods, production and sociodemographic variables described in Table 2. We used the USDA database (USDA 2019) and an Ecuadorian database (Ramírez-Luzuriaga et al. 2014) to establish caloric and other nutrient content of food and drink items for variables requiring this information[25]. While we also obtained waist circumference measurements, which we intended to analyze to assess cardiometabolic risk (Medina-Lezama et al. 2010), we ultimately discarded this data because our measurement protocol did not account for the customary use of corsets among some Indigenous women.

Table 2: Summary of quantitative variables

Outcome or area of interest	Variable name	Survey module for data collection	Operationalization
Nutritional health			
Dietary nutrient adequacy	Food Variety Score	24 hour recall	A count of unique ingredients consumed by the respondent is used to establish a continuous measure with no minimum or maximum (See: Hatløy, Torheim and Oshuag 1998)

[25] Initially, we had intended to use the Ecuadorian database, but we identified substantial discrepancies between the Ecuadorian nutrient composition information and the USDA information from which most of the Ecuadorian information was derived. These discrepancies were confirmed as human errors after conferring with one of the authors of the Ecuadorian database. As such, we deferred to the USDA database for all product nutrient data that was originally derived from that source and only utilized the Ecuadorian database for products that were not available from USDA.

	Dietary Diversity Score		We calculate dietary diversity according to the food groups established by the Minimum Dietary Diversity for Women (MDD-W) score (FAO and FHI 360 2016), with a maximum score of 10 food groups. Unlike the MDD-W protocol, we do not limit the measure to women of reproductive age.
Dietary moderation	NOVA		Using the Ecuadorian adaptation (Freire et al. 2017) of the NOVA food classification system (Monteiro et al. 2018), daily caloric intake is divided into the proportion obtained from four categories that represent different levels of processing: (1) unprocessed or minimally processed foods, (2) processed culinary ingredients, such as oils and sugar, (3) processed foods and (4) ultra-processed foods. Lower consumption of foods from categories 2 and 4 are used to indicate healthier dietary moderation.
Dietary acquisition practices	Proportion of calories acquired from diverse sources		Daily caloric intake is divided into the proportion obtained from each of three acquisition sources: (1) Conventional markets, including purchases from markets, supermarkets, grocers, corner-stores and restaurants; (2) Harvest, including food obtained from own-production and wild harvest; and, (3) Social economy, including food obtained from barter, gifting, and direct purchase from other farmers.
Nutrition-related health status	Body Mass Index	Anthropometric measurement	Height and weight measurements are used to calculate body mass index (kilograms / meters-squared). Standard cut-offs are applied for defining underweight, normal weight, overweight and obesity. (See: World

			Health Organization 2000)
	Self-reported presence of diet-related noncommunicable disease	Diet-related noncommunicable disease questionnaire	The is a dichotomous variable (yes/no) according to the presence of at least one disease.
Traditional food practices			
Traditional foods consumption	Traditional foods consumption diversity	Traditional foods food frequency questionnaire (TF-FFQ)	This is a continuous variable between 0 and 12 traditional foods reported as consumed in the TF-FFQ.
	Traditional foods consumption frequency		This continuous variable is the total annual consumption frequency of all traditional foods in the TF-FFQ.
	Traditional foods consumption frequency, by traditional food		These continuous variables are expressed as the consumption frequency of each of the 12 traditional foods in the TF-FFQ.
	Wild food consumption diversity	Wild foods questionnaire	This is a continuous variable of wild foods consumed with no maximum value.
Traditional foods acquisition	Traditional foods acquisition, by traditional food	TF-FFQ	These variables describe the most common acquisition source (conventional, harvest, social economy) for each of the 12 traditional foods in the TF-FFQ.
Traditional foods production	Traditional foods production diversity	Production diversity questionnaire	The production diversity questionnaire is used to extract production information (yes/no) of the traditional foods assessed in the FFQ. Only 11 crops are assessed, given that two of the traditional foods in the FFQ come from the same crop (quinoa leaf and quinoa grain).
Production			

Production diversity	Production diversity	Production diversity questionnaire	This is a continuous variable, with no maximum, that counts food crops produced and animals raised over the past year, either in fields or in home gardens. Species that are commonly used only as condiments, teas or medicines are excluded, as are plant and animal species that are not commonly used for human consumption (or whose eggs or milk are not consumed). (See: Jones et al. 2014)
	Intra-species diversity	Intra-species diversity questionnaire	Continuous variables (with no maximum) describe the diversity of varieties or cultivars of three products: maize, potatoes and beans.
Productive resources	Access to irrigation	Productive resources questionnaire	This is a dichotomous variable (yes/no) of whether the respondent has irrigation.
	Land surface in agricultural use		This is a categorical variable of the amount of land utilized by the respondent's household for production.
Sociodemographics			
Sociodemographic assessment	Respondent age	Sociodemographic questionnaire	This is a continuous, self-reported variable.
	Household size		This is a continuous, self-reported variable
	Monthly income per capita		This is a continuous variable created by dividing the self-reported monthly household income by the household size.
	Poverty by income		We apply Ecuador's poverty threshold (INEC 2016) to the monthly income per capita variable in order to classify farmers by three categories: extreme poverty, poverty (excluding extreme poverty) and no poverty.

	Human Development Bonus beneficiary status		This is a dichotomous, self-reported variable (yes/no) for whether any member of the household is a human development bonus beneficiary.
	Livelihood sources present in the household		This is a non-exclusive, categorical, self-reported variable. Categories include: sell in the agroecological AFN; sell agricultural products elsewhere; agricultural labor; other (with specification).
	Time to market		This is a continuous, self-reported variable (in minutes) of the time it takes the respondent to arrive at the market where they purchase the majority of their foods.
	Respondent education completed		This is a categorical, self-reported variable. Categories include: Preschool or no education; partial primary school; primary school; partial secondary school; secondary school; university or other post-secondary studies.

5.5.2 Qualitative data processing

To assess data produced by ethnography, key informant interviews and focus group discussions, we employed an iterative qualitative thematic approach, using both directed and inductive categorization (Hsieh and Shannon 2005). The directed step categorized notes according to themes identified based on existing agriculture-nutrition linkage literature (Herforth and Harris 2014; Arimond et al. 2011; Danton and Titus 2018) as well as preliminary findings from previous research phases. Subsequently, the inductive step provided additional categories or sub-categories according to emergent themes.

6. Results

6.1 Introduction to the results

The following chapter presents four published articles that respond to the goal of understanding food and nutrition relationships among agroecological farmers in Ecuador. Each of the articles explore different components of the hypotheses pathways proposed in this thesis, as shown in Figure 4. Table 3 briefly describes each article as well as my contribution as lead author and the contributions of my co-authors. To maintain internal consistency, the articles presented utilize their original section numbering (if applicable), independent of the remainder of the thesis, as well as their original reference styles.

Following the four research articles, this chapter also presents supplementary results obtained through the deliberative results dissemination and interpretation activities; these results were not submitted for peer-review, but they contributed to the objectives of this research project and supported our participatory research process. Additional results from a book chapter comparing traditional food systems in Ecuador and Palestine are provided in Annex 4; these results are not presented in this chapter because they are only tangentially related to the research objectives of this thesis.

Figure 4: Results presented exploring the linkages between agroecology and nutrition

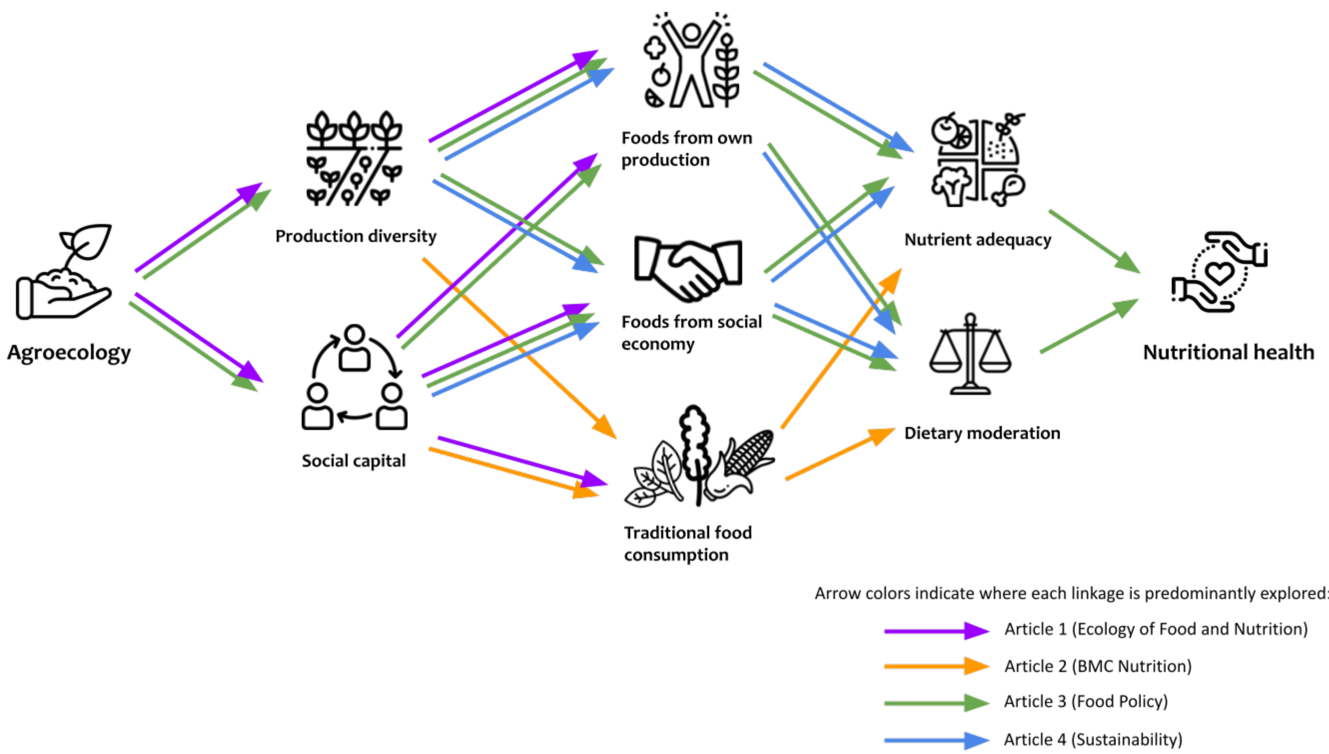


Table 3: Summary of research articles
Article 1: The Agroecological Farmers' Pathways from Agriculture to Nutrition: a practice-based case from Ecuador's highlands This article was published in *Ecology of Food and Nutrition* in 2019. It presents the results of key informant interviews with stakeholders involved with agroecology in Imbabura, as well as ethnography with agroecological farmers. Using qualitative analysis, it assesses how agroecology in Imbabura may act on established agriculture-nutrition pathways. **Citation:** Deaconu, Ana, Geneviève Mercille, and Malek Batal. 2019. "The Agroecological Farmer's Pathways from Agriculture to Nutrition: A Practice-Based Case from Ecuador's Highlands." *Ecology of Food and Nutrition* 58 (2): 142–65. https://doi.org/10.1080/03670244.2019.1570179
Article 2: Promoting Traditional Foods for Human and Environmental Health: Lessons from Agroecology and Indigenous Communities in Ecuador This article was published in *BMC Nutrition* in 2021. It utilizes data from the cross-sectional survey and focus group discussions to assess traditional food production and consumption practices of agroecological farmers and their reference neighbours. Further, it utilizes path analysis to understand the linkages between

agroecological participation and traditional food practices.

Citation: Deaconu, Ana, Ekomer, Geneviève Mercille, and Malek Batal. 2021. "Promoting Traditional Foods for Human and Environmental Health: Lessons from Agroecology and Indigenous Communities in Ecuador." *BMC Nutrition* 7 (1): 1. https://doi.org/10.1186/s40795-020-00395-y.

Article 3: Agroecology and Nutritional Health: A Comparison of Agroecological Farmers and Their Neighbors in the Ecuadorian Highlands

This article has been accepted for publication in *Food Policy*, and is currently in-press. It integrates quantitative and qualitative data from the cross-sectional survey and focus group discussion instruments to compare agroecological farmers and their reference neighbours on production diversity, dietary practices and other variables relevant to nutritional health. It further utilizes path analysis to explore the relationship between agroecology participation and nutritional health.

Citation: Deaconu, Ana, Peter R. Berti, Donald C. Cole, Geneviève Mercille, and Malek Batal. 2021. "Agroecology and Nutritional Health: A Comparison of Agroecological Farmers and Their Neighbors in the Ecuadorian Highlands." *Food Policy*, January, 102034. https://doi.org/10.1016/j.foodpol.2021.102034.

Article 4: Market Foods, Own Production and the Social Economy: how food acquisition sources influence nutrient intake among Ecuadorian farmers and the role of agroecology in supporting healthy diets

This article was published in the journal *Sustainability* in 2021. It utilizes dietary data from the cross-sectional survey to assess the nutritional contributions of foods obtained from conventional markets, own harvest and the social economy. It evaluates the food groups and nutrient densities provided by each of these three food acquisition sources, and explores relationships between reliance on different sources and dietary indexes. Finally, it explores how agroecological networks can enable health-promoting food acquisition practices.

Citation: Deaconu, Ana, Peter R. Berti, Donald C. Cole, Geneviève Mercille, and Malek Batal. 2021. "Market Foods, Own Production, and the Social Economy: How Food Acquisition Sources Influence Nutrient Intake among Ecuadorian Farmers and the Role of Agroecology in Supporting Healthy Diets." *Sustainability* 13 (8). https://doi.org/10.3390/su13084410.

Contribution to the four articles: As first author for each of these articles, my role was in establishing methodology and designing instruments (e.g. key informant interview protocol, ethnography protocol, survey instrument, focus group discussion protocol), collecting data (e.g., conducting key informant interviews; conducting ethnographic homestays; administering surveys, in conjunction with a research assistant; and, facilitating focus group discussions, in conjunction with AFN leadership), processing and analyzing data, as well as drafting each manuscript.

My co-authors for each article provided key support in framing the research objectives, defining methods for both qualitative and quantitative analyses, interpreting findings, revising each manuscript and providing general guidance. Beyond these contributions, Malek Batal and Geneviève Mercille also provided generous supervision.

6.2 Article 1: The Agroecological Farmer's Pathways from Agriculture to Nutrition: A Practice-Based Case from Ecuador's Highlands

Deaconu, Ana[1]; Mercille, Geneviève[1]; Batal, Malek[1,2]

Contact: Ana Deaconu ana.deaconu@umontreal.ca

1. Research Group on Nutrition Transition and Development (TRANSNUT), Nutrition Department, Faculty of Medicine, University of Montreal, Montreal, Canada

2. University of Montreal's Public Health Research Institute (IRSPUM), Montreal, Canada

Abstract

Agroecology is increasingly recognized as a sustainable production strategy that is appropriate for the rural poor. Meanwhile, agricultural initiatives have received much attention for their role in improving farmer nutrition, and three key pathways between agriculture and nutrition include consumption of own production, income and women's empowerment. In this study based in Ecuador's Imbabura province, we used qualitative methods to explore the practices of agroecological farmers with respect to these three key pathways. Results demonstrate the heterogeneity of lived experiences through which agroecology increases agricultural diversity and builds social and human capital to improve nutrition. We further identify barter as an under-explored means to nutrition outcomes, and we discuss the role of the complex rationale that mediate farmers' performance on agriculture-for-nutrition pathways. Finally, our results illustrate agroecology's potential to spread nutrition-promoting practices through endogenous farmers' networks.

Keywords: Agriculture; diversity; nutrition; sustainable; agroecology

Introduction

Effectively addressing malnutrition in the rural sector remains a critical international priority, especially as increasing evidence shows that people who are malnourished as children not only experience the developmental consequences of chronic nutrient deficiencies, but are also more likely to be overweight or obese as adults (Black et al. 2013; Godfrey, Gluckman, and Hanson 2010). Further, they are more likely to experience the comorbidities of obesity, such as diabetes, heart disease and metabolic syndrome (Godfrey, Gluckman, and Hanson 2010). In Ecuador, rural populations are the most affected by this double burden of malnutrition, and particularly Indigenous rural populations (Freire et al. 2014). Indeed, stunting caused by nutrient inadequacies affects 42% of Ecuador's Indigenous children, whereas the national prevalence is 25%. Meanwhile, Ecuador's rural children are more likely to be overweight or obese than their urban counterparts (Freire, Ramírez, and Belmont 2015). The nutrition transition toward high-calorie, low-nutrient foods exposes populations in rural sectors to simultaneous nutrient deficiencies and excesses even in remote and resource-poor areas of the world (Popkin, Adair, and Ng 2012).

Responding to the persistent problem of rural nutrient inadequacies, "nutrition-sensitive agriculture" and "agriculture-for-nutrition" (used here interchangeably), have become common practice in international development (Pinstrup-Andersen 2013; Balz, Heil, and Jordan 2015; Danton and Titus 2018). The associated literature highlights three demonstrated pathways connecting agriculture and nutrition: consumption of own production, increased income, and women's empowerment (Herforth and Harris 2014; Arimond et al. 2011; Danton and Titus 2018). Importantly, the effectiveness of each pathway is mediated both by local contextual factors as well as specific intervention investments in different types of capital (Danton and Titus 2018; Berti, Krasevec, and FitzGerald 2004). For example, interventions that diversify agricultural production can make important contributions to dietary diversity, which is in turn associated with micronutrient sufficiency (Arimond and Ruel 2004), but only if farmers actually know how to and want to consume the new additions to their production (Cook 2018). Similarly, increased agricultural income can provide better economic access to nutritious foods, but only if the income is in fact used for this purpose, or if nutritious food is available for purchase (Cook 2018). Because of such contingencies, agricultural interventions are more likely to have positive effects on nutrition if they simultaneously invest in multiple forms of capital (physical, natural, financial, social and human), and especially in human capital, with particular emphasis on the importance of nutrition education and gender considerations (Berti, Krasevec, and FitzGerald 2004).

While some scholars have recently made nods to the need for nutrition-sensitive agriculture to avoid harm with respect to overweight and obesity (Herforth, Lidder, and Gill 2015), its role is unclear for addressing this side of the double burden of malnutrition. Given correlations between nutrient inadequacies in early life and overweight in later life (Godfrey, Gluckman, and Hanson 2010), investing in maternal and child nutrient adequacy may inherently contribute to long term prevention of overweight. Nevertheless, rising prevalence of the double burden of malnutrition among the rural poor (Black et al. 2013; Shafique et al. 2007; Kimani-Murage 2013, Fernald and Neufeld 2007) warrants more explicit exploration to understand how agriculture-for-nutrition pathways may affect overweight and obesity.

Beyond these remaining knowledge gaps, agriculture-for-nutrition pathways have demonstrated strong potential to align with a broader global agenda toward sustainable development, which promotes ideals including economic resilience, climate change adaptation, ecological stewardship, gender equality and empowerment of Indigenous peoples (United Nations 2015). Many of these objectives have been captured in recent institutional pushes to move away from the "specialization" zeitgeist that dominated for generations toward one of diversity (Frison and IPES-Food 2016). Agricultural diversity, in particular, has received attention for its role in promoting economic resilience in the face of market disruptions or natural shocks, regenerating ecosystems, hedging against the risks of climate change, mobilizing traditional Indigenous knowledge and empowering women. These not only contribute to the Sustainable Development Goals, but can have positive indirect effects on nutrition (Frison, Cherfas, and Hodgkin 2011; Frison and IPES-Food 2016, Cook 2018). Furthermore, empirical evidence from many countries demonstrates a positive correlation between agricultural diversity and dietary diversity, leading to direct effects on nutrient adequacy. According to context, this correlation is most often attributed to the consumption of own-production, to increased income, or to a combination of the two (Powell et al. 2015; Frison, Cherfas, and Hodgkin 2011; Herforth and Harris 2014; Frison and IPES-Food 2016; Pellegrini and Tasciotti 2014). Recently, women's empowerment has also received increased attention as an important mediator of this relationship, given women's roles as stewards of agricultural diversity and primary decision-makers around food (Cook 2018).

One of the most promising means for increasing agricultural diversity appears to be agroecology, which has risen on the global governance agenda in recent years as an accessible and appropriate strategy for resource-poor farmers (Altieri and Nicholls 2012; Frison and IPES-Food 2016), and may also be compatible with agriculture-for-nutrition pathways. Agroecology applies ecological principles to the design and management of food and agricultural systems to create a self-sustaining and environmentally regenerative agro-ecosystem; this process involves eliminating synthetic agrochemicals and instead cultivating high levels of plant and animal biodiversity in order to promote beneficial interactions, protect against pests and increase productivity (Altieri and Toledo 2011; Tittonell 2014). In some spaces, agroecology functions as an institutionally-backed intervention strategy; in others, it functions as a social movement spread by farmers' networks (Wezel et al. 2009). In Ecuador, agroecology appears to be simultaneously an intervention and a social movement, as it is spread through both institutional programs as well as through self-organized networks such as Indigenous and peasant federations, and is often a collaboration between the two (Intriago et al. 2017). The multimodality of agroecology's dissemination makes it a strategic focus of research, especially because promising practices may be scaled up among future farmers by today's early adopters (Frison and IPES-Food 2016).

Agroecology initiatives may be informed by the agriculture-for-nutrition literature, which provides important lessons for intervention and policy planning. However, the outcomes of such programs, such as dietary change, occur at the level of individual practice. Behavioral science research repeatedly points out that individual practice is not usually the result of evidence-based, rational decision-making, but rather the product of social and cultural contexts, emotion and meaningful experiences (Kahneman 2003), and the same holds true for both production decisions (Herforth and Harris 2014) and dietary decisions (Chadwick, Crawford, and Ly 2013). Responding to the complexity of the physical and interpersonal influences that affect people's interactions with their food environments, and ultimately their dietary practices, food studies have gradually narrowed their focus from attempts to characterize a broader "context" to a more individual scale that can better capture these complexities (Chen and Kwan 2015). Similarly, the "practice" approach develops profound, qualitative accounts of practices to give attention to the heterogeneous array of human activities (Schatzki 2001).

In this study, we thus focus on individual practice and recount farmers' empirical lived realities such that their experiences may enter into conversation with the quantitatively-established patterns and pathways for nutrition-sensitive agriculture. Whereas previous research has reviewed what agriculture interventions have done right or wrong for improving nutrition (Berti, Krasevec, and FitzGerald 2004; Arimond et al. 2011), our attention to individual farmers' practice allows us to also recognize the agency of farmers (rather than intervention planners) in generating production and dietary changes. This article thus has the dual objective of empirically describing food and agriculture practices among agroecological farmers in our study site, as well as drawing lessons from their experiences that are relevant to the evolving body of knowledge related to agriculture-for-nutrition. Specifically, we frame qualitative inquiry on the hypothesis that agroecology in our study site would affect nutrition through some or all of the same pathways established in the agriculture-for-nutrition literature, namely consumption of own production, increased income, and women's empowerment, and that these pathways are mediated by different forms of capital. We defer to the farmers' lived experiences to understand how they do, or do not, follow these pathways.

Methodology and methods

Study site

This study is situated in the rural communities of Ecuador's northern-highland province of Imbabura, where agroecology has made strong inroads. A recent survey identified and interviewed the heads of 676 agroecological farms in Imbabura, suggesting that at least 2% of the province's total farms are agroecological; nevertheless, the authors note that this is likely an underestimate (Heifer 2014; INEC 2000). Conventional farming in the province is dominated by small-holder family farming, with many farmers practicing traditional, subsistence-oriented production practices that hold much in common with agroecology (Heifer 2014). The boundaries of the study site are defined by the locations of farmers participating in agroecology initiatives. While its extremities are no more than 60 km apart, people within the study site live and grow crops at altitudes varying between 1500 and 3500 m above sea level. They thus experience a range of ecosystems, soil types, rainfall patterns, and temperatures, resulting in diverse agricultural strategies. Communities within the study site experience high poverty rates, reaching up to 84% in some villages (INEC 2016). Such inequities are reflected in nutritional status, and Imbabura's childhood stunting prevalence of 35% surpasses the national average of 25%. This is likely related to the region's high levels of inadequate dietary intakes of protein and fat as well as deficiencies in iron, zinc, and vitamin A (Freire, Ramírez, and Belmont 2015). Meanwhile, Imbabura's adult overweight and obesity prevalence of 62% is similar to the national level (Freire, Ramírez, and Belmont 2015). Of Imbabura's total population, 25.8% self-identify as Indigenous (INEC 2010), and

86.6% of Imbabura's Indigenous population is rural (INEC 2006). In this region, today's rural Indigenous people have inherited the circumstances of a history of marginalization that relegated them to distant and unfavorable agricultural lands with challenging growing conditions and reduced market access (Waters 2007; Zamosc 1994).

Research approach

This research is part of the Farm to Plate study, which uses mixed methods to understand the dietary, agricultural and social practices of farmers in Imbabura province to examine the potential nutrition outcomes of agroecology. Prior to deploying Farm to Plate's cross-sectional comparative survey of agroecological and conventional farmers, we recognized the need to conduct qualitative research to deepen our understanding of local practice, flag predominant mediators of the relationship between agriculture and nutrition, and identify emergent themes for inclusion in the survey. We therefore applied Long's Actor-Oriented Approach (Long 2003) to develop the field and analytical methods for such inquiry. Namely, we used qualitative instruments to: identify relevant actors and actor-defined issues; document social heterogeneity; and, explore how knowledge and power are constructed and reconfigured (Long 2003). Through this approach, we pay special attention to "practice" in order to highlight, rather than dilute, deviations from preconceived expectations (Schatzki 2001).

Instruments

Qualitative instruments included ethnography, key informant interviews, and participant observation in relevant spaces. In May and June 2017, we conducted semi-structured key informant interviews with nine individuals, five of whom were agroecological farmers' association leaders, two of whom directed NGO programs promoting agroecology, and another two that were municipal employees in charge of coordinating relationships with agroecological associations. All farmers' association leaders and one NGO representative are also members of the Imbabura Indigenous Peasant Federation. Interviews focused on the history of agroecology in the region, current organizational structure and inter-organization relationships, and activities and events surrounding agroecology.

We conducted ethnography during July 2017 and January 2018 to include both the winter and summer seasons. This involved immersive homestays of approximately one week each with five agroecological families, in which the ethnographer (the first author) utilized participant observation and semi-structured interviews to collect data around food, agriculture, gender dynamics and food-related social practice in the family's homes and in their communities. We selected participating families following discussion in key informant interviews, aiming to cover a variety of ecozones and durations of participation in agroecology. We identified key themes for inquiry and observation according to our hypotheses, focusing specifically on gender dynamics, dietary content, food origin, agricultural practices, and perceptions of health with respect to diet. We used a critical ethnography approach, which recognizes that the ethnographer is not an unobtrusive "fly on the wall" and instead incorporates reflexive inquiry as to the ethnographer's influence on daily practice (Madison 2005). Data collection instruments included: handwritten field notes; a food journal kept by the ethnographer; lists of agricultural products in the field and stored food items; and, photography of meals, food storage, and farms.

We conducted participant observation in relevant events and spaces from May to August 2017, December 2017 and January 2018. These included farmers' association meetings, agroecological markets and agroecology-related workshops. Further, we integrate participant observation as documented in field notes from visits to agroecological and conventional farmers' homes (n=61 and n=30, respectively) during implementation of the cross-sectional survey from July 2017 to October 2017 (in this article, we do not discuss results of the survey itself).

Qualitative content analysis and presentation

To analyze content, we combine a directed procedure in which we organize qualitative data according to the three pathways proposed by our hypothesis, with an inductive procedure in which we also identify emergent themes (Hsieh and Shannon 2005). We return to the Actor-Oriented Approach to categorize and thematically explore the experiences and actions of farmers in their daily interactions with food and agriculture, giving attention to contextual underpinnings, social relationships, material and resource interactions, and power dynamics (Long 2003). To present our analysis results, we apply a "critical approach to food studies," that uses narrative accounts in academic research to demystify food by exploring the significance of “people, ideas and things in the reality of their food actualities,” and that also recognizes the researchers’ role as a non-invisible actor within the study (Arce, Sherwood, and Paredes 2017). We occasionally use names for clarity and to unite data points from the same farmer, but all names are fictitious to protect identity.

Ethical approval

All participants gave informed consent according to the study protocol that was approved by the Health Research Ethical Committee of the University of Montreal, certificate number 17-053-CERES-P, and by the Institutional Review Board of the *Universidad San Francisco de Quito* in Ecuador, certificate number 2016-118E.

Results

Agroecology in Imbabura

The local emergence of a new practice

Key informant interviews with local leaders of agroecological associations situate the roots of agroecology in Ecuador’s northern highland provinces within the region’s Indigenous movement and its discourse on food sovereignty, traditional identity, and solidarity-based local economy. They explain that the production aspects of agroecology emerged as a pathway to achieve food sovereignty and restore Andean traditions. Meanwhile, local NGOs were working in parallel to the Indigenous movement to promote environmentally-sustainable rural development through pesticide reduction and strategies for ecosystem regeneration. Acknowledging their similar means to compatible ends, local NGOs and farmer’s associations tied to the Indigenous movement began to collaborate, giving rise to new forms of joint civil society organization. Together, they promoted agroecological production practices and created specialized farmers’ markets for direct sale of agroecological products, with agroecological farmer’s markets emerging in 2009. As farmers and institutions expanded their interests, agroecological associations began inviting local experts, including farmers themselves, to give workshops on nutrition, food preparation, and medicinal plants, among other subjects.

NGO directors explain that, because their organizations targeted marginalized communities, many of Imbabura's agroecological farmers are from remote Indigenous communities that experience complex environmental conditions and have high poverty levels. In adaptation to their conditions, these farmers tend to maintain agricultural diversity for subsistence and utilize organic fertilization and pest control methods. Rather than a matter of conviction, they often use such practices out of lack of economic access to "modern" alternatives. NGO representatives explain that such practices are already largely agroecological, and their role is to strengthen them as well as to integrate farmers into specialized markets that recognize the higher quality of their organic products. Due to prevailing gender roles in livelihood strategies, agricultural management, and food preparation, agroecological associations are predominantly comprised of women.

While many farmers trace their routes to agroecology through the joint interventions of local Indigenous federations and NGOs, others do so via social relationships to other agroecological farmers, and still others arrive entirely by their own agency. One young farmer began growing more diversity and eliminated pesticides when her son was born with multiple allergies and she believed her own nutritional status during pregnancy and her use of pesticides were to blame. When she later happened on an agroecological market, she not only found it to be an appropriate place to commercialize her products, but also to connect with other farmers with shared interests.

Identity of the agroecological farm and farmer

Our farm observations suggest that, for most Imbabura farmers, adopting agroecology means implementing several production changes: (1) increasing diversity of products, especially of vegetables; (2) increasing inter-cropping; (3) producing and applying organic compost, green manure and organic pesticides; (4) and, eliminating or greatly reducing application of synthetic pesticides and fertilizers. The extent and means by which these strategies are implemented varies greatly by farm. For example, some farmers also base their cropping strategy on specific beneficial relationships between plants, leave areas unmanaged to create habitat for birds and pollinators, apply green barriers and/or agroforestry, collect rainwater, or restore endangered traditional crop varieties. Some agroecological farmers also integrate aspects of traditional Andean farming, such as using the moon phase to guide production activities. Farmers also explain that they maintain or recover Indigenous identity by planting traditional crops and their cultivars that have lost cultural favor, for example *melloco*, *mashua*, *oka*, *jicama* and amaranth, as well as by re-valorizing the role of certain endemic plants that traditionally had utility in food, medicine or the agro-ecosystem, but are now conventionally considered to be "weeds."

Beyond production strategy, we observed how identity as "agroecological" is most strongly determined by participation in the specialized markets created by and for agroecological production. We attended a regional meeting that brought together farmers from several agroecological markets to exchange seeds, perform educational field visits and discuss relevant political matters. To close the meeting, farmers created a ceremonial mandala comprised of traditional grains, tubers and fruits. One association leader gave a speech to motivate continuation on the agroecological path and ended by leading the group of over one hundred farmers in a chant of "*Que viva la agroecología!*" meaning "long live agroecology!" For many, affiliation with agroecology transcends participation in the market. As one farmer explains, "agroecology is not just producing in a certain way. I made my house out of natural adobe because that is also part of it. It is everything we do, the way we eat. "

Hypothesized pathways between agroecology and nutrition

Pathway 1: Consumption of own production

In one ethnographic visit, we stayed with María Dolores, an agroecological farmer on the outskirts of a growing urban center. She told us "my land is my refrigerator," and we observed that the daily cooking process began with sending her son or daughter to harvest the fresh ingredients, even though her husband's municipal job and the family's proximity to the city would have made market purchase an easy option. Many agroecological and conventional farmers echoed this rhetoric upholding the connection between the products on the farm and the ingredients on the plate, and observations in their homes concur that both groups of farmers consistently integrate their production items into their diets. When products are no longer or not yet available from the farm, they obtain them elsewhere, and when they have a surplus, they either sell it, barter it or gift it. We observed how both types of farmers maintained relatively diverse production, but this diversity was visibly greater on agroecological farms. For example, while we observed widespread production of onion, carrots, cabbage and chard, which have established roles in Ecuadorian culinary traditions, it was mostly on agroecological farms that we saw newer products, such as broccoli, spinach, several types of lettuce, cauliflower, zucchini, and now even kale. Further, agroecological farmers appear to maintain more diversity within species, such as multiple types of potatoes, maize, onions and lettuces. Such differences follow agroecological farmers into the kitchen, where we observed kale integrated into a meal that would traditionally only feature chard, broccoli sautéed to accompany potatoes, and salads featuring three lettuce varieties. To season their foods, they diverge from the ubiquitous cilantro and also use celery, parsley, fresh oregano, and lovage from their production.

We observed how multiple motivations contribute to agricultural diversity decisions. For example, farmers report that they grow some varieties for their unique taste, even if they are not considered commercially viable because they take longer to grow, are more difficult to prepare, or are aesthetically less pleasing. They integrate other products or cultivars out of a sense of curiosity and experimentation, for example to see if a low-land cultivar will eventually adapt to a high-altitude region. Many farmers express pride in having unique products, or pleasure in the aesthetics of diversity. One agroecological farmer competes each year in a contest for the highest number of maize varieties, and another farmer, who grows a papaya plant in a region for which it is not suited, states "I know it will not give fruit, but it looks nice and the birds seem to like it." Further, farmers explain that diversifying varieties increases availability throughout different moments of the growing season. Presenting her five potato varieties, one agroecological farmer explained the order in which each would be ready for harvest.

Pathway 2: Income

Farmers identify agroecological spaces as a unique opportunity to simultaneously integrate into markets and maintain diversified production for the family's diet, rather than becoming cash croppers. They explain that they cannot participate in conventional markets unless they have a wholesale quantity, which would mean that they would have to specialize in fewer products. Zoila explains, "I can't sell my babaco [*Carica pentagona*, relative of the papaya] to the [conventional] markets. I would need to take an entire crate for them to buy it. And the intermediaries, they're abusive. They always want a lower price, and they won't take the product if it isn't perfect. What would I do with my ten babacos? In the agroecological market, I can sell my few babacos, and the consumers know that if it isn't perfect, it's because I don't use poison. That's their quality guarantee." By selling to informed consumers, farmers are thus also able to sell products that would otherwise be rejected due to aesthetic blemishes. Through direct sale, farmers are also able to capture a better price on their products, such as Esperanza, who is able to sell her milk at a higher price than she would receive from the milk collection truck. Yet not all farmers that participate in agroecological markets turn a profit, and some commented that everything they earn at the market is consumed by transport costs, or else they spend it on lunch. Nevertheless, they continue to participate for social reasons and to barter, as described in sections 3.2.3 and 3.3.1.

Another economic motivator for increasing agricultural productivity and diversity is the desire to reduce expenditures on food and liberate income for other purposes. One agroecological association leader explains that the women selling at her market are able to save on the staples and vegetables that they grow, and instead spend on goods that were previously out of their budget, such as eggs, meat or dairy. Carlos, who used to specialize in tomatoes but has greatly increased the diversity on his farm in his transition to agroecology, explains: "before, sure, I could eat food from the farm, if all I wanted was tomatoes. Everything else, I had to buy. But now, I only buy the basics: rice, sugar, oil, salt... everything else is from the farm!" Because Carlos spends less on food than in the past, he uses the liberated income for other productive investments.

Pathway 3: Women's empowerment

Women's narratives describe how adopting a new production strategy, participating in markets and gaining social status can disrupt household gender dynamics. For Lourdes, agroecological production has been a slow process of gaining figurative and literal ground from her husband, a peach cash-cropper. Several years ago, he reluctantly ceded a small plot of land to Lourdes for her vegetable garden, but as she demonstrated her garden's utility, she gradually gained access to more land. For María Dolores, her husband reacted to her transition to agroecology with aggression. He was suspicious of her when she attended agroecological association meetings and he believed that her agricultural “experiments” were a waste of time. María Dolores states: “Before agroecology, I was very quiet. We Indigenous women, that’s what is expected of us. I kept my mouth shut. I never confronted my husband. But then I learned to speak, and when I began to say what I wanted to say, my husband did not like it.” María Dolores comments that her experience is not unique, and names other women whose husbands reacted violently to their involvement in agroecology, including one who had to withdraw due to escalating domestic abuse. Yet María Dolores adopted the position that “if he doesn’t beat me for this, he will beat me for something else,” and defiantly pursued agroecology.

Eventually, both Lourdes and María Dolores’s husbands became more accepting after personally experiencing the sensory benefits of agroecological production (e.g. better taste, aesthetically pleasing landscape), the convenient access to fresh products, and the reduction of household food expenditures. In fact, María Dolores’s husband now not only acknowledges his previous misconduct, but has also begun helping in agroecological production activities. For farmers like Elvía and Zoila, the transition into agroecology was received more smoothly by their husbands, who joined forces with them to support this new lifestyle. Multiple women, including Lourdes and María Dolores, note that the agroecological market is a way to have money in their own pockets, even if the amount is usually not large.

The home is not the only space where agroecology stirs up women’s social relationships. Some women, such as Lourdes, report receiving positive feedback from their villages and rising in status, as their neighbors appreciate both the aesthetic beauty of their farms and the diversity that it allows them to share. On the other hand, others like María Dolores and Esperanza report that neighbors believe their production strategy to be ignorant and whimsical, or even dangerous. María Dolores recounts: “My neighbors say I am a witch. They think I am using dark energies to grow such a nice garden. Recently, a neighbor swallowed poison [pesticide] and the village said I was responsible for her killing herself. They are envious. ” In contrast, within the agroecological sub-culture, María Dolores is well-respected and has been invited to give cooking and production workshops. For two years, she co-hosted a weekly local radio program on food sovereignty, and has been a guest on the national public radio channel. “With agroecology, I am always going from one event to another, making friends, meeting foreigners, sharing experiences,” says María Dolores. Esperanza, who is also a leader in her agroecological association states, “people here in the village, they do not like to see anything different. In the market, I am at home. I am respected." In fact, her leadership role has prompted her to enroll in secondary school for adults on weekends, such that she may develop the capacities to better serve her association. Digna, who is 73 years old, makes the long and tiring journey to the agroecological market despite the fact that she perceives the profit as nearly negligible. Instead, she says, "I go to the market for the people, for the friendships. There, we see each other, we talk, we laugh." She contrasts this with the people in her village, who she finds to be "closed off" and judgmental. Her participation in the market also introduced her to travel for the first time, taking her to Colombia as well as to different regions of Ecuador for agroecology conferences and events.

Emergent themes

Food and seed exchange in agroecological markets

In agroecological markets, transactions are not limited to those between farmers and their clients; rather, farmers commonly engage in barter and sale with each other, exchanging products, varieties, and seeds from distinct ecological zones. Carola, an agroecological farmer whose remote location gives her privileged access to wild edibles but limited access to purchased goods, states that "the reason I go to the market is to barter and eat the foods that my colleagues bring." Farmers exchange seeds for products or varieties that they do not already have. When exchanging harvested products, they explain that they mostly seek those that would not be able to grow in their region, for example exchanging high-altitude tubers (oka, melloco) for low-altitude fruit (papayas). Miguel, who lives in a region where cold, wind, and high altitude greatly limit production to starchy staples, states: "We eat more variety than others in our village, than those who are not in the agroecological market, because we barter in the market. The others only eat what they grow, but we also eat fruit, we eat products from warmer regions." They also exchange for products that are not yet ready for harvest on their own farm, or that they have in smaller quantities. One farmer states that at times, they also "exchange just to exchange," out of a sense of diplomacy and community-building.

3.3.2 Dissemination of dietary, agricultural and health knowledge

We followed the flow of dietary, agricultural and health knowledge in agricultural spaces to find that, in some cases, NGOs or food activist groups impart information in organized workshops, and in others, knowledge spreads informally from farmer to farmer, or between farmers and market clients. Esperanza, who comes from a region where high altitude and extreme diurnal temperature variation limit growth, attributes the increased diversity on her farm and in her diet to the agroecological market: "Before the market, I did not even know that there are different types of onion. I did not know about chives or leeks. I also did not know about jackfruit or chayote. I thought red lettuce only grew in greenhouses. I never thought I could grow red lettuce or zucchini on my own land." Upon learning how to grow these products in workshops and how to prepare them from her colleagues, these new fruits and vegetables are now present in her meals, entering her kitchen either from her own production or from barter at the agroecological market.

We also observed informal conversation with clients whose interest in food and health appear to be what first attracted them to agroecological markets, where they seek pesticide-free foods and unique products or varieties that they cannot find elsewhere. Farmers are aware of this, and they seek to bring unique products to leverage an economic advantage. In one instance Esperanza accidentally bought seed for spring onions instead of chives. In her market, chives were a popular product, but spring onions were largely unknown. She reluctantly brought her "failed chives" to the market, assuming they would not sell. A client came over elated to find spring onions, bought up several bunches, and explained the culinary uses to other clients as well as other farmers. Within minutes, all of Esperanza's spring onions sold, and other farmers were asking where to get the seed. That evening, Esperanza invited her neighbors to share a meal of sautéed spring onions with potatoes. Notably, the information channels between farmers and clients are two-way. As one farmer notes, "In the market, we farmers become doctors. [The clients] tell us what problem they have, and we recommend the plant or food that will help them."

Indeed, farmers in agroecological spaces frequently reiterate the notion of food as medicine, and they speak to the importance of eating more fruits, vegetables, leafy greens, whole grains and traditional products, as well as general dietary diversification. María Dolores, states, "Health is diversity in the field and in the food." These beliefs follow the farmers through the kitchen door, and one elderly woman states: "I've been trying to add chard into my potato soup. I didn't used to, or I did very little, but in the [agroecological] market they say that it's good to add." Discourse also addresses foods to avoid, such as pasta and rice, which are unanimously considered inferior due to their association with modernity and urbanization. One man attributes the longevity of his centenarian uncle to his diet: "If he eats meat, it's only from the pig that he himself raised. He only eats the ancestral grains—barley, quinoa, wheat—no rice." Similarly, seasoning cubes are denounced as "chemical," and are considered incompatible with agroecological diets. Industrial processed foods are denounced so heavily in agroecological spaces that, when María Dolores consumes a school-issued, nutrient-fortified granola bar gifted to her by a teacher, she does so hidden behind her market table and asks the researcher not to tell on her for eating "junk" food. One farmer illustrates how the translation of knowledge into practice is also contingent on sensorial attributes, stating that, "they say it's better to eat potatoes with their skins. Sometimes I do that, but not so much. I don't really like it that way." Another farmer instead explains that whether or not she eats the potatoes with their skin depends on the type of potato, as some have more palatable skin than others, and whether or not it comes from her own production: she consciously weighs the nutritional benefits of potato skins against the health risk of the pesticides they may contain.

3.3.3 Scaling agroecology into the community

Agroecological farmers' practices appear to trickle down in their villages and social networks. Esperanza states, "whenever I have a new product, I share it with my entire family," referring to her conventional-farming relatives that live nearby. Barter and gifting is not unique to the spaces of agroecological markets; rather, in Imbabura province, it is a common practice associated with Indigenous identity. Similarly, it is common to directly purchase from or sell to others in the village, rather than going to urban markets. Further, we observed farmers gifting products to elderly, ill or otherwise vulnerable relatives or neighbors. Through the dynamics of community-level trade, foods from own-production change hands to meet needs. For example, María Dolores gifted celery and parsley on one day and exchanged a sack of fava beans for barley seed on another, and Carmen sold avocados, oranges, guavas and medicinal plants. Carmen informs us that such trade practices are ubiquitous in her community, but that people seek her out because her agroecological production strategy allows her to offer a greater diversity of products.

Similarly, seeds and production strategies flow through communities. For one conventional farmer, Rubi, a confluence of factors has pushed her into extreme poverty and food insecurity. However, she credits her agroecological neighbor not only for sharing her products with her, but for having given her the seed and the knowledge to grow her own iron-rich broccoli, chard and *paico* (Dysphania ambrosioides), as well as other vegetables including cauliflower, cabbage and zucchini to accompany her production of potatoes and beans. Upon her neighbor's encouragement, she has now participated in two agroecology workshops, and hopes to eventually integrate into the agroecological market.

Discussion: From agroecology to nutrition

The practices of agroecological farmers in Imbabura province show the diverse and complex ways that they utilize agroecology to transform their production and dietary practices as well as their social environments. Ultimately, many of these transformations converge with the three major pathways identified for leveraging agricultural interventions for nutrition, namely (1) consumption of own production, (2) increased income, and (3) women's empowerment (Herforth and Harris 2014; Arimond et al. 2011). Our observations suggest that agroecology may act on these pathways not only by increasing agricultural diversity, which is a direct outcome of the production strategies espoused by agroecology, but also by constructing social capital (e.g. relationships) and human capital (e.g. knowledge). In Imbabura, agroecological markets, workshops and events appear to create a social space for the exchange of foods, seeds, production knowledge and food use knowledge, as well as creating opportunities for women to earn income, make new acquaintances, travel, and take on leadership responsibilities. These attributes of agroecology position it as an interesting integrated strategy for promoting nutrition objectives alongside environmentally regenerative agricultural practices. Yet zooming in at an individual level, our observations illustrate how farmers take multiple trails and sometimes detours as they journey on these pathways between agroecology and nutrition.

Our finding that both agroecological and conventional farmers obtain substantial parts of their diet from their own production is consistent with previous research in the region (Orozco et al. 2007), and agroecological farmers explicitly describe how their adherence to this production strategy has positively impacted their consumption of their own production. In some cases, we heard farmers quaintly mirror the framework that ties agriculture to nutrition: when María Dolores states that

“Health is diversity in the field and in the food,” this resonates with the positive relationship between agricultural diversity and dietary diversity as described in multiple reviews (Powell et al. 2015; Pellegrini and Tasciotti 2014). Yet noise is created in this correlation when aesthetics motivate a highland farmer to devote space and resources to low-land papaya (thus increasing agricultural diversity), fully knowing it will never bloom (thus having no impact on dietary diversity). These behavioral complexities may partly explain why correlations between agricultural diversity and dietary diversity are frequently statistically minor, as found in a recent meta-analysis of 45 studies (Sibhatu and Qaim 2018). Likewise, when a farmer maximizes the number of corn varieties she grows out of a sense of pride, she is likely sacrificing potential yield and nutritional intake, especially because certain rare corn varieties may be unpopular precisely due to low yields or little culinary utility. The role of affect (feelings and emotions) in determining food practice was also observed by Sherwood and colleagues, who find that food practices in a neighborhood of rural-to-urban migrants in Ecuador’s capital are at times motivated by a nostalgic cultural tie to rurality (Sherwood, Arce, and Paredes 2018). Our findings resonate with the results of behavioral studies (Kahneman 2003) in that decisions are not limited to the cause-and-effect rationality of growing more food to eat more food. As such, the way farmers experience the relationship between their own production and their diet at times diverges from the logical frameworks established by agriculture-for-nutrition literature.

Agroecology’s interaction with the income pathway to better nutrition is less clear from our observations and by no means uniform. Imbabura farmers’ experiences point to a trade-off between agricultural diversification and income generation in the region’s conventional markets, as most markets require products that can be delivered in bulk quantities, and this is difficult for farmers with limited land access. This runs contrary to numerous other contexts where increased agricultural diversity has been associated with increased income (Pellegrini and Tasciotti 2014). Agroecological markets allow farmers to bypass this situation and earn income on smaller quantities of diversified products. However, the markets do not generate a profit for all participants, and for those that do, our methods did not explore whether that income would lead to nutrition outcomes. Instead, our observations indicate that increasing agricultural diversity and partaking in barter reduce certain food expenditures, liberating income for other uses. Farmers expressed that they use liberated income for purchasing higher value food products or investing further in production. As discussed by others, the relationship between income and nutrition outcomes is complex and uncertain (Herforth and Harris

2014; Cook 2018). However, the experience of Imbabura's agroecological farmers suggests that besides generating new income, agricultural interventions may have a role to play in liberating existing income for new uses.

Women's positive and negative social experiences within their homes, communities and agroecological associations show the complicated but nevertheless existent path to women's empowerment. For many women, the influence of agroecology in their lives put money in their pockets, gave them autonomy to participate in events and travel, placed them in leadership positions, gave them control over farming decisions, and increased their status within the household. While some faced strong resistance from their husbands or communities, many overcame this resistance to develop a stronger sense of agency and self-efficacy. These experiences are largely consistent with the conceptualization of women's empowerment as assessed by the Women's Empowerment in Agriculture Index, which assesses women's role in production decisions, access to and decision-making power about productive resources, income control, leadership, and time allocation (Alkire et al. 2013). In multiple contexts, performance on this index has been positively associated with nutrition indicators, including dietary diversity among women, children and households (Malapit and Quisumbing 2015; Malapit et al. 2013; Sraboni et al. 2014). Within this framework, the gender implications of agroecology may have similar positive outcomes for nutrition.

Besides the own-production, income and women's empowerment pathways, barter emerged in our results as an unanticipated additional pathway with potential to impact nutrition in this context. Previous work describes the persisting cultural importance of barter in Imbabura province and other regions of Ecuador (Ferraro 2011; Korovkin 1998). Our results suggest that farmers with more diversity in their own production might have stronger bartering power. Further, agroecological markets give farmers an opportunity to obtain goods that are not available in their own communities, such as products from different eco-zones. Farmers also report bartering for seeds in agroecological spaces, which may further improve their agricultural diversity and thus dietary diversity down the line. In Peru, barter is similarly discussed as an important means to exchange products across eco-zones, such as by providing access to low-land vitamin C-rich fruits in high altitude regions (Argumedo and Pimbert 2010). In Nepal, barter has been described as a strategy for filling food deficits (Bohle and Adhikari 1998). Yet despite the continued importance of barter across agricultural communities in multiple cultures, it does not yet appear to be systematically integrated into agriculture-for-nutrition thinking, and may merit further attention.

Further, our results shed light on how agroecology interacts with different forms of capital that may play a role in nutrition outcomes. In a review on types of capital that mediate the effectiveness of agriculture interventions for nutrition outcomes, the authors did not find investment in social capital to stand out as a strong determinant of success (Berti, Krasevec, and FitzGerald 2004). Yet in our research context, farmers manifest how the social capital created by agroecology affects their food and agricultural practice. In some cases, social capital is an important mediating factor for practicing agroecology and thus accessing any of its potential nutritional benefits. For farmers who find the social environments in their home communities to be stifling or even oppressive, agroecology becomes a space where they find social inclusion and a supportive network. The ability of agricultural initiatives to create community may have downstream health impacts, as studies demonstrate the importance of supportive social networks for healthy lifestyles, effective learning of health behaviors, and cardiovascular health (Berkman and Glass 2000; Heaney and Israel 2008; Uchino 2006).

Social capital in agroecological spaces may also be a channel for physical and human capital, the latter of which has been identified as critical for promoting nutrition outcomes (Berti, Krasevec, and FitzGerald 2004). While we already make the case that the social spaces of agroecology, such as markets and events, are important for exchanging products and seeds, we also find that these spaces house social transactions that inform participating farmers' production and food practices. By exchanging dietary recommendations and recipes, agroecological farmers are essentially building food literacy, which is a concept that integrates nutrition knowledge, preparation skills, self-efficacy and confidence, and decision-making ability around food. Improving food literacy is increasingly considered fundamental for effecting long-term dietary change (Perry et al. 2017). By accompanying increases in agricultural diversity with food literacy development, agroecological farmers are able to effectively integrate new products from their farms into their meals, and this may translate into nutritionally relevant increases in dietary diversity. Further, the dietary information disseminated in agroecology's social spaces, such as the promotion of fruits, vegetables and whole grains and the avoidance of processed foods or high-sodium seasoning cubes, are consistent with recommendations to meet micronutrient requirements and to prevent diet-related chronic disease (Monteiro et al. 2018; WHO and FAO 2003), thus attending to both sides of the double burden of malnutrition.

Agroecology may be a pathway to effectively scale up food literacy without heavy resource investments, given that much of this knowledge is spread informally via farmers' own agency in their social interactions. Promoting nutrition and culinary knowledge has been integrated into many agriculture-for-nutrition programs (Arimond et al. 2011), but such interventions may come at a high cost, given that food literacy interventions must generally be continuous and long-term in order to have lasting and profound impacts (Murimi et al. 2017). Our observations suggest that agroecology in Imbabura has not only contributed to the construction of food literacy, but the endogenous transmission of knowledge that transpires within agroecological networks may be particularly effective because it occurs through peer learning, which has been shown to be more effective than conventional hierarchical approaches in solidifying knowledge for both the person "learning" and the person "teaching" (Topping 2005). This peer-based pedagogic approach functions through farmers' own agency, and could be pertinent for other agriculture-for-nutrition initiatives seeking to build human capital without exorbitant costs.

Our results also identify how agroecology may have downstream nutritional impacts on non-agroecological neighbors. Given community-level trade habits, high agricultural diversity may not only increase availability on agroecological farmers' own farms, but also increase availability of diversity within the community through the pathways of sale, barter and gifting. Further, relationships within communities demonstrate how other productive resources, such as seeds and knowledge, spread in the community, potentially expanding positive outcomes on production and eventually nutrition. In this sense, agroecological farmers may act as model farmers, who effectively spread knowledge, materials and legitimacy of promising agricultural practices within their communities (Taylor and Bhasme 2018). Nevertheless, each agroecological farmers' potential success as a model farmer is contingent on complex factors, such as their social standing within their communities. Farmers' allegiance to agroecology, as expressed in their ceremonial chants and in their construction of a shared identity, shows how agroecology in Imbabura takes on the form of a lifestyle that is organized and spread as a social movement, similar to what has been described in other contexts (Wezel et al. 2009). By acting as a social movement rather than simply a shared intervention strategy, agroecology may be particularly effective in the self-organized spread of ideas and practices. Sherwood, Van Bommel and Paredes propose that self-organization in agriculture and food is an effective but neglected resource for spreading sustainable practice. Farmers who feel tied to a broader movement may be more likely to want to share their knowledge and essentially recruit others into the movement (Sherwood, Van Bommel, and Paredes 2016). Such dynamics may most immediately promote the spread of agricultural diversity and other agroecological production strategies, but in the longer term, they may also spread the social transformations and dietary outcomes that follow.

Conclusions

While our observations are based on a single region in a single country, we aspire that this qualitative research has illustrated the role that agroecology may play in promoting nutrition outcomes, and that we have added some color to illustrate the pathways between agriculture and nutrition. Doing so, we hope we have also colored just enough outside the lines to expose several subjects that merit continued attention, namely:

(1) The importance of understanding farmers' complex rationale (e.g. curiosity, pride, aesthetics, social factors, health incentives) in adopting specific practices in order to better align intervention strategies with farmers' motivations.
(2) The role of less conventional, context-specific pathways for farmers to access dietary diversity, such as barter.
(3) The relevance of creating spaces for social interaction to strengthen peer bonds and create shared meaningful experiences that can build food literacy and solidify positive food practices.
(4) The downstream potential for positive impacts of agroecology (or similar initiatives) to affect the production and dietary practices of others in their communities via knowledge exchange and trade of products and seeds.
(5) The potential of social movements to scale up positive health practices, and the role of agricultural interventions as a part of them.

Acknowledgements

The authors foremost extend deep gratitude to the people who shared their knowledge and opened their homes to this research. We further thank our colleagues from the Ekomer research team and EkoRural Foundation, and especially Stephen Sherwood, who gave critical guidance throughout research. We also wish to gratefully acknowledge the financial support of the International Development Research Center and of the *Fonds de Recherche de Québec en Santé*.

Disclosure statement

The authors report no conflict of interest.

Funding

This work was carried out by the EKOMER Research Consortium, with the aid of a grant from the International Development Research Centre, Ottawa, Canada. The views expressed herein do not necessarily represent those of IDRC or its Board of Governors. [Grant number CR-48490]; The first author is supported by the Fonds de Recherche du Québec en Santé [Grant number 262314].

References

Alkire, Sabina, Ruth Meinzen-Dick, Amber Peterman, Agnes Quisumbing, Greg Seymour, and Ana Vaz. 2013. "The women's empowerment in agriculture index." *World Development* 52:71-91.

Altieri, Miguel A, and Clara I Nicholls. 2012. "Agroecology scaling up for food sovereignty and resiliency." In *Sustainable agriculture reviews*, edited by E. Lichtfouse, 1-29. Netherlands: Springer.

Altieri, Miguel A, and Victor Manuel Toledo. 2011. "The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants." *Journal of Peasant Studies* 38 (3):587-612.

Arce, Alberto, Stephen Sherwood, and Myriam Paredes. 2017. "Food embodiments, assemblages and intersubjectivities: ebbs and flows of critical food studies." In *Food, Agriculture and Social Change: The Everyday Vitality of Latin America*, edited by Stephen Sherwood, Alberto Arce and Myriam Paredes, 1-20. Earthscan.

Argumedo, Alejandro, and Michel Pimbert. 2010. "Bypassing globalization: Barter markets as a new indigenous economy in Peru." *Development* 53 (3):343-349.
Arimond, Mary, Corinna Hawkes, MT Ruel, Zeina Sifri, Peter R Berti, Jef L Leroy, Jan W Low, Lynn R Brown, and Edward A Frongillo. 2011. "Agricultural interventions and nutrition: lessons from the past and new evidence." *eds B. Thompson and L. Amoroso*:41-75.
Arimond, Mary, and Marie T Ruel. 2004. "Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys." *The Journal of nutrition* 134 (10):2579-2585.
Balz, Angelina G, Eleonore A Heil, and Irmgard Jordan. 2015. "Nutrition-sensitive agriculture: new term or new concept?" *Agriculture & Food Security* 4 (1):6.
Berkman, Lisa F, and Thomas Glass. 2000. "Social integration, social networks, social support, and health." *Social epidemiology* 1:137-173.
Berti, Peter R, Julia Krasevec, and Sian FitzGerald. 2004. "A review of the effectiveness of agriculture interventions in improving nutrition outcomes." *Public health nutrition* 7 (5):599-609.
Black, Robert E, Cesar G Victora, Susan P Walker, Zulfiqar A Bhutta, Parul Christian, Mercedes De Onis, Majid Ezzati, Sally Grantham-McGregor, Joanne Katz, and Reynaldo Martorell. 2013. "Maternal and child undernutrition and overweight in low-income and middle-income countries." *The lancet* 382 (9890):427-451.
Bohle, Hans-Georg, and Jagannath Adhikari. 1998. "Rural livelihoods at risk how Nepalese farmers cope with food insecurity." *Mountain Research and Development*:321-332.
Chadwick, PM, C Crawford, and L Ly. 2013. "Human food choice and nutritional interventions." *Nutrition Bulletin* 38 (1):36-42.
Chen, Xiang, and Mei-Po Kwan. 2015. "Contextual uncertainties, human mobility, and perceived food environment: The uncertain geographic context problem in food access research." *American journal of public health* 105 (9):1734-1737.
Cook, Seth. 2018. The Spice of Life: The fundamental role of diversity on the farm and on the plate. London and The Hague: IIED and Hivos.
Danton, Heather, and Sarah Titus. 2018. "Taking action: Five ways to improve nutrition through agriculture now." *Global Food Security* 18:44-47.

Fernald, Lia C, and Lynnette M Neufeld. 2007. "Overweight with concurrent stunting in very young children from rural Mexico: prevalence and associated factors." *European journal of clinical nutrition* 61 (5):623.
Ferraro, Emilia. 2011. "Trueque: An ethnographic account of barter, trade and money in Andean Ecuador." *The Journal of Latin American and Caribbean Anthropology* 16 (1):168-184.
Freire, Wilma B, Katherine M Silva-Jaramillo, María J Ramírez-Luzuriaga, Philippe Belmont, and William F Waters. 2014. "The double burden of undernutrition and excess body weight in Ecuador–." *The American journal of clinical nutrition* 100 (6):1636S-1643S.
Freire, Wilma, MJ Ramírez, and P Belmont. 2015. "Tomo I: Encuesta Nacional de Salud y Nutrición de la población ecuatoriana de cero a 59 años, ENSANUT-ECU 2012." *Revista Latinoamericana de Políticas y Acción Pública Volumen 2, Número 1-mayo 2015* 2 (1):117.
Frison, Emile A, Jeremy Cherfas, and Toby Hodgkin. 2011. "Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security." *Sustainability* 3 (1):238-253.
Frison, Emile A, and IPES-Food. 2016. "From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems."
Godfrey, Keith M, Peter D Gluckman, and Mark A Hanson. 2010. "Developmental origins of metabolic disease: life course and intergenerational perspectives." *Trends in Endocrinology & Metabolism* 21 (4):199-205.
Heaney, Catherine A, and Barbara A Israel. 2008. "Social networks and social support." *Health behavior and health education: Theory, research, and practice* 4:189-210.
Herforth, Anna, and Jody Harris. 2014. "Understanding and applying primary pathways and principles."
Herforth, Anna, Preetmoninder Lidder, and Margaret Gill. 2015. Strengthening the links between nutrition and health outcomes and agricultural research. Springer.
Hsieh, Hsiu-Fang, and Sarah E Shannon. 2005. "Three approaches to qualitative content analysis." *Qualitative health research* 15 (9):1277-1288.
INEC. 2006. La Población Indígena del Ecuador. Quito, Ecuador: Instituto Nacional de Estadística y Censos.
INEC. 2010. Fascículo Provincial Imbabura. Resultados del Censo 2010. Quito, Ecuador: Instituto Nacional de Estadística y Censos.

INEC. 2016. Reporte de Pobreza por Consumo Ecuador 2006-2014. Quito, Ecuador: Instituto Nacional de Estadística y Censos.

Intriago, Richard, Roberto Gortaire Amézcua, Elizabeth Bravo, and Chris O'Connell. 2017. "Agroecology in Ecuador: historical processes, achievements, and challenges." *Agroecology and Sustainable Food Systems* 41 (3-4):311-328.

Kahneman, Daniel. 2003. "Maps of bounded rationality: Psychology for behavioral economics." *American economic review* 93 (5):1449-1475.

Kimani-Murage, Elizabeth W. 2013. "Exploring the paradox: double burden of malnutrition in rural South Africa." *Global health action* 6 (1):19249.

Korovkin, Tanya. 1998. "Commodity production and ethnic culture: Otavalo, northern Ecuador." *Economic development and cultural change* 47 (1):125-154.

Long, Norman. 2003. *Development sociology. Actor perspectives. London and New York: Routledge. 2001. xiv+ 294 pp. Pb.:£ 20.99. ISBN: 0 415 23534 7*. Vol. 11, *Social Anthropology*.

Madison, D Soyini. 2005. "Introduction to critical ethnography: Theory and method." *Critical ethnography: Method, ethics & performance*:1-16.

Malapit, Hazel Jean, Suneetha Kadiyala, Agnes Quisumbing, Kenda Cunningham, and Parul Tyagi. 2013. "Women's empowerment in agriculture, production diversity, and nutrition: Evidence from Nepal."

Malapit, Hazel Jean L, and Agnes R Quisumbing. 2015. "What dimensions of women's empowerment in agriculture matter for nutrition in Ghana?" *Food Policy* 52:54-63.

Monteiro, Carlos Augusto, Geoffrey Cannon, Jean-Claude Moubarac, Renata Bertazzi Levy, Maria Laura C Louzada, and Patrícia Constante Jaime. 2018. "The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing." *Public Health Nutrition* 21 (1):5-17.

Murimi, Mary W, Michael Kanyi, Tatenda Mupfudze, Md Ruhul Amin, Teresia Mbogori, and Khalid Aldubayan. 2017. "Factors influencing efficacy of nutrition education interventions: a systematic review." *Journal of nutrition education and behavior* 49 (2):142-165. e1.

Orozco, Fadya, Donald C Cole, Verónica Muñoz, Ana Altamirano, Susitha Wanigaratne, Patricio Espinosa, and Fabian Muñoz. 2007. "Relationships among production systems, preschool nutritional status, and pesticide-related toxicity in seven Ecuadorian communities: A multi-case study approach." *Food and Nutrition Bulletin* 28 (2_suppl2):S247-S257.

Pellegrini, Lorenzo, and Luca Tasciotti. 2014. "Crop diversification, dietary diversity and agricultural income: empirical evidence from eight developing countries." *Canadian Journal of Development Studies/Revue canadienne d'études du développement* 35 (2):211-227.

Perry, Elsie Azevedo, Heather Thomas, H Ruby Samra, Shannon Edmonstone, Lyndsay Davidson, Amy Faulkner, Lisa Petermann, Elizabeth Manafò, and Sharon I Kirkpatrick. 2017. "Identifying attributes of food literacy: A scoping review." *Public health nutrition* 20 (13):2406-2415.

Pinstrup-Andersen, Per. 2013. "Can agriculture meet future nutrition challenges?" *The European Journal of Development Research* 25 (1):5-12.

Popkin, Barry M, Linda S Adair, and Shu Wen Ng. 2012. "Global nutrition transition and the pandemic of obesity in developing countries." *Nutrition reviews* 70 (1):3-21.

Powell, Bronwen, Shakuntala Haraksingh Thilsted, Amy Ickowitz, Celine Termote, Terry Sunderland, and Anna Herforth. 2015. "Improving diets with wild and cultivated biodiversity from across the landscape." *Food Security* 7 (3):535-554.

Schatzki, Theodore. 2001. "Introduction: practice theory." *The practice turn in contemporary theory*.

Shafique, Sohana, Nasima Akhter, Gudrun Stallkamp, Saskia de Pee, Dora Panagides, and Martin W Bloem. 2007. "Trends of under-and overweight among rural and urban poor women indicate the double burden of malnutrition in Bangladesh." *International journal of epidemiology* 36 (2):449-457.

Sherwood, Stephen G, Alberto Arce, and Myriam Paredes. 2018. "Affective Labor's 'unruly edge': The pagus of Carcelen's Solidarity & Agroecology Fair in Ecuador." *Journal of Rural Studies*.

Sherwood, Stephen, Severine Van Bommel, and Myriam Paredes. 2016. "Self-organization and the bypass: re-imagining institutions for more sustainable development in agriculture and food." *Agriculture* 6 (4):66.

Sibhatu, Kibrom T, and Matin Qaim. 2018. "Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households." *Food Policy*.

Sraboni, Esha, Hazel J Malapit, Agnes R Quisumbing, and Akhter U Ahmed. 2014. "Women's empowerment in agriculture: What role for food security in Bangladesh?" *World Development* 61:11-52.

Taylor, Marcus, and Suhas Bhasme. 2018. "Model farmers, extension networks and the politics of agricultural knowledge transfer." *Journal of Rural Studies* 64:1-10.

Tittonell, Pablo. 2014. "Food security and ecosystem services in a changing world: It is time for agroecology."

Topping, Keith J. 2005. "Trends in peer learning." *Educational psychology* 25 (6):631-645.

Uchino, Bert N. 2006. "Social support and health: a review of physiological processes potentially underlying links to disease outcomes." *Journal of behavioral medicine* 29 (4):377-387.

United Nations, UN General. 2015. Transforming our world: the 2030 Agenda for Sustainable Development. In *New York: United Nations*.

Waters, William F. 2007. "Indigenous Communities, Landlords, and the State: Land and Labor in Highland Ecuador, 1950-1975." *Highland indians and the state in modern Ecuador*:120-138.

Wezel, Alexander, Stéphane Bellon, Thierry Doré, Charles Francis, Dominique Vallod, and Christophe David. 2009. "Agroecology as a science, a movement and a practice. A review." *Agronomy for sustainable development* 29 (4):503-515.

WHO, and FAO. 2003. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO Expert Consultation. World Health Organization.

Zamosc, Leon. 1994. "Agrarian protest and the Indian movement in the Ecuadorian highlands." *Latin American Research Review* 29 (3):37-68.

6.3 Article 2: Promoting traditional foods for human and environmental health: lessons from agroecology and Indigenous communities in Ecuador

Deaconu, Ana[1]*; Ekomer; Mercille, Geneviève[1,]; Batal, Malek[1,2]

*Correspondence: ana.deaconu@umontreal.ca

1. Transnut WHO Collaborating Centre on Nutrition Changes and Development at Université de Montréal, Faculty of Medicine, Nutrition Department, 2900, boul. Édouard-Montpetit, Montréal, Québec H3T 1J4, Canada

2. Centre de Recherche en Santé Publique (CReSP), 7101, avenue du Parc, Montréal, Québec H3N, 1X9, Canada

Abstract

Background: The displacement of traditional dietary practices is associated with negative nutritional consequences for rural Indigenous people, who already face the brunt of both nutritional inadequacies and excesses. Traditional food (TF) consumption and production practices can improve nutritional security by mitigating disruptive dietary transitions, providing nutrients and improving agricultural resilience. Meanwhile, traditional agricultural practices regenerate biodiversity to support healthy ecosystems. In Ecuador, Indigenous people have inserted TF agricultural and dietary practices as central elements of the country's agroecological farming movement. This study assesses factors that may promote TF practices in rural populations and explores the role of agroecology in strengthening such factors.

Methods: Mixed methods include a cross-sectional comparative survey of dietary, food acquisition, production and socioeconomic characteristics of agroecological farmers (n=61) and neighboring reference farmers (n=30) in Ecuador's Imbabura province. Instruments include 24-hour dietary recall and a food frequency questionnaire of indicator traditional foods. We triangulate results using eight focus group discussions with farmers' associations.

Results: Compared to their neighbors, agroecological farmers produce and consume more TFs, and particularly underutilized TFs. Farm production diversity, reliance on non-market foods and agroecology participation act on a pathway in which TF production diversity predicts higher TF consumption diversity and ultimately TF consumption frequency. Age, income, market distance and education are not consistently associated with TF practices. Focus group discussions corroborate survey results and also identify affective (e.g. emotional) and commercial relationships in agroecological spaces as likely drivers of stronger TF practices.

Conclusions: Traditional food practices in the Ecuadorian highlands are not relics of old, poor and isolated populations but rather an established part of life for diverse rural people. However, many TFs are underutilized. Sustainable agriculture initiatives may improve TF practices by integrating TFs into production diversity increases and into consumption of own production. Agroecology may be particularly effective because it is a self-expanding global movement that not only promotes the agricultural practices that are associated with TF production, but also appears to intensify affective sentiments toward TFs and inserts TFs in commercial spaces. Understanding how to promote TFs is necessary in order to scale up their potential to strengthen nutritional health.

Keywords: Traditional foods, Agroecology, Nutrition transition, Indigenous, Farmers, Diet, Andes, Ecuador, Production diversity

Background

Globally, populations are hastily replacing their traditional food[26] practices with diets marked by excesses in sugar, sodium, fat, and calories, and this pattern is accelerating among the world's rural poor (2). In the face of this nutrition transition (3), Indigenous people in Ecuador aspire to preserve their traditional food practices, which they perceive as being healthier, more resilient and more culturally meaningful than non-traditional foods (4). However, biodiversity loss, dietary transitions and shifting agricultural strategies threaten their access to these products (4). In localities around the world, traditional practices around food have been observed to be associated with balanced diets and

[26] We follow Johns and colleagues in using "traditional" as a qualifier for products and practices that are defined both socio-culturally and bio-culturally following a period of historical continuity (1).

dietary health (5–8), cultural integrity (5,9), and resilient agricultural ecosystems, especially in the face of climate change (10,11). Such practices include the production of traditional crops and crop varieties; traditional agricultural techniques, including intercropping and high agricultural biodiversity; hunting, fishing and wild harvest of traditional foods; and, consumption of traditional foods on their own or as parts of dietary patterns (4–7,9–11). Yet the homogenizing march of globalization has made it be that traditional foods have in many cases become synonymous with "neglected" and "underutilized" crops, the former referring to crops ignored by the scientific community, and the latter referring to those that have largely fallen out of cultural and economic use (7,12).

The decline of traditional food (TF) practices has garnered attention for its impacts on nutritional health. For Indigenous people in multiple contexts, the displacement of TFs is associated variously with underweight, stunting, micronutrient deficiencies, overweight, diet-related chronic diseases and the intergenerational effects of malnutrition, especially when coupled with poverty (5,8,13,14). Researchers observe a disproportionately large prevalence of simultaneous nutrient inadequacies and excesses, dubbed the double burden of malnutrition, among Indigenous people in Canada, Brazil and Guatemala (15–18). This trend is also clear among Ecuador's Indigenous people, who have the nation's highest prevalence of micronutrient deficiencies and are also experiencing increasing prevalence of overweight and obesity (19). Further, declines in TF production practices may lead to ecological degradation that not only sets off a feedback cycle of further decline in TF practices, but can also trap farmers in poverty (20) and perpetuate food insecurity (21). In light of such evidence, supporting diverse TF practices is emerging as an international prerogative (5,7,14).

Identifying the factors that may actively promote TF practices begins with understanding how TFs are obtained, and who is producing or consuming them. Some TFs are available for local consumption through conventional market purchase (22). For the many TFs that markets neglect, own production, wild harvest and hunting, and the social economy (local trade, including direct purchase, barter and gifting) are primary forms of access, and the people that continue to obtain food from these subsistence practices are better positioned to consume TFs (5,23–25). Following suit, the most widely recognized stewards of TF practices are Indigenous people (4,5,26), older generations (4,25–27), and the rural poor (26,28). Similarly, living in remote areas is associated with stronger TF practices, and especially wild harvest, due to reduced opportunities for market integration or marginal ecological conditions that necessitate better-adapted crops (26,28,29). High inter- and intraspecies diversity is also integral to most traditional agricultural strategies (1,30). These correlates help to understand where and among whom we might expect to observe TF practices, but they do not necessarily offer reasonable courses of action. For example, it makes no sense to suggest that people be isolated, old and poor in the name of supporting TF practices.

In the Ecuadorian context, a possible proactive driver of TF practices is the growing movement toward agroecological farming. Agroecology applies ecosystem science to agriculture and uses biodiversity, symbiotic relationships, biological controls, and a healthy soil microbiome to support productive and environmentally regenerative farming (30–32). A growing number of marginalized, resource-poor and Indigenous farmers in Ecuador and around the world have adopted agroecology because of its compatibility with traditional agricultural systems (30,33,34).

While agroecology in Ecuador emerged largely out of a need for more environmentally sustainable agricultural practices (30) and as a means to prevent pesticide poisoning (35,36), the Indigenous resistance movement further saw agroecology as an opportunity to maintain cultural sovereignty in a number of spheres, including agriculture and food (33,36). While agroecology in Ecuador eventually spread to include farmers of non-Indigenous identity, today's "agroecological" identity is largely entangled with Indigenous traditions and objectives. Because agroecological farming has much in common with traditional farming strategies, the distinguishing characteristic of agroecological farmers is typically their membership in an association that participates in an alternative food network such as a farmers' market (33,37). The agroecology movement's close connections with Indigenous identity and its embrace of TF practices make it a unique space of inquiry for measurable impacts on TFs. Agroecology's potential to promote TFs is particularly relevant given its ongoing expansion as the predominant framework for connection among food-oriented social movements and peasant farmer organizations across the world (30,34).

In this study, we aim to understand the factors that are associated with and may serve to promote TF agricultural and dietary practices among farmers in the Ecuadorian highlands. We assess the diversity of production and consumption of several indicator traditional foods, as well as their frequency of consumption. Further, we assess consumption of wild harvested foods. Finally, we explore the relationship between agroecology and TF practices by comparing TF practices among farmers that do and do not participate in the agroecology movement.

Methods

Study site and population

This study was conducted in the Imbabura province of Ecuador's highland region, where people live and farm in areas ranging from around 500 to 3500 meters above sea level. The rapidly-changing ecosystems associated with this drastic topography are favorable for diversified production across climatic niches, but also lead to soil erosion and infrastructure challenges on steep slopes (38). As such, the steepest, most remote, and otherwise most marginal lands are home to the highest poverty rates, with some rural communities in the province reaching 99.8% prevalence of poverty by basic needs (39). Farmers in these communities are predominantly smallholders, with many managing less than 1 hectare of land. Imbabura is nationally distinguished as a cultural hub for Kichwa Indigenous people, and 25.8% of the population identifies as Indigenous (40). Of Imbabura's Indigenous people, 86.6% live in rural areas (41), where they utilize agriculture for both own-consumption and sale, as well as partake in other livelihood strategies.

The study population exclusively comprises female smallholder farmers, as women are primarily responsible for food preparation, and it includes women from all six of Imbabura's cantonal districts. Farmers were selected from two categories: (i) agroecological farmers: farmers who participate in agroecological market associations and are selected at random from a list of association participants, which was generated with local partners prior to recruitment; and, (ii) reference farmers: farmers who are randomly-selected neighbors of agroecological farmers and do not participate in agroecological market associations. One reference farmer was sampled for every second agroecological farmer. The sample size is larger for agroecological farmers to address additional study objectives that are beyond the scope of this article. Interventions promoting agroecology in the region primarily targeted marginalized, Indigenous communities (36), meaning that both the agroecological farmers and their reference neighbors in the present study tend to be from such communities. Farmers from the study population are semi-commercial, meaning that they produce food for own consumption but also aim to generate a surplus for sale[27].

Study Instruments

We employed a three-phase exploratory and sequential mixed methods approach (43), summarized in Figure 1. The first phase employed ethnography and key informant interviews (36). This informed the design of the second phase, which was a cross-sectional survey conducted in Imbabura province from July 2017 - October 2017 with 91 female farmers (61 agroecological and 30 reference farmers). The survey included a food frequency questionnaire on the consumption and acquisition of indicator TF products, with specific modules on wild food consumption, production diversity of edible foods and livestock, and sociodemographic characteristics. Further, it included a quantitative, multi-pass 24-hour dietary recall (44) that gathered information on the source of each food item. The survey was developed to accommodate multiple study objectives and included additional modules that are not addressed here. The survey materials used in this study are provided in Additional file 1. Surveys were conducted in farmers' homes in Spanish. For farmers who spoke only the local Indigenous language, Kichwa, a family member was recruited to translate. Finally, the third phase deployed eight focus group discussions to triangulate results, as further detailed in the section "results triangulation."

Phase 1: Qualitative inquiry

Ethnography
Key Informant Interviews

Thematic analysis used to inform Phase 2

Phase 2: Survey-based quantitative assessment

Food Frequency Questionnaire
- Traditional food (TF) consumption diversity
- TF consumption frequency
- TF acquisition patterns

Wild Food Module
- Wild food consumption diversity
- Last consumption of wild foods (sub-sample)

24 Hour Recall
- Dietary acquisition patterns

Sociodemographic Module
- Age, income, education, time to market

Production Module
- TF production diversity
- On-farm production diversity of all edibles

Descriptive, bivariate and path analyses

Phase 3: Results triangulation and qualitative elaboration

Focus Group Discussions

Thematic analysis used to triangulate and further elaborate on findings from Phase 2

Fig. 1 Overview of study phases, instruments, variables and analyses

Traditional food practice variables

[27] Pingali and Rosegrant offer a useful discussion on semi-commercial farming (42).

We follow the consumption and production of products that are socio-culturally and bio-culturally considered to be traditional in our study context (1) in order to explore TF practices. Specifically, we assess: (i) TF consumption diversity, (ii) TF consumption frequency, (iii) TF production diversity, and (iv) wild food consumption diversity.

TF consumption diversity and TF consumption frequency are measured from the survey's food frequency questionnaire (FFQ). The FFQ contains 12 indicator foods[28] selected following consultation with local experts to include both TF products that are commonly consumed and easily accessible in markets (Andean lupine, *melloco*, quinoa, sweet potato, *zanahoria blanca*) as well as those that are locally recognized as underutilized (amaranth, yacón, *oca*, *mashua*, amaranth leaf, quinoa leaf). We also include *chulpi*, which is an increasingly underutilized maize cultivar (45). The selected indicators were chosen to also represent the multiple climatic niches in Imbabura province. The sum of indicator TFs consumed produces the TF consumption diversity variable, with a maximum value of 12. Because many of the indicator TFs are only available during specific seasons, we used the frequency of consumption over the reported period of availability (in months) to calculate the annual frequency of each TF. We then summed frequencies of all TFs to obtain the aggregate annual frequency of TF consumption, or TF consumption frequency.

TF production diversity is a count of the different indicator TFs produced on the farm in the past year, with a maximum of 11 products. This is fewer than the maximum for TF consumption diversity because quinoa seed and quinoa leaf are both from the same plant; however, because amaranth seed and amaranth leaf are obtained from distinct varieties, these are maintained separate.

We calculate wild food consumption diversity based on the wild foods that farmers report consuming in an open recall with no specific timeframe. We only consider caloric wild edibles, meaning we ignore plants used exclusively as herbs or teas. For a subset of farmers (n=22), we also queried for the moment of most recent consumption for each product consumed.

[28] Latin names for indicator foods are as follows: Quinoa: *Chenopodium quinoa*; Andean lupine: *Lupinus mutabilis*; Melloco: *Ollucus tuberosus*; Mashua: *Tropaeolum tuberosum*; Oca: *Oxalis tuberosa*; Zanahoria blanca: *Arracacia xanthorrhiza*; Yacón: *Smallanthus sonchifolius*; Chulpi: *Zea mays amylosaccharata*; Sweet potato: *ipomea batata*; Amaranth: *amaranthus spp.* Yacón is known locally as jicama, but we use the regional term yacón in order to avoid confusion with *Pachyrhizus erosus.*

Sources of TFs and general dietary acquisition patterns

To understand how participants obtain each TF, the FFQ also queried for the most common source of acquisition. Similarly, to understand food acquisition practices more generally, we use the item source data from 24-hour recalls to calculate the caloric share of the diet (as a percentage of total calories) that comes from distinct food sources. For both TF acquisition and overall dietary acquisition, reported sources were grouped into three categories: harvest (own-production or wild harvest); social economy (barter, gifting, or direct purchase from other farmers); and, conventional market purchase (wet markets, supermarkets, grocers, corner-stores, other).

Sociodemographic and agricultural variables

We assess age, income, time to market, on-farm production diversity and food acquisition practices as potential correlates of TF practices. Age, monthly income (USD), time to market and education completed are participants' self-reported values. Household size is used to calculate monthly income per capita. We calculate farm production diversity as a list-based species richness count of caloric edible products (excluding spices and herbs) as well as livestock.

Statistical analysis

We performed bivariate analyses to compare agroecological farmers and their reference neighbors. We use Pearson's and Spearman's correlations (for parametric and non-parametric variables, respectively) to explore relationships between TF production diversity, TF consumption diversity, TF consumption frequency, and wild food consumption diversity, as well as their relationships with other potential correlates. Farming category is input as a dummy variable (reference = 0, agroecological = 1) and the ordinal variable on education completed is treated as continuous (none = 0, partial primary = 1, complete primary = 2, partial secondary = 3, complete secondary = 4, post-secondary = 5). Because this study explores human dietary and production behavior, we defer to behavioral statistics to characterize effect size, with R-values near or above 0.5 (R^2=0.25) considered as a large effect size and R-values near or above 0.3 (R^2=0.09) considered a medium effect size (46). We then input the strongest correlates into a path analysis to better understand predictors of TF practices. We did not include wild food consumption diversity in path analysis because we did not identify likely correlates for inclusion in the model. Given our sample size, we assessed goodness of fit using the standardized root mean squared residual, with values below 0.08 considered adequate, as well as the root mean squared error of approximation, with values below 0.06 considered adequate (47). As often occurs in behavioral research, one of our path analysis dependent variables, TF consumption frequency, is not normally distributed. Although path analysis is intended to function with normally-distributed variables, parameter estimates generally remain valid even with non-normal data; however, non-normal data may produce biased standard errors (48). Further, 24-hour recall data was missing for one farmer, producing an agroecological sample size of 60 for some variables. All analysis was conducted using SAS software, version 9.4.

Results triangulation and qualitative elaboration

We implemented focus group discussions (FGDs) (43) to assess whether farmers' perceptions converged with quantitative results and to explore how farmers explain the drivers behind the results. Further, these served to return study results to local communities. In March and April 2019, we conducted eight FGDs with 128 total participants. Participants were from the eight agroecological associations whose members had participated in the quantitative study. FGDs were carried out in Spanish, or in Spanish with Kichwa translation by the association leader on an as-needed basis. Farmers voted on "what type of farmer consumes more traditional foods," with possible answer choices of: agroecological, reference, or both consume equally/uncertain. They were then asked to explain their decision. Then, survey results regarding TF practices were revealed and compared to results from the voting activity. Farmers were asked if they agreed with the findings, and time was allotted for open discussion. Voting activity answers were tabulated, and notes on all other discussion were taken by hand. FGDs were not conducted with reference farmers because reference farmers are not necessarily aware of agroecology and do not self-identify as counterfactuals to agroecological farmers, making it inappropriate to elicit comparisons between the two groups.

Results

Traditional food practices among agroecological and reference farmers

Table 1 describes the sample and compares agroecological and reference farmers on study variables. Agroecological farmers have greater TF production diversity, TF consumption diversity and TF consumption frequency than their reference neighbors. The two groups perform equally on wild food consumption diversity. We detected compelling differences in production diversity and food acquisition practices, but not in sociodemographic characteristics.

Table 1: Sample description and comparison of agroecological (n=61) and reference (n=30) farmers on study variables

	Descriptive measurements	Comparison by farmer category	
	Pooled sample	Agroecological	Reference
	mean [SD] or percent	mean [SD] or percent	mean [SD] or percent
Traditional food (TF) practices			
TF production diversity (0-11 products)	4.7 [2.5]	5.7 [2.3]***	2.8 [1.9]
TF consumption diversity (0-12 products)	7.5 [2.0]	8.3 [1.7]***	5.9 [1.6]
TF consumption frequency (annual)	221 [182]	260 [193]	144 [129]
median (interquartile range)	*164 (82 - 301)*	*209 (130 -351)****	*102 (56 - 180)*
Wild food consumption diversity (products)	7.5 [3.1]	7.7 [3.0]	7.0 [3.2]
Sociodemographics			
Age (years)	45 [13]	46 [13]	42 [13]
Monthly income per capita (USD)	92 [89]	87 [81]	100 [105]
median (interquartile range)	*67 (37 - 110)*	*61 (37 - 110)*	*85 (40 - 109)*
Time to market (minutes)	47 [36]	49 [35]	43 [38]
median (interquartile range)	*40 (30 - 60)*	*38 (30 - 60)*	*43 (20 - 50)*
Education completed			
None or partial primary	44%	39%	53%
Primary or partial secondary	38%	43%	30%
Secondary or post-secondary	18%	18%	17%
Farm production diversity (products)	39 [16]	45 [15]***	28 [14]
Share of total calories acquired from diverse sources			
Conventional markets (0-100%)	52 [27]	44 [23]***	69 [25]
Harvest (0-100%)	27 [24]	32 [24]***	17 [19]

Social economy (0-100%)	20 [24]	23 [24]	13 [23]
median (interquartile range)	*12 (0.2 - 31)*	*17 (6 - 34)****	0.3 (0.0 - 16)

For continuous variables, mean is reported with standard deviation. For variables with non-parametric distributions, median and interquartile range are also reported. Frequency is reported for categorical variables. Share of total calories is based on an agroecological sample size of 60, due to missing information. Difference tested between agroecological and reference farmers with Student's t-test, Mann-Whitney U-test or Chi-Squared test depending on variable distribution and type. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Supplemental Table 1 (Additional File 2) shows the consumption prevalence, frequency and most common acquisition source for each TF for the pooled population and by farmer group. Agroecological farmers were much more likely to consume underutilized TFs (amaranth, yacón, oca, mashua, amaranth leaf, quinoa leaf) than reference famers, and consumed even the most common TFs (quinoa seed, lupine) at a greater frequency. Among both groups, indicator TFs are most commonly acquired from harvest and most rarely from market purchase. Underutilized TFs are never or very rarely purchased from markets. However, agroecological farmers are more likely than their counterparts to obtain TFs from harvest, and reference farmers are more likely than their counterparts to obtain TFs by means of market purchase. Reliance on social economy for TFs is similar between the two groups.

All farmers consume at least one wild food, and on average, they consume between 7 and 8. Wild foods and their consumption prevalence are shown in Supplemental Table 2 [Additional File 2]. In the sub-sample of most recent wild food consumption, 32%, 23%, 27%, and 14% did so in the past day, week, month and year, respectively, with only 5% having not consumed a wild food in the past year.

Correlates and pathways toward traditional food practices

Correlations among TF practices and with other variables are summarized in Table 2. The strongest correlations appear among the four TF practices themselves, as well as with farm production diversity and farmer category. We identified no correlations between TF practices and market distance and only weak, inconsistent relationships with age, income or education. Farmers that obtain a higher share of their food by conventional market purchase tend to have weaker TF practices, whereas those that obtain a higher share of their food from non-market sources (harvest and social economy) tend to have stronger TF practices.

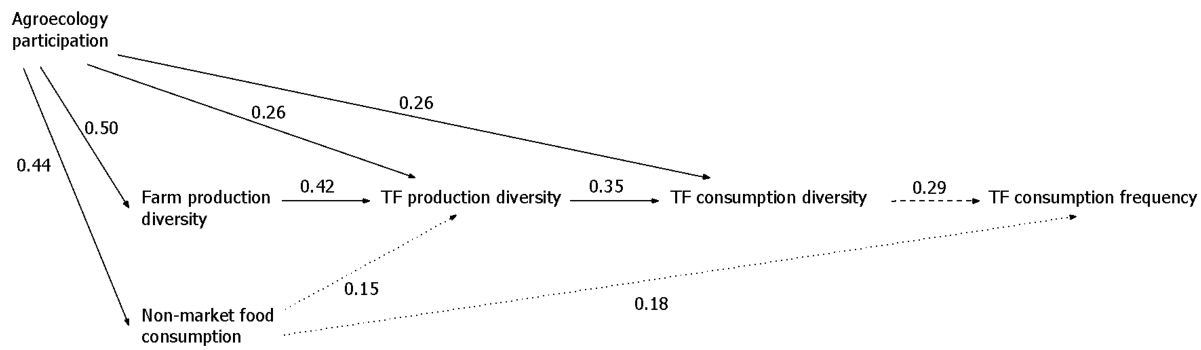
Table 2: Correlates of traditional food practices

	TF Production Diversity	TF Consumption Diversity	TF Consumption Frequency	Wild Food Consumption Diversity
Traditional food (TF) practices				
TF consumption diversity	0.61***			
TF consumption frequency	0.33***	0.51***		
Wild food consumption diversity	-	0.30***	-	
Sociodemographics				
Age	0.24**	-	-	-
Monthly income per capita	-0.21**	-	0.28***	-
Time to market	-	-	-	-
Education completed	-	-	0.25*	-
Farmer category (agroecological)	0.54***	0.57***	0.35***	-
Farm Production Diversity	0.58***	0.51***	0.40***	0.24**
Caloric share of diet acquired from diverse sources				
Conventional markets	-0.38***	-0.41***	-0.34***	-
Harvest	0.28***	0.30***	0.28***	-
Social economy	0.20	0.23**	-	-

Correlations are reported using Pearson's or Spearman's Rho (R), according to variable distribution. Farmer category is a dummy variable with agroecological set at 1 and reference at 0. Education completed is treated as a continuous variable with values from 0 (none) to 5 (post-secondary). Correlations with R<0.20 are considered too small to be meaningful and are thus removed for clarity. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Figure 2 shows the significant pathways resulting from path analysis, and Table 3 details all path non-standardized and standardized estimates. The modeled pathway shows that higher TF production diversity predicts higher TF consumption diversity, which in turn predicts higher TF consumption frequency. Model estimates suggests that it would take four additional products in TF production diversity to gain an increase of one product to TF consumption diversity. In turn, each additional product in TF consumption diversity predicts 26 additional instances of consumption to the annual TF consumption frequency. Total on-farm production diversity acts on this pathway through TF production diversity, wherein an additional 16 products on the farm predict one additional indicator TF in production. Agroecology participation acts on the pathway through both TF production diversity and TF consumption diversity, contributing an increase of about one product to both TF production and consumption. The share of foods obtained from non-market sources is associated with TF consumption frequency, although the association is not as strong.

Figure 2: Pathways to traditional food (TF) practices



Standardized estimates for direct effects on traditional food production and consumption are represented with arrows. Dotted lines, dashed lines and solid lines indicate significance levels at 10%, 5% and 1% respectively.

Table 3: Path analysis estimates for traditional food (TF) production and consumption patterns

Pathway		Path estimate [SE]	Standardized path estimate [SE]	p-value
Effects on TF consumption frequency				
TF consumption diversity		26.28 [12.10]	0.29 [0.13]	0.025
TF production diversity		-1.40 [9.66]	-0.02 [0.13]	0.885
Farm production diversity		1.05 [1.36]	0.09 [0.12]	0.439
Agroecology participation		8.68 [48.69]	0.02 [0.13]	0.859
Non-market food consumption		1.22 [0.74]	0.18 [0.11]	0.091
R-square	0.1995			
Effects on TF consumption diversity				
TF production diversity		0.27 [0.08]	0.35 [0.10]	0.000
Farm production diversity		0.02 [0.01]	0.15 [0.10]	0.135
Agroecology participation		1.07 [0.41]	0.26 [0.10]	0.008
Non-market food consumption		0.01 [0.01]	0.12 [0.09]	0.171
R-square	0.4779			

Effects on TF production diversity				
Farm production diversity		0.06 [0.01]	0.41 [0.09]	0.000
Agroecology participation		1.38 [0.53]	0.26 [0.10]	0.008
Non-market food consumption		0.01 [0.01]	0.15 [0.09]	0.082
R-square	0.4349			
Effects on farm production diversity				
Agroecology participation		17.43 [3.20]	0.50 [0.08]	0.000
R-square	0.2500			
Effects on non-market food consumption				
Agroecology participation		24.81 [5.39]	0.44 [0.09]	0.000
R-square	0.1925			
SRMR	0.0110			
RMSEA	0.0000			

Path estimates and standardized path estimates are shown with standard error (SE) in brackets. SRMR is the standardized root mean square residual. RMSEA is the root mean squared error of approximation.

While correlation and path analyses show a relationship between production and consumption of TFs in general, we find that the extent of this relationship varies from one indicator TF to another (Supplemental Table 3 [Additional File 2]). With the exceptions of quinoa and Andean lupine, farmers that produce a given indicator TF are more likely to consume it and to consume it more often.

Results triangulation and qualitative elaboration

Table 4 shows that across all focus group discussions (FGDs), participants perceived that agroecological farmers consume more TFs than their reference farming neighbors. FGD participants also perceived survey findings to be accurate.

Table 4: Agroecological farmer perceptions on what type of farmer consumes more traditional foods

		Prevalence of response choice		
Focus group number	n respondents	Agroecological farmers consume more	Reference farmers consume more	Both groups consume equally / uncertain
1	19	89%	5%	5%

2	17	59%	12%	29%
3	12	83%	0%	17%
4	17	59%	12%	29%
5	16	81%	13%	6%
6	11	82%	18%	0%
7	15	60%	33%	7%
8	12	75%	17%	8%
Aggregate	119	73%	13%	13%

Responses to focus group discussion (FGD) voting activity on "What type of farmer consumes more traditional foods?" The aggregate prevalence is the prevalence of responses across all FGDs.

Asked to explain why agroecological farmers consume a greater diversity of TF products and with more frequency, all eight FGDs spontaneously produced answers similar to "because we produce more traditional products." Farmers in six FGDs explained that they produce more TFs in response to consumer demand in the agroecological market. One farmer and market president elaborated:

"With the Que Rico Es *[civil society responsible consumption] campaign, one objective is to reposition traditional products. In the [agroecological] markets, the consumer began to understand and request these products, and the farmers also began to assimilate them in their diets. Traditional products are nothing new for the most conscious consumers, and these are the consumers that come to our market."*

Similarly, some participants credited NGOs and Indigenous federations for their positive influence on TF practices for both farmers and clients involved in agroecological markets. FGD participants identified the role of the agroecological market in strengthening the cultural value that they place on TFs and informing their understanding of TF medicinal or health properties. Many farmers expressed that agroecology strengthened their interest in reclaiming Indigenous identity, and they saw utilizing TFs as a means of doing so. One farmer was met with resounding agreement when she stated, "Since being in the [agroecological] market, we value traditional foods more. Before, we were not like this."

In further discussion on the importance of TFs, several farmers told stories about how reclaiming TFs allowed them to re-discover the foods of their childhood, and they reminisced on the diverse shapes, colors and flavors of lost varieties. Similarly, one farmer expressed that planting TFs is a means of respecting and reconnecting with his ancestors who developed these products through generations of seed selection. Others saw TFs as a strategic part of agroecological farming, given their pest resistance, low water needs, and adaptability to marginal lands.

Other farmers found TFs to be an important means of supporting nutritional health. Some sustained that TFs contain more vitamins and minerals than “modern” foods, which they saw as the vectors of overweight and disease. Women in particular saw TF preparation as necessary “for the health of the children,” despite requiring more effort to prepare. Discussions tended to emphasize the importance of TFs for children and younger generations, and make reference to healthy growth.

Discussion

The state of traditional foods in rural Imbabura diets

Traditional foods remain a part of daily life for farmers in our study population, but there is no bar to gauge how much traditional food consumption is “enough” to curb TF displacement and mitigate the nutrition transition toward foods that contribute to a double burden of over- and undernutrition. Most farmers consume at least half of the indicator TFs assessed, and they consume them often: agroecological farmers report consuming indicator TFs 260 times a year, and reference farmers do so 144 times a year. All farmers continue to practice wild harvest to some extent, and most do so on a weekly basis. TF consumption appears more alive in this farming population than in other spaces in the country; for example, a recent representative study in three Ecuadorian highland cities found that only 19% of participants consumed either quinoa, amaranth or Andean lupine more than three times per month (49). The comparable figures in our study population would be 60% of reference farmers and 85% of agroecological farmers. Even the indicator TFs that we selected because they are locally recognized as underutilized (amaranth, yacón, oca, mashua, quinoa leaf, amaranth leaf) are all still present to some extent in our study population’s diets. Some of these products are receiving attention for their potential to support dietary health. For example, amaranth seed is recognized for its protein and lipid profiles(50), and amaranth and quinoa leaves are green leafy vegetables with high concentrations of nutrients that are of special concern in the Ecuadorian rural population, notably vitamin A, iron, calcium, zinc and vitamin C (19,50,51). Even though some of these products are only marginally alive in the diets of reference farmers (i.e., with median consumption of only once yearly), they point to opportunities to strengthen the use of endogenous foods to support nutritional health.

Opportunities for traditional food promotion

Our analysis suggests that TF consumption is associated with TF production. This is no surprise in light of the expanding literature on the pathways between production and consumption, and namely production diversity and dietary diversity (52). Indeed, we find that farmers that grow a given TF are not only more likely to consume it, but they also consume it more frequently. Some underutilized TFs are exclusively obtained from own harvest. For other TFs, farmers who do not produce them obtain them from farmers who do, relying on social economy transactions such as barter or direct purchase. That these underutilized products are never purchased at markets is likely a consequence of their reduced availability (53), and signals the importance of the social economy in filling supply gaps.

The diversity of TF products grown on the farm is associated with higher overall farm production diversity of edible products. Nevertheless, it is unlikely that increasing agrobiodiversity alone would guarantee an increase in TF production diversity. Instead, the association we detected may reflect adherence to more traditional cropping systems, which depend on relatively high agrobiodiversity (1), or it may be a reflection of the diversity supported by the ecological niche. While there may not be a direct causal relationship between overall farm production diversity and TF production diversity, the two may be mutually reinforced as farmers and organizations aim to increase farm production diversity for ecological, productive and nutritional reasons (32). Doing so by targeting TF production diversity may be particularly relevant for nutrition-sensitive agriculture initiatives, given that TFs are shown to simultaneously contribute to agricultural resilience, food access (54–57) and to dietary intake of key macronutrients, micronutrients and phytochemicals (56–61), and they further play a protective role against chronic diseases (6,8,59).

We further find that farmers whose diets rely less on conventional markets and more on own harvest or the social economy maintain stronger TF practices. Other scholars similarly discuss the importance of non-market subsistence practices such as own production and local trade in conserving traditional crops (5,23). In contrast to other studies (4,26,28,29), market distance, income and age did not emerge as strongly or consistently associated with TF practices among our study population. This means that in this context, TF practices are not merely a relic of the most isolated, impoverished and aging—or in short, marginalized—people, as public opinion has long perceived them to be (7). In the development literature, practices that are the purview of the most marginalized people, and especially of subsistence-oriented farmers, tend to be discussed as "coping" or "adaptive" strategies driven by reactive necessity rather than proactive agency (62). In contrast, the fact that we detected an association with reliance on non-market food sources but did not detect a strong association with marginalization implies that TF practices in our study population are not merely a reaction to adverse conditions. Possibly, farmers may be participating in a globalized cultural shift toward re-valorization of TFs, as has been described in Europe (63). Doing so, some may even perceive TF practices as active agents in strengthening cultural identity and food sovereignty (36).

Agroecology as an incubator for traditional food promotion

Agroecological farmers unambiguously perform better than their reference neighbors on three of the four TF practices assessed. They produce twice as much TF diversity, consume 40% more TF diversity and consume TFs 80% more often compared to their reference counterparts. In our path analysis, participation in agroecology was directly associated with both TF production diversity and TF consumption diversity, leading to a downstream association with TF consumption frequency. While we did not measure changes over time, agroecological farmers emphatically identify their participation in agroecological markets as the drivers of increased TF production and consumption, pointing to agroecology as a means to strengthen TF practices. Moreover, the strongest differences in consumption of specific TFs appear precisely in those that are locally recognized as underutilized. Agroecology may thus be key for reclaiming at-risk TFs in this region and re-inserting them into healthy dietary patterns.

Part of the reason why agroecological farmers in our population perform so much better on TF practices may be because agroecology explicitly promotes farm production diversity and reliance on non-market food sources (34,36), which are correlates of TF practices. Yet even when these are held constant, agroecology participation still shows an association, suggesting that other forces are at play.

Focus group discussions help clarify these unknowns, identifying two additional potential drivers that may motivate agroecological farmers to increase their TF practices.

First, the social environment of the agroecological market association may drive farmers to produce and consume TFs for their nutritional properties, taste, agricultural resilience, cultural value and even aesthetics. While such convictions around TFs are also found among other farmers in Northern Ecuador (64), the social encounters in agroecological spaces appear to further concentrate these convictions by inserting TF practices into social norms that strengthen a shared cultural identity. Further, they seem to embed TF consumption into the moral impetus of feeding healthy food to the family. The importance of these socially-driven elements in guiding TF practices is consistent with dietary behavior models that find food decisions to be informed by "affective" components, including feelings and emotions, moral obligations, and social norms and pressures (65).

Second, focus group discussions also identified the specialized consumer demand for TFs in agroecological markets as a potential driver of TF practices among farmers. Other studies on TFs similarly find that consumer demand-driven value chains influence TF production (66,67). However, discussion participants further sustained that when they grow TFs for sale, they also increase their own consumption. These flows of influence are probably bidirectional, given that agroecological farmers' associations played an important role in the emergence of a nation-wide campaign to form "responsible" consumers that seek out traditional Andean crops as well as nutritious, socially just and ecologically sustainable food (68,69). As such, there appears to be a feedback loop between agroecological market farmers and clients in forming affective spaces (36) that support traditional foods.

Wild harvest

Wild harvest appears to be a common practice among our study population, even though most of the harvested foods are consumed in small amounts as condiments or snacks. As far as we can tell, wild food consumption diversity among our study population is not associated with age, income, distance to markets, food acquisition strategies or agroecology participation. This relative democratization is compelling given that wild foods can be remarkably nutritious, but also remarkably neglected and underutilized (7,70,71). This combination often relegates wild foods to coping strategies for the poorest of the poor and erroneously dismisses them as “famine foods” (7,70). While we were unable to detect plausible pathways promoting wild food consumption, we find that people who consume a greater diversity of TFs in general also consume a greater diversity of wild harvested products, potentially signaling similar drivers for these two dietary outcomes. While our findings suggest that wild foods have not been prioritized by the local agroecology movement, its unique affective and commercial spaces may hold the enabling conditions to effectively promote wild foods.

Internal and external validity of findings

We believe a word of caution is warranted regarding our data on TF consumption frequency, given the cognitive recall difficulties that beleaguer FFQs (72) as well as the added complexity of seasonality (73)[29]. However, farmers participating in focus group discussions corroborated the detected pathways between TF production and consumption. This triangulation between qualitative and quantitative methods gives us more confidence in our findings, despite the relatively small sample assessed in the survey. Nevertheless, we only conducted FGDs with agroecological farmers and we are uncertain of the subjective biases at play. FGDs were also key for identifying farmers' perceptions of causality between agroecology and TF practices. Moreover, path analysis has the advantage that it can identify likely chains of influence, even with cross-sectional data (74). While neither the subjective experiences of farmers nor the results of path analysis are sufficient to definitively establish causality, the triangulation of the two strengthens the internal validity of our results. Nevertheless, our study is limited to a single region, and we recognize that many contextual factors could affect external validity. Not only is agroecology a term that embraces many local expressions (30), but other factors that are subject to broad variation include the cultural presence of TFs, ecological context, food acquisition patterns, gender norms around food and many more. Rather than providing a proscriptive formula for strengthening TF practices, it is our hope that we shed light on how these possible paths can play out, recognizing that they will likely be different in other localities.

[29] Farmers in our study population would often report that they ate a given product “every day while it’s available”, which, for a product that is available for two months, would lead to an unrealistic estimated frequency of 60 during that time period. While we believe this inflation would be equally distributed across both agroecological and reference farmers, we do not have a reliable means of correction in order to obtain a more accurate TF consumption frequency.

Conclusions

In the Ecuadorian highlands, traditional foods (TF) remain a routine part of rural life to a certain extent, but for some TF products, production and consumption decline is a compelling concern. Meanwhile, the nutrition transition away from traditional diets and toward calorie-dense, micronutrient-poor foods marches forward, undermining Indigenous health (2,75). Aiming to understand how TF practices may be strengthened, we found evidence supporting a pathway between the production of TFs and their consumption. Key starting points on this pathway appear to be higher farm production diversity of edible products and a stronger reliance on non-market food sources, namely foods from own harvest and from the social economy. Just as interesting as the correlates of TF practices are the non-correlates. Older age, lower income, less education, and greater market distance do not generally predict TF practices in this context. This is cause for optimism, in that it suggests that TF practices are not an exclusive relic of marginalized populations, but rather a dynamic part of the food habits of relatively diverse farming populations.

Agroecological farmers in our study site drastically out-perform their neighbors on TF practices. This may be because agroecology promotes farm production diversity and reliance on non-market foods (34,36), thus enabling the pathway we identified for TF promotion. However, agroecology also appears to support TF practices in other ways. First, the social spaces surrounding agroecological associations intensify affective (e.g. emotional) relationships with TFs by emphasizing their cultural, health and sensory qualities. Moreover, agroecological markets place farmers in specialized value chains where there is consumer demand for TFs. Importantly, these factors are likely to be locally specific and cannot be copy-pasted to other contexts. Nevertheless, the diversity of ways in which agroecology interacts with TF practices provides hope that it may enhance the role of TFs in the diet without separate investments of capital. It may further be strategic because it is already a rapidly growing global movement (30) with emphatic buy-in among Indigenous people and the rural poor (33,34,36), who disproportionately face a double burden of nutrient deficiencies and excesses (2,5,21). Given the growing body of evidence that links traditional diets to the mitigation of the nutrition transition, stronger food security and healthier nutritional status (5,6,12,57–61), we hope the pathway we identified serves to inform effective strategies for TF promotion.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40795-020-00395-y

(1) **Additional file 1.** This file contains the survey material used in this study.

(2) **Additional file 2.**. This file contains **Supplemental Tables 1, 2** and **3.**

Abbreviations

FGD: focus group discussion

TF: traditional food

FFQ: food frequency questionnaire

SE: standard error

RMSR: root mean square residual

Acknowledgements

We are greatly indebted to the leaders of agroecological associations who shared their knowledge and opened the doors to their communities, and to the farmers of Imbabura province who patiently and thoughtfully answered our questions. We deeply thank EkoRural Foundation and the Ekomer research team, without whom this research would not have been possible. We further thank Leonardo Velasco for his diligent assistance in data collection, as well as Eduar Pinzón and Michelle O. Fried for their input. We are grateful for the generous support of the organizations that funded our research and results dissemination activities.

Authors' contributions

AD, MB and Ekomer conceived the study objectives; All authors contributed to protocol design and analytical framework; AD collected, cleaned, and analyzed the data, and drafted the manuscript; MB, GM and Ekomer provided substantive revisions to the manuscript. All authors read and approved the final manuscript.

Authors' information

AD, GM and MB are affiliated with the Transnut WHO Collaborating Centre on Nutrition Changes and Development at Université de Montréal, Faculty of Medicine, Nutrition Department, as well as with the Centre de Recherche en Santé Publique (CReSP). Ekomer is an Ecuadorian-Canadian research consortium that studies food and food environments in Ecuador. At the time of this study, the following people were part of Ekomer: Stephen Sherwood (Wageningen University andFundación EkoRural), Myriam Paredes (Facultad Latinoamericana de Ciencias Sociales, Ecuador), Peter Berti (Healthbridge Foundation of Canada), Pablo López (Pontífica Universidad Católica del Ecuador), Donald Cole (University of Toronto), Fabian Muñoz (Visor Análisis Estadístico Cía. Ltd.a.), Pedro Oyarzún (Fundación EkoRural), Ross Borja (Fundación EkoRural), Marcelo Aizaga (Minga por la Pachamama), Eliana Estrella (Minga por la Pachamama), Gabriel April-Lalonde (Université de Montréal), as well as MB and AD.

Funding

Data collection, analysis and manuscript writing was carried out by the Ekomer Research Consortium, with the aid of a grant from the International Development Research Centre, Ottawa, Canada. The views expressed herein do not necessarily represent those of IDRC or its Board of Governors [Grant number CR-48490;]. The project further received publication support from the Canadian Institutes of Health Research [Grant number 406536] and from IDRC [Grant number 109101-001] as part of the Global Alliance for Chronic Diseases. AD received general support from the Fonds de Recherche du Québec en Santé [Grant number 262314] and from the Université de Montréal Faculty of Medicine, as well as support for results dissemination from the Quebec Population Health Research Network. MB is supported by the Canada Research Chair program.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was approved by the Health Research Ethical Committee of the University of Montreal, certificate number 17-053-CERES-P, and from the Institutional Review Board of the Universidad San Francisco de Quito in Ecuador, certificate number 2016-118E. As approved by the ethics committees and documented in survey data collection, all participants gave informed verbal consent. This form of consent was chosen given low literacy rates among the study population and cultural discomfort with signing documents.

Consent for publication

NA

Competing interests

The authors declare that they have no competing interests.

References

1. Johns T, Powell B, Maundu P, Eyzaguirre PB. Agricultural biodiversity as a link between traditional food systems and contemporary development, social integrity and ecological health: Traditional food systems, agricultural biodiversity and sustainable development. J Sci Food Agric. 2013 Nov;93(14):3433–42.

2. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012 Jan;70(1):3–21.

3. Popkin BM. Nutritional Patterns and Transitions. Popul Dev Rev. 1993 Mar;19(1):138.

4. Penafiel D, Termote C, Lachat C, Espinel R, Kolsteren P, Van Damme P. Barriers to Eating Traditional Foods Vary by Age Group in Ecuador With Biodiversity Loss as a Key Issue. J Nutr Educ Behav. 2016 Apr;48(4):258-268.e1.

5. Kuhnlein HV, Erasmus B, Spigelski D, FAO, editors. Indigenous peoples' food systems: the many dimensions of culture, diversity and environment for nutrition and health. Reprinted. Rome: Food and Agriculture Organization of the United Nations; 2009. 339 p.

6. Lee M-J, Popkin BM, Kim S. The unique aspects of the nutrition transition in South Korea: the retention of healthful elements in their traditional diet. Public Health Nutr. 2002 Feb;5(1a):197–203.

7. Padulosi S, Thompson J, Rudebjer P. Fighting poverty, hunger and malnutrition with neglected and underutilized species (NUS): needs, challenges and the way forward. [Internet]. Rome: Bioversity International; 2013. Available from: https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Fighting_poverty__hunger_and_malnutrition_with_neglected_and_underutilized_species__NUS__1671.pdf

8. Receveur O, Boulay M, Kuhnlein HV. Decreasing Traditional Food Use Affects Diet Quality for Adult Dene/Métis in 16 Communities of the Canadian Northwest Territories. J Nutr. 1997 Nov 1;127(11):2179–86.

9. Corntassel J. Re-envisioning resurgence: Indigenous pathways to decolonization and sustainable self-determination. Decolonization Indig Educ Soc. 2012;1(1).

10. Chivenge P, Mabhaudhi T, Modi A, Mafongoya P. The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa. Int J Environ Res Public Health. 2015;12(6):5685–711.

11. Cook S. The Spice of Life: The fundamental role of diversity on the farm and on the plate. London and The Hague: IIED and Hivos; 2018.

12. Padulosi S, Hodgkin T, Williams JT, Haq N. Underutilised crops: trends, challenges and opportunities in the 21st Century. In: Engels J, Rao VR, Jackson M, editors. Managing plant genetic diversity [Internet]. CAB International; 2002. p. 323–38. Available from: https://eprints.soton.ac.uk/53786/

13. Willows ND. Determinants of healthy eating in Aboriginal peoples in Canada: the current state of knowledge and research gaps. Can J Public Heal Can Santee Publique. 2005;S32–6.

14. Gracey M, King M. Indigenous health part 1: determinants and disease patterns. The Lancet. 2009 Jul;374(9683):65–75.

15. Kuhnlein HV, Receveur O, Soueida R, Egeland GM. Arctic Indigenous Peoples Experience the Nutrition Transition with Changing Dietary Patterns and Obesity. J Nutr. 2004 Oct 1;134(6):1447–53.

16. Egeland GM, Johnson-Down L, Cao ZR, Sheikh N, Weiler H. Food Insecurity and Nutrition Transition Combine to Affect Nutrient Intakes in Canadian Arctic Communities. J Nutr. 2011 Sep 1;141(9):1746–53.

17. Coimbra CE, Santos RV, Welch JR, Cardoso AM, de Souza MC, Garnelo L, et al. The First National Survey of Indigenous People's Health and Nutrition in Brazil: rationale, methodology, and overview of results. BMC Public Health. 2013;13(1):52.

18. Ramirez-Zea M, Kroker-Lobos MF, Close-Fernandez R, Kanter R. The double burden of malnutrition in indigenous and nonindigenous Guatemalan populations. Am J Clin Nutr. 2014 Dec 1;100(6):1644S-1651S.

19. Freire W, Ramírez M, Belmont P. Tomo I: Encuesta Nacional de Salud y Nutrición de la población ecuatoriana de cero a 59 años, ENSANUT-ECU 2012. Rev Latinoam Políticas Acción Pública Vol 2 Número 1-Mayo 2015. 2015;2(1):117.

20. Lade SJ, Haider LJ, Engström G, Schlüter M. Resilience offers escape from trapped thinking on poverty alleviation. Sci Adv. 2017 May;3(5):e1603043.

21. FAO, IFAD, WFP. The state of food insecurity in the world 2015: meeting the 2015 international hunger targets: taking stock of uneven progress. Rome: FAO, 2015. 2015; Available from: http://www.fao.org/3/a-i4646e.pdf

22. Hermann M. 8 Successes and pitfalls of linking nutritionally promising Andean crops to markets. Divers Food Diets Using Agric Biodivers Improve Nutr Health. 2013;165–85.

23. Aliber M, Hart TG. Should subsistence agriculture be supported as a strategy to address rural food insecurity? Agrekon. 2009;48(4):434–58.

24. Singh RK, Singh A, Sureja AK. Traditional Foods of Monpa tribe of West Kameng, Arunachal Pradesh. 2007;6(1):12.

25. Chan HM, Fediuk K, Hamilton S, Rostas L, Caughey A, Kuhnlein H, et al. Food security in Nunavut, Canada: barriers and recommendations. Int J Circumpolar Health. 2006;65(5):416–31.

26. Keller GB, Mndiga H, Maass BL. Diversity and genetic erosion of traditional vegetables in Tanzania from the farmer's point of view. Plant Genet Resour. 2005 Dec;3(3):400–13.

27. Smale M, Lipper L, Koundouri P. Scope, Limitations and Future Directions. University Library of Munich, Germany; 2006.

28. Smale M, Bellon MR, Jarvis D, Sthapit B. Economic concepts for designing policies to conserve crop genetic resources on farms. Genet Resour Crop Evol. 2004 Mar;51(2):121–35.

29. Ghosh-Jerath S, Singh A, Kamboj P, Goldberg G, Magsumbol MS. Traditional Knowledge and Nutritive Value of Indigenous Foods in the Oraon Tribal Community of Jharkhand: An Exploratory Cross-sectional Study. Ecol Food Nutr. 2015 Sep 3;54(5):493–519.

30. HLPE. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. [Internet]. Rome: High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security; 2019 p. 163. Available from: http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-14_EN.pdf

31. Altieri MA, Toledo VM. The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants. J Peasant Stud. 2011;38(3):587–612.

32. Frison EA, IPES-Food. From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems. 2016;

33. Intriago R, Gortaire Amézcua R, Bravo E, O'Connell C. Agroecology in Ecuador: historical processes, achievements, and challenges. Agroecol Sustain Food Syst. 2017 Apr 21;41(3–4):311–28.

34. Altieri MA, Nicholls CI. Agroecology scaling up for food sovereignty and resiliency. In: Lichtfouse E, editor. Sustainable agriculture reviews. Netherlands: Springer; 2012. p. 1–29.

35. Sherwood S, Arce A, Berti P, Borja R, Oyarzun P, Bekkering E. Tackling the new materialities: Modern food and counter-movements in Ecuador. Food Policy. 2013 Aug;41:1–10.

36. Deaconu A, Mercille G, Batal M. The Agroecological Farmer's Pathways from Agriculture to Nutrition: A Practice-Based Case from Ecuador's Highlands. Ecol Food Nutr. 2019;58(2):142–65.

37. Heifer Ecuador. Agroecology is here to stay: Mapping agroecological farmers and the status of agroecology in Ecuador's Highlands and Coastal regions [Internet]. Quito, Ecuador: Heifer-Ecuador Foundation; 2014. Available from: http://www.heifer-ecuador.org/wp-content/uploads/libros/1_La_agroecologia_esta_presente_EN.pdf

38. Sherwood S. Learning from Carchi: agricultural modernisation and the production of decline [Internet]. [S.l.]: s.n.]; 2009. Available from: https://library.wur.nl/WebQuery/wurpubs/fulltext/7207

39. INEC. Tabulados pobreza por necesidades básicas incumplidas. Resultados del Censo 2010 [Internet]. Instituto Nacional de Estadística y Censos; 2010. Available from: http://www.ecuadorencifras.gob.ec/documentos/web-inec/POBREZA/NBI/NBI-FUENTE-CPV/Tabulados_pobreza_por_NBI.xlsx

40. INEC. Fascículo Provincial Imbabura. Resultados del Censo 2010 [Internet]. Quito, Ecuador: Instituto Nacional de Estadística y Censos; 2010. Available from: http://www.ecuadorencifras.gob.ec/censo-de-poblacion-y-vivienda/

41. INEC. La Población Indígena del Ecuador [Internet]. Quito, Ecuador: Instituto Nacional de Estadística y Censos; 2006. Available from: http://www.acnur.org/fileadmin/Documentos/Publicaciones/2009/7015.pdf

42. Pingali PL, Rosegrant MW. Agricultural commercialization and diversification: processes and policies. Food Policy. 1995 Jun;20(3):171–85.

43. Creswell JW. Research design: qualitative, quantitative, and mixed methods approaches. 3rd ed. Thousand Oaks, Calif: Sage Publications; 2009. 260 p.

44. Gibson RS, Ferguson EL. An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries. ILSI Press Washington, DC; 1999.

45. Díaz Martínez AE. Primer Ciclo de Selección de 162 Familias de medios hermanos de Maíz Negro y 120 de Maíz Chulpi (Zea mays L.) de la sierra ecuatoriana, en Tunshi, parroquia Licto, provincia de Chimborazo. 2011;

46. Cohen J. Statistical power analysis for the behavioral sciences. Routledge; 2013.

47. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Model Multidiscip J. 1999 Jan 1;6(1):1–55.

48. McDonald RP, Ho M-HR. Principles and practice in reporting structural equation analyses. Psychol Methods. 2002;7(1):64–82.

49. Paredes M, Cole DC, April-Lalonde G, Valero Y, Prado P, Boada L, et al. Assessing responsible consumption in three Ecuadorian city-regions to inform a social movement. In: Blay-Palmer A, Conaré D, Meter K, Di Battista A, Johnston C, editors. Sustainable food system assessment: lessons from global practice. Milton Park, Abingdon, Oxon ; New York, NY: Routledge; 2020. (Routledge studies in food, society and the environment).

50. Venskutonis PR, Kraujalis P. Nutritional components of amaranth seeds and vegetables: a review on composition, properties, and uses. Compr Rev Food Sci Food Saf. 2013;12(4):381–412.

51. Kozioł M. Chemical composition and nutritional evaluation of quinoa (Chenopodium quinoa Willd.). J Food Compos Anal. 1992;5(1):35–68.

52. Jones AD. Critical review of the emerging research evidence on agricultural biodiversity, diet diversity, and nutritional status in low- and middle-income countries. Nutr Rev. 2017 Oct 1;75(10):769–82.

53. King SR, Gershoff SN. Nutritional evaluation of three underexploited andean tubers:Oxalis tuberosa (Oxalidaceae),Ullucus tuberosus (Basellaceae), andTropaeolum tuberosum (Tropaeolaceae). Econ Bot. 1987 Oct;41(4):503–11.

54. Borron S. Building resilience for an unpredictable future: how organic agriculture can help farmers adapt to climate change. Food Agric Organ U N Rome. 2006;

55. Stigter C, Dawei Z, Onyewotu L, Xurong M. Using traditional methods and indigenous technologies for coping with climate variability. In: Increasing Climate Variability and Change. Springer; 2005. p. 255–71.

56. Grivetti LE, Ogle BM. Value of traditional foods in meeting macro-and micronutrient needs: the wild plant connection. Nutr Res Rev. 2000;13(1):31–46.

57. Vorster I, Jansen van Resnsburg W, Van Z, Venter S. The importance of traditional leafy vegetables in South Africa. Afr J Food Agric Nutr Dev. 2007;7(4):1–13.

58. Roche M, Creed-Kanashiro H, Tuesta I, Kuhnlein H. Traditional food diversity predicts dietary quality for the Awajún in the Peruvian Amazon. Public Health Nutr. 2008 May;11(5):457–65.

59. Batal M, Hunter E. Traditional Lebanese recipes based on wild plants: an answer to diet simplification? Food Nutr Bull. 2007;28(2_suppl2):S303–11.

60. Burgos G, Amoros W, Morote M, Stangoulis J, Bonierbale M. Iron and zinc concentration of native Andean potato cultivars from a human nutrition perspective. J Sci Food Agric. 2007;87(4):668–75.

61. Campos D, Noratto G, Chirinos R, Arbizu C, Roca W, Cisneros-Zevallos L. Antioxidant capacity and secondary metabolites in four species of Andean tuber crops: native potato (Solanum sp.), mashua (Tropaeolum tuberosum Ruiz & Pavón), Oca (Oxalis tuberosa Molina) and ulluco (Ullucus tuberosus Caldas). J Sci Food Agric. 2006;86(10):1481–8.

62. Davies S. Are coping strategies a cop out? IDS Bull. 1993;24(4):60–72.

63. Balogh P, Békési D, Gorton M, Popp J, Lengyel P. Consumer willingness to pay for traditional food products. Food Policy. 2016;61:176–84.

64. Gross J, Guerrón Montero C, Hammer M, Berti P. Creating Healthy Bodies in Rural Ecuador at a Time of Dietary Shift. In: Sherwood S, Arce A, Paredes M, editors. Food, Agriculture and Social Change [Internet]. 1st ed. Routledge; 2017 [cited 2019 Oct 8]. p. 34–47. Available from: https://www.taylorfrancis.com/books/9781315440071/chapters/10.4324/9781315440088-3

65. Arvola A, Vassallo M, Dean M, Lampila P, Saba A, Lähteenmäki L, et al. Predicting intentions to purchase organic food: The role of affective and moral attitudes in the Theory of Planned Behaviour. Appetite. 2008;50(2–3):443–54.

66. Vanhonacker F, Kühne B, Gellynck X, Guerrero L, Hersleth M, Verbeke W. Innovations in traditional foods: Impact on perceived traditional character and consumer acceptance. Food Res Int. 2013 Dec;54(2):1828–35.

67. Nicklin C, Rivera M, Nelson R. Realizing the potential of an Andean legume: roles of market-led and research-led innovations. Int J Agric Sustain. 2006;4(1):61–78.

68. Sherwood S, Arce A, Paredes M. Affective Labor's 'unruly edge': The pagus of Carcelen's Solidarity & Agroecology Fair in Ecuador. J Rural Stud. 2018 Jul;61:302–13.

69. QRE. Guía de Ferias Agroecológicas. Quito, Ecuador: ¡Qué Rico Es!; 2013.

70. McBurney RPH, Griffin C, Paul AA, Greenberg DC. The nutritional composition of African wild food plants: from compilation to utilization. J Food Compos Anal. 2004 Jun;17(3–4):277–89.

71. Food and Agriculture Organization of the United Nations, editor. Expert consultation on nutrition indicators for biodiversity. 2: Food consumption. Rome: Food and Agriculture Organization of the United Nations; 2010. 59 p.

72. Kristal AR, Peters U, Potter JD. Is It Time to Abandon the Food Frequency Questionnaire? Cancer Epidemiol Biomarkers Prev. 2005;14(12):2826–8.

73. Tsubono Y, Nishino Y, Fukao A, Hisamichi S, Tsugane S. Temporal Change in the Reproducibility of a Self-administered Food Frequency Questionnaire. Am J Epidemiol. 1995 Dec 1;142(11):1231–5.

74. Streiner DL. Finding our way: an introduction to path analysis. Can J Psychiatry. 2005;50(2):115–22.

75. Freire WB, Silva-Jaramillo KM, Ramírez-Luzuriaga MJ, Belmont P, Waters WF. The double burden of undernutrition and excess body weight in Ecuador–. Am J Clin Nutr. 2014;100(6):1636S-1643S.

Supplementary Tables

Supplemental tables to the article: Promoting traditional foods for human and environmental health: lessons from agroecology and Indigenous communities in Ecuador

Supplemental Table 1: Consumption prevalence and frequency of indicator traditional foods (TF) and their most common sources of acquisition, by agroecological (AE) and reference (R) farmer categories

	TF consumption						Prevalences of TF acquisition sources reported as primary source (%)								
	Prevalence (%)			Annual frequency			Conventional markets			Harvest			Social economy		
	Pooled	AE	R	Pooled	AE	R	Pooled	AE	R	Pooled	AE	R	Pooled	AE	R
Quinoa leaf	22	32***	3	2 [5]	2 [8]	1 [0]	0	0	0	93	96	75	7	4	25
Quinoa seed	96	95	97	24 [40]	36 [40]***	12 [33]	17	10**	31	48	56**	31	35	34	38
Amaranth leaf	20	25*	10	6 [23]	12 [51]	1 [5]	0	0	0	100	100	100	0	0	0
Amaranth seed	19	25**	7	8 [10]	8 [24]	7 [10]	3	0*	14	47	48	43	50	52	43
Andean lupine	99	100	97	52 [28]	52 [28]**	30 [40]	38	23***	69	29	35*	17	33	42***	14
Melloco	94	98**	87	24 [40]	52 [40]*	24 [40]	28	17***	50	30	36	20	42	47	30
Mashua	38	50***	13	3 [11]	3 [11]	1 [26]	16	8***	42	48	55*	25	36	37	33
Oca	84	90**	73	5 [13]	5 [16]	4 [11]	12	9	22	37	36	39	51	55	39
Zanahoria blanca	79	87**	63	4 [11]	4 [11]	3 [13]	6	4	13	61	71***	38	33	25**	50
Yacon	53	63***	33	2 [11]	3 [21]***	1 [1]	0	0	0	66	69	54	34	31	46
Chulpi	63	77***	37	12 [24]	12 [50]	12 [11]	25	17***	47	52	62***	26	23	21	26

Sweet potato	83	88*	73	4 [23]	4 [17]	6 [32]	12	7**	24	42	48*	28	46	45	48
n farmers		60	30			Aggregate prevalence (%)	16	10***	33	48	55***	32	36	36	35

TF consumption prevalence shows the percentage of farmers that report consuming each TF item over the past year. TF consumption annual frequency reports the median frequency of consumption among farmers that consumed the TF, with interquartile range in brackets. The prevalence of certain products among reference farmers, especially quinoa leaf, amaranth leaf, amaranth seed and mashua, may be too low to accurately detect a difference in annual consumption frequency between the two groups. For each TF item, farmers reported their primary source for acquiring the item, and these were categorized into three groups: conventional markets, harvest (including harvest from own production and wild harvest), and social economy (including barter, gifting or direct purchase from another farmer). The aggregate prevalence of each acquisition source is the percentage of times that the source is mentioned as the primary source across all TF items. Differences in prevalence are tested between agroecological and reference farmers with the Chi-square test, and differences in frequency are tested with the Mann-Whitney U-test. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Supplemental Table 2: Consumption of wild foods among study participants

Local name of wild food	Alternative local names	Consumption prevalence
Berro		92%
Mora de monte	Mora de árbol	80%
Bledo	Lido, Ledo	71%
Nabo de monte	Nabo de chagra, Chagrayuyu, Nabo de maíz, Alli yuyu, Nabo nacional	69%
Chimbalo		65%
Mortiño		60%
Uvilla de monte		56%
Taxo de monte	Anga taxo	52%
Rábano de monte	Rábano yuyu	48%
Lengua de vaca	Wagrahayu	30%
Uvilla de lobo	Uvilla sin cáscara, Lluchu uvilla, Uvilla macho, Uvilla eljersita	20%
Quinua de monte	Allpa quinua, Panrra	16%
Motilón		14%
Walicón	Chaupalón, Capulí de monte, Chupalulu, Chupalulun, Pinol	11%
Tuna		7%
Ságalan	Ságala	7%
Tocte		7%
Chugonda	Chugunda	4%
Chihualcán	Chamburo silvestre	3%
Sacha piña	Piñuela	3%
Frutilla de monte		2%
Frambuesa silvestre		1%
Machia		1%
Waka mollo		1%

Nopal		1%
Kanayuyo		1%
Manzanita	Niwas	1%
Serote		1%
Uchu moras		1%
Juña foro		1%
Berro de laguna		1%
Verdolaga		1%
Mandarina de monte		1%
Hongos blancos		1%

Table summarizes prevalence of each wild food across all study participants (n=91), excluding wild products identified as used only for brewing as herbal tea or medicinal remedies. Local names are used, with alternative local names identified as equivalent products.

Supplemental Table 3: Relationship between traditional food (TF) production and consumption, by TF Product

TF Item	TF item in production	Prevalence of TF consumption (%)	Odds ratio of TF consumption	Median TF consumption frequency
Quinoa leaf	Yes	35***	7.1	2*
	No	7		1
Quinoa seed	Yes	98	3.6	30
	No	93		24
Amaranth leaf	Yes	39***	10.7	12**
	No	6		1
Amaranth seed	Yes	48***	9.3	12
	No	9		2.5
Andean lupine	Yes	100	not computed	52
	No	98		52
Melloco	Yes	100**	not computed	43
	No	90		24
Mashua	Yes	83***	16.5	6
	No	22		1
Oca	Yes	94*	3.7	17***
	No	80		3
Zanahoria Blanca	Yes	91***	6.7	6**
	No	60		2
Yacon	Yes	74***	6.7	3***
	No	30		1
Chulpi	Yes	87***	6.5	24***
	No	51		5
Sweet potato	Yes	96***	9.8	5
	No	70		3

To compare farmers that do and do not produce a given TF item, differences in prevalence of TF item consumption are tested with the Chi-square test and differences in frequency are tested with the Mann-Whitney U-test. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Odds ratios indicated as "not computed" occur when a category contains a 0-value. In both cases, this occurs when there is no individual that produces a given TF but does not consume it.

6.4 Article 3: Agroecology and nutritional health: A comparison of agroecological farmers and their neighbors in the Ecuadorian highlands

Ana Deaconu[a,b], Peter R. Berti[c], Donald C. Cole[d,e], Geneviève Mercille[a,b], and Malek Batal[a,b]*

[a] Nutrition Department, Faculty of Medicine, Université de Montréal, P.O. Box 6128, succ. Centre-ville, Montreal, QC H3C 3J7, Canada

[b]Centre de Recherche en Santé Publique (CReSP), Pavillon 7101 avenue du Parc, CP 6128, Succursale Centre-Ville, Montréal (Québec) H3C 3J7

[c]HealthBridge Foundation of Canada, 1 Nicholas Street, Suite 1004, Ottawa, ON KIN 7B7

[d]Dalla Lana School of Public Health, 155 College St, Toronto, ON, Canada M5T3M7

[e]Fair Fields, 221689 Concession 14, RR1 Neustadt, ON, Canada, N0G 2M0

* Corresponding author at: Nutrition Department, Faculty of Medicine, Universite de Montreal, P.O. Box 6128, succ. Centre-ville, Montreal, QC H3C 3J7, Canada. E-mail addresses: ana.deaconu@umontreal.ca (A. Deaconu), pberti@healthbridge.ca (P.R. Berti), donald.cole@utoronto.ca (D.C. Cole), genevieve.mercille.1@ umontreal.ca (G. Mercille), malek.batal@umontreal.ca (M. Batal).

Highlights

- Agroecological farmers have more nutritious and balanced diets.
- Agroecology may improve nutrient adequacy through higher production diversity.
- Agroecology may improve dietary moderation through non-market food consumption.
- Social and human capital, but not income, may mediate agroecology's diet effects.
- Agroecological farmers have healthier diets despite spending less money on food.

Abstract

Agroecology has received much attention as a sustainable production strategy that may leverage agriculture-nutrition linkages to positively impact farmer nutritional health, but its potential has not been thoroughly established through empirical assessment. This mixed methods study uses survey data from Ecuador to assess how farmers' participation in agroecological associations may impact their diets. Our results suggest that agroecological farmers outperform reference farming neighbors on both nutrient adequacy (i.e. meeting key nutrient needs) and dietary moderation (i.e. avoiding dangerous excesses). Stronger nutrient adequacy is likely related to agroecological farmers' higher production diversity as well as the social and human capital developed within their networks, while stronger dietary moderation is likely related to their greater consumption of foods obtained through own-production and the social economy (e.g. barter). Dietary differences between agroecological and reference farmers occur despite similar incomes and other socioeconomic characteristics, and in fact, agroecological farmers achieve healthier diets while spending less money to purchase foods. Agroecology-based famers' networks may thus hold promise for integrating nutritional health priorities into sustainable food systems.

Keywords: agroecology, nutrition, sustainable farming, Ecuador, alternative food networks, health

1. Introduction

The Food and Agriculture Organization of the United Nations (FAO) describes “sustainable diets” as “those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations.” The FAO further explains that, “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” (Burlingame and Dernini 2012). This complex, multisectoral definition reflects a growing understanding that diets are more than a collection of nutrients (Scrinis 2008; Patel et al. 2015), and that good diets must account not just for individual well-being, but also for planetary health consequences (Willett et al. 2019). Sustainable diets must therefore be discussed together with sustainable agriculture (FAO 2014). The policy challenge remains to better implement such integration into practice (Gillespie et al. 2019).

In recent years, agroecology has received much attention for its potential to do just that (HLPE 2019; Frison and IPES-Food 2016; FAO 2018; Tittonell 2014; Deaconu, Mercille, and Batal 2019). This dynamic, locally-adapted concept (HLPE 2019) applies regenerative ecological principles to agricultural practices—such as by optimizing production diversity, eliminating harmful inputs, and leveraging beneficial biotic relationships (Altieri and Toledo 2011; Tittonell 2014; HLPE 2019)—and integrates these practices with environmental, social and economic priorities to contribute to sustainable food systems (Francis et al. 2003; FAO 2018).

Most agroecological farming is the purview of smallholder, family farmers, many of whom are resource-poor (Altieri and Toledo 2011; FAO 2018) and continue to struggle with food insecurity and compromised nutrition (FAO 2014; FAO, IFAD, and WFP 2015). As such, the FAO's High-Level Panel of Experts on Food Security and Nutrition outlined how several key principles of agroecology can specifically contribute to farmer nutritional health, namely: diversified farm systems can contribute to dietary diversity and nutrient adequacy; reduced dependency on purchased agricultural inputs can reduce expenditures and debt, liberating funds for food; construction of food systems based on cultural identity can directly impact diets; economic connectivity between producers and consumers can help farmers capture more value, which can then be used for nutritional outcomes; and, the co-creation of knowledge between local and scientific innovation and farmer-to-farmer exchange can indirectly impact food security and nutrition (HLPE 2019).

These proposed links between agroecology and dietary outcomes are supported by several well-established underlying pathways between agriculture and nutrition. First, the connection between production diversity and dietary diversity has seen extensive research (Herforth et al. 2019; Powell et al. 2015; Jones 2017; Frison and IPES-Food 2016; Herforth and Harris 2014). Likewise, income generation is recognized as a key mediator for economic access to food (FAO, IFAD, and WFP 2015) and there is an understanding that diverse types of expenditures can support or diminish food security (Smith, El Obeid, and Jensen 2000). Increasingly, research also emphasizes how social and human capital as well as gender-based cultural norms can impact the effectiveness of agricultural practices in generating positive nutritional outcomes (Berti, Krasevec, and FitzGerald 2004; Malapit and Quisumbing 2015).

Given the growing global interest in agroecology, there is a recognized need to better understand how it may act on agriculture-nutrition pathways in an empirical setting (HLPE 2019). However, agroecology is not a singular, well-defined farming strategy, but rather a dynamic set of agricultural, economic, social and cultural practices (Wezel et al. 2009; HLPE 2019). What consolidates these seemingly disparate practices into locally-cohesive paradigms are the social networks formed by smallholder farmers' organizations and their alliances with NGOs, research institutions and public entities (Altieri and Toledo 2011). Examining farmers' participation in these networks is necessary to understand whether and how agroecology supports rural nutritional health.

In previous exploratory work, we used detailed ethnography to examine potential linkages between participation in agroecological associations and nutrition in the Ecuadorian highlands, identifying the promotion of production diversity, as well as the creation of social and human capital as likely mediators (Deaconu, Mercille, and Batal 2019). Building on those results, in this study, we use survey data to compare the food and production practices of agroecological association farmers and their non-agroecological neighbors in order to systematically inspect relationships between agroecology and dietary health, and the mediators of those relationships. As part of a participatory approach, we then elaborate on quantitative results in discussions with research participants and bring together the knowledge generated by these mixed methods to assess pathways between espousing agroecology and obtaining dietary outcomes.

1.1 Agroecology and agroecological associations in Ecuador

In Ecuador, agroecology is a convergence point of multiple objectives that largely reacted to the agricultural, cultural, and environmental changes heralded by the “Green” Revolution. While academics and NGOs were seeking alternatives to environmentally destructive industrialized agriculture, Indigenous peasant organizations identified ancestral farming strategies as a key element in their struggle for cultural recognition and sovereignty (Intriago et al. 2017). Meanwhile, lost revenue on cash crops (Sherwood 2009; Waters 2007) and the health hazards of pesticides (Cole, Carpio, and León 2000; Paredes 2010) led some families to return to the safer route of traditional agricultural approaches (Intriago et al. 2017). A shared understanding grew that the technological principles of agroecology were largely coherent with ancestral agricultural knowledge, positioning agroecology as a unifying front for Indigenous and peasant organizations, NGOs, academic scholars and numerous other actors (Intriago et al. 2017).

This coalescence around agroecology was accompanied by the formation of partnerships to create alternative food networks intended for farmers to grow and sell their pesticide-free, agroecological products under socially and economically favorable conditions. These networks most often took the form of farmers' markets run by farmers' associations, but other forms also emerged, including solidarity stores and food baskets selling products from independent farmers rather than from associations (Heifer 2014). Agroecological associations in Ecuador utilize internal mechanisms, such as "participatory guarantee systems", to ensure that members employ farming practices consistent with the association's understanding of agroecology. While standards vary across associations, common practices include: implementation of agrobiodiversity (both inter- and intra-species), crop rotation and association, integration of livestock, application of organic inputs made on the farm (compost, compost tea, biological pesticides), use of green manure and agroforestry, and abstaining from use of synthetic agricultural inputs (Macas and Echarry 2009; Heifer 2014). Within associations, individual farmers' adherence to such practices varies widely (Heifer 2014). Many of these practices are consistent with traditional farming techniques that predate the Green Revolution and that continue to be implemented to varying extents by many farmers, regardless of agroecological identity (Gortaire 2016).

Partly due to an interest in supporting the most vulnerable populations, agroecological associations are predominantly composed of women, and many associations consider Indigenous culture a key part of their identity (Heifer 2014; Deaconu, Mercille, and Batal 2019). These associations are also the primary spaces in which agroecological farmers discuss ideas, share knowledge, initiate new practitioners, create a common identity (Heifer 2014; Deaconu, Mercille, and Batal 2019), and otherwise align with the key principles of agroecology as outlined by the HLPE (2019). At a national level, agroecological farmers' associations are well-connected with each other as well as with NGOs, academic research groups and consumer-based initiatives for sustainable food; together, these groups form networks that convene for discourse and public action to promote shared interests (Sherwood et al. 2013). Through such articulated activity, agroecology in Ecuador takes on the form of a social movement (Deaconu, Mercille, and Batal 2019). Far from being unique to Ecuador, the simultaneous operationalization of agroecology as a production strategy and as a social movement (Wezel et al. 2009), has become one of its defining characteristics around the world (HLPE 2019).

In this study, we heretofore refer to farmers who participate in agroecological associations as "agroecological farmers" and those who do not as "reference farmers." However, our classification of "agroecological" and "reference" farmers does not make *a priori* assumptions about farming techniques. Rather, it describes people's participation in the associations where agroecology is promoted. Given that in Ecuador agroecological associations act as incubators of the production practices, social norms, and civil society actions that ultimately form a shared agroecological identity (Intriago et al. 2017; Sherwood et al. 2013; Deaconu, Mercille, and Batal 2019), we use participation in these networks as a proxy to capture the local understanding of "agroecological farming."

2. Methodology

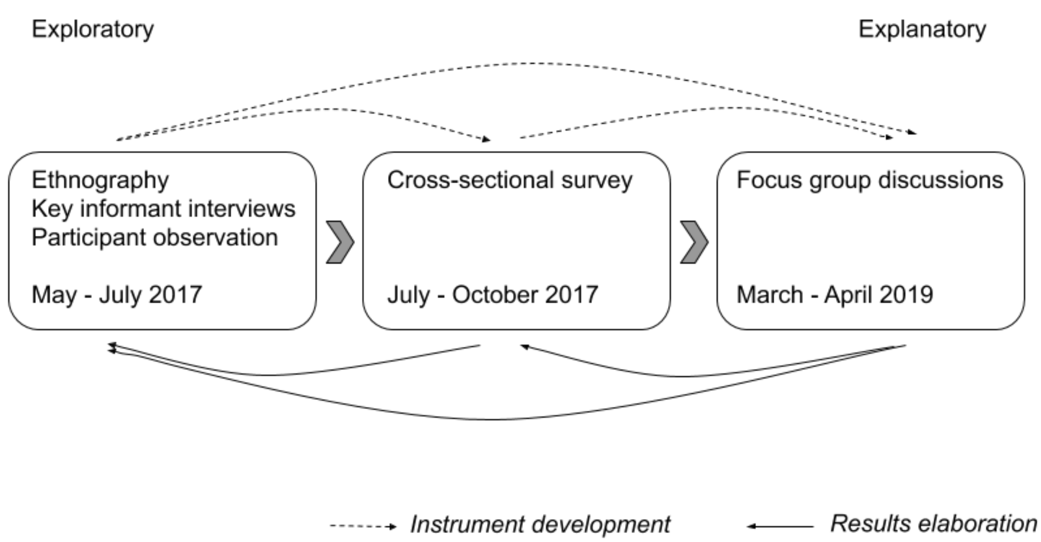
2.1 Setting

This study was conducted in Ecuador's Imbabura province, a documented national hotspot of agroecological activity (Heifer 2014). Imbabura province belongs to Ecuador's highland region and altitudinal variation spans multiple climatic niches, meaning that farmers who are geographically close may produce in distinct ecosystems. Farmers participating in our study resided as low as 1550 meters above sea level (masl) in hot, humid subtropical valleys and as high as 3570 masl in the wet montane *páramo* ecosystem. People living at all altitudes raise livestock and grow a wide variety of products, with ubiquitous production of maize, beans and potatoes. Lower altitudes support more diverse fruit production, including tropical fruit, as well as production of sugar cane and sweet potato, whereas higher altitudes support production of traditional Andean products such as lupine, melloco, oca and mashua. Temperature and rainfall patterns in the region allow most farmers to harvest a diversity of products throughout the year, even without irrigation (Prefectura de Imbabura 2017). Of Imbabura's farmers, 86% are smallholders, but due to land concentration they only occupy 16% of agricultural land; women and Indigenous farmers disproportionately occupy the smallest parcels (Brassel et al. 2008).

2.2 Mixed methods design

We applied a sequential mixed methods design involving both exploratory and explanatory phases in order to triangulate findings across instruments and give voice to the participating communities (Creswell 2009, 10–12, 208–27; Cornwall and Jewkes 1995). The methods of and results from the first phase of exploratory ethnography, key informant interviews and participant observation have been previously reported (Deaconu, Mercille, and Batal 2019). We then conducted a cross-sectional survey to obtain quantitative measurements (phase II), and finally implemented explanatory community consultation through focus group discussions (FGDs) (Colucci 2007) (Phase III) oriented around key question-prompts. This final phase sought to assess the extent to which farmers' lived perceptions converged with quantitative results and to understand farmers' explanations for the mechanisms underlying the results. As illustrated in Figure 1, our sequential implementation initially informed development of instruments, and later more fully elaborated on complex topics.

Figure 1: Mixed methods design and timeline



2.3 Survey

The survey included modules on socioeconomics, production, diet and health, and was administered to female agroecological and female reference farmers. Although our first phase of research signaled potential linkages between the social environment of agroecology and dietary practices, we were unable to identify an appropriate quantitative means to assess this in the survey.

We referred to existing documentation (Heifer 2014) and worked with two local NGOs (EkoRural and Vibrant Village) to identify relevant agroecological associations in Imbabura (n=8). Local partners assisted in contacting leadership to discuss the project and obtain preliminary consent. All associations contacted agreed to participate. We then worked with association leaders to develop rosters of female farmers. From the combined roster, we used a random number generator to select farmers for recruitment into the agroecological sample (n=61). Agroecological farmers were contacted by phone or in-person (at their farmers' market) in order to schedule a visit to their homes, where the survey was conducted. For every second agroecological farmer we visited, we also recruited a reference female farmer (n=30) from a neighboring household. To do so, we approached a neighboring home at random. If an adult female farmer was available in the household, she was recruited for the reference sample only if she had never participated in an agroecological association. Because no reference farmers approached had participated in agroecological associations, none were excluded. When possible, the survey was conducted right away; otherwise, a later date and time was arranged. Our sample size for agroecological farmers was greater than that for reference farmers in order to accommodate additional study objectives for this group (not discussed here). No farmers refused participation.

2.3.1 Socioeconomic and production variables

The survey instrument collected household-level socioeconomic data including household size[30], average monthly household income, human development bonus beneficiary status (yes/no), and time to market in usual transport, as well as the age and educational attainment of the respondent. The human development bonus is a conditional cash transfer given by the government to households determined to be the most economically vulnerable, according to unmet basic needs (Moreno 2017). Because lower per capita monthly income was associated with receiving the human development bonus (Supplementary Table 1), we consider per capita income to be an adequate continuous measurement.

[30] Household size is calculated based on the number of people that sleep in the home at least four nights a week.

To understand the household's agricultural production and productive resources, we queried on the presence of irrigation (yes/no); amount of land in agricultural use (<1 hectare, 1-3 hectares, 3-5 hectares, and greater than 5 hectares); production diversity and intra-species diversity. Studies on agroecological farmers in the region have included additional variables to evaluate production practices, such as use of agroforestry and organic amendments (Heifer 2014). While including such variables would provide for greater depth, we limited our inquiry in order to reduce participant burden. Production diversity is a species richness measurement of edible products cultivated over the past year, based on an exhaustive list shown in Supplementary Table 2. The list was developed based on exploratory work and additional consultation with our two partner NGOs. The production diversity measurement only included plant and animal products that are consumed as foods; the measure excluded animals whose flesh, eggs or milk are not typically consumed as well as plants that are used only as condiments, seasonings, aromatics or medicinal remedies. We did not distinguish between garden crops and field crops because observations on intercropping strategies found that there is no clear distinction between them on some farms, making it more appropriate to query for all crops together. We further assessed intra-species diversity of three common crops (potatoes, maize, beans) by asking respondents to identify the distinct cultivars or varieties in the past year's production. We were interested in both inter- and intra-species diversity because both can play important roles in nutrition as well as ecosystem resilience, economic diversification, and cultural heritage (Cook 2018; Herforth et al. 2019; Johns et al. 2013).

2.3.2 Food acquisition, diet and health variables

The survey included an individual quantitative 24-hour dietary recall of the foods consumed by the survey respondent, which we used to assess the respondent's food acquisition practices as well as several dimensions of dietary nutrient adequacy (i.e. meeting nutrient needs) and dietary moderation (i.e. avoiding harmful excesses) (Shim, Oh, and Kim 2014). We opted to employ multiple dietary assessment indicators given the exploratory nature of this research. We utilized an open-ended 24-hour recall to first obtain all the products that were consumed by the participant, and then the quantities. This is the recommended instrument for obtaining the dietary indicators we employ, even though it is known to underestimate energy and overestimate micronutrients, and does not necessarily reflect long-term food intake trends for individuals (Poslusna et al. 2009). Food models and props were used to assist in querying for quantities by volume. In order to understand how respondents acquired their food, we then queried for the origin of each item listed on the 24-hour recall, and grouped answers into three categories: (i) conventional markets, including purchases from markets, supermarkets, grocers, corner-stores and restaurants; (ii) harvest, including food obtained from own-production and wild harvest; and, (iii) social economy, including food obtained from barter, gifting, and direct purchase from other farmers. For some analyses, we further collapsed the first category as "market" food sources and the second two categories as "non-market" food sources. We then calculated the percentage of total calories obtained from each food acquisition strategy, using USDA and Ecuadorian nutrient databases to determine caloric contribution of each item (USDA 2019; Ramírez-Luzuriaga et al. 2014).

To assess dietary nutrient adequacy, we used three measures of dietary diversity as a proxy (Ruel 2003). First, we applied a Dietary Diversity Score (DDS) using the ten food group protocol established by the Minimum Dietary Diversity for Women (MDD-W) score[31] (FAO and FHI 360 2016). MDD-W establishes a dichotomous cut-off of 5 food groups indicating probable nutrient adequacy in populations of women of reproductive age. While not all women in our sample were of reproductive age, we employed this cut-off as an approximation of adequacy to facilitate comparison between the agroecological and reference farmer groups (our second measure). Finally, we calculated a Food Variety Score (FVS) by counting the unique ingredients consumed by each respondent (Hatløy, Torheim, and Oshaug 1998). While FVS is somewhat less effective in predicting micronutrient adequacy than DDS (Ruel 2003; Hatløy, Torheim, and Oshaug 1998), it can provide further insight on dietary complexity, which is key to the consumption of beneficial secondary metabolites (Egert and Rimbach 2011). FVS is also relevant to discussions on correlates of overweight and obesity (Saibul et al. 2009; Lee et al. 2010; McCrory et al. 1999).

To evaluate dietary moderation, we assessed processed foods in the diet following an Ecuadorian adaptation (Freire et al. 2017) of the NOVA food classification system (Monteiro et al. 2018). We chose

---

[31] The ten food groups are as follows: grains, white roots and tubers and plantains; legumes; nuts and seeds; dairy; eggs; meat; dark green leafy vegetables; other vitamin-A rich fruits and vegetables; other vegetables; other fruits.

this classification system because its attention to food processing has successfully predicted overweight and diet-related chronic diseases in Latin American contexts (PAHO 2015). NOVA assesses caloric share obtained from four food categories: (i) unprocessed or minimally processed foods, (ii) processed culinary ingredients, such as oils and sugar, (iii) processed foods and (iv) ultra-processed foods (Monteiro et al. 2018). We also explored use of the Healthy Eating Index-2015, which assesses dietary quality according to both nutrient adequacy and moderation (Krebs-Smith et al. 2018). However, we ultimately rejected this index because it is based on American dietary guidelines and, to our knowledge, no adaptations have been validated for rural Andean populations.

To assess past and current health status, we used a portable stadiometer and scale to measure height and weight, which allowed us to assess stunting, defined as short adult stature (<145 cm), as well as Body Mass Index (kg / m-squared). To reduce participant burden, these measurements were optional[32]. We also assessed self-reported diagnosis of diet-related chronic diseases (diabetes, heart disease, hypertension, high cholesterol, cancer). Farmers who expressed that they had never visited a medical professional were not excluded from this analysis.

2.4 Community consultation through focus group discussions

Eight activity-based focus group discussions (FGDs) (Colucci 2007) were conducted to consult with the eight agroecological associations whose members had participated in the survey. To recruit participants, association leaders explained the purpose of the voluntary FGDs to association members. FGDs were open to all association members, including men as well as women who were not recruited for the survey, in order to promote a diversity of opinions and inclusivity. In total, 128 individuals participated (mean: 16), of which 19% were men. Supplementary Table 3 shows participation by association and gender. Because FGDs were conducted in each association's usual meeting space and were convened to follow their usual meeting time or market schedule, most association members participated.

[32] We also measured waist circumference, but this data was eventually rejected from analysis because field protocols did not account for the use of traditional corsets among some Indigenous women.

FGDs began with a paired ranking exercise (Colucci 2007), presented as a voting activity, in which farmers were asked questions comparing agroecological and reference farmers on various dietary and production characteristics before revealing any study results (see first column, Table 4). Reference farmers were referred to as “your farming neighbors who are not in an agroecology association.” Farmers also voted on whether they believed their diet had changed in any way since joining the association. In accordance with our mixed methods design, these questions were determined according to key points of interest arising from our previous exploratory work (Deaconu, Mercille, and Batal 2019) and from bivariate analysis of survey results. Farmers cast individual votes in ballot boxes for each question. Because not all farmers were comfortable with reading, the question-prompt on each ballot box was supported with visual depictions, and each ballot question was explained prior to voting. Colored slips of paper were used to represent different answer choices. After voting, discussion went question-by-question following the format: (i) reveal of results from voting activity and discussion on why participants voted as they did; (ii) reveal of preliminary results from cross-sectional survey and comparison to voting activity results; (iii) discussion on agreement or disagreement between FGD perceptions and survey results. FGDs culminated with open discussion on farmers’ questions or comments regarding the research. FGDs were facilitated in Spanish by the first author, with the help of the association leader, who provided Kichwa translation if necessary. FGDs lasted 1.5 - 2 hours. Each association was paid to cater refreshments for their FGD session, with the earned income dedicated to the association's communal fund. The association leader received $50 USD as compensation.

FGD results from the voting activity were counted and assessed using descriptive statistics. Discussion notes were taken by the first author (hand-written), then typed up and elaborated upon immediately following the discussion. Notes were then manually coded and assessed through an iterative qualitative thematic approach, using both directed and inductive categorization approaches (Hsieh and Shannon 2005). We began with a directed approach to categorize discussion contributions based on their relevance to the nine prompts from the voting activity (first column, Table 4). Once notes were organized into these nine directed categories, we used an inductive approach to identify themes that emerged within each category. All themes were noted, even if they were only expressed by one or a few participants. Themes that were reiterated extensively within and across the eight FGDs were highlighted for their importance. Finally, the identified themes were compared with the agriculture-nutrition pathways framework proposed by Herforth and Harris (2014) to explore implications of the

FGD data for plausible pathways between agroecology association participation and nutritional outcomes.

2.5 Statistical approach

All statistical analyses were conducted using SAS software, version 9.4 (Copyright © 2002-2012 SAS Institute Inc.). We first used bivariate analyses to compare survey results on the two farmer samples, as well as to explore associations between study variables and dietary outcomes. We then conducted path analysis to assess both direct effects and indirect effects of agroecology and other relevant covariates on dietary outcomes, as well as to explore plausible causal pathways. While numerous factors are likely to act on these pathways, we were parsimonious in our selection of which variables to include in order to respect the limits of our sample size. Drawing on our mixed methods design, we used three criteria to select variables for inclusion and to establish plausible path directionality in the hypothesized models: (i) theoretical plausibility based on existing literature, (ii) association ($p < 0.10$) with both agroecology participation and dietary outcomes in bivariate analyses, and (iii) supporting qualitative evidence from focus group discussions. Based on these criteria, we selected the following outcome variables: Dietary Diversity Score, Food Variety Score, caloric contribution to unprocessed or minimally processed foods (group 1 of the NOVA classification) and caloric contribution to processed culinary ingredients (group 2 of the NOVA classification). Covariates retained for path analysis included land amount in production, production diversity and non-market food consumption (bivariate associations are provided in Supplementary Tables 4 and 5). While some socioeconomic variables, namely education, showed associations with dietary variables, they were not included in the path analysis because they were not also associated with agroecology participation. Because FGDs produced evidence to suggest that agroecology participation impacts the amount of land that farmers dedicate to production, this variable is included downstream from agroecology participation, rather than as an exogenous covariate. Preliminary models were used to assess pathways between agroecology participation, land amount in production, production diversity, and food acquisition. The supported pathways were then applied in partial models for each dietary quality variable, and robust results were combined into a final model. This multi-step approach was used to conserve path analysis parameters. Bentler and Chou (1987) recommend having at least 5, but ideally 10 or more, observations per path analysis parameter. According to this recommendation, our sample size of 90 observations is sufficient, though not ideal, for accommodating the 13 parameters (i.e. variances, regression coefficients and covariances) produced by our path models. In order to test the strength of our models (i.e. minimize the probability of Type I and Type II errors), we assessed both Bentler's Comparative Fit Index (CFI; robust models > 0.95) and the Root Mean Square Error of Approximation (RMSEA; robust models < 0.06), as recommended by Hu and Bentler (1999). Path analysis was conducted using the SAS software "calis" procedure.

2.6 Ethics and consent

The study protocol was approved by the Health Research Ethical Committee of the *Université de Montréal* in Canada, certificate number 17-053-CERES-P, and by the Institutional Review Board of the *Universidad San Francisco de Quito* in Ecuador, certificate number 2016-118E. All participants gave informed verbal consent.

3. Results

3.1 Sociodemographic, land and production measures

Table 1 shows that agroecological farmers and reference neighbors were largely similar on sociodemographic characteristics, with no differences detected in market distance, income measures, education or household demographics. However, we identified differences in land and production variables. Agroecological farmers tended to utilize more land for production purposes, although still primarily under 3 hectares. Mean production diversity among agroecological farmers was 45 products, compared to 28 products among reference farmers. Importantly, this measure includes crops grown or livestock raised in very small quantities (e.g. one blackberry bush, one pig). Supplementary Table 2 shows the prevalence of each crop grown and livestock species raised, stratified by farmer group. Our sample size was too small to reliably detect whether there exists a difference in access to irrigation (power = 0.14).

Table 1: Sample description and comparison of agroecological and reference farmers on sociodemographic, land and production

	Population description of pooled sample (n=90)		Comparison by farmer category			
			Agroecological (n=60)		Reference (n=30)	
	mean [SD] or %	median (IQR)	mean [SD] or %	median (IQR)	mean [SD] or %	median (IQR)
Sociodemographics						
Age (years)	45 [13]	45 (37 - 52)	46 [13]	44.5 (37.5 - 53)	42 [13]	43.5 (34 - 49)
Household size	5.3 [2.6]	5 (4 - 6)	5.6 [2.7]	5 (4 - 6.5)	4.8 [2.3]	4 (3 - 6)
Monthly income per capita (USD)	91 [90]	67 (37 - 109)	87 [81]	61 (37 - 110)	100 [105]	84.5 (40 - 109
Poverty by income						
No poverty	42%		38%		50%	
Poverty	24%		27%		20%	
Extreme poverty	33%		35%		30%	
Household member receives the Human Development Bonus	42%		43%		40%	
Livelihood sources present in household						
Occasional or regular agricultural daily wage labor	27%		27%		27%	
Agricultural sales (excluding agroecological markets)	39%		37%		43%	
Other livelihood sources	72%		70%		77%	
Time to market (minutes)	47 [36]	40 (30 - 60)	49 [35]	37.5 (30 - 60)	43 [38]	43 (20 - 50)
Education completed by interviewee (% of sample)						
None or partial primary	44%		39%		53%	
Primary or partial secondary	38%		43%		30%	
Secondary or postsecondary	18%		18%		17%	
Land and production						
Access to irrigation (% of sample with access)	43%		47%		37%	
Land size in agricultural use (% of sample)						
<1 hectare	56%		45%		77%	
1 - 3 hectares	33%		42%		17%	
3 - 5 hectares	9%		12%		3%	

>5 hectares	2%		2%		3%	
Production diversity (products)	39 [17]	42 (27 - 51)	45 [15]	45.5 (36.5 - 54.5)	28 [14]	25 (17 - 41)
Intra-species production diversity						
Maize	4.8 [3.3]	4 (3 - 6)	5.5 [3.5]	5 (4 - 7)	3.3 [1.9]	3 (1 - 5)
Beans	6.8 [5.4]	5 (3 - 10)	7.9 [5.6]	6 (3 - 12)	4.5 [3.9]	3 (2 - 6)
Potatoes	3.4 [2.2]	3 (2 - 4)	3.8 [2.5]	3 (2 - 5)	2.4 [1.0]	2 (2 - 3)

For categorical variables, prevalence is shown as percentages. For continuous variables, both sample means [standard deviation] and median (interquart shown to describe variable distributions. P-values are for the difference between agroecological and reference farmers, which are compared using the cl student T-test or the U-test according to variable type and distribution. We applied the Satterthwaitte approximation to determine p-values when unequ a concern. For intra-species diversity, only farmers who produce the products in question are considered, giving an agroecological sample size of 56 for e products, and a reference sample size of 27, 26 and 27 for corn, beans and potatoes, respectively.

3.2 Food acquisition, dietary quality and health measures

As seen in Table 2, performance differed on food acquisition practices, several measures of dietary quality and health status between agroecological and reference farmers. Agroecological farmers spent less money on food purchases and obtained a greater proportion of their caloric intake from their own harvest and the social economy than did their reference neighbors. In turn, reference farmers obtained more of their caloric intake from conventional markets. Agroecological farmers out-performed reference farmers on all three measures of nutrient adequacy. On the day of the 24-hour recall, they reported consuming one additional food group on the ten food group Dietary Diversity Score, resulting in a probable nutrient adequacy (according to the dichotomous cut-off of the Dietary Diversity Score) of 85% among agroecological farmers, compared to 57% among reference farmers. Similarly, the Food Variety Score showed that agroecological farmers consumed three additional foods on the 24-hour recall. The two farmer groups also differed according to type and level of food processing in their diets, expressed by the NOVA food classification system. Agroecological farmers tended to consume a greater proportion of their caloric intake from foods that are unprocessed or minimally processed (NOVA 1) and they consumed a smaller proportion from processed culinary ingredients (NOVA 2). Agroecological and reference farmers shared similar histories of childhood stunting and Body Mass Indexes. However, agroecological farmers reported higher diagnosis of diet-related chronic disease (52% versus 33%, p=0.100). Our sample size for this variable provided a power of 0.40, which is insufficient to confidently determine whether there is a difference between the two groups.

Table 2: Sample description and comparison of agroecological and reference farmers on food acquisition practices, dietary quality an
variables

	Population description of pooled sample (n=90)		Comparison by farmer category			
			Agroecological (n=60)		Reference (n=30)	
	mean [SD] or %	median (IQR)	mean [SD] or %	median (IQR)	mean [SD] or %	median (IQR
Monthly food expenditure per capita (USD)	18 [18]	11 (7 - 20)	15 [16]	10 (6 - 20)	23 [21]	16 (8 - 30)
Food acquisition: proportion of calories acquired from diverse sources						
Conventional markets (%)	52 [27]	53 (32 - 70)	44 [23]	43 (27 - 59)	69 [25]	66 (55 - 93)
Harvest (%)	27 [24]	21 (6.5 - 48)	32 [24]	26 (10 - 56)	17 [19]	10 (0 - 33)
Social economy (%)	20 [24]	12 (0 - 31)	23 [24]	17 (6 - 34)	13 [23]	0 (0 - 16)
Dietary quality						
Nutrient adequacy						
Dietary Diversity Score (0–10 food groups)	5.6 [1.5]	5.5 (5 - 7)	5.9 [1.4]	6 (5 - 7)	4.8 [1.5]	5 (4 - 6)
Probable Nutrient Adequacy	76%		85%		57%	
Food Variety Score (total food items)	19 [5]	18 (16 - 23)	20 [5]	20 (17 - 24)	17 [5]	16.5 (13 - 19)
Dietary moderation						
NOVA 1 - unprocessed or minimally processed foods (%)	75 [14]	78 (69 - 85)	77 [12]	80 (70 - 86)	71 [17]	73 (61 - 82)
NOVA 2 - processed culinary ingredients (%)	13 [9]	11 (7 - 18)	12 [7]	10 (7 - 16)	16 [10]	15 (9 - 23)
NOVA 3 - processed foods (%)	9 [10]	7 (0 - 15)	9 [9]	8 (0 - 15)	10 [14]	5 (0 - 13)
NOVA 4 - ultra-processed foods (%)	2 [5]	0 (0 -3)	2 [3]	0 (0 - 3)	3 [7]	0 (0 - 2)
Health status						
Stunting history (adult height <145 cm)	32%		29%		37%	
Body Mass Index (kg/m-squared)	28.3 [4.0]	28.1 (25.3 - 30.8)	28.7 [4.3]	28.1 (25.4 - 31.6)	27.6 [3.5]	27.9 (25.2 - 29
Self-reported presence of diet-related noncommunicable disease (% of sample with at least one disease)	46%		52%		33%	

For categorical variables, prevalence is shown as percentages. For continuous variables, both sample means [standard deviation] and median (interquart
to describe variable distributions. P-values are for the difference between agroecological and reference farmers, which are compared using the chi-squa
test, or U-test according to variable type and distribution. We applied the Satterthwaitte approximation to determine p-values when unequal variances v
Probable Nutrient Adequacy is the percentage of the population achieving a Dietary Diversity Score of 5 or higher. Indicators of dietary moderation desc
of caloric intake obtained from each of four food processing groups established by the NOVA classification system. Sample size for stunting history and B
agroecological and conventional farmers, respectively.

Table 3 shows the consumption prevalence of the ten food groups assessed in the Dietary Diversity Score. Agroecological farmers were more likely to consume foods from the "dairy" and "other fruits" group, and possibly more likely to consume foods from the "pulses", "green leafy vegetables" and "other vegetables" groups.

Table 3: Consumption prevalence of dietary diversity food groups by agroecological and reference farmers

	Consumption prevalence		Comparison of farmer categories		
Food group	Agroecological	Reference	Odds ratio	95% CI	P-value
Grains, white roots and tubers, plantains	100%	100%	-	-	-
Pulses	68%	53%	1.888	0.768 - 4.645	0.1664
Nuts and seeds	10%	7%	1.556	0.295 - 8.215	0.6028
Dairy	48%	17%	4.677	1.580 - 13.849	0.0053
Meat	60%	50%	1.5	0.621 - 3.626	0.3679
Eggs	28%	27%	1.087	0.406 - 2.911	0.8679
Green leafy vegetables	27%	13%	2.364	0.713 - 7.833	0.1594
Other vitamin A-rich fruits and vegetables	73%	67%	1.375	0.531 - 3.557	0.5114
Other vegetables	95%	87%	2.923	0.610 - 14.011	0.1797
Other fruits	83%	63%	2.895	1.058 - 7.917	0.0384

Odds ratio not computed for the Grains food group because all observations have the same response.

3.3 Relationships between study variables

Relationships between dietary variables and other study variables are shown in Supplementary Table 4 (correlations between continuous variables) and Supplementary Table 5 (associations between categorical variables). We detected multiple, strong correlations among dietary quality variables; however, we found no correlation between dietary quality variables and Body Mass Index. Sociodemographic variables correlated to several dietary quality variables, but most correlations were small. The largest was between education completed and Food Variety Score ($R=0.36$, $p<0.01$).

3.4 Triangulation with agroecological farmers

Table 4 shows that agroecological farmers' perceived multiple differences between themselves and reference farmers, as elicited through the voting activity that commenced focus group discussions. Although they cast their votes prior to receiving information on survey results, their perceptions of differences and similarities generally mirrored those obtained in our quantitative measurements (Tables 1 and 2). For example, they predominantly perceived themselves to utilize more land for production, to have more diverse diets, to have greater production diversity and to spend less money on food, all of which were differences that were also detected through quantitative assessment. Also similar to survey results, a small majority perceived that overweight and obesity are equal among the two groups, and there was no consensus on prevalence of chronic disease. Additionally, 78% reported that their diet has changed in some way since joining the agroecological association.

Table 4. Agroecological farmer focus group discussion anonymous votes on key discussion questions, prior to result sharing

Discussion question	n	Answer choices		
		Agroecological farmers do	*Reference neighbors do*	*Equal / Unsure*
Who uses more land for agriculture and livestock?	112	56%	18%	26%
Who has a more diverse diet?	93	76%	12%	12%
Who produces more diversity on their farm?	123	76%	11%	13%
Who has more overweight or obesity?	106	16%	32%	52%
Who spends more money to buy food?	94	14%	67%	19%
Who eats more carbohydrates?	121	27%	33%	40%
Who eats more sugar or brown sugar?	111	31%	34%	35%
Who has more food-related illnesses, such as high blood pressure, high cholesterol, diabetes, heart disease or cancer?	121	25%	44%	31%
		Yes	*No*	*Unsure*
My diet has changed since I am part of the agroecological association	126	78%	10%	13%

Aggregate responses from eight focus group discussion sessions involving a total of 128 participants. Questions have different response numbers due to activity time limits and the self-directed nature of the activity. Reference farmers were described to agroecological farmers as "your farming neighbors who are not in an agroecology association."

3.5 Community consultation on pathways between agroecology and nutrition

Community consultation through focus group discussions (FGDs) with eight agroecological associations generated insights into participants' perceptions of the pathways between agroecology and nutrition. Key themes that emerged are shown in Table 5, and example quotations supporting each theme are provided in Supplementary Table 6.

Table 5: Key themes emerging from focus group discussions and implications for pathways between agroecology and nutrition

Discussion prompt	Key themes	Agroecology-nutrition pathway implications
Who uses more land for agriculture and livestock?	**Agroecological farmers do not own more land, but make better use of their land**	Agroecology participation impacts land area in production
	Agroecological farmers rent or borrow additional land for use	
	Agroecological farmers own less land	
	Non-agroecological farmers use less land	
Who has a more diverse diet?	**Agroecological farmers have more dietary diversity because they barter in the agroecological market**	Social capital impacts dietary diversity
	Agroecological farmers have more dietary diversity because they consume from the diversity of their own production	Production diversity impacts dietary diversity
	Agroecological farmers have a more varied diet because they cook at home	
Who produces more diversity on their farm?	**Agroecological farmers have more production diversity because agroecological associations promote seed exchange and teach about production diversity**	Agroecology participation impacts production diversity
	Increased production diversity is the result of external assistance that promotes agroecology	
	Non-agroecological farmers have equal amounts of diversity	
Who has more overweight or obesity?	**Overweight levels are the same due to similar excesses**	N/A
	Overweight levels are the same, despite different diets	

	Agroecological farmers are more overweight because their food is tastier	
	Agroecological farmers are less overweight because they purchase fewer foods and are more aware of healthy eating habits	
	Agroecology leads to weight loss	
Who spends more money to buy food?	**By increasing production quantity and diversity, agroecological farmers reduce food expenditures**	Increased production diversity may reduce income spent on food
	Food expenditures depend on access to land for production	
	Buying from supermarkets is perceived negatively	
Who eats more carbohydrates?	Non-agroecological farmers consume more carbohydrates because of lack of production diversity	No clear linkage
	Agroecological farmers consume more carbohydrates because they produce them	
Who eats more sugar, brown sugar or raw cane sugar?	Consumption of sugar and salt has decreased with increased awareness	No clear linkage
	Non-agroecological farmers consume more sugar due to lack of awareness	
	Perception that raw cane sugar does not count as sugar	
Who has more food-related illnesses, such as high blood pressure, high cholesterol, diabetes, heart disease or cancer?	**Farmers join the agroecological association to mitigate disease**	Disease impacts agroecology participation
	Agroecological farmers have more disease because they have less time to eat healthy	Agroecology participation impacts disease
	Agroecological farmers have less disease because they do not use pesticides	
	Disease levels are the same, because agroecology is still new	
My diet has changed since I am part of the agroecological association	**Agroecology has increased awareness to improve food practices by increasing diversity, reducing processed foods, and eating more fruits and vegetables.**	Agroecological association generates social capital that impacts knowledge around food and impacts dietary practices
	Relationships formed in agroecological market introduce farmers to new foods	
	Agroecology promotes producing more for own consumption, leading to dietary change	Agroecology participation impacts consumption of own production

	Diet has not changed, because always had healthy eating traditions
	The struggle for healthy foods creates community around healthy lifestyles
	Diet has not changed, even with increased awareness of healthy diets

Key themes emerged from eight focus group discussions with a total of 128 farmers participating in agroecological associations. Themes that appeared to have strongest agreement are in bold, and implications for agroecology-nutrition pathways are based on these themes.

Discussion participants emphasized the importance of their agroecology association in enabling agricultural diversity, consumption of own-production and participation in the social economy, all of which they saw as key to providing access to a diverse diet. One farmer explained that "In my family, there are two types of diversity. Bartering is interesting for increasing both diversity on the farm and diversity in our food. We diversify our food through our connection with the agroecological association." In another FGD, a farmer described her experience: "Before, all I had was one type of potato, one type of corn. But now I have many varieties. Thanks to the agroecological association, I learned to grow this way. Before, all I had was five different products. Now, after four years of being in the agroecology association, I have something like 45 products."

When presented with survey results showing that agroecological farmers utilize more land in production than do reference farmers, FGD participants clarified that this is not a result of greater ownership of land. They instead explained that this is a reflection of the value they place on agriculture as a livelihood strategy, leading them to expand by renting land or putting marginal lands into agricultural use. One farmer summarized that "Agroecological farmers own the same amount of land in the papers, we do not own more. But we use more land to produce because we rent it from others, or we use more of the land that we own for production."

Community consultation provided opportunity to further explore the quantitative result that overweight is similar between the two groups. Some farmers contend that they have lost weight or otherwise improved their health since joining agroecology, such as one who explains: "Our ancestors ate well. But now we are eating modern foods. Sodas, noodles. We acquired many diseases. Personally, I gained weight, I have diabetes, my eyesight is bad. And all of this happened because of a poor diet.

But now I have recovered quite a lot. I'm much better. I've improved my dietary habits ever since joining the process of the agroecological market." Others perceive that the difference between themselves and reference farmers is not in their weight, but in the causes of overweight. As one farmer explains, "Conventional farmers are overweight because they eat more fats and sugars and junk food, but agroecological farmers are overweight because we eat more quantity - healthier foods, but in bigger quantities." Or, as another farmer contends, "We have fresh products, which makes them more flavorful. When you cook tastier, you eat more."

Agroecological farmers did not perceive that they had higher prevalence of chronic disease (Table 4), even though survey results on this variable (Table 2) suggest that they might (p=0.100). Farmers offered multiple explanations to reconcile these findings. One woman reported, "I joined agroecology because of my health situation, and I know of others who did the same." In other FGDs, similar explanations were offered to suggest that chronic disease prevalence may be higher among agroecological farmers because some farmers specifically turned to agroecology as a means to mitigate existing health conditions. Farmers participating in FGDs also express that a strong devotion to caring for health is present within their association. One farmer's statement resonates with her group when she states that "Here in this group, we are in this fight together, to live better, to live more healthily."

3.6 Path analysis on agriculture-nutrition linkages

Relationships between variables that were identified from survey results (Supplementary Table 4 and Supplementary Table 5) and from focus group discussions (Table 5) supported our choice of variables to include in path analysis. Preliminary analysis of non-dietary quality variables (Supplementary Table 7) established the path order for agroecology participation, land amount in production, production diversity and non-market food consumption. Notably, our data did not produce strong evidence to suggest that production diversity is upstream from non-market food consumption, even when only assessing its effects on consumption from own harvest (standardized path estimate = 0.14, p = 0.18). Table 6 shows that the resulting analyses produced robust models, as determined by the strength of the fit statistics (RMSEA and CFI), to support probable paths connecting agroecology participation to Dietary Diversity Score, Food Variety Score and dietary share from NOVA group 2, but not to NOVA group 1.

Table 6: Path estimates between agroecology and dietary outcomes

Pathway		Path estimate [SE]	Standardized path estimate [SE]	p-value
Effects on Dietary Diversity Score				
	Agroecology participation	0.85 [0.40]	0.26 [0.12]	0.029
	Production Diversity	0.02 [0.01]	0.19 [0.11]	0.094
	Non-market food consumption	0.00 [0.01]	-0.04 [0.12]	0.732
	Land amount in production	-0.05 [0.22]	-0.02 [0.10]	0.833
	R-square	0.14		
Effects on Food Variety Score				
	Agroecology participation	1.2 [1.4]	0.11 [0.12]	0.385
	Production Diversity	0.09 [0.04]	0.28 [0.11]	0.010
	Non-market food consumption	0.03 [0.02]	0.15 [0.11]	0.194
	Land amount in production	-0.25 [0.76]	-0.03 [0.10]	0.746
	R-square	0.17		
Effects on NOVA 1 (dietary share from unprocessed and minimally processed foods)				
	Agroecology participation	3.47 [3.71]	0.12 [0.13]	0.348
	Production Diversity	0.08 [0.10]	0.10 [0.12]	0.385
	Non-market food consumption	0.06 [0.06]	0.12 [0.12]	0.320
	Land amount in production	-0.54 [2.02]	-0.03 [0.11]	0.789
	R-square	0.07		
Effects on NOVA 2 (dietary share from processed culinary ingredients)				
	Agroecology participation	-1.42 [2.24]	-0.08 [0.12]	0.526
	Production Diversity	-0.07 [0.06]	-0.13 [0.11]	0.260
	Non-market food consumption	-0.09 [0.04]	-0.27 [0.11]	0.015
	Land amount in production	0.53 [1.22]	0.05 [0.11]	0.666
	R-square	0.13		
Effects on Production Diversity				
	Agroecology participation	17.43 [3.20]	0.50 [0.08]	0.000
	R-square	0.25		
Effects on Non-market food consumption				
	Agroecology participation	20.95 [5.25]	0.37 [0.09]	0.000
	Land amount in production	10.52 [3.32]	0.29 [0.09]	0.001

R-square	0.27		
Effects on Land amount in production			
Agroecology participation	0.367 [0.16]	0.23 [0.10]	0.021
R-square	0.05		

Four path analysis models were used to assess agroecology's direct and indirect effects on each dietary variable (Dietary Diversity Score, Food Variety Score, NOVA 1 and NOVA 2) as mediated by production diversity, non-market food consumption and land amount in production. All models produced robust fit statistics (root mean square error approximation = 0.000, adjusted goodness of fit > 0.9). Agroecology participation is a dichotomous dummy variable (0 = reference, 1 = agroecological), production diversity is a continuous variable representing the number of species on the farm, non-market food consumption is a percentage of total caloric intake (expressed as 0 to 100), and land amount in production is an ordinal variable (1 = <1 hectare, 2 = 1-3 hectares, 3 = 3-5 hectares, 4 = >5 hectares). Path estimate coefficients and standardized path estimate coefficients are shown with standard error [SE] in brackets.

Figure 2 depicts the combined model of probable pathways detected between agroecology and dietary outcomes. Similar to the perceptions of farmers expressed in FGDs, path analysis produced a path running from agroecological farming to higher production diversity and finally to both higher individual Dietary Diversity Score and Food Variety Score. Unlike farmers' perceptions, non-market food consumption (from own harvest and from the social economy) did not produce a pathway to either Dietary Diversity Score or Food Variety Score. Instead, it produced a negative effect on dietary share from processed culinary ingredients (NOVA group 2). Agroecological participation also had a direct (i.e. not passing through other variables) positive effect on Dietary Diversity Score, which may be indicative of other factors that we were not able to assess quantitatively. For example, focus group discussions point to social capital created in agroecological associations, but we did not include this in path analysis because we did not have an appropriate quantitative variable.

Figure 2: Diagram of combined pathways between agroecology and dietary outcomes

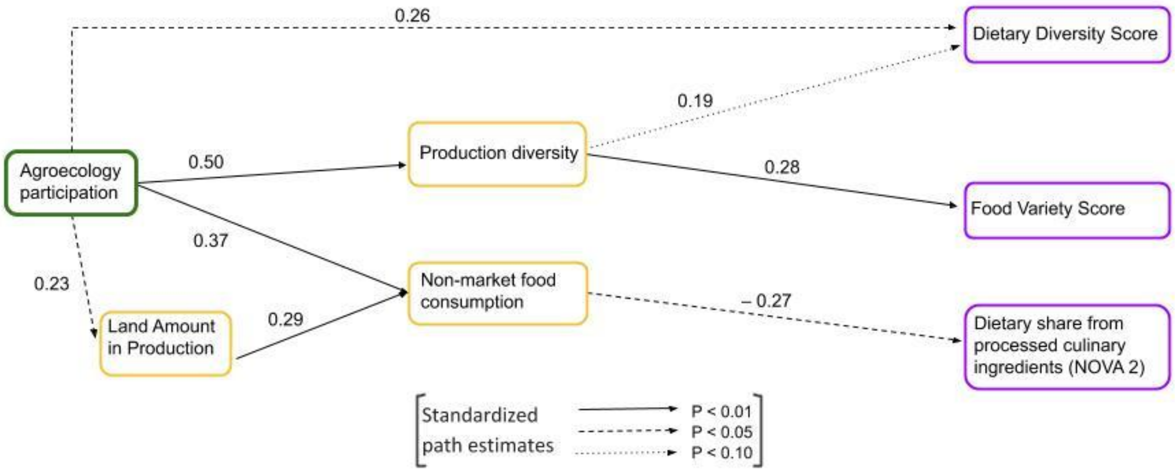


Figure shows standardized path estimates for variables acting directly or indirectly on dietary outcomes. Dotted lines, dashed lines and solid lines indicate significance levels at 10%, 5% and 1% respectively.

4. Discussion

4.1 Agroecology and dietary health

In Ecuador's highland Imbabura province, it appears that agroecology is not only a farmers' movement promoting environmentally sustainable production (Francis et al. 2003; FAO 2018; HLPE 2019), but participating in agroecological alterative food networks may also be a path for smallholder farmers living in marginalized communities to achieve healthier nutritional outcomes. In a comparison of farmers who participated in agroecological associations ("agroecological farmers") and their neighbors ("reference farmers") who were not involved with agroecology, we found that agroecological farmers performed better on multiple dietary quality measures. Not only did they outperform reference farmers on all measures of nutrient adequacy (i.e. meeting key nutrient needs), but they also did so on two measures of dietary moderation (i.e. avoiding harmful nutrient excesses).

4.1.1 Dietary nutrient adequacy

With respect to dietary nutrient adequacy, the consistently stronger performance of agroecological farmers across multiple dietary diversity measures indicates a greater likelihood of meeting critical nutrient needs (Ruel 2003) and of consuming beneficial secondary metabolites. These outcomes are pertinent considering that dietary intake of iron, vitamin A and zinc is reported to be insufficient in 83%, 77%, and 42% of Ecuador's population respectively, and nutrient deficiencies are even higher in many rural Indigenous communities such as those of our study region (Freire, Ramírez, and Belmont 2015). Moreover, inadequate nutrient intake is implicated in Imbabura province's stunting rate of 35% among children under 5 years old (Freire, Ramírez, and Belmont 2015). In this region, food is customarily distributed equitably across the family (Berti, Leonard, and Berti 1997; Oyarzun et al. 2013), making it is plausible that men and children in the households of agroecological women would also have diets that more adequately meet their nutrient needs.

4.1.2 Dietary moderation

Unlike results found in Guatemala (Lee et al. 2010) and among Indigenous Malaysians (Saibul et al. 2009), we did not find dietary diversity to be associated with higher Body Mass Index, suggesting that our study population's dietary patterns that curtail nutrient deficiencies are likely not contributing to overweight and obesity. Our comparison of agroecological and reference farmers on level of food processing in their diets (NOVA classification) found that agroecological farmers had healthier patterns with respect to dietary moderation. Specifically, they consumed more of their dietary share from unprocessed and minimally processed foods (such as fruits, vegetables and grains), and less of their dietary share from processed culinary ingredients (such as sugars and oils). This eating pattern of fewer processed foods has been described to promote healthier weight and reduce risk of diet-related chronic diseases (WHO 2018).

Even so, we found that both agroecological and reference farmers had an equally high prevalence of overweight and obesity of 80%, which is comparable to nationally representative data for women in the age group that is most represented in our sample[33] (Freire, Ramírez, and Belmont 2015). Although agroecological farmers in focus group discussions were unsurprised by this finding, some saw it as a failure of their efforts to instigate sufficient dietary change regarding moderation of excesses. Their assessment is likely too harsh, given the body of evidence suggesting that overweight is more than a

[33] Women in our study population had a median age of 45 (IQR 37 - 52). Nationally, women aged 40 to 49 have a 77.2% prevalence of overweight and obesity (Freire, Ramírez, and Belmont 2015).

reflection of current diet, but also a complex problem related to diet in the life course, socio-biological responses to stress, childhood malnutrition, and epigenetic as well as intergenerational factors (Davis, Stange, and Horwitz 2012; Black et al. 2013; Gluckman and Hanson 2008). It is therefore unsurprising that advances in dietary moderation are not directly reflected in body weight.

We were, however, initially surprised to find that agroecological farmers were slightly more likely to self-report that they were diagnosed with a diet-related chronic disease. Yet in focus groups, most farmers contested this finding. The minority that did agree with it explained that the added workload of agroecological farming and selling at agroecological markets undermined their efforts toward a healthy lifestyle. This explanation is consistent with findings elsewhere that women's time and work load impact dietary quality (Malapit and Quisumbing 2015). On the other hand, multiple farmers reported that they had joined agroecology specifically with the hope of mitigating pre-existing conditions, potentially inflating the prevalence of chronic disease. Moreover, the focus on health and well-being in the discourse of agroecological associations could presumably unite farmers who are more likely to visit medical professionals and therefore discover latent chronic diseases. These findings point to a need for further exploration of social dynamics in agroecological associations that may differentially impact dietary knowledge generation, women's empowerment or decisions related to health care.

4.2 Pathways to dietary differences

A second objective of our study was to understand what pathways may link participation in agroecological associations to specific dietary outcomes. Our results suggest that agroecological farmers' higher production diversity and higher consumption of non-market foods are likely implicated on the pathway to healthier dietary quality, with the former associated with dietary adequacy, and the latter with dietary moderation. This finding is consistent with previously established pathways that highlight the importance of production diversity and consumption of own production in linking agricultural practices to nutritional outcomes (Herforth and Harris 2014; Jones 2017). Yet unlike this previous work, we did not detect income to play a role in food access. Instead, we found that agroecological farmers spent less money on food and achieved stronger nutritional outcomes, despite equivalent socioeconomic factors. Our results further indicate that social factors consolidated through participation in agroecological associations might mediate interactions with nutritional health. Just as agroecology is defined by social dynamics that go beyond farming techniques (Wezel et al. 2009; HLPE 2019), its pathways to nutrition may also transcend agricultural practices.

4.2.1 Production diversity

Agroecological farmers in our study had 61% higher production diversity than their counterparts, and production diversity was positively associated with both indicators of dietary diversity that we assessed in path analyses. As in previous work on relationships between production diversity and dietary diversity in highland Ecuador (Oyarzun et al. 2013; Melby et al. 2020) and in numerous other contexts (Jones 2017), the relationship detected was mild. Even so, agroecological farmers in focus group discussions consistently and emphatically related how diversity on their farms begets diversity in their meals. This disparity may signal a need to re-evaluate the way that the relationship between production diversity and dietary diversity is typically assessed. Our item-based production diversity score had a stronger relationship to the item-based Food Variety Score than to the group-based Dietary Diversity Score. Berti (2015) explains why this is to be expected[34], and how the use of different measurements can affect our understanding of the relationship between production diversity and dietary diversity. However, we believe another measurement issue may be an inconsistency in temporal scale, wherein production diversity was assessed for the entire year while dietary diversity was assessed for a single day. Given that products harvested in a specific season are not usually available for year-round consumption, this might explain why farmers perceived production diversity to be more important than what we detected in path analysis.

4.2.2 Consumption from non-market food sources

[34] Berti provides the useful example that growing rice, corn and barley would increase production diversity by three, but would only increase food group-based dietary diversity by one (i.e. cereals). Conversely, raising chickens increases production diversity by one, but contributes to two food groups in dietary diversity (i.e. meat and eggs) (Berti 2015).

Compared to their reference neighbors, we found agroecological farmers to consume nearly double the proportion of their caloric intake from non-market food sources, including foods from own harvest and social economy. This, in turn, was associated with healthier dietary moderation, but not to dietary adequacy. The latter may be because our food acquisition source measure was based on calories, but certain nutrient-rich foods that contribute to dietary diversity (e.g. leafy greens) make negligible caloric contributions, thus occulting possible relationships. Further analysis is necessary to understand the specific nutrient or food group contributions of distinct food sources. In focus group discussions, farmers contended that harvest and barter give them access to healthy foods, whereas markets enabled the purchase of unhealthy foods. Their observations coincide with global evidence that the transition from consuming foods acquired through traditional means toward consuming foods purchased in markets is implicated in overweight and diet-related chronic disease (Popkin 2014; PAHO 2015).

In assessing the pathway leading to non-market food consumption, we found that dedicating more land to production enabled higher consumption of foods from own harvest, mirroring previous findings in the Ecuadorian highlands (Oyarzun et al. 2013). Yet defying predominant agriculture-nutrition linkage frameworks (Herforth and Harris 2014), as well as the expectations expressed by farmers during community consultation, production diversity did not clearly mediate the caloric share of foods consumed from own harvest. Any potential relationship may also have been occulted by the calorie-based nature of our food acquisition measurement, given that certain foods obtained from diverse production may make minimal caloric contributions. Another explanation may relate to the relatively high production diversity in the Ecuadorian highlands, shown by our data as well as by others (Oyarzun et al. 2013; Melby et al. 2020). It is possible that such a relationship is not evident because it is not linear; there may be diminishing returns to own consumption after a certain threshold of production diversity.

4.2.3 Income and other socioeconomic factors

In our study region, we did not find support to suggest that agroecology would impact diets through an income pathway. Although agroecological associations hold their own markets for the direct sale of agroecological products, farmers did not perceive these markets to increase their incomes, and some even expressed that agroecology led them to make economic sacrifices. This was mirrored by our socioeconomic measurements, which found no difference between agroecological and reference farmers on income, education or other related variables. Across the two samples 57% lived in poverty or extreme poverty, and 44% did not complete a primary school education. Agroecological farmers had more nutrient-rich diets despite these socioeconomic circumstances, leading us to believe that such factors were not driving dietary differences.

Although agroecology did not generate additional income for Imbabura's farmers, it may alter the use of income. We found that agroecological farmers spent about 35% less money on food purchases than reference farmers, which they proudly explained to be because they acquire more foods from their own harvest and through barter. While higher food expenditures are usually expected to improve intake of nutrient-rich foods (Smith, El Obeid, and Jensen 2000; FAO, IFAD, and WFP 2015; Herforth and Harris 2014), agroecological farmers achieve stronger nutrient intake while spending less money.

4.2.4 Social environment

Our queries in community consultation with agroecological farmers focused on production, diet and health, with no questions asking about social dynamics. However, farmers consistently drove discussion in that direction, expressing that agroecological associations are spaces that strengthen shared values around production and food. Values that resonated fervently were the promotion of production diversity, participation in barter and consumption of own harvest. Farmers further recounted that their associations increased their knowledge around food and uniquely enabled exchange relationships for the barter of seed to increase production diversity as well as foods to increase dietary diversity. Some even spoke of agroecology as a communal space to "fight" for healthy lifestyles and exert cultural vitality. Such complex social dynamics have been previously observed among agroecological networks in Ecuador (Deaconu, Mercille, and Batal 2019; Sherwood et al. 2013) and elsewhere (Wezel et al. 2009). Our findings specifically show how agroecology's social capital (i.e. interactions) translates to both human capital (i.e. knowledge) and material goods (i.e. seeds, food products) that can support healthy diets. Doing so, our results support previous assertions that agroecological social capital has the potential to incubate fertile spaces for the co-creation of knowledge with potential to impact nutritional health (HLPE 2019; Deaconu, Mercille, and Batal 2019). Nutrition knowledge in particular has been recognized as fundamental for agriculture initiatives to achieve improvements in nutrient intake (Berti, Krasevec, and FitzGerald 2004), but making meaningful and lasting contributions to nutrition knowledge generally requires intensive and continuous investments (Murimi et al. 2017). That such attention to food is being integrated into agroecology-based social norms and values is promising, as it may create an endogenous venue for farmer-to-farmer dissemination of nutritional knowledge and healthy food practices.

While community consultation made it clear that social capital has a place in pathways between agroecology and nutrition, our quantitative data was unfortunately not prepared to capture such complexity. Although our previous qualitative research signaled the importance of social capital (Deaconu, Mercille, and Batal 2019), we were unable to identify an appropriate method to assess it quantitatively. Our path analysis was, however, able to identify that agroecology exhibited direct effects on one dietary quality measure without passing through other mediators. Possibly, this observed linkage may be reflecting the role of social capital. Specifically, agroecology's direct positive effects on Dietary Diversity Score, a measure of nutrient adequacy, may reflect knowledge of the importance of consuming certain nutrient-rich foods, thereby contributing to agroecological farmers' higher consumption prevalence of dairy and fruit and perhaps dark green leafy vegetables. Further inquiry, including both qualitative methods and perhaps quantitative assessment through social network analysis (Valente and Pitts 2017), may highlight the health-promoting social mechanisms at play.

4.3 Reflections on methodology

In this mixed methods study, we aimed to give equal weight to qualitative and quantitative findings, with the understanding that both have advantages as well as limitations. In our qualitative work, focus group discussions with agroecological farmers were susceptible to subjective biases, as farmers were asked to compare themselves to a perceived "other." However, these discussions produced unique insights that would otherwise have eluded us, such as how women's time may impact dietary moderation. Integration of mixed methods also allowed us to identify new concerns with how the relationship between production diversity and dietary diversity is assessed. We suggest that future researchers assess diet and the foods available from production diversity on the same time-scale (e.g. "What have you recently harvested or what are you currently producing that could be utilized today?").

Our sample size limited the number of variables that we could include in path analysis models and also limited the power for detecting potential differences between agroecological and reference farmers on certain variables. Nevertheless, our analysis was strengthened by the fact that the two groups of randomly selected farmers were almost perfectly matched on sociodemographic factors, allowing for a strong understanding of nutritional correlates of production practices even with a relatively small sample size. Further, the use of mixed methods informed by prior exploratory research (Deaconu, Mercille, and Batal 2019) allowed us to carefully select variables for inclusion in models as well as reduce the risk of statistical false positives.

Path analysis is useful for exploring causality, but it cannot definitively establish it (Streiner 2005). It may be that farmers with particular dietary patterns are more likely to join agroecological associations. However, changing the order of our path analysis produced poor model fits, suggesting that alternative directions of causality are unlikely. This is further supported by community consultation, in which farmers made recurrent mentions of "before" and "after" joining their agroecological association and suggested causal mechanisms in their explanations of their own perceived dietary change. Such community consultation not only helped to establish likely directionality of the pathways between agroecology and nutritional health, but it also revealed the complexities in these pathways, as exemplified in the finding that poor nutritional health may have motivated some farmers to join their agroecological association.

Finally, our study was a measure of agroecological participation, but beyond production diversity it did not capture farmers' adherence to the numerous farming practices that local agroecology networks promote, and it lacked a quantitative measure of social capital despite the importance of this variable. Exploring specific farming practices as well as social capital among farmers who do and do not participate in agroecological networks may enhance our understanding of relevant agriculture-nutrition linkages.

4. Policy implications

In 2018, Ecuador's Ministry of Health worked with the Ministry of Agriculture and other entities to develop a new national food guide to serve as a beacon for national policy. The product of this collaboration drew ties between nutritional health, environmentally sustainable agriculture and economically just value chains, recognizing that food consumption is inextricable from other food sectors (MSP and FAO 2018). This example is congruent with international calls for integrated, multisectoral actions to bridge the gap between agriculture and food (Gillespie et al. 2019). As Ecuador and other countries seek practical and just ways to unite sustainable production and dietary health, Imbabura province's agroecology-based alternative food networks provide an existing example. The lessons of this experience may be particularly ripe because agroecology in the area did not begin with explicit nutritional objectives (Intriago et al. 2017; Deaconu, Mercille, and Batal 2019) and it is a "policy" that resulted primarily from an amalgamation of civil society initiatives rather than a coordinated national or institutional effort (Sherwood, Van Bommel, and Paredes 2016).

The uniquely high production diversity documented on Imbabura's agroecological farms also illustrates how investments in agroecology may simultaneously contribute to ecosystem regeneration and resilience (HLPE 2019; Frison and IPES-Food 2016). From an economic perspective, Imbabura farmers show that they can increase their intake of nutrient-rich foods while reducing their food expenditures. This empirically observed nexus between nutrition, environmental health, and economic access makes agroecology an exciting option for policy makers to continue to explore, both in Ecuador and elsewhere. The traction that agroecology has gained among the rural poor (Altieri and Toledo 2011; HLPE 2019) may make it particularly effective. As Sherwood and colleagues state, "any scientific orientation requires an endorsement from peoples' grounded realities" (2013). Inter-sectoral initiatives may thus operationalize the linkages between agroecology and nutritional health by implementing policies that facilitate the creation and strengthening of agroecology-based alternative food networks. In Ecuador's case, policy environments that have enabled agroecology include the confluence of national and provincial decrees promoting the Indigenous vision of *Sumak Kawsay*, or "living well," sustainable production, social and solidarity based economies, and food sovereignty (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017).

5. Summary and concluding remarks

While agroecology is relatively new to Imbabura province (Deaconu, Mercille, and Batal 2019; Heifer 2014), our data empirically demonstrate that farmers participating in agroecology-based alternative food networks have higher diversity on the farm as well as higher diversity on their plates. Moreover, agroecological farmers' associations that were created to support economic justice also seem to act as health-enabling social environments. Our analyses specifically suggest that participating in agroecology in Ecuador's Imbabura province: (i) promotes adequate nutrient intake through increased production diversity; (ii) creates a health-enabling social environment; and, (iii) supports dietary moderation by increasing consumption of unprocessed or minimally processed foods from own-harvest and barter and reducing consumption of processed foods from conventional markets.

Doing so, our findings corroborate previous literature positing that agroecology should theoretically be associated with higher likelihood of meeting nutrient needs (Gliessman and Tittonell 2015; HLPE 2019; Deaconu, Mercille, and Batal 2019) and also shed light on linkages between agriculture and dietary moderation. The latter has not received sufficient attention (Popkin 2014), despite a pressing need in rural contexts where diet-related chronic diseases are becoming a paramount concern among populations that are still experiencing nutrient inadequacies (Freire et al. 2014; NCD RisC 2019), and as these chronic diseases are recognized as major risk factors for severity of infectious disease such as COVID-19 (Kimball et al. 2020). The association we identified between consumption of non-market foods and dietary moderation opens a path for future exploration. In particular, non-market food acquisition practices may help support diverse, predominantly plant-based diets, which may be key to managing diet-related chronic diseases (Tuso et al. 2013). Finally, our findings concur with other research in Ecuador that social action can act as a resource for health, particularly through the interface of knowledge, actors and social spaces (Sherwood et al. 2013; Sherwood, Van Bommel, and Paredes 2016; Deaconu, Mercille, and Batal 2019). In this sense, the social actions embodied in Imbabura’s agroecology associations may prove to be an especially compelling resource.

Data availability: The datasets analyzed during the current study are available from the corresponding author on reasonable request.

CReDiT author contribution statement

Ana Deaconu: Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Writing - original draft. Peter R. Berti: Conceptualization, Methodology. Donald C. Cole: Methodology. Geneviève Mercille: Supervision. Malek Batal: Supervision, Conceptualization, Methodology.

Acknowledgement

We foremost wish to acknowledge the study participants and farmers' association leaders, who generously offered their time and knowledge, and believed in the goals of this research. We further thank EkoRural Foundation and the Ekomer research team, whose members include: Stephen Sherwood, Myriam Paredes, Sara Latorre, Bana Salameh, Kate Zinszer, Fabián Muñoz, Pablo López, Ross Borja, Pedro Oyarzún, Gabriel April-Lalonde, Marcelo Aizaga, Eliana Estrella, as well as AD, PRB, DCC and MB. We also thank Leonardo Velasco for his diligent support in data collection, as well as Michelle O. Fried and Eduar Pinzón for their advice and general support.

Funding

Data collection, analysis and manuscript writing was carried out by the EKOMER Research Consortium, with the aid of a grant from the International Development Research Centre, Ottawa, Canada. The views expressed herein do not necessarily represent those of IDRC or its Board of Governors [Grant number CR-48490;]. The project further received publication support from the Canadian Institutes of Health Research [Grant number HA1-164002] and from IDRC [Grant number 109101-001] as part of the Global Alliance for Chronic Disease. The first author received general support from the Fonds de Recherche du Québec en Santé [Grant number 262314] and from the Université de Montréal Faculty of Medicine, as well as support for results dissemination from the Quebec Population Health Research Network. MB is supported by the Canada Research Chair program.

Appendix A. Supplementary material

Supplementary data to this article can be found online at

https://doi.org/10.1016/j.foodpol.2021.102034

References

Altieri, Miguel A, and Victor Manuel Toledo. 2011. “The Agroecological Revolution in Latin America: Rescuing Nature, Ensuring Food Sovereignty and Empowering Peasants.” *Journal of Peasant Studies* 38 (3): 587–612.

Bentler, Peter M, and Chih-Ping Chou. 1987. “Practical Issues in Structural Modeling.” *Sociological Methods & Research* 16 (1): 78–117.

Berti, Peter R. 2015. “Relationship between Production Diversity and Dietary Diversity Depends on How Number of Foods Is Counted.” *Proceedings of the National Academy of Sciences* 112 (42): E5656–E5656. https://doi.org/10.1073/pnas.1517006112.

Berti, Peter R, Julia Krasevec, and Sian FitzGerald. 2004. “A Review of the Effectiveness of Agriculture Interventions in Improving Nutrition Outcomes.” *Public Health Nutrition* 7 (5): 599–609.

Berti, Peter R, William R Leonard, and Wilma J Berti. 1997. “Malnutrition in Rural Highland Ecuador: The Importance of Intrahousehold Food Distribution, Diet Composition, and Nutrient Requirements.” *Food and Nutrition Bulletin* 18 (4): 1–11.

Black, Robert E, Cesar G Victora, Susan P Walker, Zulfiqar A Bhutta, Parul Christian, Mercedes De Onis, Majid Ezzati, Sally Grantham-McGregor, Joanne Katz, and Reynaldo Martorell. 2013. “Maternal and Child Undernutrition and Overweight in Low-Income and Middle-Income Countries.” *The Lancet* 382 (9890): 427–51.

Brassel, Frank, Stalin Herrera, Michel Laforge, and SIPAE, eds. 2008. *¿Reforma Agraria En El Ecuador? Viejos Temas, Nuevos Argumentos*. Quito, Ecuador: Sistema de Investigación sobre la Problemática Agraria en el Ecuador.

Burlingame, Barbara, and Sandro Dernini. 2012. “Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action.” In *Proceedings of the International Scientific Symposium BIODIVERSITY AND SUSTAINABLE DIETS UNITED AGAINST HUNGER*. FAO Headquarters, Rome: Food and Agriculture Organization of the United Nations (FAO).

Cole, Donald C., Fernando Carpio, and Ninfa León. 2000. "Economic Burden of Illness from Pesticide Poisonings in Highland Ecuador." *Revista Panamericana de Salud Pública* 8 (3): 196–201. https://doi.org/10.1590/S1020-49892000000800007.

Colucci, Erminia. 2007. "'Focus Groups Can Be Fun': The Use of Activity-Oriented Questions in Focus Group Discussions." *Qualitative Health Research* 17 (10): 1422–33. https://doi.org/10.1177/1049732307308129.

Contreras Díaz, Jackeline, Myriam Paredes Chauca, and Sandra Turbay Ceballos. 2017. "Circuitos Cortos de Comercialización Agroecológica En El Ecuador." *Idesia (Arica)* 35 (3): 71–80.

Cook, Seth. 2018. "The Spice of Life: The Fundamental Role of Diversity on the Farm and on the Plate." Discussion Paper. London and The Hague: IIED and Hivos.

Cornwall, Andrea, and Rachel Jewkes. 1995. "What Is Participatory Research?" *Social Science & Medicine* 41 (12): 1667–76.

Creswell, John W. 2009. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 3rd ed. Thousand Oaks, Calif: Sage Publications.

Davis, Esa M, Kurt C Stange, and Ralph I Horwitz. 2012. "Childbearing, Stress and Obesity Disparities in Women: A Public Health Perspective." *Maternal and Child Health Journal* 16 (1): 109–18.

Deaconu, Ana, Geneviève Mercille, and Malek Batal. 2019. "The Agroecological Farmer's Pathways from Agriculture to Nutrition: A Practice-Based Case from Ecuador's Highlands." *Ecology of Food and Nutrition* 58 (2): 142–65.

Egert, Sarah, and Gerald Rimbach. 2011. "Which Sources of Flavonoids: Complex Diets or Dietary Supplements?" *Advances in Nutrition* 2 (1): 8–14. https://doi.org/10.3945/an.110.000026.

FAO, ed. 2014. *Innovation in Family Farming*. The State of Food and Agriculture 2014. Rome.

———. 2018. "FAO's Work on Agroecology: A Pathway to Achieving the SDGs." Rome: FAO. http://www.fao.org/3/I9021EN/i9021en.pdf.

FAO, and FHI 360. 2016. "Minimum Dietary Diversity for Women: A Guide for Measurement. 2016." Rome: FAO.

FAO, IFAD, and WFP. 2015. "The State of Food Insecurity in the World 2015: Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress. Rome: FAO, 2015." http://www.fao.org/3/a-i4646e.pdf.

Francis, C., G. Lieblein, S. Gliessman, T. A. Breland, N. Creamer, R. Harwood, L. Salomonsson, et al. 2003. “Agroecology: The Ecology of Food Systems.” *Journal of Sustainable Agriculture* 22 (3): 99–118. https://doi.org/10.1300/J064v22n03_10.
Freire, Wilma B, Philippe Belmont Guerrón, E Jiménez, D Román, and E Burgos. 2017. “Lista de Alimentos, Preparaciones y Bebidas Que Se Consumen En Ecuador Según La Clasificación NOVA 2017.” Quito: Universidad San Francisco de Quito USFQ, Escuela de Salud Pública, Instituto de Investigaciones de Salud y Nutrición.
Freire, Wilma B, MJ Ramírez, and P Belmont. 2015. “Tomo I: Encuesta Nacional de Salud y Nutrición de La Población Ecuatoriana de Cero a 59 Años, ENSANUT-ECU 2012.” *Revista Latinoamericana de Políticas y Acción Pública Volumen 2, Número 1-Mayo 2015* 2 (1): 117.
Freire, Wilma B, Katherine M Silva-Jaramillo, María J Ramírez-Luzuriaga, Philippe Belmont, and William F Waters. 2014. “The Double Burden of Undernutrition and Excess Body Weight in Ecuador–.” *The American Journal of Clinical Nutrition* 100 (6): 1636S-1643S.
Frison, Emile A and IPES-Food. 2016. “From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems.”
Gillespie, Stuart, Nigel Poole, Mara van den Bold, R. V. Bhavani, Alan D. Dangour, and Prakash Shetty. 2019. “Leveraging Agriculture for Nutrition in South Asia: What Do We Know, and What Have We Learned?” *Food Policy*, Special Issue: Leveraging Agriculture for Nutrition in South Asia, 82 (January): 3–12. https://doi.org/10.1016/j.foodpol.2018.10.012.
Gliessman, Steve, and Pablo Tittonell. 2015. “Agroecology for Food Security and Nutrition.” *Agroecology and Sustainable Food Systems* 39 (2): 131–33. https://doi.org/10.1080/21683565.2014.972001.
Gluckman, PD, and MA Hanson. 2008. “Developmental and Epigenetic Pathways to Obesity: An Evolutionary-Developmental Perspective.” *International Journal of Obesity* 32 (7): S62–71.
Gortaire, Roberto. 2016. “Agroecología En El Ecuador. Proceso Histórico, Logros, y Desafíos.” *Antropología Cuadernos de Investigación*, no. 17: 12–38.
Hatløy, A., L. E. Torheim, and A. Oshaug. 1998. “Food Variety—a Good Indicator of Nutritional Adequacy of the Diet? A Case Study from an Urban Area in Mali, West Africa.” *European Journal of Clinical Nutrition* 52 (12): 891–98. https://doi.org/10.1038/sj.ejcn.1600662.
Heifer. 2014. “La Agroecología Está Presente. Mapeo de Productores Agroecológicos y Del Estado de La Agroecología En La Sierra y Costa Ecuatoriana.” Quito, Ecuador: MAGAP.

Herforth, Anna, and Jody Harris. 2014. "Understanding and Applying Primary Pathways and Principles Brief#1." Improving Nutrition through Agriculture Brief Series. Arlington, VA: USAID/Strengthening Partnerships, Results and Innovations in Nutrition Globally (SPRING) Project.

Herforth, Anna, Timothy Johns, Hilary M Creed-Kanashiro, Andrew D Jones, Colin K Khoury, Timothy Lang, Patrick Maundu, Bronwen Powell, and Victoria Reyes-García. 2019. "Agrobiodiversity and Feeding the World: More of the Same Will Result in More of the Same." In *Agrobiodiversity: Integrating Knowledge for a Sustainable Future*, edited by Karl S. Zimmerer and Stef De Haan, 185–211. Strüngmann Forum Reports Book 24. The MIT Press.

HLPE. 2019. "Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition." Rome: High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-14_EN.pdf.

Hsieh, Hsiu-Fang, and Sarah E Shannon. 2005. "Three Approaches to Qualitative Content Analysis." *Qualitative Health Research* 15 (9): 1277–88.

Hu, Li-tze, and Peter M. Bentler. 1999. "Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria versus New Alternatives." *Structural Equation Modeling: A Multidisciplinary Journal* 6 (1): 1–55. https://doi.org/10.1080/10705519909540118.

Intriago, Richard, Roberto Gortaire Amézcua, Elizabeth Bravo, and Chris O'Connell. 2017. "Agroecology in Ecuador: Historical Processes, Achievements, and Challenges." *Agroecology and Sustainable Food Systems* 41 (3–4): 311–28. https://doi.org/10.1080/21683565.2017.1284174.

Johns, Timothy, Bronwen Powell, Patrick Maundu, and Pablo B Eyzaguirre. 2013. "Agricultural Biodiversity as a Link between Traditional Food Systems and Contemporary Development, Social Integrity and Ecological Health: Traditional Food Systems, Agricultural Biodiversity and Sustainable Development." *Journal of the Science of Food and Agriculture* 93 (14): 3433–42. https://doi.org/10.1002/jsfa.6351.

Jones, Andrew D. 2017. "Critical Review of the Emerging Research Evidence on Agricultural Biodiversity, Diet Diversity, and Nutritional Status in Low- and Middle-Income Countries." *Nutrition Reviews* 75 (10): 769–82. https://doi.org/10.1093/nutrit/nux040.

Kimball, Anne, Kelly M Hatfield, Melissa Arons, Allison James, Joanne Taylor, Kevin Spicer, Ana C Bardossy, Lisa P Oakley, Sukarma Tanwar, and Zeshan Chisty. 2020. “Preliminary Estimates of the Prevalence of Selected Underlying Health Conditions among Patients with Coronavirus Disease 2019—United States, February 12–March 28, 2020.”

Krebs-Smith, Susan M., TusaRebecca E. Pannucci, Amy F. Subar, Sharon I. Kirkpatrick, Jennifer L. Lerman, Janet A. Tooze, Magdalena M. Wilson, and Jill Reedy. 2018. “Update of the Healthy Eating Index: HEI-2015.” *Journal of the Academy of Nutrition and Dietetics* 118 (9): 1591–1602. https://doi.org/10.1016/j.jand.2018.05.021.

Lee, Jounghee, Robert F Houser, Aviva Must, Patricia Palma de Fulladolsa, and Odilia I Bermudez. 2010. “Disentangling Nutritional Factors and Household Characteristics Related to Child Stunting and Maternal Overweight in Guatemala.” *Economics & Human Biology* 8 (2): 188–96.

Macas, Benjamin, and Koldo Echarry. 2009. “Caracterización de Mercados Locales Agroecológicos y Sistemas Participativos de Garantía Que Se Construyen En El Ecuador.” *Quito: Coordinadora Ecuatoriana de Agroecología*.

Malapit, Hazel Jean L, and Agnes R Quisumbing. 2015. “What Dimensions of Women’s Empowerment in Agriculture Matter for Nutrition in Ghana?” *Food Policy* 52: 54–63.

McCrory, Megan A, Paul J Fuss, Joy E McCallum, Manjiang Yao, Angela G Vinken, Nicholas P Hays, and Susan B Roberts. 1999. “Dietary Variety within Food Groups: Association with Energy Intake and Body Fatness in Men and Women.” *The American Journal of Clinical Nutrition* 69 (3): 440–47.

Melby, Christopher L, Fadya Orozco, Jenni Averett, Fabián Muñoz, Maria José Romero, and Amparito Barahona. 2020. “Agricultural Food Production Diversity and Dietary Diversity among Female Small Holder Farmers in a Region of the Ecuadorian Andes Experiencing Nutrition Transition.” *Nutrients* 12 (8): 2454.

Monteiro, Carlos Augusto, Geoffrey Cannon, Jean-Claude Moubarac, Renata Bertazzi Levy, Maria Laura C Louzada, and Patrícia Constante Jaime. 2018. “The UN Decade of Nutrition, the NOVA Food Classification and the Trouble with Ultra-Processing.” *Public Health Nutrition* 21 (1): 5–17.

Moreno, Lorena. 2017. “Assessing the Effect of Conditional Cash Transfers in Children Chronic Stunting: The Human Development Bonus in Ecuador” 13: 49.

MSP, and FAO. 2018. “Documento Técnico de Las Guías Alimentarias Basadas En Alimentos (GABA) Del Ecuador. GABA-ECU 2018.” Quito-Ecuador.: Ministerio de Salud Pública del Ecuador y Organización de las Naciones Unidas para la Alimentación y la Agricultura.
Murimi, Mary W, Michael Kanyi, Tatenda Mupfudze, Md Ruhul Amin, Teresia Mbogori, and Khalid Aldubayan. 2017. “Factors Influencing Efficacy of Nutrition Education Interventions: A Systematic Review.” *Journal of Nutrition Education and Behavior* 49 (2): 142-165. e1.
NCD RisC. 2019. “Rising Rural Body-Mass Index Is the Main Driver of the Global Obesity Epidemic in Adults.” *Nature* 569 (7755): 260–64. https://doi.org/10.1038/s41586-019-1171-x.
Oyarzun, Pedro J, Ross Mary Borja, Stephen Sherwood, and Vicente Parra. 2013. “Making Sense of Agrobiodiversity, Diet, and Intensification of Smallholder Family Farming in the Highland Andes of Ecuador.” *Ecology of Food and Nutrition* 52 (6): 515–41.
PAHO. 2015. “Ultra-Processed Food and Drink Products in Latin America: Trends, Impact on Obesity, Policy Implications.” Washington, DC: Pan American Health Organization.
Paredes, Myriam. 2010. *Peasants, Potatoes and Pesticides: Heterogeneity in the Context of Agricultural Modernization in the Highland Andes of Ecuador*.
Patel, Raj, Rachel Bezner Kerr, Lizzie Shumba, and Laifolo Dakishoni. 2015. “Cook, Eat, Man, Woman: Understanding the New Alliance for Food Security and Nutrition, Nutritionism and Its Alternatives from Malawi.” *The Journal of Peasant Studies* 42 (1): 21–44. https://doi.org/10.1080/03066150.2014.971767.
Popkin, Barry M. 2014. “Nutrition, Agriculture and the Global Food System in Low and Middle Income Countries.” *Food Policy* 47 (August): 91–96. https://doi.org/10.1016/j.foodpol.2014.05.001.
Poslusna, Kamila, Jiri Ruprich, Jeanne HM de Vries, Marie Jakubikova, and Pieter van’t Veer. 2009. “Misreporting of Energy and Micronutrient Intake Estimated by Food Records and 24 Hour Recalls, Control and Adjustment Methods in Practice.” *British Journal of Nutrition* 101 (S2): S73–85.
Powell, Bronwen, Shakuntala Haraksingh Thilsted, Amy Ickowitz, Celine Termote, Terry Sunderland, and Anna Herforth. 2015. “Improving Diets with Wild and Cultivated Biodiversity from across the Landscape.” *Food Security* 7 (3): 535–54.
Prefectura de Imbabura. 2017. “PLAN PROVINCIAL DE RIEGO Y DRENAJE DE IMBABURA 2017-2037.Pdf.” Gobierno Autónomo Descentralizado de Imbabura.

https://www.imbabura.gob.ec/phocadownload/K-Planes-programas/PLAN%20PROVINCIAL%20DE%20RIEGO%20Y%20DRENAJE%20DE%20IMBABURA%202017-2037.pdf.

Ramírez-Luzuriaga, María J., MK Silva-Jaramillo, Philippe Belmont, and Wilma Freire. 2014. “Tabla de Composición de Alimentos Del Ecuador: Compilación Del Equipo Técnico de La ENSANUT-ECU 2012.” Quito, Ecuador: Ministerio de Salud Pública del Ecuador.

Ruel, Marie T. 2003. “Operationalizing Dietary Diversity: A Review of Measurement Issues and Research Priorities.” *The Journal of Nutrition* 133 (11): 3911S-3926S. https://doi.org/10.1093/jn/133.11.3911S.

Saibul, Nurfaizah, Zalilah Mohd Shariff, Khor Geok Lin, Mirnalini Kandiah, Abdul Ghani Nawalyah, and Abdul Rahman Hejar. 2009. “Food Variety Score Is Associated with Dual Burden of Malnutrition in’Orang Asli’(Malaysian Indigenous Peoples) Households: Implications for Health Promotion.” *Asia Pacific Journal of Clinical Nutrition* 18 (3): 412.

Scrinis, Gyorgy. 2008. “On the Ideology of Nutritionism.” *Gastronomica* 8 (1): 39–48. https://doi.org/10.1525/gfc.2008.8.1.39.

Sherwood, Stephen. 2009. “Learning from Carchi: Agricultural Modernisation and the Production of Decline.” S.l.: s.n.]. https://library.wur.nl/WebQuery/wurpubs/fulltext/7207.

Sherwood, Stephen, Alberto Arce, Peter Berti, Ross Borja, Pedro Oyarzun, and Ellen Bekkering. 2013. “Tackling the New Materialities: Modern Food and Counter-Movements in Ecuador.” *Food Policy* 41 (August): 1–10. https://doi.org/10.1016/j.foodpol.2013.03.002.

Sherwood, Stephen, Severine Van Bommel, and Myriam Paredes. 2016. “Self-Organization and the Bypass: Re-Imagining Institutions for More Sustainable Development in Agriculture and Food.” *Agriculture* 6 (4): 66.

Shim, Jee-Seon, Kyungwon Oh, and Hyeon Chang Kim. 2014. “Dietary Assessment Methods in Epidemiologic Studies.” *Epidemiology and Health* 36.

Smith, Lisa C., Amani E. El Obeid, and Helen H. Jensen. 2000. “The Geography and Causes of Food Insecurity in Developing Countries.” *Agricultural Economics* 22 (2): 199–215. https://doi.org/10.1111/j.1574-0862.2000.tb00018.x.

Streiner, David L. 2005. “Finding Our Way: An Introduction to Path Analysis.” *The Canadian Journal of Psychiatry* 50 (2): 115–22.

Tittonell, Pablo. 2014. "Food Security and Ecosystem Services in a Changing World: It Is Time for Agroecology."

Tuso, Philip J, Mohamed H Ismail, Benjamin P Ha, and Carole Bartolotto. 2013. "Nutritional Update for Physicians: Plant-Based Diets." *The Permanente Journal* 17 (2): 61.

USDA. 2019. "FoodData Central." U.S. Department of Agriculture, Agricultural Research Service. 2019. fdc.nal.usda.gov.

Valente, Thomas W, and Stephanie R Pitts. 2017. "An Appraisal of Social Network Theory and Analysis as Applied to Public Health: Challenges and Opportunities." *Annual Review of Public Health* 38: 103–18.

Waters, William F. 2007. "Indigenous Communities, Landlords, and the State: Land and Labor in Highland Ecuador, 1950-1975." In *Highland Indians and the State in Modern Ecuador*, edited by A. Clark and M. Becker, 120–38.

Wezel, A., S. Bellon, T. Doré, C. Francis, D. Vallod, and C. David. 2009. "Agroecology as a Science, a Movement and a Practice. A Review." *Agronomy for Sustainable Development* 29 (4): 503–15. https://doi.org/10.1051/agro/2009004.

WHO. 2018. "Healthy Diet Fact Sheet No. 394." World Health Organization. https://www.who.int/en/news-room/fact-sheets/detail/healthy-diet.

Willett, Walter, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, et al. 2019. "Food in the Anthropocene: The EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems." *The Lancet* 393 (10170): 447–92. https://doi.org/10.1016/S0140-6736(18)31788-4.

Supplementary tables

Supplementary material to the article: Agroecology and nutritional health: a comparison of agroecological farmers and their neighbors in the Ecuadorian highlands

Supplementary Table 1: Association between Human Development Bonus beneficiary status and per capita monthly household income

Beneficiary status	Per capita monthly household income (USD) mean (95% confidence Interval)

No	108 (78 - 139)	
Yes	68 (54 - 81)	
p-value		0.0168

P-value obtained using the Student t-test with the Satterthwaite method to account for unequal variance.

Supplementary Table 2: Production prevalence of livestock and plants, stratified by agroecological and reference farmers

		Production prevalence	
English or Latin name (for disambiguation)	Local name	Agroecological (n=61)	Reference (n=30)
Livestock whose flesh, milk or eggs are typically consumed			
Poultry (for eggs or meat)	Pollo o gallina	86.9%	66.7%
Guinea pig	Cuy	82.0%	66.7%
Pig	Chancho	63.9%	60.0%
Bovine livestock (for milk or meat)	Ganado	60.7%	30.0%
Rabbit	Conejo	27.9%	16.7%
Sheep	Borrego	9.8%	0.0%
Goat	Cabra o chivo	8.2%	0.0%
Pigeon	Paloma o pichón	4.9%	3.3%
Tilapia, trout or other edible fish	Tilapia, trucha u otro pez comestible	4.9%	3.3%
Llama	Llama	3.3%	0.0%
Quail	Codorniz	0.0%	0.0%
Livestock whose flesh, milk or eggs are typically not consumed			
Duck	Pato	9.8%	10.0%
Alpaca	Alpaca	4.9%	0.0%
Horse	Caballo	3.3%	0.0%
Goose	Ganso	1.6%	0.0%
Plant-foods			
Bean (all varieties)	Frejol	95.1%	90.0%
Maize	Maíz	93.4%	90.0%
Potato	Papa	93.4%	90.0%
Onion (all varieties)	Cebolla (blanca, perla, paiteña, cebollín, puerro u otro)	88.5%	76.7%
Fava bean	Haba	88.5%	76.7%

Cabbage (all varieties)	Col (verde o morada)	85.2%	66.7%
Curcubita ficifolia	Zambo	85.2%	73.3%
Chard	Acelga	82.0%	60.0%
Ground cherry (*Physallis peruviana*)	Uvilla	82.0%	60.0%
Pea	Arveja	78.7%	53.3%
Passionfruit (all varieties)	Granadilla, maracuyá o tacso	78.7%	63.3%
Lemon or lime (all varieties)	Limón (verde o amarillo) o lima	77.0%	63.3%
Blackberry (all varieties)	Mora (de castilla, silvestre u otro)	77.0%	53.3%
Radish	Rábano	75.4%	26.7%
Arracacha	Zanahoria blanca	75.4%	33.3%
Tamarillo (*Solanum betaceum*)	Tomate de árbol	73.8%	43.3%
Highland papaya (various species: *Carica pentagona*, *Carica candamarcensis,* and *Carica chrysopetala)*	Babaco, chihualcán o chamburo	72.1%	36.7%
Carrot	Zanahoria amarilla	72.1%	40.0%
Lettuce (all varieties)	Lechuga (repollo, crespa u otra)	70.5%	46.7%
Beet	Remolacha	68.9%	43.3%
Zucchini	Zucchini o calabazín	65.6%	30.0%
Sweet potato (all flesh colors)	Camote	63.9%	30.0%
Yacón (Smallanthus sonchifolius)	Jícama	63.9%	26.7%
Watercress	Berro	63.9%	43.3%
Prunus serotina	Capulí	62.3%	40.0%
Amaranth (all varieties)	Amaranto, ataco o sangorache	60.7%	26.7%
Quinoa	Quinua	60.7%	40.0%
Peach	Durazno	59.0%	30.0%
Spinach	Espinaca	57.4%	33.3%
Pumpkin	Zapallo	52.5%	33.3%
Brassica napus leaves	Nabo	52.5%	46.7%
Broccoli	Brócoli	50.8%	20.0%
Andean lupin *(Lupinus mutabilis)*	Chocho	50.8%	33.3%
Avocado	Aguacate	49.2%	33.3%
Mandarin orange	Mandarina	49.2%	33.3%
Ullucus tuberosus	Melloco	49.2%	36.7%
Cauliflower	Coliflor	47.5%	23.3%

Fig	Higo	47.5%	26.7%
Apple	Manzana	47.5%	23.3%
Refers locally to Napa cabbage, kale or other recently-introduced leafy greens	Nabo chino	47.5%	20.0%
Cyclanthera pedata	Achojcha	44.3%	30.0%
Inga edulis	Guaba	44.3%	26.7%
Barley	Cebada	42.6%	20.0%
Oxalis tuberosa	Oca	39.3%	26.7%
Sweet pepper	Pimiento	39.3%	20.0%
Wheat	Trigo	39.3%	13.3%
Tropaeolum tuberosum	Mashua	34.4%	10.0%
Turnip (root)	Papanabo	31.1%	10.0%
Cherimoya	Chirimoya	29.5%	20.0%
Orange	Naranja	29.5%	23.3%
Strawberry	Frutilla	27.9%	16.7%
Oatmeal	Avena	24.6%	3.3%
Green bean	Vainita	24.6%	10.0%
Guava	Guayaba	23.0%	16.7%
Solanum muricatum	Pepino	23.0%	10.0%
Tomato	Tomate riñon	23.0%	13.3%
Cucumber	Pepinillo	21.3%	13.3%
Brussel sprout	Col de brussela	19.7%	0.0%
Loquat	Níspero	19.7%	16.7%
Plum	Reina claudia	19.7%	10.0%
Solanum quitoense	Naranjilla	18.0%	3.3%
Grape	Uva	16.4%	10.0%
Chayote	Cidra o cidrayote	14.8%	0.0%
Cherry plum	Cereza mirabel	13.1%	13.3%
Romanesco	Romanesco	13.1%	3.3%
Cactus fruit	Tuna	13.1%	13.3%
Artichoke	Alcachofa	11.5%	0.0%
Andean blueberry *(Vaccinium floribundum)*	Mortiño	11.5%	13.3%
Sorrel	Acedera, lechuga limón o vinagre	11.5%	3.3%
Yuca	Yuca	11.5%	3.3%

Sugarcane	Caña de azúcar	11.5%	10.0%
Taro	Papa china	8.2%	0.0%
Banana	Banano o orito	6.6%	10.0%
Asparagus	Espárrago	4.9%	0.0%
Plantain	Plátano verde	4.9%	3.3%
Juglans neotrópica nut	Tocte	4.9%	0.0%
Pear	Pera	3.3%	0.0%
Mango	Mango	3.3%	6.7%
Yellow dragon fruit	Pitahaya	3.3%	0.0%
Garbanzo	Garbanzo	1.6%	0.0%
Papaya	Papaya	1.6%	0.0%
Watermelon	Sandía	1.6%	0.0%
Spondius purpurea	Ovo	1.6%	0.0%
Macadamia	Macadamia	1.6%	0.0%
Raspberry (all varieties)	Frambuesa (roja, morada u otro)	1.6%	0.0%
Arugula	Rúcula	1.6%	3.3%
Grapefruit	Toronja	1.6%	6.7%
Peanut	Maní	1.6%	0.0%
Soybean	Soya	1.6%	0.0%
Eugenia stipitata	Arazá	1.6%	0.0%
Rhubarb	Ruibarbo	0.0%	0.0%
Achras sapota	Zapote	0.0%	0.0%
Mangostine	Mangostino	0.0%	0.0%
Pineapple	Piña	0.0%	0.0%
Tamarind	Tamarindo	0.0%	0.0%
Soursop	Guanábana	0.0%	0.0%
Plant-foods typically used in very small quantities (condiments, seasonings, aromatics and medicinal herbs)			
Aromatic or medicinal plants	Plantas aromáticas o medicinales	98.4%	76.7%
Chenopodium ambrosioides	Paico	93.4%	66.7%
Coriander	Culantro	86.9%	73.3%
Parsley	Perejil	78.7%	36.7%
Celery	Apio	70.5%	46.7%
Lovage	Hierba maggi	70.5%	6.7%
Oregano	Orégano	70.5%	23.3%
Hot pepper	Ají	63.9%	40.0%

Alfalfa	Alfalfa	62.3%	53.3%
Aloe vera	Sábila	60.7%	46.7%
Garlic	Ajo	27.9%	6.7%
Basil	Albahaca	27.9%	6.7%
Flax	Linaza	26.2%	10.0%
Fennel	Hinojo	23.0%	6.7%
Agave *(Agave americano andino)*	Penco	23.0%	26.7%
Stevia	Estévia	21.3%	6.7%
Chia	Chía	18.0%	6.7%
Coffee	Café	3.3%	3.3%
Ginger	Jengibre	3.3%	0.0%
Turmeric	Cúrcuma	1.6%	3.3%
Cacao	Cacao	0.0%	0.0%

Farmers were asked "of the following animals/products, which have you raised/produced in the past year, even if only in a very small amount?" The list of animals and products was established according to findings from ethnography and key informant interviews. All products in the table were included in the list, with the exception of the following, which were elicited using the prompt "do you raise/grow any other farm animals/products that were not listed?" : horse, papaya, dragon fruit, garbanzo, watermelon and *Juglans neotrópica*. Products that are exclusively used for purposes other than human consumption are not included.

Supplementary Table 3: Focus Group Discussion (FGD) participants, by gender

FGD number	Male	Female	Total participants
1	4	17	21
2	3	13	16
3	1	13	14
4	5	13	18
5	4	12	16
6	2	9	11
7	4	17	21
8	1	10	11
Total	24	104	128
Percent	18.8%	81.3%	

Table shows the number of individuals, by gender, that participated in FGDs for each of eight agroecological farmers' associations

Supplementary Table 4: Correlates of dietary outcomes

	Dietary Diversity Score	Food Variety Score	NOVA Group 1	NOVA Group 2	NOVA Group 3	NOVA Group 4	BMI
Dietary outcomes							
Food Variety Score	0.67***	–					
NOVA Group 1			–				
NOVA Group 2	-0.27**	-0.30**	-0.49***	–			
NOVA Group 3			-0.72***		–		
NOVA Group 4						–	
BMI							–
Sociodemographics							
Age	-0.22*	-0.29**					
Household size		0.26**					
Monthly income per capita			0.23*	-0.23*			
Time to market						0.31**	
Education completed	0.33***	0.36***		-0.26*			
Land and Production							
Production diversity		0.24*					
Land size in agricultural use							
Food Expenditure per Capita							
Caloric share of diet acquired from diverse sources							
Conventional markets		-0.22*		0.23*			
Harvest		0.24*	0.26**				
Social economy							

Correlations are reported using Pearson's or Spearman's Rho (R), according to variable distribution. Education completed is treated as a continuous variable with values from 0 (none) to 5 (post-secondary), and land size is treated as a continuous variable with values 1 (<1 hectare) to 4 (5-10 hectares). Correlations with R<0.20 are considered too small to be meaningful and are thus removed for clarity. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Supplementary Table 5: Associations between non-ordinal, non-continuous variables and dietary outcomes

	Dietary Diversity Score	Food Variety Score	NOVA Group 1	NOVA Group 2	NOVA Group 3	NOVA G
Poverty level						
No poverty	6.0 (5.6 - 6.5)**	20.6 (18.9 - 22.2)**	76.7% (73.0% - 80.4%)**	13.3% (10.5% - 16.1%)	8.1% (5.0% - 11.3%)	1.9% (0. 2.9%)
Poverty	5.0 (4.4 - 5.7)	16.9 (14.5 - 19.3)	79.2% (75.5% - 82.9%)	11.5% (8.8% - 14.1%)	7.9% (4.4% - 11.4%)	1.5% (0. 2.6%)
Extreme poverty	5.3 (4.7 - 6.0)	18.8 (16.7 - 20.8)	70.1% (63.5% - 76.8%)	14.7% (11.0% - 18.5%)	11.7% (6.8% - 16.7%)	3.5% (0. 6.2%)
Household member receives the Human Development Bonus						
No	5.7 (5.3 - 6.1)	19.7 (18.1 - 21.3)	75.8% (72.3% - 79.3%)	12.6% (10.3% - 15.0%)	9.9% (6.7% - 13.1%)	1.7% (0. 2.6%)
Yes	5.4 (4.9 - 5.9)	18.2 (16.6 - 19.8)	74.2% (69.2% - 79.2%)	14.2% (11.4% - 17.1%)	8.4% (5.3% - 11.4%)	3.2% (1. 5.3%)
Livelihood sources present in household						
Occasional or regular agricultural daily wage labor						
No	5.5 (5.2 - 5.9)	18.7 (17.4 - 20.0)	76.4% (73.1% - 79.6%)	12.9% (10.8% - 14.9%)	8.7% (6.0% - 11.4%)	2.1% (0. 3.3%)**
Yes	5.6 (4.9 - 6.4)	20.2 (17.8 - 22.6)	71.7% (65.6% - 77.8%)	14.5% (10.8% - 18.3%)	10.8% (6.6% - 15.0%)	3.0% (1. 4.8%)
Agricultural sales (excluding agroecological markets)						
No	5.3 (4.9 - 5.7)**	18.1 (16.6 - 19.7)**	73.7% (70.0% - 77.4%)	13.8% (11.4% - 16.3%)	10.4% (7.2% - 13.6%)	2.1% (0. 3.5%)
Yes	6.0 (5.5 - 6.5)	20.5 (18.9 - 22.1)	77.4% (72.8% - 82.0%)	12.5% (9.9% - 15.0%)	7.5% (4.6% - 10.4%)	2.6% (1. 4.1%)
Other livelihood sources						
No	5.6 (4.9 - 6.3)	20.2 (17.9 - 22.4)	72.6% (66.5% - 78.6%)	14.8% (10.9% - 18.7%)	9.2% (5.4% - 12.9%)	3.5% (1. 5.5%)
Yes	5.5 (5.2 - 5.9)	18.6 (17.3 - 20.0)	76.1% (72.8% - 79.4%)	12.8% (10.7% - 14.8%)	9.3% (6.5% - 12.1%)	1.9% (0. 3.1%)
Irrigation						
No	5.2 (4.8 - 5.6)**	17.9 (16.4 - 19.4)**	74.6% (70.6% - 78.6%)	14.9% (12.4% - 17.4%)**	7.7% (5.1% - 10.3%)	2.8% (1. 4.4%)
Yes	6.0 (5.5 - 6.5)	20.6 (19.0 - 22.3)	75.8% (71.5% - 80.0%)	11.3% (8.8% - 13.8%)	11.2% (7.3% - 15.2%)	1.7% (0. 2.7%)

Table shows mean values of dietary health measures. NOVA scores are percentages of total caloric share. Differences by poverty level are assessed usin are assessed using student t-test or U-test, depending on variable distribution. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respect

Supplementary Table 6: Select discussion quotations accompanying key themes from focus group discussions

Discussion question-prompt	Key themes	Selected discussion quotations
Who uses more land for agriculture and livestock?	**Agroecological farmers do not own more land, but make better use of their land**	We grow on more land because we are more dedicated. We have the same amount of l
		Agroecological farmers, we grow on the steep slopes; we do not waste any space. Conv to do difficult work. They only produce where it's easy.
	Agroecological farmers rent or borrow additional land for use	Agroecological farmers own the same amount of land in the papers, we do not own mo produce because we rent it from others, or we use more of the land that we own for pr
	Agroecological farmers own less land	I think it's the opposite of what the survey results show. The conventional farmers have the hectare. We agroecological farmers only have a little bit.
	Non-agroecological farmers use less land	The other farmers use chemicals, so in less land they produce more. They don't let the l
Who has a more diverse diet?	**Agroecological farmers have more dietary diversity because they barter in the agroecological market**	We have more diversity in our foods because of barter. If a friend has a product that we
		We eat more diversity because we grow our food, and because we barter. We bring pro and barter at the agroecological market. And we grow diversity: fruits, grains, vegetable
		In my family, there are two types of diversity. Bartering is interesting for increasing both diversity in our food. We diversify our food through our connection with the agroecolog agroecological market, there is no barter.
	Agroecological farmers have more dietary diversity because they consume from the diversity of their own production	We eat more diversity because we eat from our own production. We only buy salt, oil, b home, from what is left over [after sales]. We also bring foods back from the agroecolog completes our diet. We trade with other farmers for what we do not have.
		We [agroecological farmers] have diversity in our production, which contributes to wha
	Agroecological farmers have a more varied diet because they cook at home	In my community, several of my neighbors migrate to work with the flowers [flower ind thing every day, whatever is fastest: rice, noodles. But in my case, we cook at home and because we do not cook in a hurry.
Who produces more diversity on their farm?	**Agroecological farmers have more production diversity because agroecological associations promote seed exchange and teach about production diversity**	Now we trade seeds with each other to experiment and see if they adapt well on our la our biodiversity.
		Having more products gives us more security... I went to an agroecology workshop in Ta much about that. Before, all I had was one type of potato, one type of corn. But now I h the agroecological association, I learned to grow this way. Before, all I had was five diffe years of being in the agroecology association, I have something like 45 products.
	Increased production diversity is the result of external assistance that promotes agroecology	The foundation [a local non-governmental organization] helped us with our gardens and foundation, we have these changes.
	Non-agroecological farmers have equal amounts of diversity	In our community, everyone has diversity, because even our neighbors who are not agr farmers. If I do not have something, I buy it from them. They do not use chemicals, and everything.
Who has more overweight or obesity?	**Overweight levels are the same due to similar excesses**	I think all of us are overweight, whether we are agroecological or not, because we keep For example, I've made my diet more varied, but I can't lose weight. It's difficult. I like to
		I think everyone is the same on overweight because we still have not addressed the issu agroecology.
	Overweight levels are the same, despite different diets	Conventional farmers are overweight because they eat more fats and sugars and junk fo farmers are overweight because we eat more quantity - healthier foods, but in bigger q
	Agroecological farmers are more overweight because their food is tastier	We have fresh products, which makes them more flavorful. When you cook tastier, you tastier... yum! The ones that eat [industrial] chicken feed are not so good.

	Agroecological farmers are less overweight because they purchase fewer foods and are more aware of healthy eating habits	We agroecological farmers take our own food with us when we travel so that we do no
		Conventional farmers are more overweight because they buy food with the money tha not have their own foods to eat. This is why they are more overweight. In our case, our people, but the agroecological farmers, we are taking care of ourselves in what we eat.
	Agroecology leads to weight loss	I've lost weight. Before, I was much heavier. Agroecology has been good for me.
Who spends more money to buy food?	**By increasing production quantity and diversity, agroecological farmers reduce food expenditures**	The more we increase our production diversity, the less we have to buy.
		We save money because we have our foods growing on our own lands. Before, we had conventional markets. Now, if I do not have something, I trade for it or buy it from my f market, and the product is more fresh.
	Food expenditures depend on access to land for production	Those of us with little land, we have to buy more. It all depends on how much land you
	Buying from supermarkets is perceived negatively	We still buy from supermarkets when we need something from there. We still need to b contradicting ourselves.
Who eats more carbohydrates?	Non-agroecological farmers consume more carbohydrates because of lack of production diversity	Conventional farmers eat more carbohydrates because they lack diversity to eat somet
	Agroecological farmers consume more carbohydrates because they produce them	Agroecological farmers consume more carbohydrates because they grow them.
Who eats more sugar, brown sugar or raw cane sugar?	Consumption of sugar and salt has decreased with increased awareness	In my house, we no longer eat much salt or sugar. We got used to it. But when we eat e is too sweet or too salty. Part of the process of reducing the quantity of sugar and salt i products themselves already have their own natural sugars and natural salts, like fruits
	Non-agroecological farmers consume more sugar due to lack of awareness	I think conventional farmers eat more sugar because they do not know have much kno [agroecological farmers] at least have a little bit of knowledge.
	Perception that raw cane sugar does not count as sugar	I don't eat sugar! I only eat *panela* [raw cane sugar].
Who has more food-related illnesses, such as high blood pressure, high cholesterol, diabetes, heart disease or cancer?	**Farmers join the agroecological association to mitigate disease**	I joined agroecology because of my health situation, and I know of others who did the s
		Since the [agroecological] group was formed, they have invited us to various courses an which foods are good, which are not good.... in our house, we use a lot of vegetables, fr have to be careful what we eat. This has been our objective for being a part of this pro
		Our ancestors ate well. But now we are eating modern foods. Sodas, noodles. We acqu I gained weight, I have diabetes, my eyesight is bad. And all of this happened because o recovered quite a lot. I'm much better. I've improved my dietary habits ever since joinir agroecological market.
		I used to go out to work every day, and I only ate what they [the employers] gave me. B disease. I was sick here in my neck, like I was asphyxiated. My intestine was all black. I v But now I am much better. I will never be all the way better, but now I am much better own land. With the agroecological market, I don't go out to work as much [on others' la land.
		I've changed my lifestyle very much with agroecology, and my health has changed too. got better.
	Agroecological farmers have more disease because they have less time to eat healthy	Agroecological farmers, we have health problems because we do not eat at the right ti at the market, so we eat a piece of bread instead of a healthy breakfast. This has conse like diabetes and hypertension.
		We have diseases due to poor eating schedules, because we have to milk the cow, harv so by three in the afternoon, I am finally eating breakfast. It's because we work in agric
	Agroecological farmers have less disease because they do not use pesticides	The others, they have more diseases. They spray their land and they do not eat organic

	Disease levels are the same, because agroecology is still new	Agroecology has only been here for a few years, so we still have not changed the issue o path, but we still need to increase awareness. We need to know not to eat too many ca tradition that is difficult to change.
My diet has changed since I am part of the agroecological association	**Agroecology has increased awareness to improve food practices by increasing diversity, reducing processed foods, and eating more fruits and vegetables.**	Personally, I've changed my habits. Before, I ate rice, noodles, whatever was in front of market, I eat more organic, more salads, fruits. The market is about to be two years old courses, workshops, we've learned about the vitamins in the products.
		We have to go little by little to change our diets. For example, I no longer buy sodas. If s can't say no.
		This process has been an opportunity to learn. In my case, before, I did not value what r ate. Now I understand that the most nutritious is what we have in our own homes, on o convenience store, and well, I drank soda. Since being in this process, I no longer drink s growing my own foods. Thanks to the workshops, I have learned.
	Relationships formed in agroecological market introduce farmers to new foods	Because of the agroecological market, we know about new products. We eat more vege vegetables especially. I eat amaranth, romanesco, chia. I put amaranth in my juice, and
		In the [agroecological] market, we are producers from all over, so I get to trade for prod before: araza, breadfruit.
	Agroecology promotes producing more for own consumption, leading to dietary change	I think each family has changed. Personally, I changed entirely because now we eat alm homes. Before, we did not grow everything, and now we do.
		When we entered the [agroecological] market, we began growing fruits. Tamarillo, pepi passionfruit, lemon... before we had to buy them.
	Diet has not changed, because always had healthy eating traditions	We always ate healthily and agroecologically, even before we called it that, so for us th
	The struggle for healthy foods creates community around healthy lifestyles	Here in this group, we are in this fight together, to live better, to live more healthily. We conventional practices. Entering agroecology is difficult because you limit yourself econ healthier - you eat well, you have friendships and companionship. This is why we are to
	Diet has not changed, even with increased awareness of healthy diets	They always say not to eat too much butter, too much bread, too much rice. But I still e sodas, but still, if someone gives it to me... Change is little by little.

Key themes emerged from eight focus group discussions with a total of 128 farmers participating in agroecological associations. Themes t strongest agreement are in bold. Only select quotations are included, to avoid redundancy.

Supplementary Table 7: Linkages between agroecology participation, land use, production diversity and food acquisition

Pathway	Standardized estimate [SE]	p-value
Effects on Land amount in production		
Agroecology participation	0.23 [0.10]	0.021
Effects on Production diversity		
Agroecology participation	0.51 [0.08]	0.000
Land amount in production	-0.03 [0.09]	0.750
Effects on Non-market food consumption		
Agroecology participation	0.34 [0.10]	0.001
Production diversity	0.07 [0.10]	0.519
Land amount in production	0.30 [0.09]	0.001
Effects on Harvest consumption		
Agroecology participation	0.13 [0.11]	0.230
Production diversity	0.14 [0.10]	0.180
Land amount in production	0.40 [0.09]	0.000
Effects on Social economy consumption		
Agroecology participation	0.25 [0.12]	0.037
Production diversity	-0.06 [0.12]	0.587
Land amount in production	-0.06 [0.11]	0.550

Path analysis models were used to assess linkage pathways between agroecology participation, production diversity, land amount in production and food consumption from non-market sources, including both foods from harvest and from social economy. Non-market sources are assessed together in one model, as well as separately in a model for harvest and another model for social economy. Agroecology participation is a dichotomous dummy variable (0 = reference, 1 = agroecological); production diversity is a continuous variable representing the number of species on the farm; land amount in production is an ordinal variable (1 = <1 hectare, 2 = 1-3 hectares, 3 = 3-5 hectares, 4 = >5 hectares); and, non-market food consumption, harvest food consumption and social economy food consumption are percentages of total caloric intake (expressed as 0 to 100). Non-market food consumption is the sum of harvest food consumption and social economy food consumption. Standardized path estimate coefficients are shown with standard error [SE] in brackets.

6.5 Article 4: Market Foods, Own Production and the Social Economy: How Food Acquisition Sources Influence Nutrient Intake among Ecuadorian Farmers and the Role of Agroecology in Supporting Healthy Diets

Ana Deaconu[a,b], Peter R. Berti[c], Donald C. Cole[d,e], Geneviève Mercille[a,b] and Malek Batal[a,b]

[a] Nutrition Department, Faculty of Medicine, Université de Montréal, P.O. Box 6128, succ. Centre-ville, Montreal, QC H3C 3J7, Canada

[b]Centre de Recherche en Santé Publique de l'Université de Montréal et du CIUSS du Centre-Sud-de-l'Île-de-Montréal (CReSP), 7101 avenue du Parc, CP 6128, Succursale Centre-Ville, Montréal (Québec) H3C 3J7

[c]HealthBridge Foundation of Canada, 1 Nicholas Street, Suite 1004, Ottawa, ON KIN 7B7

[d]Dalla Lana School of Public Health, 155 College St, Toronto, ON, Canada M5T3M7

[e]Fair Fields, 221689 Concession 14, RR1 Neustadt, ON, Canada, N0G 2M0

Abstract

Rural Ecuadorians are experiencing a double burden of malnutrition, characterized by simultaneous nutrient inadequacies and excesses, alongside the social and environmental consequences of unsustainable agriculture. Agriculture can support farmer nutrition by providing income for market purchases and through the consumption of foods from own production. However, the nutritional contributions of these food acquisition strategies vary by context. We surveyed smallholder women farmers (n = 90) in Imbabura province to assess the dietary contributions of foods obtained through market purchase, own production, and social economy among farmers participating in agroecology—a sustainable farming movement—and neighboring reference farmers. We found that foods from farmers' own production and the social economy were relatively nutrient-rich, while market foods were calorie-rich. Consumption of foods from own production was associated with better nutrient adequacy and moderation, whereas market food consumption was associated with a worse performance on both. Food acquisition patterns differed between farmer groups: agroecological farmers obtained 44%, 32%, and 23% of their calories from conventional markets, own production, and the social economy, respectively, while reference neighbors obtained 69%, 17%, and 13%, respectively.

Our findings suggest that, in this region, farmer nutrition is better supported through the consumption of their own production than through market purchases, and sustainable farming initiatives such as agroecology may be leveraged for healthy diets.

Keywords: agriculture-nutrition pathways; biodiversity; agroecology; social economy; food intake; dietary diversity; diet quality; cross-sectional survey; Ecuador; Indigenous people

1. Introduction

Smallholder family farmers feed the world: they produce an estimated 80% of the world's food [1]. Yet paradoxically, many are malnourished [1,2]. Whereas in the past this primarily took on the form of nutrient inadequacies, now rural people, and especially Indigenous rural people, increasingly experience a double burden of malnutrition, wherein families or individuals have simultaneous nutrient inadequacies and excesses [3–5]. As a result, obesity and diet-related chronic diseases are becoming increasingly prevalent in rural areas even as the health problems associated with nutrient deficiencies continue [3,6]. This widespread double burden of malnutrition has been linked to the displacement of traditional food systems in favor of new productionist paradigms that deteriorate diversity at multiple levels, including in agricultural production from global to local scales, the availability of products in the food environment, household food access, and individual dietary intake [7].

In Ecuador, much of the Indigenous population is concentrated in the rural sector of the highland region, where smallholder farming is the predominant livelihood activity [8,9] and nutritional disparities are evident: 38% of rural children under five are stunted, compared to 27% of their urban counterparts [10], and Indigenous children are disproportionately affected [5]. Meanwhile, overweight and obesity prevalence among rural children (10%) is similar to that of their urban counterparts (8%). Among adults in the highland region, rural overweight and obesity prevalence (56%) is catching up to that among the urban population (64%), and so is the prevalence of associated chronic diseases [10]. Meanwhile, rural people's access to health care services lags far behind that of their urban counterparts [11]. The nutritional inequalities lived by farming populations around the world have spurred much interest in how to effectively mobilize agriculture for nutritional health outcomes [12–14].

Discourse has reached a growing consensus that agriculture can positively impact dietary diversity of nutritious foods among farming populations through multiple pathways. Two pathways that have received strong attention are: (i) the purchase of foods using income generated by selling agricultural products and (ii) the subsistence consumption of foods from own production [15]. For both of these pathways, agrobiodiversity can be an important mediator; for example, by diversifying products for market sale or by producing diverse foods for own consumption [16,17]. Recently, a debate has emerged regarding which of these pathways is most effective and should be prioritized [18]. In some locations, subsistence consumption (i.e., consuming foods from own production) appears to be the main pathway by which higher agricultural diversity translates to higher dietary diversity [19,20]. Others challenge the role of own production as a primary source of farmer dietary intake [21], and instead propose that strengthening access to rural markets is key to improving dietary quality [22]. Still, others point out that heavy prioritization of the market purchase pathway can be problematic because of inequalities in market access [23], insufficient diversity of foods in local markets [18], or otherwise unhealthy market food environments [24].

These discussions often utilize dietary diversity as their outcome of interest, which serves as a useful proxy for nutrient adequacy [25], but unfortunately speaks little to the pressing problem of overweight and diet-related chronic disease. A body of literature is instead developing on how the types of foods obtained through the retail environment can differentially influence overweight and obesity prevalence, with special attention to the availability of processed and ultra-processed foods [26]. In high-income countries, the numerous studies assessing how the food environment affects obesity have produced uncertain and often contradictory results [27], reflecting the complexity of the relationship between environmental factors and dietary health [28]. This subject has received less attention in low- and middle-income countries, but the evidence thus far predominantly suggests that proximity to urban markets and consumption from supermarkets is associated with higher overweight and obesity prevalence and associated chronic diseases [29–31]. In these settings, retail markets appear to encourage the consumption of inexpensive calorie-rich and nutrient-poor foods [3,26], and increasingly, even the most remote regions are becoming flooded with products that supplant traditional diets and instead propagate a nutrition transition toward diets high in sugar, saturated fat, and sodium [32,33]. This tendency may undermine the gains to nutritional health that may otherwise be made through market purchases [24].

The sum of these arguments underlines a need to better understand the nutritional contributions made by foods acquired through distinct pathways to farmers' diets. Alongside this need, a growing chorus is now voicing the urgency of better understanding how agriculture-nutrition linkages can nurture positive feedback cycles with environmental sustainability [7,34,35]. This aligns with the growing understanding that undernutrition, obesity, and climate change constitute an inextricable global syndemic [36], and that food and agriculture need to be transformed together to systematically support planetary health [37]. In this article, we turn to Ecuador's highland Imbabura province to assess the linkages between farmers' food acquisition practices and their diets, and we further give special attention to farmers participating in the local agroecology movement to better understand how sustainable agriculture rooted in traditional farming practices may be mobilized for farmers' nutritional health.

1.1 Agroecology

In the Ecuadorian highlands, Indigenous farmers' organizations, NGOs, and other actors have coalesced around agroecological farming as a path toward environmentally and culturally restorative agricultural ecosystems, and for escaping the noxious health effects of heavy pesticide use [38,39]. As a result, some groups of smallholder farmers across the highlands are organized in agroecological farmers' associations, through which they commercialize their products in alternative food networks such as farmers' markets and share certain norms and values around food and agricultural practices; among these norms, they emphasize consuming foods from their own farms and through the social economy, perceiving these acquisition pathways to be better aligned with cultural traditions [40,41]. We are interested in the dietary dynamics of these farmers because agroecology in Ecuador has taken on the form of a social movement [42,43] that is expanding endogenously among farmers to influence their food practices, and that aspires to create a healthier, more sustainable food system for both producers and consumers [38]. Our previous research in the region identified that participation in the agroecology movement was associated with stronger performance on measures of nutrient adequacy and dietary moderation, even when controlling for socioeconomic variables. One of the outcomes of this research was the need to better understand how participation in agroecology impacts farmers' food acquisition practices, and whether this explains the relative nutritional advantage that agroecological farmers displayed over their neighbors [44].

1.2 Social economy

While most studies on farmers' food acquisition practices and nutritional outcomes distinguish between market foods and own production, the sociocultural context in rural Ecuador calls for consideration of a third food source, summarized as the social economy [40,44]. Related to the popular economy or solidarity economy, the social economy emphasizes transactions with social intentions that transcend profit maximization [45]. In Ecuador and elsewhere in the Andes, social economy practices are rooted in the Indigenous emphasis on reciprocity, and they include barter, gifting, and direct monetary transactions between people that have meaningful relationships with each other [40,46,47]. These three social economy practices—barter, gifting, and direct purchase—occur on a continuum, wherein goods, money, and services can simultaneously enter the exchange, and the relationship between the trading parties not only determines the terms of the transaction, but the transaction is also utilized to strengthen the relationship [48,49]. In Imbabura province, social economy practices are rooted in the region's history as a bartering center for goods from the country's coastal, highland, and Amazonian regions [48], and they have endured not only in spite of, but largely as a reaction to, modern capitalist economies [49]. Although the social economy has not received much attention for its potential to support farmers' nutritional health, it may hold several relevant linkages. For example, Andean farmers utilize the social economy to exchange foods from distinct eco-zones, to support each other in times of need, and to exchange seeds, which can be sown to generate production diversity [40,47,50].

1.3 Study aims and overview

A first objective of this study was to assess the nutritional contribution of foods obtained from market purchase, own production, and the social economy. We used dietary recall data with information on the acquisition source of each ingredient consumed to evaluate the types of foods consumed from each source and the contributions to measures of nutrient adequacy (i.e., meeting key nutrient needs) and dietary moderation (i.e., avoiding harmful excesses). We further compared the micronutrient density and caloric density of the three food acquisition sources. A second objective was to explore the influence of the local agroecology movement on farmers' food acquisition practices. To these ends, our study compared the food acquisition practices of female smallholder farmers from two groups: (i) farmers that participate in agroecological associations (hereafter, "agroecological farmers"); and (ii) neighbors of the first group who have never participated in agroecological associations (hereafter, "reference farmers").

2. Methods

2.1 Setting and study population

This study was conducted with women smallholder farmers in Imbabura province. Participants lived at altitudes between 1550 and 3570 m above sea level, spanning a range of ecosystems and agricultural zones from hot, humid subtropical valleys to the wet montane páramo ecosystem. Across the study region, rainfall patterns permit most farmers to grow a diversity of crops with little or no irrigation [51]. Imbabura has the third largest Indigenous population of Ecuador's 24 provinces, most of whom identify as Kichwa and live in rural areas [9,52]. Rural poverty in Imbabura is estimated at 54% [53], with the highest poverty rates found among Indigenous people [9]. Rural highland diets are predominated by grains and tubers and by a nutrition transition that is increasing the intake of simple sugars, sodium, edible oils, and processed and ultra-processed foods [10,54].

2.2 Study design and instruments

Data were derived from a survey applied to 90 smallholder women farmers in 2017. Only women were surveyed because of their predominant cultural role in household food procurement and preparation [55], and given previous studies suggesting that intrahousehold food distribution in rural highland Ecuador is not affected inequitably by gender disparities [56,57]. This study population was comprised of 60 agroecological farmers, who were selected at random from the rosters of agroecological associations, and 30 reference farmers, who were the randomly selected neighbors of the agroecological farmers. The survey included an open, quantitative 24-h dietary recall instrument [58], as well as modules to collect socioeconomic and production data. Full details of this study's conceptualization of agroecological and reference farmers, sampling methods, survey development, 24-h recall instrument, and data collection protocols are described in Deaconu et al. [44].

2.3 Sociodemographic and production variables

The sociodemographic variables in this study included age, monthly income per capita (in USD, the official currency of Ecuador), time to market (in the participant's usual transport), household size, household livelihood sources, and education completed by the respondent. We used monthly income per capita to establish household poverty levels, based on the 2014 income-based poverty line [53]. For household livelihood sources, agroecological market sales were excluded because our sampling strategy stipulated that all agroecological farmers sold in these markets, whereas no reference farmers did. Participants also reported their monthly food expenditures. Production variables included production diversity, access to irrigation, and land surface in agricultural use. Production diversity was a species richness measure of crops and animals used for food. Land surface was a measure of land utilized, not land possessed, and could include land that was rented or borrowed. These variables are further described in Deaconu et al. [44].

2.4 Food acquisition variables

The survey's 24-h recall instrument collected the quantities of all foods and beverages consumed, and for each item, it queried on the source of food acquisition. Enumerators then coded responses according to the following categories: own production, wild harvest, direct purchase from other farmer, barter with other farmer, purchase from an alternative food network (e.g., farmers' market), barter within an alternative food network, gifting economy, purchase from a conventional market (wet markets, supermarkets, corner stores, ambulatory salesmen, grocers, and all other points of sale). For meals that were not prepared at home, respondents listed the main ingredients that they could identify in the meal and all the products in the meal were categorized in their most appropriate category. Meals that were eaten at a neighbor's house were categorized as gifted; meals that were purchased from a restaurant were categorized as purchased from a conventional market.

Food acquisition sources were then re-coded into three categories: (i) conventional markets; (ii) own harvest, including both own production and wild harvest; and (iii) social economy, including direct purchases from other farmers, barter with other farmers, purchases or barter from an alternative food network, and the gifting economy. Decisions on food source categorization were based on our exploratory qualitative research in the region, which involved ethnographic observation and key informant interviews [40]. This informed two decisions: (i) since farmers' management of wild foods often meant that the line was blurred between their own production and wild harvest, these were grouped into "own harvest"; and (ii) all forms of direct monetary and non-monetary exchange between farmers, including that which occurs within alternative food networks, were grouped together because there was frequently no clear distinction between these types of exchange.

2.5 Nutrient contributions of food acquisition sources

We obtained calorie and other nutrient contents of each food item consumed in 24-h recalls using the United States Department of Agriculture nutrient database [59] as well as the Ecuadorian nutrient database for local foods that were not available in the former [60]. Doing so permitted us to understand the relative intake of foods from the three food acquisition sources, which we assessed as the proportion of total caloric energy obtained from each. Further, we assessed the contribution of each source to five other macronutrients (proteins, carbohydrates, fats, saturated fats, and fiber) and nine micronutrients (vitamin A, vitamin C, calcium, iron, zinc, thiamin, riboflavin, niacin, and folate).

2.6 Dietary variables

Given the double burden of malnutrition in our study region, we are interested in measures of both nutrient adequacy and dietary moderation. To assess nutrient adequacy, we utilized the 24-h recall data to apply both a food variety score (FVS) and a dietary diversity score (DDS). FVS counts individual foods eaten, whereas DDS separates foods into food groups [61]. Our DDS followed the 10 food group protocol established by the minimum dietary diversity for women score (where the 10 food groups are: grains, white roots and tubers, and plantains; legumes; nuts and seeds; dairy; eggs; meat; dark green leafy vegetables; other vitamin A-rich fruits and vegetables; other vegetables; other fruits.) [62]. Both FVS and DDS have been associated with numerous nutritional status indicators, including energy and micronutrient adequacy, across multiple country contexts [25]. We applied both because the relative strength of each as an indicator of nutrient adequacy varies according to context [25,61].

Unfortunately, validated dietary indexes assessing moderation in low- and middle-income countries are largely lacking [63]. We evaluated dietary moderation by assessing processed food consumption following an Ecuadorian protocol [64] for applying the NOVA food classification system [26]. NOVA assesses the level of food processing in the diet by comparing the percentage of calories obtained from four food categories: (i) unprocessed or minimally processed foods, (ii) processed culinary ingredients such as oils and sugar, (iii) processed foods, and (iv) ultra-processed foods [26]. This classification system has successfully predicted overweight and diet-related chronic diseases in Latin American contexts [65]. Consuming foods from the first NOVA category is consistent with recommendations for healthy diets, whereas consuming an excess of foods from the remaining categories, and particularly the fourth, can lead to harmful nutrient imbalances [66]. In rural Ecuador, the most widespread manifestation of the nutrition transition up to this point appears to be in its propagation of culinary ingredients such as sugar and edible oils [10,54], making the second NOVA category particularly informative.

2.7 Analysis approach

We conducted bivariate analyses using SAS Software, version 9.4 (SAS Institute Inc, Cary, North Carolina, USA) to compare agroecological and reference farmers' perfor-mance on sociodemographic and production variables, as well as on caloric intake from distinct food acquisition sources. To explore how the three food acquisition sources con-tributed to distinct DDS food groups, we generated line graphs representing pattern profiles; for each source, these profiles illustrated the proportion of farmers that had consumed a food item pertaining to a given food group. We then evaluated the relative nutrient contributions of the three food acquisition sources by assessing each source's mean contribution to farmers' daily intake of distinct nutrients, stratified by farmer group. That is, the mean contributions of conventional markets, farmers' own harvest, and the social economy to a farmer group's intake of a given nutrient were expressed as per-centages X, Y, and Z, respectively, which add up to 100% of daily intake for that nutrient. Using this information, we then evaluated the relative nutrient density of each food acquisition source. For this analysis, we divided each source's contribution to a given nutrient by its contribution to caloric energy. Values over 1 were considered relatively nutrient-rich and those under 1 were considered relatively calorie-rich. For example, a hypothetical source contributing to 40% of the mean daily iron intake and 30% of the caloric energy intake would produce an iron density of 1.33, meaning that it was rela-tively iron-rich. Finally, we assessed correlations between the three food acquisition sources and other study variables. Correlations producing r-values near or above 0.5 were considered strong, those with values near or above 0.3 were considered moderate, and the remainder were considered weak [67].

3. Results

3.1 Socioeconomic and production variables

Table 1 provides a sample description as well as a comparison of women agroecological and reference farmers on sociodemographic, land, and production variables. The two groups were largely similar on sociodemographic variables, and poverty emerged as a pressing concern in the study population. Agricultural income contributed to the livelihoods of both farmer groups, although the majority also had non-agricultural livelihood sources. Production diversity was high among the study population (pooled mean = 39). Agroecological farmers had significantly greater production diversity and utilized more land for productive purposes.

Table 1: Sample description and comparison of women agroecological and reference farmers on sociodemographic variables, food expenditures and production

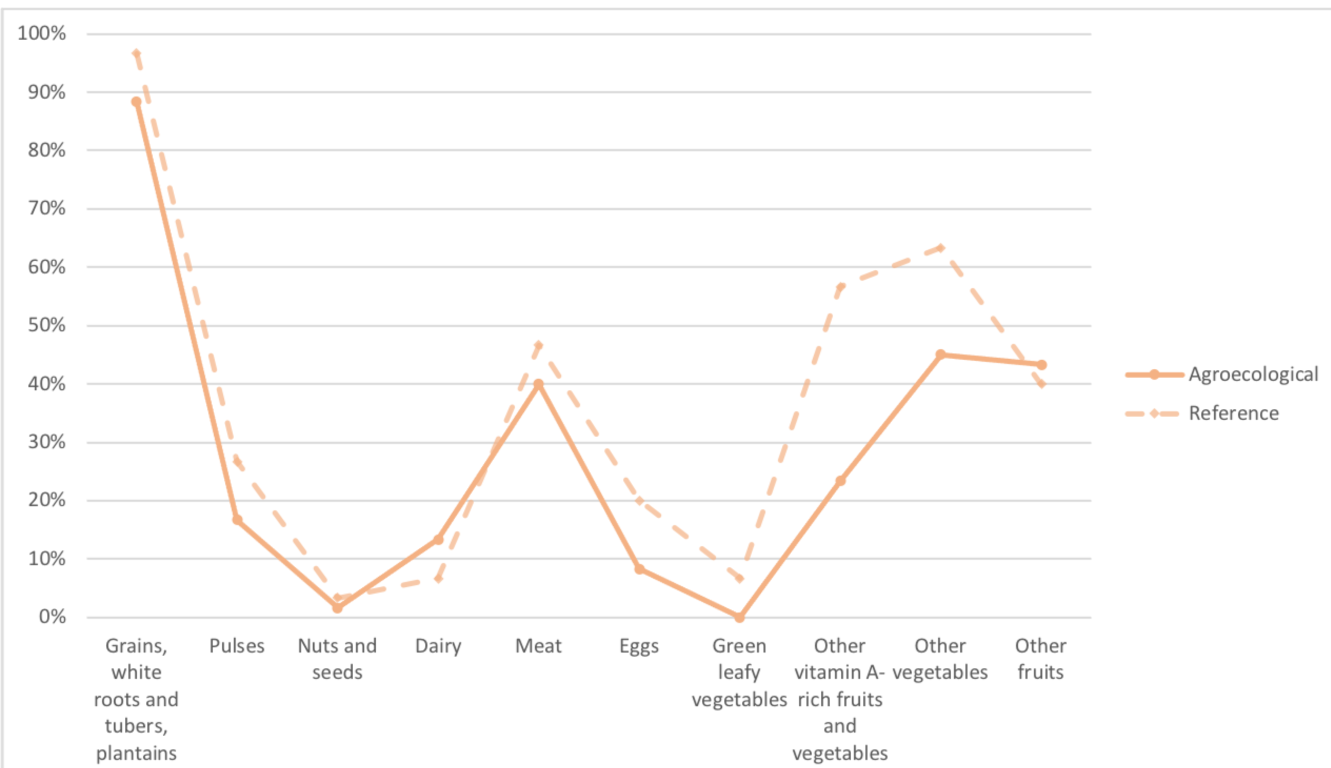
	Pooled sample (n=90)		Agroecological (n=60)		Reference (n=30)	
	mean [SD] or %	median (IQR)	mean [SD] or %	median (IQR)	mean [SD] or %	median (IQR)
Sociodemographics						
Age (years)	45 [13]	45 (37 - 52)	46 [13]	44.5 (37.5 - 53)	42 [13]	43.5 (34 - 49)
Monthly income per capita (USD)	91 [90]	67 (37 - 109)	87 [81]	61 (37 - 110)	100 [105]	84.5 (40 - 109)
Time to market (minutes)	47 [36]	40 (30 - 60)	49 [35]	37.5 (30 - 60)	43 [38]	43 (20 - 50)
Household size	5.3 [2.6]	5 (4 - 6)	5.6 [2.7]	5 (4 - 6.5)	4.8 [2.3]	4 (3 - 6)
Poverty by income						
No poverty	42%		38%		50%	
Poverty	24%		27%		20%	
Extreme poverty	33%		35%		30%	
Livelihood sources present in household						
Occasional or regular agricultural daily wage labor	27%		27%		27%	
Agricultural sales (excluding agroecological markets)	39%		37%		43%	
Other livelihood sources	72%		70%		77%	
Education completed by interviewee (% of sample)						
None or partial primary	44%		39%		53%	
Primary or partial secondary	38%		43%		30%	
Secondary or postsecondary	18%		18%		17%	
Monthly food expenditure per capita (USD)	18 [18]	11 (7 - 20)	15 [16]	10 (6 - 20)	23 [21]	16 (8 - 30)
Production						
Production diversity (products)	39 [17]	42 (27 - 51)	45 [15]	45.5 (36.5 - 54.5)	28 [14]	25 (17 - 41)

Access to irrigation (% of sample with access)	43%	47%	37%
Land surface in agricultural use (% of sample)			
<1 hectare	56%	45%	77%
1 - 3 hectares	33%	42%	17%
3 - 5 hectares	9%	12%	3%
>5 hectares	2%	2%	3%

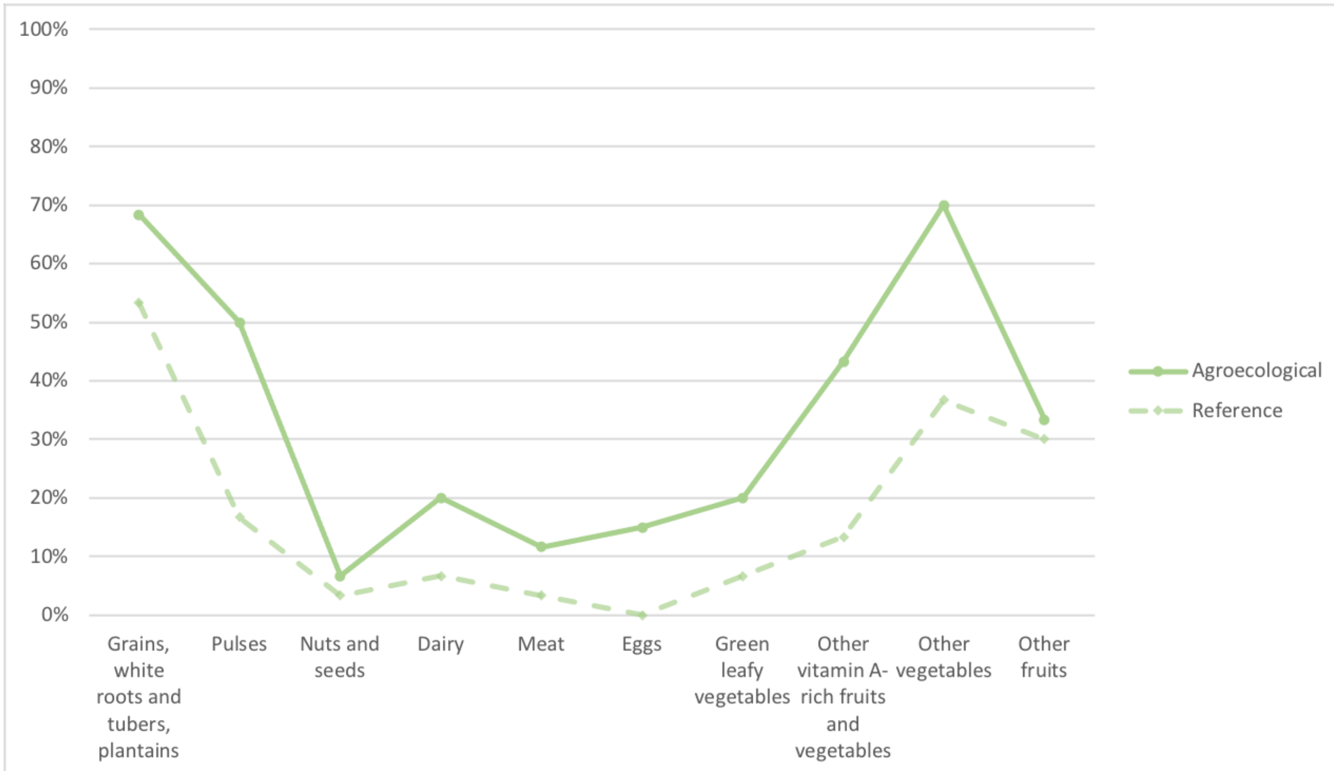
For categorical variables, prevalences are shown as percentages. For continuous variables, both sample means [standard deviation] and m (interquartile range) are shown to describe variable distributions. P-values are for the difference between agroecological farmers (farmer participate in agroecological associations) and reference farmers (the neighbors of agroecological farmers, but who do not participate in agroecological associations), which are compared using the chi-square test, student T-test (indicated by a superscript "t") or the U-test (in a superscript "u") according to variable type and distribution. We applied the Sattherthwaitte approximation to determine p-values when variances were a concern.

3.2 Food acquisition sources and their nutrient contributions

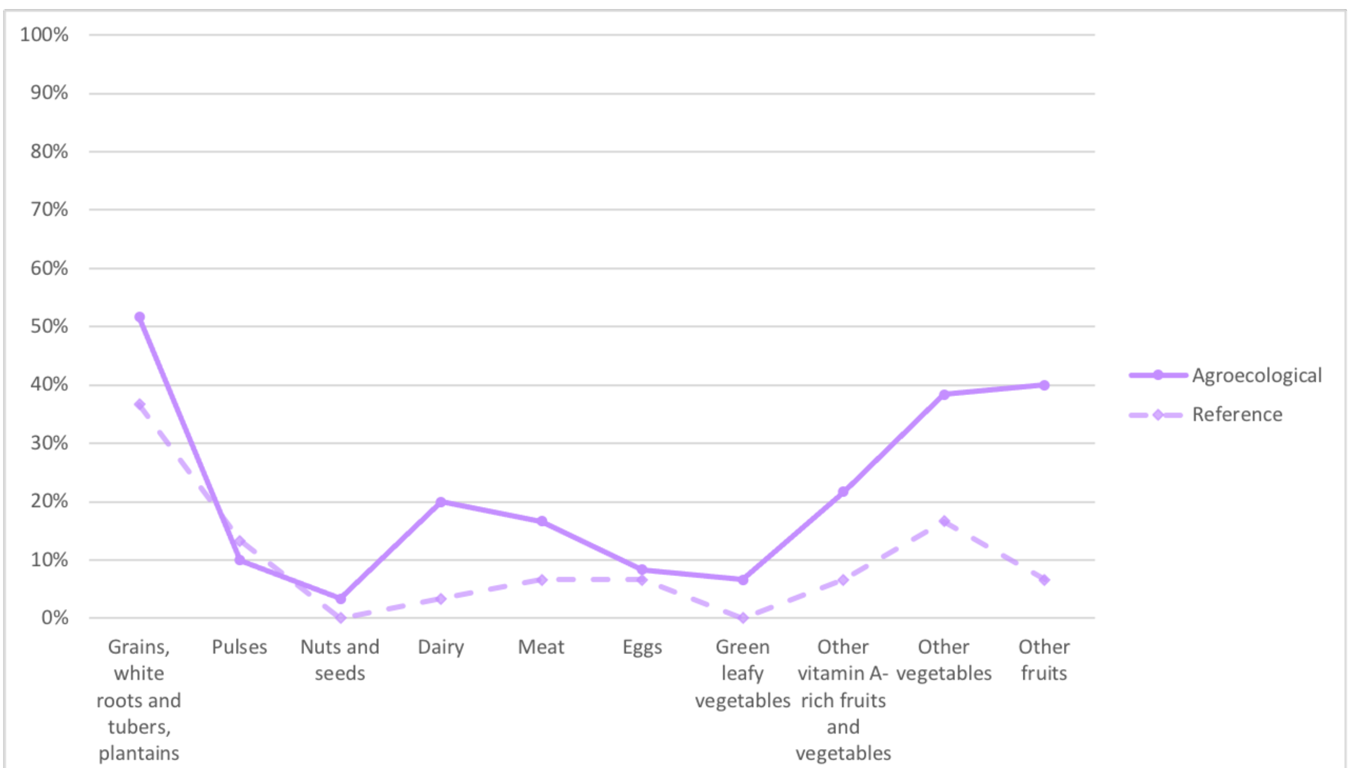
Farmers obtained different types of foods from a diversity of food acquisition sources, often relying on multiple sources for the same food group. Figure 1a, Figure 1b and Figure 1c show the proportions of agroecological and reference farmers who consumed items of each food group from conventional markets, their own harvest, and the social economy, respectively. Conventional markets stood out as a ubiquitous source of starchy staples (grains, white roots and tubers, and plantains) (Figure 1a), although these were also frequently obtained from their own harvest (Figure 1b) and the social economy (Figure 1c). Both conventional markets and farmers' own harvest were important sources of vegetables and fruits for both farmer groups. Differences appeared between agroecological farmers and reference farmers with respect to their acquisition sources of distinct food groups. Compared to reference farmers, agroecological farmers relied less on conventional markets and more on their own harvest for the majority of the food groups assessed. Further, among agroecological farmers, the social economy made relevant contributions to starchy staples, dairy, meat, vitamin A-rich fruits and vegetables, other vegetables, and other fruits. Among reference farmers, the social economy was much less important, primarily contributing to starchy staples and vegetables.



(a)



(b)



(c)

Figure 1. Proportion of farmers who consumed distinct food groups in a 24-hour period from (a) conventional markets, (b) own harvest and (c) the social economy, by farmer type.

Figure 2 illustrates that, for both farmer groups, conventional markets presented the greatest energy source of the three food acquisition sources. The two farmer groups exhibited differences in their reliance on distinct food sources for dietary energy intake. Compared to reference farmers, agroecological farmers obtained a significantly greater proportion of their dietary energy from their own harvest (p = 0.005) and the social economy (p = 0.002), and a significantly smaller proportion from conventional markets (p = 0.000).

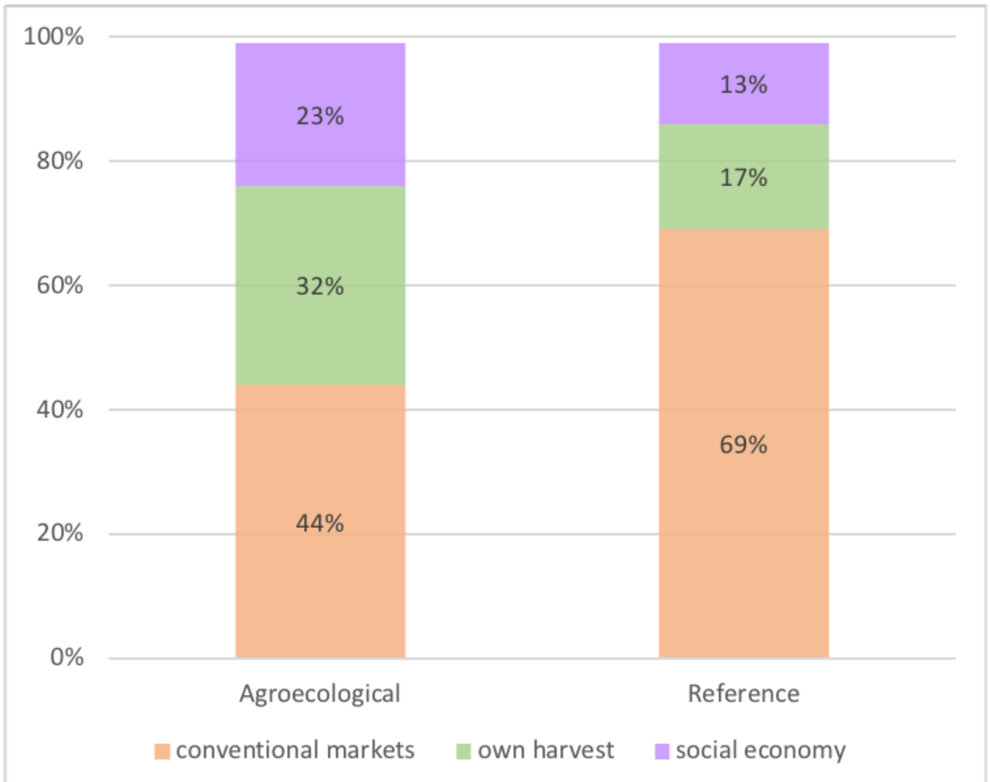


Figure 2. Sources of dietary energy among agroecological and reference farmers over a 24-hour period.

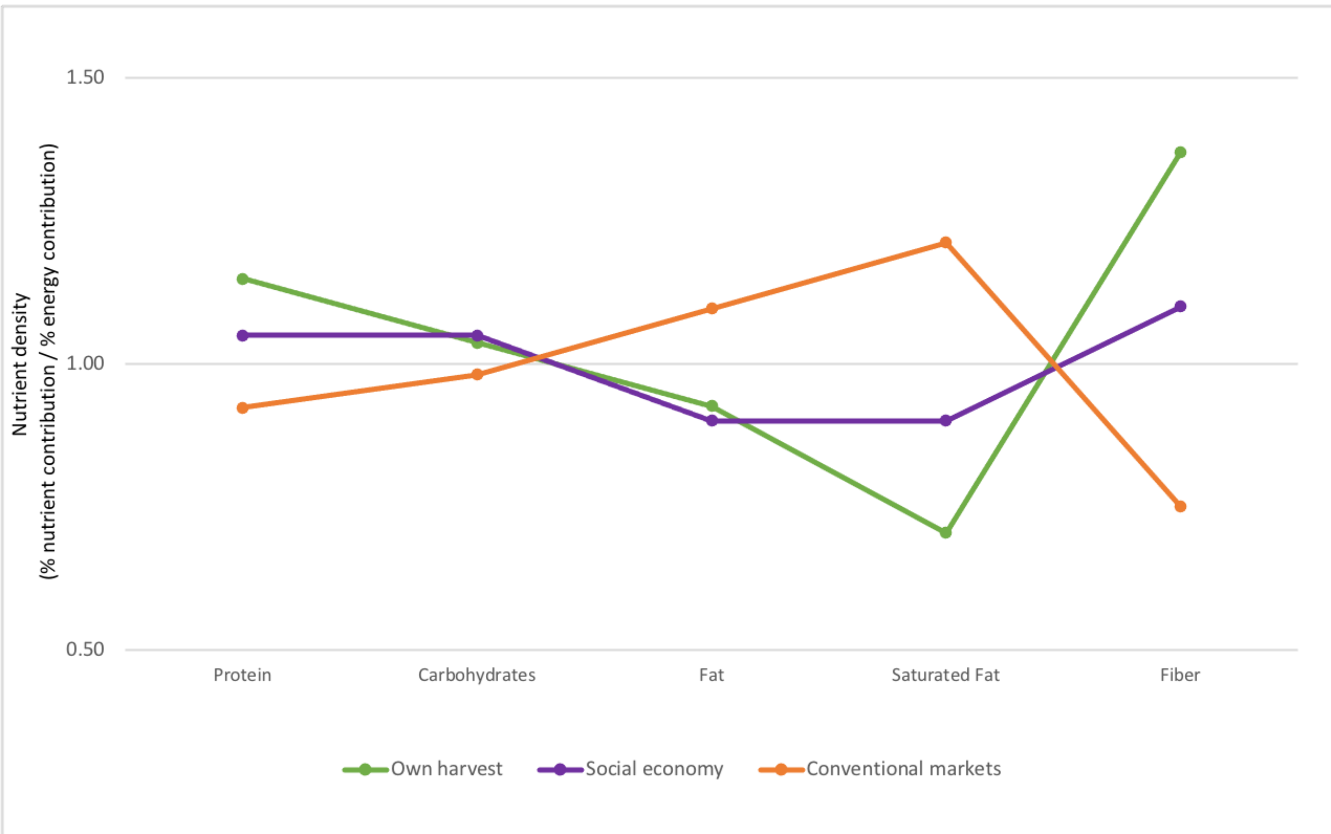
Table 2 shows the mean contributions made by the three food acquisition sources to distinct macronutrients and micronutrients, stratified by farmer group. When compared to contribution to dietary energy, each food source's relative contribution to each nutrient followed similar trends between the two farmer groups. We thus assessed the pooled sample for subsequent analyses on nutrient density.

Table 2: Mean relative contribution of conventional markets, own harvest and social economy to nutrient intake, by farmer category

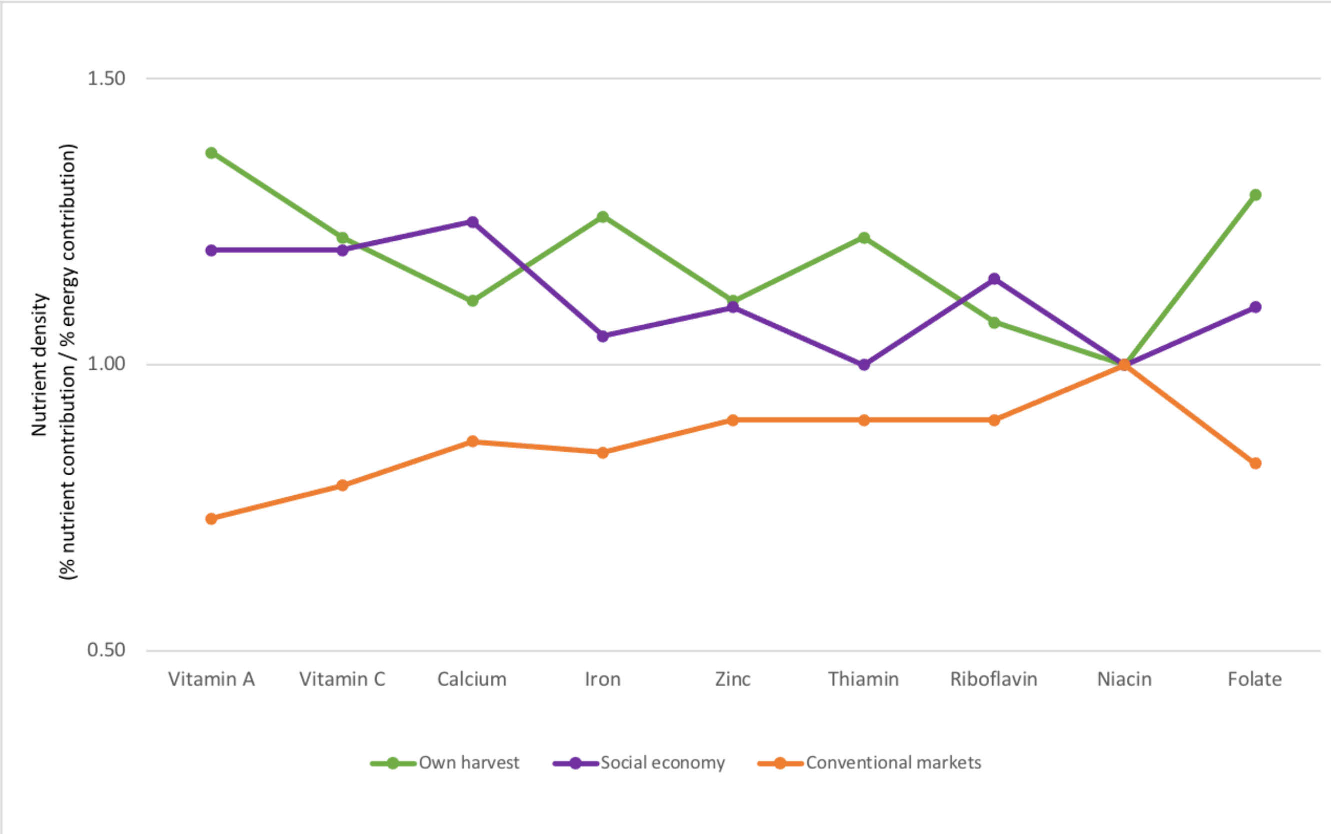
		Agroecological farmers			Reference farmers		
		conventiona l markets	own harvest	social economy	conventiona l markets	own harvest	social economy
Macronutrients							
	Energy	44%	32%	23%	69%	17%	13%
	Protein	39%	38%	24%	67%	17%	16%
	Carbohydrates	43%	32%	24%	65%	20%	14%
	Fat	47%	30%	22%	75%	14%	11%
	Saturated Fat	53%	23%	23%	83%	10%	7%
	Fiber	30%	43%	26%	58%	27%	14%
Micronutrients							
	Vitamin A	25%	44%	31%	66%	23%	11%
	Vitamin C	33%	35%	31%	59%	30%	11%
	Calcium	34%	35%	30%	65%	20%	14%
	Iron	36%	41%	23%	60%	20%	18%
	Zinc	38%	36%	25%	65%	18%	16%
	Thiamin	39%	38%	23%	62%	21%	16%
	Riboflavin	38%	35%	27%	67%	18%	14%
	Niacin	44%	33%	23%	69%	17%	14%
	Folate	33%	41%	25%	61%	22%	17%
Mean micronutrient contribution		36%	38%	26%	64%	21%	15%

Table shows the average share of nutrient intake, by nutrient, that farmers obtained from each food source over a 24-hour period. Mean micronutrient contribution is the average of contributions to vitamin A, vitamin C, calcium, iron, zinc, thiamin, riboflavin, niacin and folate.

Figure 3a and Figure 3b illustrate the macronutrient and micronutrient contributions of each food acquisition source in terms of nutrient density. On a per-calorie basis, conventional markets made disproportionately high contributions to fat and saturated fat, and low contributions to fiber, protein, and to most micronutrients. In contrast, foods from farmers’ own harvest made disproportionately low contributions to fat and saturated fat and high contributions to fiber, protein, and most micronutrients. Nutrient density contributions of the social economy generally followed the same trends as those of farmers' own harvest, although they were generally less pronounced.



(a)



(b)

Figure 3. (a) Macronutrient and **(b)** micronutrient density contributions of food acquisition sources over a 24-hour period for the pooled population. Densities above 1 are relatively nutrient-rich; densities below 1 are relatively energy-rich. The pooled population is presented for clarity; trends were similar for agroecological and reference farmers.

3.3 Sociodemographic, productive and dietary correlates of distinct food acquisition patterns

Table 3 shows the correlations between dietary intake (as the proportion of caloric energy) from the three food acquisition patterns and sociodemographic, production, and dietary variables. In the pooled sample, dietary intake from conventional markets was positively correlated with monthly income and food expenditures and negatively correlated with education, production diversity, and land surface in use. Correlations were moderate (r-value near or above 0.3) or weak (r-value below 0.3). Intake from own harvest consistently demonstrated correlations of similar strength, but in the opposite direction of those identified for conventional markets. With respect to dietary measures, intake from conventional markets was negatively correlated with the food variety score and with intake of foods in the NOVA 1 category (unprocessed and minimally processed foods). Instead, it was moderately positively correlated with consumption of foods from the NOVA 2 category (processed culinary ingredients).

Again, intake from farmers' own harvest predominantly presented correlations that were of similar strength, but the opposite direction, to those found for conventional markets. No significant correlations were identified with the social economy.

Identified correlations differed between the two farmer groups. For example, a higher monthly income was clearly identified to correlate with a higher dietary intake from conventional markets (r = 0.44) among reference farmers, but not among agroecological farmers. Moreover, most dietary correlates were only identified among agroecological farmers (n = 60) and the pooled sample (n = 90), for which sample sizes were substantially larger than for reference farmers (n = 30). However, the magnitude of correlation remained similar between the agroecological sample and pooled sample. For example, the correlation between consumption from markets and of foods from NOVA 2 (processed culinary ingredients) was similar in the agroecological (r = 0.29) and pooled sample (r = 0.32), indicating that the direction was likely similar among reference farmers, but the smaller sample size may have failed to detect it.

Table 3: Correlates of proportion of caloric intake from conventional markets, own harvest and the social economy

	Pooled sample (n=90)			Agroecological farmers (n=60)			Reference farme	
	Conventional markets	Own harvest	Social economy	Conventional markets	Own harvest	Social economy	Conventional markets	Own harvest
Sociodemographics								
Age (years)							-0.19	0.23
Monthly income per capita (USD)	0.19*	-0.24**	-		-0.2		0.44**	-0.25*
Time to market (minutes)	-0.16			-0.24	0.15	-		
Household size				-0.18	0.31**			
Education (score 0-5)	-0.19*	0.28***					0.16	
Food expenditure per capita (USD)	0.24**	-0.34***			-0.38***	0.22*	0.23	
Production								
Production diversity (products)	-0.25**	0.24**						
Access to irrigation (no = 0, yes = 1)							0.15	
Land surface in use	-0.38***	0.44***		-0.36***	0.43***		-0.23	0.17
Dietary indicators								
Dietary Diversity Score								
Food Variety Score	-0.26**	0.25**		-0.22*	0.24*			
NOVA 1 - unprocessed & minimally processed foods	-0.18*	0.21**		-0.18	0.26**			
NOVA 2 - processed culinary ingredients	0.32***	-0.15	-0.15	0.29**	-0.16	-0.15	0.16	
NOVA 3 - processed foods					-0.16	0.23*		
NOVA 4 - ultra-processed foods					-0.16		-0.27	

Correlations are reported using Pearson's or Spearman's Rho (R), according to variable distribution. *, ** and *** indicate significance at and 1% levels, respectively. Proportion of caloric intake from each source is the calories obtained from the given source divided by the tot the diet. Caloric intake and all dietary indicators are based on a single 24-hour recall period. Education completed is an ordinal variable w (none) to 5 (post-secondary). Land surface in use is an ordinal variable where: 1 = <1 hectare (ha), 2 = 1-3 ha, 3 = 3-5 ha, 4 = >5 ha. Correla coefficients below |+/-0.15| are left blank for clarity.

4. Discussion

In the interest of better understanding how agriculture can be mobilized to impact farmers' nutritional health, this study turned to smallholder women farmers in Ecuador's Imbabura highland province to evaluate the dietary contributions of foods obtained from three different sources: conventional markets, farmers' own harvest, and the social economy. We further assessed how food acquisition differed between agroecological farmers (i.e., women farmers who are members of agroecological associations) and reference farmers (i.e., women farmers who are the neighbors of the first group, but are not involved with agroecology), with the intent of better understanding how sustainable agriculture initiatives may interact with farmers' dietary practices.

4.1 Food acquisition sources and dietary health

Our findings shed light on how different food sources contribute to the nutrient intake and dietary health of farmers in this region. On balance, market foods consumed by study participants tended to be more calorie-dense than micronutrient-dense, and they made disproportionately high contributions to fat and saturated fat intake on a per-calorie basis. On the other hand, foods that were obtained from farmers' own harvest tended to be more micronutrient-dense than they were calorie-dense, and they also made key contributions to dietary fiber. Meanwhile, foods obtained through the social economy (e.g., gifting, barter, or direct purchase from other farmers) tended to follow the same trends as those obtained from a farmer's own harvest, although to a lesser degree; this is not surprising, as these are, for the most part, foods that are simply obtained through another farmer's harvest.

These distinct nutrient contributions were reflected in dietary outcomes. Farmers with higher energy intake from markets tended to fare worse on indicators of both nutrient adequacy and of dietary moderation: they consumed a lower diversity of foods, obtained a smaller share of their daily energy from unprocessed and minimally processed foods (such as fruits and vegetables), and they obtained a greater share of their daily energy from processed culinary ingredients (such as sugar and oils). This resounds with the growing concerns implicating retail environments in promoting access to unhealthy foods [3,26], particularly in low- and middle-income settings [29–31]. Meanwhile, we found higher energy intake from farmers' own harvest to be associated with both stronger nutrient adequacy and dietary moderation, aligning with previous research demonstrating that the consumption of foods from farmers' own production remains an important resource for farmer health in many settings [17]. Although the relationship between food acquisition practices and dietary outcomes appeared for our pooled farmer sample, the correlation was significant among agroecological farmers, but not among reference farmers. As the magnitude of the correlation was similar across the agroecological sample and pooled sample, the direction of these relationships between food acquisition and dietary outcomes were likely similar for reference farmers, but not significant due to their smaller sample size.

Our findings also appear to be consistent with previous research in Ecuador. An early study from the Ecuadorian highlands found that families who consumed a greater share of foods from subsistence production had higher dietary adequacy [68]. In more recent studies in the highlands, greater reliance on market foods was associated with protein deficiencies and carbohydrate excesses [69], and markets were posited to supplant nutritious foods from the farm with less nutritious sugars, oils, refined grains, and sugar-sweetened beverages [70]. Studies with Indigenous people in the Ecuadorian Amazon found that greater subsistence orientation and lower market integration was associated with healthier outcomes among children in terms of both stunting and overweight prevalence [71], and that higher consumption of market foods was associated with higher cholesterol levels among adults [72]. Despite pronounced cultural, economic, and ecological differences across the rural sectors of Ecuador's biogeographic regions [8], it appears that foods from farmers' own harvest are consistently healthier than those purchased from markets.

4.2 Social economy

Although the social economy made the least important contribution to dietary intake of the three food acquisition pathways assessed, it nevertheless contributed close to a quarter of agroecological farmers' energy intake, and for reference farmers, it was nearly as important as their own harvest. The social economy can be effective for obtaining products that are not available on one's own farm, but are otherwise available locally [47], as well as for filling dietary and other resource gaps during times of difficulty, as was evidenced during market disturbances related to the Covid-19 pandemic [50]. The social economy is largely distinguished from other food acquisition strategies because of its reliance on social capital [48,49], a resource that is constructed through the norms, relationships, and interactions in a network, and is particularly important in farming communities [73]. Numerous studies have illustrated how social capital can beget other forms of capital, including by providing access to resources and lowering transaction costs [73]. Through the social economy, farmers may mobilize social capital to bridge other resource gaps (e.g., money, livestock, productive land) that may limit their ability to obtain certain foods. This may be a particularly important means to supplement food acquisition for farmers who otherwise lack sufficient resources to engage in equal financial or material transactions (i.e., paying the full cost for food, or exchanging foods of equal monetary value).

The social economy has been documented for its relevance as a traditional source of food not only in the rural Andes [47,48], but also among other farming communities [74–76]. Nevertheless, it has not received explicit attention in predominant agriculture-nutrition linkage frameworks [44]. Even so, the connection is tenable, as farmers can mobilize the social economy both for productive resources (e.g., seeds) as well as directly for foods, both of which can contribute to their dietary health. We sustain that the Ecuadorian agroecology movement clearly illustrates the role of the social economy in agriculture-nutrition pathways. Although the movement is rooted in specific agricultural practices, it has evolved to transcend agriculture per-se, and to also create norms around the importance of engaging in barter, gifting, and direct purchase of seeds and foods with other farmers [40,44]. As our data show, the social economy contributed to agroecological farmers' privileged access to a wide variety of food groups, including dairy, meat, vitamin A-rich fruits and vegetables, and other fruits and vegetables, and provided a quarter of their daily caloric intake. Some caution is warranted, as foods obtained through the social economy are not guaranteed to be healthy. For example, in the Ecuadorian highlands, processed foods, such as soft drinks and sweets, play an increasing role in norms around gifting and sharing, especially in celebratory contexts [77]. However, we found the foods obtained through the social economy to be overall more micronutrient-dense than calorie-dense, suggesting that this is a promising local pathway for supporting nutritional health.

4.3 Food acquisition among agroecological and reference farmers

The different approaches to food acquisition among agroecological and reference farmers in our study may provide key lessons on how to support health-promoting practices. In general, agroecological farmers obtained a greater share of their energy intake from their own harvest and the social economy than did their reference neighbors, who instead relied more heavily on conventional markets. Moreover, the acquisition of distinct food groups varied between the two farmer groups. For example, farmers' own harvest and the social economy were much more important sources of fruits and vegetables for agroecological farmers than for reference farmers, who instead were more likely to purchase fruits and vegetables from markets. Additionally, agroecological farmers obtained animal source foods from all three food acquisition sources, while the vast majority of reference farmers exclusively obtained them through conventional market purchase. Previous studies have linked key protein and micronutrient deficiencies in the Ecuadorian rural highlands to a low intake of animal source foods [57,78]. A national nutrition study also identified important deficiencies in vitamin A, iron, zinc, and calcium, which are primarily present in animal source foods, as well as in fiber and vitamin C, which are primarily present in fruits and vegetables [10]. By maintaining diversified food acquisition strategies that include farmers' own harvest and the social economy, agroecological farmers may have superior access to critical food groups and nutrients.

These findings are not surprising in light of our previous research showing that social norms developed in Imbabura's agroecological farmers' associations promote consumption from farmers' own harvest as well as from the social economy [40,44], and that agroecological farmers take advantage of a higher production diversity—which is a central practice in agroecological farming [35,79]—in order to support dietary diversity [44]. Specifically, our previous analyses found that agroecological farmers achieved a mean dietary diversity score (DDS) of 5.9 food groups (out of a maximum of 10) and a mean food variety score (FVS) of 20 food items; this was significantly larger than the mean DDS and FVS among reference farmers, which were 4.8 and 17, respectively [44]. Agroecological farmers' privileged access to animal source foods may also be a result of agroecology's emphasis on the integration of livestock, which is raised not only as a source of food, but also to support soil fertility [35,79]. These connections between ecologically restorative farming practices and farmers' food acquisition underline how agroecology may simultaneously serve as an environmentally-sustainable and as a nutrition-sensitive agricultural paradigm.

The socioeconomic correlates of distinct food acquisition practices also revealed a curious difference in how the two farmer groups mobilized income in their food practices. Among reference farmers, higher incomes were strongly associated with consumption from conventional market purchases. This was not observed among agroecological farmers, despite a larger sample size that would otherwise make detecting correlations easier. Interventions to increase incomes have been frequently proposed and implemented as a means to support farmers' dietary health [80,81], albeit to varying degrees of success [80]. However, among reference farmers in our study, who are presumably more representative of farmers in the region than are the agroecological farmers, higher incomes seemed to support food acquisition patterns that undermine, rather than support, dietary health. The fact that this was not the case for agroecological farmers is compelling, especially because their low-income levels were comparable to those of the reference farmers and market purchases also made the largest relative contribution to their caloric intake. Possibly, the knowledge around food, nutrition, and agriculture developed in agroecological associations [40,44] may be intervening to determine how incomes are used. If this is the case, it would be valuable to better understand how the knowledge that is spread among farmers participating in agroecology could be scaled outward.

4.4 Relevance for agriculture-nutrition pathways

Pathways between agriculture and nutrition have been observed to operate differently in distinct contexts [17,80]. Because there is no one-size-fits-all approach, it is necessary to have a contextual understanding of how agriculture can impact nutrition in order to leverage promising pathways. Our data suggest that, for farmers in the Ecuadorian highlands, it is more appropriate to support dietary health through the consumption of farmers' own production rather than through income generation for food purchases. The foods that the farmers in our study population obtained from their own harvest were nutrient-rich, and farmers who consumed a greater share of their dietary energy from this source performed better on indicators of nutrient adequacy and moderation.

Previous research in the Ecuadorian highlands [44,70,82] points to a role for production diversity in supporting this outcome. Indeed, our data show that farmers who relied more strongly on their own harvest also had higher production diversity, although the relationship was not strong. This is consistent with numerous studies showing that production diversity can support farmers' nutrient adequacy when they consume the foods that they produce [17]. However, the low magnitude of the correlation that we detected, and that has otherwise been detected in Ecuadorian studies [70,82], calls into question whether this relationship is being measured and analyzed appropriately. This issue has received increased attention [17,83], with multiple explanations available for the dissonance between the relationships that farmers perceive between production diversity and dietary diversity, and that which is quantitatively measured [44]. Regardless of the precise role of production diversity, what remains clear in our data is that the consumption of foods from farmers' own harvest is associated with healthier dietary habits.

Regarding income generation for market food purchases, our findings corroborate concerns that markets can promote access to the calorie-dense, micronutrient-poor foods that characterize the nutrition transition and drive the increase in overweight and obesity prevalence in low-income settings [3,29–31,70]. Even so, many studies support the role of markets in providing access to dietary diversity and in reducing acute and chronic malnutrition [18,22,29]. As a result, some scholars have proposed that markets are in need of a healthier equilibrium between their simultaneous potentials to strengthen and to undermine dietary health [29]. However, in our study context, farmers who relied more strongly on market foods performed worse on both dietary moderation and nutrient adequacy assessments, suggesting that the potential of markets to make positive contributions to health in this particular food environment is severely compromised. This recalls the concerns voiced by Herforth and Ahmed, who proposed that the agriculture-nutrition evidence base needs to lend more attention to the role of market food environments, and that better tools for assessing food environments in rural, low-income settings can enable a stronger understanding for how to support nutritional health [24].

Conventional markets nevertheless represented the greatest source of food intake for our study population, in terms of both energy intake and the consumption of distinct food groups, and they were particularly important for accessing animal source foods. It would therefore be imprudent to attempt to ignore the role of markets. Instead, local programs and policies would be wise to support nutrition-sensitive markets alongside nutrition-sensitive agriculture approaches. In Afghanistan, for example, well-functioning markets with a strong diversity of healthy foods made important contributions to rural people's nutritional health [18]. However, until we have a greater understanding of how Ecuadorian farmers can utilize markets to their nutritional advantage, our data suggest that income generation for market purchases is unlikely to achieve positive dietary effects, whereas foods from farmers' own harvest deserve greater protagonism.

Agroecological farmers in the Ecuadorian highlands provide a unique example of how a farmers' agriculture movement, rather than a top-down intervention, can influence food acquisition practices [44], and our data further show that their food acquisition practices are more likely to result in healthy diets. It is recognized that norms and knowledge around food and nutrition are important for agriculture initiatives to have meaningful nutritional impacts [15], and agroecology may be well-positioned to curate and facilitate the spread of these norms. Agroecology's orientation around sustainable agriculture, rooted largely in traditional practices [35], may also mean that pathways to human health can simultaneously support environmental health through culturally-appropriate means, thereby acting as a much-needed interdisciplinary resource for tackling the global syndemic of undernutrition, obesity and climate change [36].

4.5 Methodological reflections

Like most dietary research in low- and middle-income countries [84], this study relied on 24-h recall. While this instrument has numerous practical advantages [84], it also has several recognized limitations, including a tendency to underestimate energy intake and overestimate micronutrient intake [85], as well as an inability to capture intraindividual variation when a single recall is deployed [86]. Our study also had a relatively small sample size, which undoubtedly affected our ability to assess certain relationships between variables. Among reference farmers in particular, where the sample size was only 30, we were unable to detect certain statistically significant correlations that otherwise appeared for both the agroecological (n = 60) and pooled sample (n = 90). We thus inferred the likely relationships within the reference farmer group by comparing the difference in the magnitude of correlations between the agroecological and pooled samples, though this practice runs the risk of producing spurious correlations [87].

These limitations notwithstanding, we found that our assessment of food acquisition practices by querying for the source of each item in 24-h recalls provided a useful means of measuring how farmers obtain distinct foods and nutrients. This differed from the approaches observed in many other studies, such as those reviewed by Jones [17], that primarily rely on more distant proxies (e.g., market distance, cash crop production, self-reported reliance) to infer the pathways by which farmers acquire their foods. Additionally, we believe our attention to nutrient-density—calculated as a ratio between a food source's relative contribution to key nutrients and its relative contribution to caloric energy—is well-suited for better understanding how different food acquisition sources contribute to nutritional health in the context of the double burden of malnutrition, particularly given the complexity of interactions between food environments and diets [28]. Despite a breadth of research on farmer nutritional health, we have not identified previous studies that have measured how all three food acquisition sources assessed (market foods, farmers' own production, and the social economy) contribute to nutrient density. Finally, we echo the words of others [7] who encourage future studies concerning rural populations in low- and middle-income settings to consider not only measures of nutrient adequacy, but also of moderation. While we found the NOVA classification scheme to be suitable for assessing dietary moderation in our context, we are aware that new indexes are currently being developed that may be even more appropriate.

5. Conclusions

Several salient points emerged from our study on food acquisition and dietary health among smallholder women farmers in the Ecuadorian highlands. First, we found that foods obtained from farmers' own harvest and the social economy tended to be micronutrient-dense, whereas those purchased in conventional markets tended to be more calorie-dense and micronutrient-poor. Similarly, farmers who obtained a greater proportion of their caloric intake from their own harvest tended to perform better on indicators of both nutrient adequacy and dietary moderation, whereas those who relied more heavily on conventional markets tended to perform worse on both. This finding supports the notion that, in this particular food environment, farmers' consumption of foods from their own production is likely a more effective means for agriculture to support dietary health. In contrast, increasing agricultural income for food purchases may inadvertently undermine both nutrient adequacy and moderation. We further identified the social economy as a traditional food acquisition source that remains relevant in this sociocultural context, and that has an underexplored potential to contribute to farmers' dietary health. Our evidence from Ecuador's agroecological farmers indicates that this movement toward sustainable farming practices may also be an existing means to support healthy food acquisition practices. In doing so, it can contribute to the much needed systemic transformation of the food system, which holds the formidable duty to simultaneously support human and environmental health in both agricultural production and in the food environment [7,24,36,37].

Author contributions: Conceptualization, A.D., M.B., and P.R.B.; methodology, A.D., M.B., P.R.B., and D.C.C.; software, A.D.; formal analysis, A.D.; investigation, A.D.; resources, M.B.; data curation, A.D.; writing—original draft preparation, A.D.; writing—review and editing, M.B., P.R.B., D.C.C., and G.M.; visualization, A.D.; supervision, M.B. and G.M.; project administration, M.B.; funding acquisition, M.B., P.R.B., and D.C.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Ekomer Research Consortium under grants from the International Development Research Centre, Ottawa, Canada, grant numbers CR-48490 and 109101-001, as well as the Canadian Institutes of Health Research, grant number HA1-164002. The views expressed herein do not necessarily represent those of the IDRC or its Board of Governors. A.D. received support from the Fonds de Recherche du Québec en Santé, grant number 262314, from the Université de Montréal Faculty of Medicine, as well as the Quebec Population Health Research Network. M.B. is supported by the Canada Research Chair program. The APC was funded by the Canadian Institutes of Health Research, grant number 109101-001.

Institutional review board statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Health Research Ethics Committee of the Université de Montréal in Canada (certifi-cate number 17–053-CERES-P, approved on May 2, 2017) and by the Institutional Review Board of the Universidad San Francisco de Quito in Ecuador (certificate number 2016-118E, on May 12, 2017).

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgements: The authors sincerely thank the study participants for their time, knowledge, and interest in this research, and Leonardo Velasco for his diligent support in data collection. We further thank the EkoRural Foundation and the Ekomer research team, whose members include: Stephen Sherwood, Myriam Paredes, Sara Latorre, Bana Salameh, Kate Zinszer, Fabián Muñoz, Pablo López, Ross Borja, Pedro Oyarzún, Gabriel April-Lalonde, Marcelo Aizaga, and Eliana Estrella, as well as A.D., P.R.B., D.C.C., and M.B.

Conflicts of interest: The authors declare no conflict of interest.

Data availability: The datasets analyzed during the current study are available from the corresponding author on reasonable request.

References

1. *The State of Food and Agriculture: Innovation in Family Farming*; Food and Agriculture Organization of the United Nations (FAO),: Rome, Italy, 2014; ISBN 978-92-5-108536-3.

2. *The State of Food Insecurity in the World 2015: Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2015.
3. Popkin, B.M.; Adair, L.S.; Ng, S.W. Global Nutrition Transition and the Pandemic of Obesity in Developing Countries. *Nutr. Rev.* **2012**, *70*, 3–21, doi:10.1111/j.1753-4887.2011.00456.x.
4. Ramirez-Zea, M.; Kroker-Lobos, M.F.; Close-Fernandez, R.; Kanter, R. The Double Burden of Malnutrition in Indigenous and Nonindigenous Guatemalan Populations. *Am. J. Clin. Nutr.* **2014**, *100*, 1644S–1651S, doi:10.3945/ajcn.114.083857.
5. Ramírez-Luzuriaga, M.J.; Belmont, P.; Waters, W.F.; Freire, W.B. Malnutrition Inequalities in Ecuador: Differences by Wealth, Education Level and Ethnicity. *Public Health Nutr.* **2020**, *23*, S59–S67.
6. FAO; IFAD; UNICEF; WFP; WHO *The State of Food Security and Nutrition in the World 2020: Transforming Food Systems for Affordable Healthy Diets*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2020; ISBN 978-92-5-132901-6.
7. Herforth, A.; Johns, T.; Creed-Kanashiro, H.M.; Jones, A.D.; Khoury, C.K.; Lang, T.; Maundu, P.; Powell, B.; Reyes-García, V. Agrobiodiversity and Feeding the World: More of the Same Will Result in More of the Same. In *Agrobiodiversity: Integrating Knowledge for a Sustainable Future*; Zimmerer, K.S., De Haan, S., Eds.; The MIT Press: Cambridge, MA, USA, 2019; pp. 185–211, ISBN 0-262-03868-4.
8. Molestina, R.C.; Villagómez Orosco, M.; Sili, M. *Atlas Rural Del Ecuador*; 1st ed.; Instituto Geográfico Militar del Ecuador: Quito, Ecuador, 2017; ISBN 978-9942-22-128-5.
9. *La Población Indígena Del Ecuador*; Instituto Nacional de Estadística y Censos (INEC): Quito, Ecuador, 2006.
10. Freire, W.B.; Ramírez, M.; Belmont, P. Tomo I: Encuesta Nacional de Salud y Nutrición de La Población Ecuatoriana de Cero a 59 Años, ENSANUT-ECU 2012. *Rev. Latinoam. Políticas Acción Pública* **2015**, *2*, 117.
11. Lopez-Cevallos, D.F.; Chi, C. Health Care Utilization in Ecuador: A Multilevel Analysis of Socio-Economic Determinants and Inequality Issues. *Health Policy Plan.* **2010**, *25*, 209–218.
12. Haddad, L. A Conceptual Framework for Assessing Agriculture–Nutrition Linkages. *Food Nutr. Bull.* **2000**, *21*, 367–373, doi:10.1177/156482650002100405.

13. Arimond, M.; Hawkes, C.; Ruel, M.; Sifri, Z.; Berti, P.R.; Leroy, J.L.; Low, J.W.; Brown, L.R.; Frongillo, E.A. Agricultural interventions and nutrition: lessons from the past and new evidence. In *Combating micronutrient deficiencies: food-based approaches*; Thompson, B., Amoroso, L., Eds.; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2011; pp. 41–75.
14. Herforth, A.; Lidder, P.; Gill, M. Strengthening the Links between Nutrition and Health Outcomes and Agricultural Research. *Food Secur.* **2015**, *7*, 457–461, doi:10.1007/s12571-015-0451-z.
15. Herforth, A.; Harris, J. *Understanding and Applying Primary Pathways and Principles Brief#1*; Improving nutrition through agriculture brief series; USAID/Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) Project: Arlington, VA, USA, 2014.
16. Frison, E.A.; Cherfas, J.; Hodgkin, T. Agricultural Biodiversity Is Essential for a Sustainable Improvement in Food and Nutrition Security. *Sustainability* **2011**, *3*, 238–253.
17. Jones, A.D. Critical Review of the Emerging Research Evidence on Agricultural Biodiversity, Diet Diversity, and Nutritional Status in Low- and Middle-Income Countries. *Nutr. Rev.* **2017**, *75*, 769–782, doi:10.1093/nutrit/nux040.
18. Zanello, G.; Shankar, B.; Poole, N. Buy or Make? Agricultural Production Diversity, Markets and Dietary Diversity in Afghanistan. *Food Policy* **2019**, *87*, 101731.
19. Jones, A.D.; Creed-Kanashiro, H.; Zimmerer, K.S.; De Haan, S.; Carrasco, M.; Meza, K.; Cruz-Garcia, G.S.; Tello, M.; Plasencia Amaya, F.; Marin, R.M. Farm-Level Agricultural Biodiversity in the Peruvian Andes Is Associated with Greater Odds of Women Achieving a Minimally Diverse and Micronutrient Adequate Diet. *J. Nutr.* **2018**, *148*, 1625–1637.
20. Ecker, O. Agricultural Transformation and Food and Nutrition Security in Ghana: Does Farm Production Diversity (Still) Matter for Household Dietary Diversity? *Food Policy* **2018**, *79*, 271–282, doi:10.1016/j.foodpol.2018.08.002.
21. Sibhatu, K.T. Farm-Level Agricultural Biodiversity Is Not the Principal Contributor to Diverse and Micronutrient-Rich Diets, nor to Overall Food Consumption in Smallholder Farm Households. *J. Nutr.* **2019**, *149*, 1482–1483.
22. Sibhatu, K.T.; Qaim, M. Rural Food Security, Subsistence Agriculture, and Seasonality. *PLoS ONE* **2017**, *12*, e0186406, doi:10.1371/journal.pone.0186406.

23. Remans, R.; DeClerck, F.A.J.; Kennedy, G.; Fanzo, J. Expanding the View on the Production and Dietary Diversity Link: Scale, Function, and Change over Time. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, E6082–E6082, doi:10.1073/pnas.1518531112.
24. Herforth, A.; Ahmed, S. The Food Environment, Its Effects on Dietary Consumption, and Potential for Measurement within Agriculture-Nutrition Interventions. *Food Secur.* **2015**, *7*, 505–520.
25. Ruel, M.T. Operationalizing Dietary Diversity: A Review of Measurement Issues and Research Priorities. *J. Nutr.* **2003**, *133*, 3911S–3926S, doi:10.1093/jn/133.11.3911S.
26. Monteiro, C.A.; Cannon, G.; Moubarac, J.-C.; Levy, R.B.; Louzada, M.L.C.; Jaime, P.C. The UN Decade of Nutrition, the NOVA Food Classification and the Trouble with Ultra-Processing. *Public Health Nutr.* **2018**, *21*, 5–17.
27. Cobb, L.K.; Appel, L.J.; Franco, M.; Jones-Smith, J.C.; Nur, A.; Anderson, C.A. The Relationship of the Local Food Environment with Obesity: A Systematic Review of Methods, Study Quality, and Results. *Obesity* **2015**, *23*, 1331–1344.
28. Lam, T.M.; Vaartjes, I.; Grobbee, D.E.; Karssenberg, D.; Lakerveld, J. Associations between the Built Environment and Obesity: An Umbrella Review. *Int. J. Health Geogr.* **2021**, *20*, 1–24.
29. Darrouzet-Nardi, A.F.; Masters, W.A.; Urbanization, Market Development and Malnutrition in Farm Households: Evidence from the Demographic and Health Surveys, 1986–2011. *Food Secur.* **2015**, *7*, 521–533.
30. Demmler, K.M.; Klasen, S.; Nzuma, J.M.; Qaim, M. Supermarket Purchase Contributes to Nutrition-Related Non-Communicable Diseases in Urban Kenya. *PLoS ONE* **2017**, *12*, e0185148.
31. Otterbach, S.; Oskorouchi, H.R.; Rogan, M.; Qaim, M. Using Google Data to Measure the Role of Big Food and Fast Food in South Africa's Obesity Epidemic. *World Dev.* **2021**, *140*, 105368.
32. de Jesus Silva, R.; Garavello, M.E. de P.E.; Nardoto, G.B.; Mazzi, E.A.; Martinelli, L.A. Factors Influencing the Food Transition in Riverine Communities in the Brazilian Amazon. *Environ. Dev. Sustain.* **2017**, *19*, 1087–1102.
33. Popkin, B.M. Nutrition Transition and the Global Diabetes Epidemic. *Curr. Diab. Rep.* **2015**, *15*, 64.
34. HLPE *Nutrition and Food Systems. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2017.

35. High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE) *Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition*; Committee on World Food Security: Rome, Italy, 2019; p. 163.
36. Swinburn, B.A.; Kraak, V.I.; Allender, S.; Atkins, V.J.; Baker, P.I.; Bogard, J.R.; Brinsden, H.; Calvillo, A.; De Schutter, O.; Devarajan, R. The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission Report. *Lancet* **2019**, *393*, 791–846.
37. Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S.; Garnett, T.; Tilman, D.; DeClerck, F.; Wood, A.; et al. Food in the Anthropocene: The EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems. *Lancet* **2019**, *393*, 447–492, doi:10.1016/S0140-6736(18)31788-4.
38. Sherwood, S.; Arce, A.; Berti, P.R.; Borja, R.; Oyarzun, P.; Bekkering, E. Tackling the New Materialities: Modern Food and Counter-Movements in Ecuador. *Food Policy* **2013**, *41*, 1–10, doi:10.1016/j.foodpol.2013.03.002.
39. Intriago, R.; Gortaire Amézcua, R.; Bravo, E.; O'Connell, C. Agroecology in Ecuador: Historical Processes, Achievements, and Challenges. *Agroecol. Sustain. Food Syst.* **2017**, *41*, 311–328, doi:10.1080/21683565.2017.1284174.
40. Deaconu, A.; Mercille, G.; Batal, M. The Agroecological Farmer's Pathways from Agriculture to Nutrition: A Practice-Based Case from Ecuador's Highlands. *Ecol. Food Nutr.* **2019**, *58*, 142–165.
41. *Agroecology Is Here to Stay: Mapping Agroecological Farmers and the Status of Agroecology in Ecuador's Highlands and Coastal Regions;* Heifer Foundation-Ecuador: Quito, Ecuador, 2014.
42. Wezel, A.; Bellon, S.; Doré, T.; Francis, C.; Vallod, D.; David, C. Agroecology as a Science, a Movement and a Practice. A Review. *Agron. Sustain. Dev.* **2009**, *29*, 503–515, doi:10.1051/agro/2009004.
43. Sherwood, S.; Van Bommel, S.; Paredes, M. Self-Organization and the Bypass: Re-Imagining Institutions for More Sustainable Development in Agriculture and Food. *Agriculture* **2016**, *6*, 66.
44. Deaconu, A.; Berti, P.R.; Cole, D.C.; Mercille, G.; Batal, M. Agroecology and Nutritional Health: A Comparison of Agroecological Farmers and Their Neighbors in the Ecuadorian Highlands. *Food Policy* **2021**, doi:10.1016/j.foodpol.2021.102034.

45. Utting, P.; van Dijk, N.; Matheï, M.-A. *Social and Solidarity Economy: Is There a New Economy in the Making? UNRISD Occasional Paper: Potential and Limits of Social and Solidarity Economy*; United Nations Research Institute for Social Development (UNRISD): Geneva, Switzerland, 2014.
46. Jiménez, J. Movimiento de Economía Social y Solidaria Del Ecuador: Circuitos Económicos Solidarios Interculturales. *Rev. Sociol.* **2014**, *24*, 123–140.
47. Argumedo, A.; Pimbert, M. Bypassing Globalization: Barter Markets as a New Indigenous Economy in Peru. *Development* **2010**, *53*, 343–349.
48. Ferraro, E. Trueque: An Ethnographic Account of Barter, Trade and Money in Andean Ecuador. *J. Lat. Am. Caribb. Anthropol.* **2011**, *16*, 168–184.
49. Robelly Espinoza, A. Barter, Old Fashioned or a Modern Alternative? Master's Thesis, Wageningen University, Wageningen, The Netherlands, 2019.
50. Córdoba, D.; Peredo, A.M.; Chaves, P. Shaping Alternatives to Development: Solidarity and Reciprocity in the Andes during COVID-19. *World Dev.* **2021**, *139*, 105323.
51. *Plan Provincial de Riego y Drenaje de Imbabura 2017-2037.*; Prefectura de Imbabura, Gobierno Autónomo Descentralizado de Imbabura: Imbabura, Ecuador, 2017.
52. *Fascículo Provincial Imbabura. Resultados Del Censo 2010*; Instituto Nacional de Estadística y Censos (INEC): Quito, Ecuador, 2010.
53. *Reporte de Pobreza Por Consumo Ecuador 2006-2014*; Instituto Nacional de Estadística y Censos (INEC): Quito, Ecuador, 2016.
54. Gross, J.; Guerrón Montero, C.; Hammer, M.; Berti, P.R. Creating Healthy Bodies in Rural Ecuador at a Time of Dietary Shift. In *Food, Agriculture and Social Change*; Sherwood, S., Arce, A., Paredes, M., Eds.; Routledge: Oxfordshire, UK, 2017; pp. 34–47, ISBN 978-1-315-44008-8.
55. Soto, M. Prácticas Alimentarias: Género y Globalización en Cuatro Comunidades de Saquisilí. Master's Thesis, Facultad Latinoamericana de Ciencias Sociales sede Ecuador (FLACSO), Quito, Ecuador, 2014.
56. Berti, P.R.; Leonard, W.R.; Berti, W.J. Malnutrition in Rural Highland Ecuador: The Importance of Intrahousehold Food Distribution, Diet Composition, and Nutrient Requirements. *Food Nutr. Bull.* **1997**, *18*, 1–11.
57. Berti, P.R.; Krasevec, J.; Cole, D. *Diet Inadequacies and Neurobehavioural Impairment in Rural Highland Ecuadoreans*; HealthBridge: Ottawa, Canada, 2004; p. 23.

58. Shim, J.-S.; Oh, K.; Kim, H.C. Dietary Assessment Methods in Epidemiologic Studies. *Epidemiol. Health* **2014**, *36*, doi:10.4178/epih/e2014009.
59. FoodData Central. USDA. Available online: Fdc.nal.usda.gov (accessed on June 1, 2020)
60. Ramírez-Luzuriaga, M.J.; Silva-Jaramillo, M.; Belmont, P.; Freire, W. *Tabla de Composición de Alimentos Del Ecuador: Compilación Del Equipo Técnico de La ENSANUT-ECU 2012*; Ministerio de Salud Pública del Ecuador: Quito, Ecuador, 2014.
61. Steyn, N.P.; Nel, J.H.; Nantel, G.; Kennedy, G.; Labadarios, D. Food Variety and Dietary Diversity Scores in Children: Are They Good Indicators of Dietary Adequacy? *Public Health Nutr.* **2006**, *9*, 644–650.
62. *Minimum Dietary Diversity for Women: A Guide for Measurement;* Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2016.
63. Trijsburg, L.; Talsma, E.F.; De Vries, J.H.; Kennedy, G.; Kuijsten, A.; Brouwer, I.D. Diet Quality Indices for Research in Low-and Middle-Income Countries: A Systematic Review. *Nutr. Rev.* **2019**, *77*, 515–540.
64. Freire, W.B.; Belmont Guerrón, P.; Jiménez, E.; Román, D.; Burgos, E. *Lista de Alimentos, Preparaciones y Bebidas Que Se Consumen En Ecuador Según La Clasificación NOVA 2017*; Universidad San Francisco de Quito USFQ, Escuela de Salud Pública, Instituto de Investigaciones de Salud y Nutrición: Quito, Ecuador, 2017.
65. Moubarac, J.C. *Ultra-Processed Food and Drink Products in Latin America: Trends, Impact on Obesity, Policy Implications;* Pan American Health Organization: Washington, DC, USA, 2015.
66. *Healthy Diet Fact Sheet No. 394*; World Health Organization (WHO): Geneva, Switzerland, 2018.
67. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*; Routledge: Oxfordshire, UK, 2013; ISBN 1-134-74270-3.
68. Leonard, W.R.; Dewalt, K.M.; Uquillas, J.E.; Dewalt, B.R. Ecological Correlates of Dietary Consumption and Nutritional Status in Highland and Coastal Ecuador. *Ecol. Food Nutr.* **1993**, *31*, 67–85.
69. Orozco, F.; Cole, D.C.; Muñoz, V.; Altamirano, A.; Wanigaratne, S.; Espinosa, P.; Muñoz, F. Relationships among Production Systems, Preschool Nutritional Status, and Pesticide-Related Toxicity in Seven Ecuadorian Communities: A Multi-Case Study Approach. *Food Nutr. Bull.* **2007**, *28*, S247–S257.

70. Oyarzun, P.J.; Borja, R.M.; Sherwood, S.; Parra, V. Making Sense of Agrobiodiversity, Diet, and Intensification of Smallholder Family Farming in the Highland Andes of Ecuador. *Ecol. Food Nutr.* **2013**, *52*, 515–541.
71. Houck, K.; Sorensen, M.V.; Lu, F.; Alban, D.; Alvarez, K.; Hidobro, D.; Doljanin, C.; Ona, A.I. The Effects of Market Integration on Childhood Growth and Nutritional Status: The Dual Burden of Under-and Over-nutrition in the Northern Ecuadorian Amazon. *Am. J. Hum. Biol.* **2013**, *25*, 524–533.
72. Liebert, M.A.; Snodgrass, J.J.; Madimenos, F.C.; Cepon, T.J.; Blackwell, A.D.; Sugiyama, L.S. Implications of Market Integration for Cardiovascular and Metabolic Health among an Indigenous Amazonian Ecuadorian Population. *Ann. Hum. Biol.* **2013**, *40*, 228–242.
73. Kansanga, M.; Luginaah, I.; Bezner Kerr, R.; Lupafya, E.; Dakishoni, L. Beyond Ecological Synergies: Examining the Impact of Participatory Agroecology on Social Capital in Smallholder Farming Communities. *Int. J. Sustain. Dev. World Ecol.* **2020**, *27*, 1–14.
74. Kegel, H. The Significance of Subsistence Farming in Georgia as an Economic and Social Buffer. *Subsist. Agric. Cent. East. Eur. Break Vicious Circ.* **2003**, 147–160.
75. Wilkie, D.S.; Curran, B.; Tshombe, R.; Morelli, G.A. Modeling the Sustainability of Subsistence Farming and Hunting in the Ituri Forest of Zaire. *Conserv. Biol.* **1998**, *12*, 137–147.
76. Singh, R.K.; Singh, A.; Sureja, A.K. Traditional Foods of Monpa Tribe of West Kameng, Arunachal Pradesh. *Indian J. Tradit. Knowl.* **2007**, *6*, 12.
77. Chamorro, A. Dieta y Agrobiodiversidad Durante La Modernización de Las Chakras En La Sierra Central Ecuatoriana. Master's Thesis, Wageningen University, Wageningen, The Netherlands, 2011.
78. Melby, C.L.; Orozco, F.; Ochoa, D.; Muquinche, M.; Padro, M.; Munoz, F.N. Nutrition and Physical Activity Transitions in the Ecuadorian Andes: Differences among Urban and Rural-dwelling Women. *Am. J. Hum. Biol.* **2017**, *29*, e22986.
79. Macas, B.; Echarry, K. Caracterización de Mercados Locales Agroecológicos y Sistemas Participativos de Garantía Que Se Construyen En El Ecuador. *Quito Coord. Ecuat. Agroecol.* **2009**.
80. Hawkes, C.; Ruel, M. T. *From Agriculture to Nutrition: Pathways, Synergies and Outcomes*; World Bank: Washington, DC, USA, 2007.

81. Du, L. *Leveraging Agriculture for Nutritional Impact through the Feed the Future Initiative: A Landscape Analysis of Activities Across 19 Focus Countries*; USAID/Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) Project: Arlington, VA, USA, 2014.
82. Melby, C.L.; Orozco, F.; Averett, J.; Muñoz, F.; Romero, M.J.; Barahona, A. Agricultural Food Production Diversity and Dietary Diversity among Female Small Holder Farmers in a Region of the Ecuadorian Andes Experiencing Nutrition Transition. *Nutrients* **2020**, *12*, 2454.
83. Berti, P.R. Relationship between Production Diversity and Dietary Diversity Depends on How Number of Foods Is Counted. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, E5656–E5656, doi:10.1073/pnas.1517006112.
84. *Dietary Assessment: A Resource Guide to Method Selection and Application in Low Resource Settings;* Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2018.
85. Poslusna, K.; Ruprich, J.; de Vries, J.H.; Jakubikova, M.; van't Veer, P. Misreporting of Energy and Micronutrient Intake Estimated by Food Records and 24 Hour Recalls, Control and Adjustment Methods in Practice. *Br. J. Nutr.* **2009**, *101*, S73–S85.
86. Gibson, R.S.; Charrondiere, U.R.; Bell, W. Measurement Errors in Dietary Assessment Using Self-Reported 24-Hour Recalls in Low-Income Countries and Strategies for Their Prevention. *Adv. Nutr.* **2017**, *8*, 980–991.
87. Hassler, U.; Thadewald, T. Nonsensical and Biased Correlation Due to Pooling Heterogeneous Samples. *J. R. Stat. Soc. Ser. Stat.* **2003**, *52*, 367–379.

6.6 Supplementary results: deliberative results dissemination and interpretation

6.6.1 Introduction

This research project committed to a participatory research approach. Participatory research involves key communities and actors throughout all stages of research, from study conceptualization to results interpretation, dissemination and use (Cornwall and Jewkes 1995). Discussing the study through a deliberative process allows researchers, participants and stakeholders to maximize comprehension of the research results and identify appropriate means to utilize them in practice (Gauvin 2009). This also provides an opportunity to reflect on the study's implementation process and identify lessons for future work (Cornwall and Jewkes 1995). This section thus describes this project's deliberative results dissemination and interpretation process, presents its main findings, and reflects on the findings as well as on the process itself.

6.6.2 Methods

Consistent with the deliberative process (Gauvin 2009), results dissemination activities were conducted with study participants and other relevant stakeholders to meet four objectives: (i) sharing results; (ii) co-interpretation of results; (iii) reflection on the research process; and, (iv) discussion on translation of results into practice. This involved three forms of participatory engagement, which I conducted between May 3 and April 24, 2019. The activities received ethics approval along with other study components presented in this thesis (Annex 1). The three forms of participatory engagement were:

(1) focus group discussions (FGDs) with agroecological AFNs that had participated in the research project's cross-sectional survey;
(2) semi-structured key informant interviews (KII) with agroecological AFN leaders;
(3) semi-structured KIIs or group meetings with other stakeholders, including representatives of NGOs active in Imbabura, civil society organization leadership, local authorities and state agencies at different scales (municipal, provincial, national).

The first form of participatory engagement, FGDs, targeted individuals who had participated in the quantitative phases of the research project (i.e. cross-sectional survey). This activity was critical for achieving supporting the first two objectives of the results dissemination process (sharing and co-interpretation of results). Methods and results related to this activity are presented in Section 6.3: Article 2 and Section 6.4: Article 3. The second form of participatory engagement, KIIs with AFN leaders, was intended to contribute to all four results dissemination objectives. The third form, KIIs and group meetings with other stakeholders, was primarily oriented toward the first objective (sharing results) as well as the fourth objective (discussing next steps).

Additionally, I presented results to a broader audience through public fora and media appearances. These public activities and media were intended to further support the first results dissemination objective (sharing results), but we did not submit them to further analysis. A visual lay report (Annex 5) and a summary flyer (Annex 6) facilitated all results dissemination activities. These materials were developed to promote comprehension by people from diverse educational backgrounds and they currently remain for use by agroecological associations and key local partners from EkoRural.

Analysis

Notes from KIIs with AFN leaders and KIIs (or group meetings) with other stakeholders were examined using a thematic analysis (Hsieh and Shannon 2005). We assessed the following themes, which were related to the objectives of the results dissemination process: (i) perceptions on implementation of the research project; (ii) interpretation of study results; and, (iii) opportunities and next steps for translating research findings into practice.

6.6.3 Results

The results dissemination process resulted in the following activities: eight focus group discussions (FGDs) with agroecological AFNs (n = 128 total participants); 7 KIIs with AFN leaders; 10 semi-structured KIIs and 5 group meetings (for a total of 78 participants in group meetings) with other stakeholders. Public results dissemination activities included presentations in three public fora (in the cities Ibarra, Quito and Riobamba), one appearance on a radio program with national reach and a bulletin on the website of the Que Rico Es responsible consumption campaign[35]. Analysis of activities with AFN leaders and other stakeholders provided helpful insights on the three themes that were anticipated by our analysis approach. An additional, unexpected theme emerged among a minority of the stakeholders consulted: challenges to the research premise.

Perceptions on implementation of the research project

KIIs with agroecological AFN leaders provided new insights regarding study implementation, specifically relating to how the project was presented to the AFN, how the survey component was conducted, and how results were returned in FGDs. All leaders consulted expressed a positive overall perception regarding study implementation, and some also offered constructive ideas for how future research projects may be improved.

Regarding community engagement for the initial presentation of the project, several AFN leaders expressed their appreciation that the project's survey component was explained and discussed with both AFN leaders as well as other AFN members prior to implementation. One AFN leader, Alberto[36], emphasized the importance of this process to building trust: "Sometimes, research projects can be very overwhelming for our people. For example [a different research project] did not do a good job explaining the who-what-why. This can lead to a lot of distrust, so it was good that you explained your project beforehand and everyone could understand what you were here to do, and not just the leaders." On this same subject, both Mayra and Francisco (other AFN leaders) suggested that for future studies it would be helpful to provide a more detailed explanation of how study results would be utilized so that AFN members would have a stronger understanding of why their participation in research was important.

Regarding survey implementation, some AFN leaders found the survey length to be long and tiring, while others found it to be appropriate in length. Those of the latter opinion suggested the survey length was a reasonable burden given the value that the survey provided, and one cited other surveys that were much more extensive, yet ultimately failed to deliver valuable information to the

[35] Available at: https://www.quericoes.org/category/investigaciones/diversidad-de-la-tierra-al-plato/
[36] Names in this section have been altered.

participating community. When asked how survey implementation could be improved, AFN leaders Carla and Amaranta suggested that researchers be accompanied by a community member when conducting surveys to increase the project's credibility and connection with the community. Carla and Amaranta also expressed that the survey, and therefore the scope of the research, should be expanded to include other variables as well as participants in other regions. Some of the subjects they suggested included: comparing Imbabura to other provinces, assessing economic rentability of agroecology, and field assessments for more detailed characterizations of agroecological practices. Carla also suggested that the study should be replicated in other provinces that have a longer history with agroecological AFNs, specifically the provinces in the southern highland region of the country.

AFN leaders were enthusiastic about the participatory methods used to share and co-interpret results with other AFN members in FGDs, and they contrasted this to previous research projects that either never returned results or failed to do so in a meaningful way. One AFN leader, Carla, stated: "Many people have come to study our [AFN], and they all promise that they will come back to return the results. But of all the people who have come, you are the only one to actually come back and return the results." Upon further inquiry, she specified that other researchers had indeed attempted to return results, but they often failed to present them using effective communication strategies; they instead relied on powerpoints or lectures that presented complex graphics, statistics and technical terms that were inappropriate for the education backgrounds of most AFN members. They emphasized that many AFN members have difficulty understanding Spanish (they instead speak Kichwa), let alone know how to read or understand statistical charts. When asked how results dissemination could be further improved, Alberto suggested that future projects include thorough training workshops for how to use data and implement results.

Interpretation of study results

In close discussion regarding preliminary results from our quantitative methods, AFN leaders provided multiple insights and perspectives that helped inform our understanding of themes relevant to our project's research objectives, as well as revealed subjects of future research interest for the community. These insights are summarized in Table 4.

Table 4: AFN leadership insights on study results	
Theme	**Summary**
Origin of calories and nutrients	One AFN leader, Carla was concerned by the results that show where agroecological and conventional farmers get their calories and nutrients (conventional purchase, own harvest, or social economy), because she believes that agroecological farmers are still obtaining too much of their food from conventional purchase. In contrast, Alberto and Esperanza saw this result as overwhelmingly positive, because it shows that agroecological farmers obtain substantially more of their food from their own harvest and the social economy than do reference farmers, suggesting that their initiatives to promote these food acquisition strategies have been successful.
Dietary diversity and nutrients	Several AFN leaders believed that agroecological products are more nutritious due to their agroecological nature (e.g. agroecological products contain more nutrients).
Overweight and obesity, and diet-related chronic disease	Most AFN leaders were disappointed to find that agroecological farmers did not perform better on overweight and obesity or on associated diseases. Some had expected that, by virtue of people's diversification of their diets, their consumption of traditional products, their rejection of certain "modern" foods, their avoidance of toxic pesticides, or their dedication to agricultural work, they would perform better on these indexes. Aiming to then understand why agroecological farmers do not perform better, they suggested several reasons: agroecology is too new to have had an impact on overweight and associated diseases; not enough attention has been given to the general problem of overweight or specifically to excess consumption of calories, sugar, salt, and fat; farmers eat well at home, but when they go to the city, including to participate in the agroecological market, they do not eat well. They discussed this as a priority area to address through workshops or other means.
Pathways between agroecological markets and dietary diversity	AFN leaders generally perceived that agroecology may promote nutritional health by increasing production diversity (and therefore dietary diversity), by creating a space for barter (thus increasing access to dietary diversity), and by sharing food knowledge. They also strongly believed that people's participation in the agroecological market has a causal effect in generating positive change. As Carla said, "agroecological production without the [agroecological] markets has no impact." She went on to say, "you build a family within the group. What one person does influences the others. This generates differences in lifestyle and diet."
Production diversity	While AFN leaders spoke of production diversity as an inherent part of agroecology, some also referred to it as a response to consumer demand. Amaranta explained that, "in the markets, consumers demand diversified production. This is why we learn to plant this way, to meet consumer demand." She further specified that this is a unique characteristic of AFNs, as they have a unique consumer base.
Barter	AFN leaders emphasized the role of barter in increasing dietary diversity, especially in markets in which people come from different ecological zones. Alberto discussed how his AFN had worked to strengthen barter in order to strengthen cultural roots and support food sovereignty.

Traditional foods	AFN leaders were not at all surprised that the data showed that agroecological farmers consume and produce more traditional foods. Specifically, they said that agroecological farmers consume more traditional foods because they produce more traditional foods. Francisco explained that traditional foods are largely coherent with agroecological production strategies, because they grow better on marginal lands, do not require as much water, and are more resistant to pests, so agroecological farmers choose to grow them. Carla and Amaranta drew the connection between consumer demand for traditional foods in agroecological markets and farmers' production to meet that demand. Several market leaders also mentioned that traditional foods are a part of their Indigenous identity, and strengthening this identity is a priority in the social environment of the agroecological markets. For example, Carla explained that the organizations that supported the market from the beginning explicitly promoted traditional food production as a means of strengthening identity. Esperanza mentioned her AFN's affiliation with FICI (Imbabura Indigenous and Peasant Federation) as an additional impulse toward the valorization of Indigenous identity and thus of traditional foods. Additionally, Francisco mentioned that traditional foods have medicinal properties or are generally more nutritious or healthy.
Land surface in production	While some AFN leaders disputed the result that agroecological farmers would have more land surface in production than their neighbours, others saw it as logical. For example, Esperanza and Francisco stated that agroecological farmers might not necessarily *own* more land, but that they certainly *used* more land, either by making better use of the land that they own, or by renting space from others. Further, they said that agroecological farmers value farming more, making them more likely to make productive investments in purchasing more land. Some also suggested that this question on the survey led to confusion, with some people responding regarding how much land they *own*, even though the question asked about how much land they used for productive purposes.
Irrigation	Carla suggested the importance of access to irrigation in providing access to dietary diversity (through production yield and production diversity).
Migration	Paula summarized the importance of AFNs in attenuating rural-urban migration: "Market participants do not migrate; they join the market to be able to capture economic funds from production and not have to migrate."

Translating research findings into practice

KIIs with AFN leaders as well as KIIs and group meetings with other stakeholders were an opportunity to discuss how research outputs (i.e. the lay report and other publications related to the results) could be utilized, and how findings could ultimately translate into tangible practices within AFNs or within stakeholder organizations.

With respect to research outputs, AFN leaders found the lay report to be particularly useful in providing an evidence base and lending scientific credibility to their initiatives. Alberto stated that he would use these results in a municipal ordinance that he is currently developing to support responsible consumption in Ibarra (the capital of Imbabura province). He specified: "This information allows us to substantiate what we do. It gives us indicators." He further identified the results as a tool to support efforts related to the Movement for Social and Solidarity-based Economy, in which he is also a local leader. Another AFN leader, Francisco stated he would use the lay report as a tool in capacity-building activities that he leads with other (non-agroecological) farmer associations. Similarly, Carla found the study's lay report to be a useful tool for supporting her AFN's efforts to spread understanding of the benefits of agroecology. Several AFN leaders expressed that study findings would support in planning their association's future because it provides them with a basis to assess what the association is doing well and what it can improve. AFN leaders also expressed hopes that the research results could garner increased support for agroecology at a provincial and national level, particularly for public policy. To these ends, several AFN leaders identified additional audiences (e.g. local ministry representatives, NGOs) for which they believed the study results would be useful, and placed me in contact with the relevant people to coordinate the meeting.

Given the findings of the study, AFN leaders also brainstormed ideas on how to use their activities to strengthen impacts on nutritional health. Some targeted the issue that farmers do not have time to eat well on their AFN's market day, and they thus considered means to provide healthy meals at the market as well as to set a good example in meals that the association members eat together. For example, Patricia was interested in introducing more wild leafy greens into the foods that the association members share during their planning meetings and market days, such as making the commonly consumed "papa con berro" (potatoes with watercress), but instead adding greens such as amaranth leaves, bledo, taraxaco, lengua de vaca or verdolaga. She also considered ways to "include more Indigenous foods" that mixed grains with legumes, such as hominy with beans. She suggested these practices would serve to both provide nutritious meals for AFN members, who are otherwise very busy on market days, as well as to promote traditional foods. Other AFN leaders suggested that they would increase emphasis on discussing dietary excesses that lead to overweight and associated diseases.

To further support linkages between agricultural practices and nutritional health, AFN leaders also discussed the importance of connections with ally organizations. For example, Carla spoke of the role of the NGOs Agronomists and Veterinarians without Borders, Oxfam and Vibrant Village in funding activities related to the Que Rico Es responsible consumption campaign. Through this funding, her association was able to organize and participate in multiple replicas of the Que Rico Es responsible consumption educational workshops, which she identified as being particularly effective in sharing nutritional knowledge. Patricia cited the importance of gastronomy workshops given by Vibrant Village for learning how to translate production diversity into dietary diversity. Given the results of the study, AFN leaders proposed that strengthening engagement with NGOs and other civil society organizations would serve to build on existing successes and to continue working on areas that need further attention.

For some of the other stakeholders consulted, discussing results was useful for identifying ways in which agricultural programming could become more nutrition-sensitive. For example, the Imbabura Minister of Agriculture expressed interest in strengthening initiatives aimed at increasing production diversity, and particularly diversity of traditional crops and varieties. To support this goal, he organized for me to facilitate a half-day workshop with his entire staff, with the dual objectives of presenting research results and facilitating activities for his staff to brainstorm specific actions they can take to strengthen agriculture-nutrition linkages. Similarly, two NGOs discussed how they could more systematically include activities promoting pathways from agriculture to nutrition, such as through gastronomy workshops that support healthy dietary practices or through competitions where prizes are given to farmers who stand out in their ability to accomplish certain feats related to agroecological practices. Representatives from these same two NGOs also found the research methods shared to be useful in supporting their own monitoring, evaluation and research activities. For example, one requested training on the dietary methodology utilized in the project such that they may use the same methods in forthcoming work. Subsequently, we met to discuss the use of the 24-hour recall instrument and the methods available for analyzing dietary data.

Challenges to the research premise

Stakeholders from agroecological AFNs, NGOs, other civil society organizations and state authorities overwhelmingly found the study's methods and findings to be coherent with their own knowledge, experiences and observations. However, in two meetings with agencies within the Ministry of Agriculture, a small minority of meeting participants challenged the methodological validity of the study as well as the study's conclusion that agroecology may be an appropriate avenue to support nutritional health among farmers. Their concerns cited: the "impossibility" of using statistical methods to compare average values of farming groups of different sample size ("of course the average production diversity is bigger in the agroecological group if you surveyed twice as many people"); the unfounded "satanization" of industrial processed foods, which they perceived to be preferable from a microbiological food safety point of view than non-industrial foods; food safety of foods consumed from own-production and sold in agroecological AFNs, which they sustained could be contaminated with bacteria; the "fundamental flaw" in our research of not assessing potential heavy metal contamination in agroecological products; the "impossibility" of agroecological AFNs as a means of supporting farmer nutrition through lower food expenditures, given that foods sold in AFNs are often more expensive than in other food outlets; and, the "backwardness" of "anti-modern" agricultural approaches. The statements of these two individuals were surprising, both to myself and apparently to other meeting participants, because they were voiced with strong emotions that were discordant with the tones otherwise being used by the group. They also appeared out of context, as they did not connect with other subjects being discussed by the group, and the two individuals also did not contribute in other ways to the group's discussions. It seemed possible that these were attempts to derail discussion and distract from other subjects.

6.6.4 Discussion

We believe the deliberative results dissemination and interpretation process was effective in supporting our participatory research approach, providing valuable insights and points of reflection for the research team as well as the AFN leaders and other stakeholders who participated. Moreover, although our research framework had not explicitly adopted an "Indigenous approach" (Drawson, Toombs, and Mushquash 2017), results interpretation activities with AFN leaders divulged the ways in which our research engaged responsibly with Indigenous communities, and the ways it could be further improved.

Study implementation

Although we had consulted AFN leaders throughout the research process to design appropriate study protocols, obtaining their retrospective feedback on research implementation was key for understanding how we had been effective and how we could improve in the future. AFN leaders highlighted the importance of community engagement in multiple steps of the research process and offered three key lessons. First, presenting the project effectively prior to research is key for building trust and garnering support for the research project. While they found our process to be effective in supporting a trusting relationship, they suggested that we could have offered stronger levels of detail on the utility of the project in order for participants to understand the value of their involvement. Establishing a stronger sense of purpose with respect to the research would perhaps assuage concerns regarding the time burden of responding to the survey questions. Building trust and empowering participants in the research process are recurring themes, particularly for research with Indigenous communities (Drawson, Toombs, and Mushquash 2017).

Second, AFN leaders expressed the importance of engaging community members in the data collection process to further support trust between the researchers and the participants. While members of our team had prior experience working with community researchers in Indigenous contexts and could attest to their role in supporting appropriate study protocols (Chan et al. 2019), we chose not to do so because we were uncertain of our ability to effectively identify and train community researchers. However, AFN leaders alerted us to what would have likely been a favorable alternative, wherein the non-community researcher could be accompanied by a community researcher, thereby taking advantage of the strengths offered by each.

Finally, AFN leaders highlighted the importance of a diligent process for returning results to participants. This appeared to be our strongest success, and AFN leaders' satisfaction with our process pointed to the effectiveness of the interactive, participatory activities that we utilized in FGDs. Such activities are gaining stronger support in nutritional programming and research (CARE 2013). The assertion by one AFN leader that this was the first time researchers returned results in a way that was meaningful for her AFN is a call for pause and self-reflection within the research community. It underlines the importance of not only presenting study results, but of carefully developing appropriate means to effectively communicate results and promote participatory reflection among the communities that participated in the research process and that may hold the greatest direct investment and interest in the research findings.

Interpretation and translation of results

In the co-interpretation of results, insights provided by AFN leaders on key themes were largely consistent with those that emerged during FGDs (Section 6.3: Article 2 and Section 6.4: Article 3). Moreover, AFN leaders were able to identify the successes of their groups' activities (e.g. promoting own-consumption and barter, promoting traditional foods) as well as the areas that need further attention (e.g. addressing overweight, finding ways for AFN farmers to eat well on market days, promoting wild traditional foods). This process also identified themes that were not discussed in FGDs (e.g. irrigation, migration) and signaled areas of future research that may be of interest to participating communities. For example, our future research may consider further exploration of the nutritional value of foods produced through agroecological farming, the medicinal value of traditional foods, the role of irrigation in supporting nutritional health, and how agroecology may impact rural-urban migration. These discussions not only contributed to our understanding of the research results, but also provoked meaningful, formative reflections for both AFN leaders and for the research team as we each approach future objectives in our activities. These discussions further allowed us to identify points of mutual interest on which we may continue to collaborate, thereby strengthening the foundation of trust and alignment around shared objectives that are key to both participatory and Indigenous research (Macaulay et al. 1999; Drawson, Toombs, and Mushquash 2017).

Discussions on how research outputs could be utilized and how the findings could be translated into practice demonstrated how the research could hold value and provide benefit not only to the research team, but to the participating community as well as to other stakeholders. This is consistent with the goals of participatory research and Indigenous research paradigms, both of which aim to implement a research process and produce findings that mutually benefit the participating communities and the researchers (Macaulay et al. 1999; Drawson, Toombs, and Mushquash 2017). Moreover, the level of specificity that AFN leaders and other stakeholders provided for their use of study outputs and for how they may translate findings into practices—and the urgency with which they organized follow-up meetings—suggested that the deliberative results dissemination process was effective in strengthening benefits to the study community and to other stakeholders; it did not appear to merely be an expression of positive platitudes intended to appease or otherwise please the research team. Additionally, the ideas they brainstormed provided tangible examples of how practices can be nutrition-sensitive.

Challenges to research premises

The heated challenges to the validity of research methods and findings that were brought forth by two members from different groups within the Ministry of Agriculture were a cause for reflection within the study team. The points they brought up were not only unexpected because they were tangential to the discussion[37], but because they made unfounded jumps in logic[38] or seemed to intentionally distort facts. During later discussion with Ekomer research team members, one member identified the discourse used by the two individuals as being consistent with the talking points promoted by the *Asociación Nacional de Fabricantes de Alimentos y Bebidas* (ANFAB; national association of food and beverage manufacturers), which is the special interest group representing processed foods and beverages in Ecuador. He described similar tactics—creating confusion around scientific methods; conflating food safety with food security; misrepresentation of facts; unusual leaps in logic—used by industry actors in attempts to alter the efficacy of Ecuador's "stoplight" nutritional labeling system for content of fat, sugar and sodium in processed foods. Similar actions from the processed food industry have been reported in Brazil (Mialon et al. 2020) and in Canada (Vandenbrink, Pauzé, and Kent 2020). That we would hear similar rhetoric during the results dissemination process of the present research project was concerning, possibly signaling the extent to which the processed food and beverage industry has infiltrated state agencies in order to undermine efforts to support nutritional health.

---

[37]One such tangential discussion subject was their concern with microbiological food safety (i.e. possibility of contamination with *E. coli* or other pathogens) of unprocessed foods sold by farmers versus that of industrially processed foods. This subject was not relevant to discussions on how farmers can leverage their farming strategies to obtain nutritious foods, yet it was used to suggest that agroecological farming is unsafe.

[38] For example, their concern on heavy metal contamination in foods produced through agroecology is unfounded because agroecological farmers do not grow on soil that would have distinct heavy metal content than that of their non-agroecological neighbours. Even so, our lack of assessment of heavy metal contaminants was used as an argument to suggest that our research was fundamentally flawed.

6.6.5 Conclusions

The themes discussed with participating communities, AFN leadership and other stakeholders illustrated the importance of a participatory approach including a deliberative results dissemination process. Participating communities and other stakeholders were able to not only obtain results in a way that was relevant to them, but they also took the opportunity to reflect on the results, provide input for future research, and identify tangible means of translating research results into future programming and practice. For the research team, this was key for both obtaining a deeper understanding of our results and for engaging in a research process that could make meaningful contributions to programming and practices around food and agriculture. We gleaned actionable lessons on how to improve our research protocols, identified new subjects of mutual interest for the research team and participating communities and strengthened bonds for continued collaboration. The unexpected confrontation with what appeared to be food industry actors gave us insights on the challenges that we face in supporting nutritional health, but also strengthened our resolve to continue meaningful research in this field.

7. General discussion

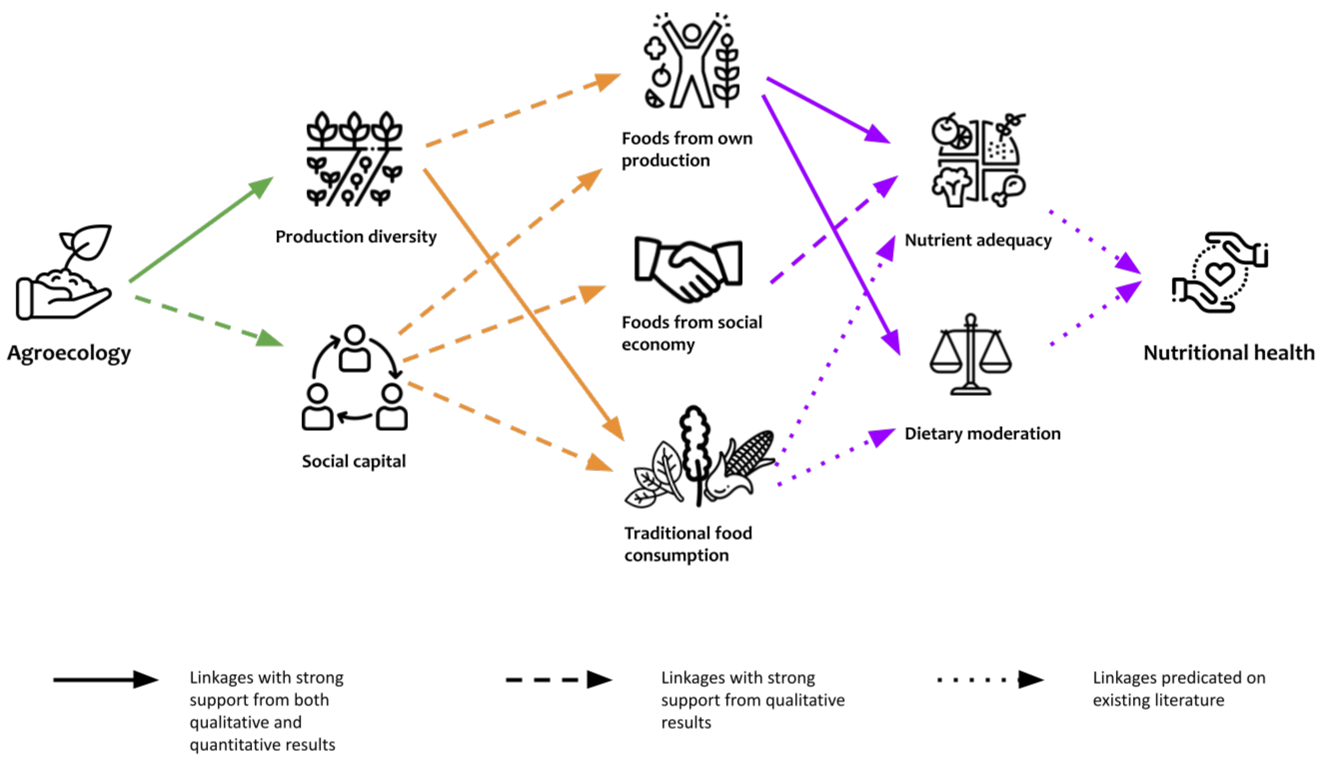
This thesis was guided by the goal to explore agroecology's potential to support farmers' nutritional health in the Ecuadorian highlands, and to contribute to knowledge on how agroecology may act on agriculture-nutrition linkage pathways to address the double burden of malnutrition. This chapter synthesizes the findings from the different components of the study to respond to the hypotheses that drove this research and to offer an integrated portrayal of nutrition and food relationships identified among agroecological farmers in Imbabura, Ecuador. Further, it highlights directions for future research, discusses the contributions of this study and offers reflection on key methodological lessons.

7.1 Linkages between agroecology and nutritional health

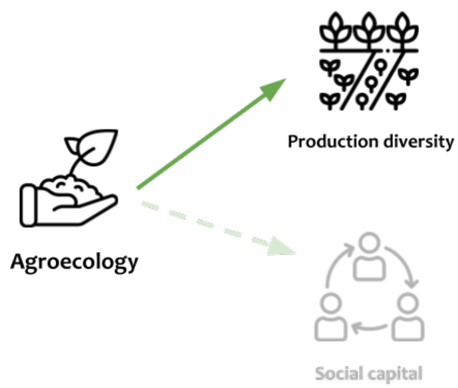
Predominant agriculture-nutrition linkage frameworks identify pathways for agriculture to positively affect nutrition through consumption of own-production, agricultural income used for food purchases and women's empowerment (Hawkes and Ruel 2008; Arimond et al. 2011; Herforth and Harris 2014), and many of these pathways are expected to be mediated by agrobiodiversity (Jones 2017; Frison and IPES-Food 2016; Powell et al. 2015). In our research we posited that agroecology, as a farmers' agricultural movement, would act on similar pathways to promote nutritional health among farmers participating in agroecological alternative food networks (AFNs) in Imbabura province. Given previous research and NGO experience with agroecological AFNs in the Ecuadorian highlands (Deaconu, Borja, and Oyarzún 2015), the specific pathways we proposed to lead from agroecology to farmer nutritional health differ somewhat from the predominant framework laid out by previous agriculture-nutrition linkage literature, but nevertheless have multiple key points of interaction. We began with the hypothesis that agroecology would increase not only production diversity, but also social capital. In turn, we expected these to promote consumption of foods from own-production, foods from the social economy as well as traditional foods. Finally, we expected these consumption practices to be associated with stronger nutrient adequacy and dietary moderation, leading to overall better nutritional health in the face of the double burden of malnutrition.

Through a mixed methods research design, we found empirical evidence to support the validity of each of these hypotheses among agroecological AFN farmers in our study region. Figure 5 summarizes the linkages that our qualitative and quantitative findings identified with respect to our hypothesized pathways. The sections that follow provide further discussion of each linkage presented in Figure 5 (beginning with agroecology to production diversity), and place our findings in context of existing agriculture-nutrition frameworks as well as other literature.

Figure 5: Linkages detected supporting the pathways from agroecology to stronger nutritional health



7.1.1 Mobilization of production diversity



One of the most salient differences that emerged between agroecological and reference farmers in our study was that agroecological farmers had much higher production diversity. This was no surprise, given that the use of agrobiodiversity is a practice that has become fundamental to agroecology in Ecuador (Macas and Echarry 2009; Heifer 2014) and around the world (HLPE 2019). Numerous studies (Jones 2017), including two in Ecuador (Oyarzun et al. 2013; Melby et al. 2020) have identified an association between production diversity and dietary diversity, using dietary diversity as a proxy for nutrient adequacy (Ruel 2003). The mediators of this relationship are complex (Berti and Jones 2013), but two have attracted much attention: (i) farmers can utilize production diversity to generate agricultural income, thereby obtaining more money for purchase of diverse foods; and, (ii) farmers can consume the diverse foods that they grow on the farm, leading to more diversity on their plates (Jones 2017). In our study context, we found greater support for the latter.

A potential role for agricultural income from AFNs

The agroecological farmers who participated in our study demonstrated that they had exceptionally high production diversity compared to reference farmers; however, they did not suggest that their production diversity increased their income or their capacity to purchase foods. Indeed, we found that they obtained stronger dietary diversity than reference farmers despite lower food expenditures. We further found that, among all farmers, consumption of foods purchased from markets was negatively correlated with one of our dietary diversity indicators (Food Variety Score). While we did not find evidence linking production diversity to dietary diversity through income generation, evaluations of agroecology interventions in Brazil and India found participation in agroecology to improve both incomes and dietary outcomes (Chappell et al. 2018). Among Imbabura's AFNs, it also remains plausible that agroecology may support an income pathway to nutrition, albeit indirectly. For example, in Section 6.2: Article 1, we discuss how agroecological markets create a space where farmers can sell a diversity of products in small quantities, as opposed to requiring them to sell in bulk to intermediaries—a market pathway to which many smallholder farmers and particularly women have limited access (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017). Doing so, it is possible that agroecological markets may mobilize production diversity to place income directly in the hands of women. Even if there is no net increase in household income and no net increase in the amount of money spent on food, women's control of income can nevertheless support food purchases that are more nutritious (Alkire et al. 2013) and other care practices that ultimately impact nutrition (Kadiyala et al. 2014). Given the complexity of agriculture-gender-nutrition linkages (Kadiyala et al. 2014), the relationship between agroecology participation, women's empowerment and nutritional health merit further research.

From production diversity to diets

Consumption of own-production is considered the most proximal means by which diversity on the farm can lead to diversity on the plate (Herforth and Harris 2014). Likewise, the farmers we consulted expressed that greater diversity on their farms directly provided greater diversity for their meals, with one farmer memorably referring to her land as her "refrigerator" (Section 6.2: Article 1). Our statistical analyses verified the correlation between production diversity and dietary diversity, but our quantitative results were inconclusive as far as the mediating role of consumption of own-production. However, we believe this inconsistency was a product of our methodological decisions in quantitative research rather than an error of perception made by farmers.

For example, our small sample size led us to make certain analytical decisions that likely compromised our ability to assess this relationship. In Section 6.4: Article 3 we collapsed foods from own-production together with foods from the social economy in order to facilitate path analysis, arguing that together these represented a "non-market" alternative to conventional market purchases. The fact that we did not find production diversity to support non-market food consumption in this path analysis may have been a result of this decision. Instead, in Section 6.5: Article 4, we did find production diversity to correlate with consumption of foods from own-production. Even so, the correlation was rather small (r=0.24) and only appeared for the pooled sample, rather than for either of the two farmer groups when assessed separately.

Another explanation may be that our study instruments and analysis methods were not adequate for capturing the relationships between production diversity and diet more generally. Just as the correlation was small between production diversity and consumption from own-production, the relationship was also small between production diversity and measures of dietary diversity. In our path analysis on dietary outcomes of agroecological farming, production diversity produced a standardized path estimate of 0.19 for the Dietary Diversity Score (DDS) and 0.28 for the Food Variety Score (FVS). Among the pooled sample, correlation analysis produced an r-value of 0.31 for DDS and 0.37 for FVS (data not shown). This weak relationship was similar to those found by other studies in Ecuador (Oyarzun et al. 2013; Melby et al. 2020) and elsewhere (Jones 2017).

We nevertheless suspect that multiple factors attenuated the magnitude of the correlation in our study, and these factors are likely relevant to other studies as well. We had expected the correlation to be smaller when utilizing DDS than FVS because our production diversity measurement is species-based whereas DDS is food group-based. This creates inconsistent scales of measurement, as previously discussed by Berti (Berti 2015). Another factor that would have affected the relationship with all our dietary measures was the inconsistency in temporal scales used in assessment: while we measured production for an entire year, we only measured diet based on a 24-hour period of consumption. Foods that people grow throughout the year cannot be expected to be ripe and available for consumption on every single day[39]. Finally, other scholars explain that the relationship between production diversity and dietary diversity may be difficult to capture because it is not necessarily linear, particularly in highly agrobiodiverse settings (Sibhatu, Krishna, and Qaim 2015), such as that in our study context.

Given these considerations, we believe that the agroecological farmers we spoke with were likely correct in their assessment that production diversity impacted dietary diversity through consumption of own-production, and this relationship is likely stronger than was detected by our quantitative analyses. Moreover, if production diversity indeed promotes consumption of own-production, then it

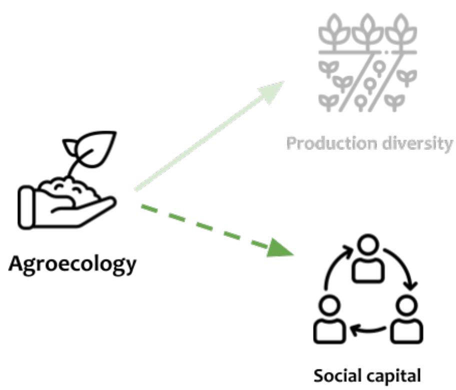
[39] The analyses we conducted specific to traditional foods [TF] production and consumption (Section 6.3: Article 2) demonstrate that using equivalent measurement and temporal scales can produce more robust results. For these analyses, we measured both TF production diversity and TF consumption diversity on a species-basis and both were measured for the past year, rather than for a single day. The resultant standardized estimate from path analysis for agroecological farmers was 0.35, and the correlation analysis between TF production diversity and TF consumption diversity for the pooled sample produced a strong r-value of 0.61.

may also be indirectly involved in the downstream relationship we found in Section 6.4: Article 3 between consumption of non-market foods (including both own-production and social economy) and dietary moderation. If this is the case, then this is particularly interesting because most literature on the role of production diversity in nutrition focuses solely on nutritional adequacy, not moderation (Jones 2017; Herforth et al. 2019). Potentially, production diversity may be playing an undercredited role in mitigating the harmful nutrient excesses implicated in overweight and obesity as well as cardiometabolic chronic disease.

Production diversity as a complex behaviour

Our statistical findings notwithstanding, our ethnographic observations (Section 6.2: Article 1) served as a reminder that farming and eating are behaviours that are ultimately subject to the complexities of human decision-making. The economist Daniel Kahneman received the Nobel prize for his work establishing that human behavioural decisions do not follow the calculated rationality of economic theory (Kahneman 2003). Similarly, we found that farmers do not always follow a cause-and-effect rationality of growing more diversity to eat more diversity, but also grow certain otherwise edible products for aesthetic reasons, sentimental reasons, or out of a sense of experimentation. At times, these decisions can dilute the relationship between production and diet. For the farmer who intentionally planted papaya trees at an altitude that was too high to bear fruit because “it looks nice and the birds seem to like it,” it is arguable that she is contributing to a healthy ecosystem by creating habitat for wildlife. Downstream, supporting healthy ecosystems can certainly impact diets (Frison, Cherfas, and Hodgkin 2011; Berti and Jones 2013), but such a relationship may be so indirect and complex that it eludes our causal framework. These observations align with the commentary of Natividad and colleagues, who criticize that many discussions on production diversity and nutrition create the “abstraction that agriculture, food and nutrition are the product of a series of highly instrumental, independent, and linear chain-like linkages composed of discrete value” (Natividad et al. 2021). They instead propose that agrobiodiversity and nutrition are better understood through a relational perspective, in which people, their agrobiodiversity and their food are closely interconnected, rather than spatially segregated or otherwise cleanly compartmentalized (Natividad et al. 2021). In our research, we are guilty of precisely the “abstraction” that Natividad and colleagues criticize, in that we prioritized understanding chain-like linkages over the complex, nonlinear processes that underlie the relationships we explore. We believe both approaches have value, and our qualitative observations around production diversity stood out in their ability to illustrate that each statistical trend we detected contains deviations and complexities that can throw off-course our intention to simplify our understanding of the relationship between agrobiodiversity and nutrition.

7.1.2 Strengthening of social capital



The social movement orientation of agroecology in Ecuador, the intricate connectivity between agroecological organizations (Sherwood et al. 2013; Gortaire 2016) and the positive social relationships formed within agroecological AFNs (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017; Deaconu, Borja, and Oyarzún 2015) led us to hypothesize that social capital (i.e. the resources inherent in relationships) may contribute to nutrition outcomes among participating farmers. Indeed, our qualitative observations, particularly those described in Section 6.2: Article 1, bore witness to the role that agroecology plays in constructing and expanding farmers' social networks: for some women, their AFN gave them a unique opportunity to engage with people outside their village; for others, their AFN even opened the door to travel outside the country and engage with an international agroecology community. Moreover, farmers described how the types of relationships they forged through their AFNs were different in quality than many of their prior relationships, allowing them to find like-minded people and mutual respect. Although the literature on agroecology and social capital is limited, in a recent longitudinal study in Malawi, Kansanga and colleagues also found that agroecology participation was associated with sizable improvements to participants' social capital endowment (Kansanga et al. 2020).

Agroecology's social capital begets other forms of capital for dietary outcomes

In their valuable exploration of agroecology and social capital, Kansanga and colleagues discussed how strengthening social capital enabled agroecology to also indirectly strengthen other, more tangible forms of capital that are frequently obtained through social relationships, such as productive resources and knowledge (Kansanga et al. 2020). Kansanga and colleagues' study concentrated on the role of social capital in advancing agricultural practices, but they did not extend the link into nutritional outcomes. This link is instead supported by Kumar and colleagues, who reviewed studies on rural women's groups in South Asia to understand how social capital can ultimately lead to nutritional outcomes. They sustain that the social capital created through women's groups enable women to better mobilize financial resources, agricultural income and outputs, health and nutrition information and access to services for their nutritional advantage (Kumar et al. 2018).

While our own research did not directly measure social capital, our qualitative analyses nevertheless indicate that the social capital formed in agroecology can act on food and nutrition norms and knowledge, which are considered key mediators between agricultural practices and dietary outcomes (Herforth and Harris 2014). Agroecological farmers repeatedly credited their social relationships for leading them to adopt or strengthen certain norms and knowledge related to agriculture and food. Farmers described, for example, that their AFNs allowed them to discuss food uses, health benefits and recipes with other farmers and with AFN clients. Their relationships with other farmers within their own AFN as well as from other AFNs also enabled them to increase their barter networks, both of foods and of seeds. They further described how the social expectations around food differed between their AFN and village communities: unlike in their village, in their AFN, industrial processed foods are taboo while home-made and traditional foods are prized. Moreover, AFN farmers expressed great pride in obtaining food from their own production or through the social economy. Similar to the findings of Kansanga and colleagues (Kansanga et al. 2020), these examples show how social capital begets other forms of capital, such as human capital in the form of food literacy and nutrition knowledge as well as material capital in the form of diverse foods and seeds. Importantly, these specific resources have recognized potential to positively impact the quality of dietary intake (Perry et al. 2017; Herforth et al. 2019), particularly when they are mobilized concomitantly (Berti, Krasevec, and FitzGerald 2004).

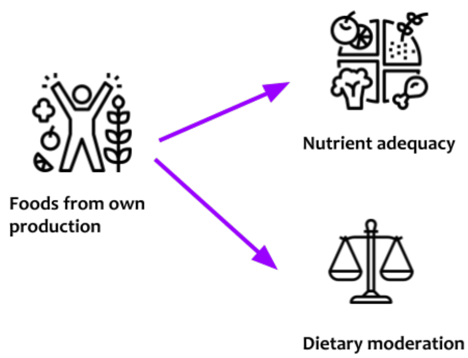
Social bonding and bridging in agroecology

Kansanga and colleagues also offered a helpful description of how agroecology contributes to both "bonding" and "bridging" social capital, with the former referring to the capital created through farmers' ties to others with similar social characteristics, such as other farmers, whereas the latter refers to the capital derived from ties extending beyond their immediate social connections (Kansanga et al. 2020). Our study aligns with their findings: the farmers we consulted also expressed that they developed their social capital through a diversity of relationships, including with other AFN farmers, with urban AFN clients and with various organizations extending beyond their AFN, such as national agroecology networks, civil-society food activist movements, NGOs and Indigenous federations. Bonding and bridging social capital have been shown to influence health outcomes in different ways; the former can contribute to strengthening internal norms and identity, whereas the latter can bring in new resources and information (Eriksson 2011). The diversity of relationships enabled through agroecology may thus support multiple social mechanisms for influencing nutritional health among farmers.

Quantifying social capital's impacts on dietary intake

Our qualitative data and the existing literature provided support for the role of agroecological networks in mobilizing social capital for dietary outcomes. Unfortunately, we were unable to directly assess the quantitative relationship between social capital and dietary measures, as our survey did not include an adequate instrument for measuring social capital. However, some of our results in path analysis hinted at its role. For example, in Section 6.4: Article 3, we detected that agroecology acted both on one of our measures of nutrient adequacy (Dietary Diversity Score) as well as on non-market food consumption without passing through other mediators. It is plausible that this linkage is a reflection of the role of social capital, especially given that agroecological farmers expressed that their social networks promote the consumption of diverse foods, as well as the consumption of foods from own-production and from the social economy (which together made up our non-market food consumption variable). If social capital is indeed acting on these food acquisition sources, and particularly on consumption of foods from own-production, then it may be enabling the associated positive effects on nutrient adequacy and dietary moderation.

7.1.3 Nutritional contributions of foods from own-production



Growing foods for own-consumption, also known as "subsistence farming," has received a bad rap among some actors in the development economics community. Despite certain recent shifts in discourse, the World Bank has an extensive history of portraying subsistence farming as the bottom rung on the development ladder and instead espousing the view that market integration forges the path to a better life (McMichael 2009). This perception is repeated to a certain extent in the agriculture-for-nutrition literature, in which some scholars express that agriculture is better positioned to improve nutritional outcomes through market pathways than through own-consumption (Sibhatu 2019). While it is possible this may hold true in some regions, we believe agroecological farmers in our study context would squarely reject this perspective. Farmers in our study and in previous work in Ecuador (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017; Deaconu, Borja, and Oyarzún 2015) did express benefitting from integrating into AFN markets; however, much of this benefit was derived from evading the harms they had otherwise experienced when operating in conventional market spaces, including price volatility, incompatible product quality and quantity expectations, and distressful interactions with intermediaries (Contreras Díaz, Paredes Chauca, and Turbay Ceballos 2017; Deaconu, Borja, and Oyarzún 2015). Agroecological farmers in our study instead repeatedly emphasized the value of own-consumption as a means to maintain sovereignty over their culture, production and food, and to access healthier foods. Their view is consistent with a body of evidence that shows consumption of own-production to improve food security (Baiphethi and Jacobs 2009) and provide access to diverse diets (Jones 2017).

In our own quantitative assessment, presented in Section 6.5: Article 4, we also found that among both agroecological and reference farmers, the foods they consumed from their own-production tended to be more nutrient-dense than those obtained through market purchase, which were instead more calorie-dense and nutrient-poor. Farmers who relied more heavily on own-production for their foods—which we assessed according to the proportion of their caloric intake that came from this source—tended to have higher dietary diversity, which we used as a measure of nutrient adequacy. Meanwhile, farmers who relied more heavily on market purchase tended to perform worse both on measures of nutrient adequacy and of moderation: their diets were less diverse and included a greater relative caloric proportion of processed culinary ingredients such as added sugars and oils. Given that these foods contribute to the looming increase of the double burden of malnutrition in Ecuador's rural sector (Freire, Ramírez, and Belmont 2015; Freire et al. 2014), we believe that production for own consumption may be a more appropriate means of supporting access to nutritious foods in the food environment of our study context.

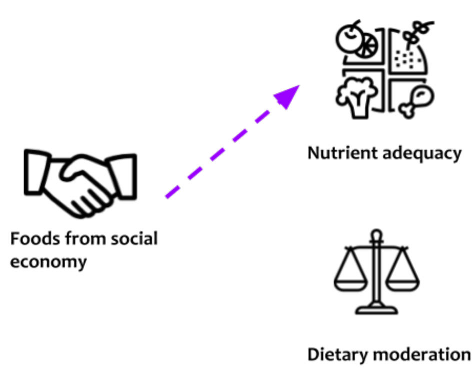
The importance of access to land

While we already gave careful consideration to the role of production diversity as well as social capital in supporting production for own-consumption, another factor that emerged in Section 6.4: Article 3 was the amount of land in production. It makes sense that greater land can enable greater yield for own-consumption, regardless of the diversity being produced or consumed. This is also consistent with findings reported elsewhere in the Ecuadorian highlands, wherein greater land holdings enabled greater consumption of own-production up to a certain threshold, at which point additional land was primarily dedicated to agriculture income rather than own-consumption (Oyarzun et al. 2013). Access to land for smallholder farmers in Ecuador has been a wrought issue for decades, if not centuries. Inequality in land access is so extreme that, in Imbabura, 86% of farmers are considered smallholders, but they only occupy 16% of total agricultural land by area, and women and Indigenous farmers disproportionately occupy the smallest parcels (Brassel et al. 2008). Indigenous people's access to land remains affected by the history of colonization and centuries of subjugation, and is also complicated by modern forces, including rising costs of buying land, incentive to sell land and limited access to credit. Further, inheritance-based subdivision practices, in which children split the land inherited from their parents, mean that without opportunity to acquire additional land, parcels can only become smaller and smaller with the passing of generations (Goodwin 2021).

Our survey results showed that agroecological farmers had greater land surface in production than did reference farmers, and path analysis revealed that greater land surface in production enabled greater consumption from non-market food sources. Agroecological farmers sustained that they did not have privileged access to land, but rather that placing land into production was a greater priority for them due to their agroecological practices. They cited that some neighbours, including their own family members, had moved away from agriculture as a livelihood strategy, meaning that they left land unused. Agroecological farmers thus borrowed or rented land from their neighbours to expand their production possibilities. Some farmers also expressed maximizing production surface by utilizing parts of their land holdings that are more difficult to farm, such as steep slopes or otherwise marginal lands. These findings bring up several complicated concerns. First, if accessing more land for consumption of own-production depends on having neighbours who have minimized their dedication to agriculture, then this may not be a strategy that can operate at a larger scale within the community; however, this may be where production diversity becomes the key protagonist by replacing some of the land dedicated to cash crops with more diverse production for own-consumption. Second, if farmers are placing new lands into production, and particularly highly sloped lands and ravines near waterways, this may degrade soil, waterways and non-agricultural biodiversity (Fonte et al. 2012), thereby contradicting agroecology's intentions to regenerate ecological function.

Although agroecological farmers insisted that they did not in fact *own* more land than their neighbours (but simply *used* more land), it would nevertheless be valuable to have a more systematic understanding of this issue. Previous research suggests that smallholder farmers with more secure land tenure make stronger long-term investments in the health of their land and also have greater production diversity (Abbott 2005). This would present a tenable link between access to land, production diversity, own-consumption, the ability to participate in agroecological networks, and ultimately to downstream nutritional health impacts.

7.1.4 Nutritional potential of foods from social economy



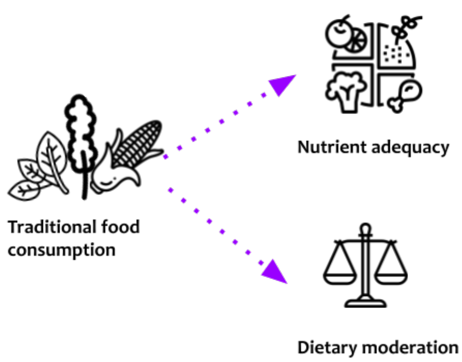
The social economy (i.e. gifting, barter, direct purchase) is important in many agricultural communities around the world (Ferraro 2011; Argumedo and Pimbert 2010; Kegel 2003; Wilkie et al. 1998; Singh, Singh, and Sureja 2007), and it was clearly so for farmers in our study, who named it as an important means for accessing both food and productive resources. Despite this, social economy does not explicitly figure into predominant agriculture-nutrition linkage frameworks. Based on both our qualitative and quantitative results, we believe that the social economy is an important part of the food system in our study context and that it holds potential to impact both agricultural practices and dietary outcomes.

We found that agroecological and reference farmers obtained substantial portions of their caloric intake from the social economy, although agroecological farmers obtained nearly double that of reference farmers (32% and 17% of caloric intake, respectively). Our observations and discussions with agroecological farmers, presented primarily in Section 6.2: Article 1 and Section 6.4: Article 3, allowed us to understand the cultural value that they placed on social economy. Other studies suggest that this is not unique to agroecological farmers, but rather an integral part of rural culture in the region (Ferraro 2011; Robelly Espinoza 2019). Because we did not also conduct qualitative research with reference farmers, we cannot say whether foods from the social economy played a bigger role in agroecological farmers' diets because they place stronger value on it, because they have greater access through their AFNs, or for other reasons.

Regardless of the reason behind agroecological farmers' greater engagement in social economy for obtaining food, what is perhaps more important is the dietary outcome. We found that, for both farmer groups, foods obtained through the social economy tended to be slightly more nutrient-dense than calorie-dense (Section 6.5: Article 4). While consuming a greater proportion of daily caloric intake from the social economy was not associated with any specific positive or negative dietary outcomes, it may nevertheless play an interesting role in mitigating the negative dietary effects that we observed to be associated with greater relative intake from conventional markets. Given that farmers primarily exchange what they produce themselves, it follows that the foods in social economy transactions generally exclude the unhealthy industrially processed and ultra-processed products that are widely available in conventional retail markets (Monteiro et al. 2019; Popkin, Adair, and Ng 2012). A similar phenomenon is observed in other non-conventional food acquisition channels, such as in community gardens and farmers' markets in high income countries, where healthy diets are supported by the predominant supply of fruits and vegetables (McCormack et al. 2010).

The farmers we consulted with had a broader perspective that extended beyond the nutritional quality of the foods they exchanged: they found social economy to provide access to diverse seeds, thus improving production potential; they found it to be an important means to access foods from different eco-zones or to try foods they were less familiar with; and, they saw it as a means to support each other in times of need. These benefits have also been described elsewhere in the Andes (Argumedo and Pimbert 2010), and the last point resonated very strongly over the past year, when the Covid-19 pandemic disrupted market chains (Córdoba, Peredo, and Chaves 2021). Thus, even though our quantitative analyses did not detect a clear dietary impact of consuming more calories from the social economy, we believe that the underlying links between the social economy and rural diets are tangible. As such, we believe that greater research attention is warranted regarding farmer food practices and nutritional health.

7.1.5 Traditional food consumption



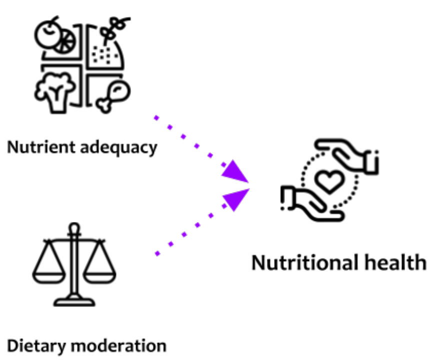
Traditional food (TF) practices warrant special attention in the Ecuadorian highlands given the local agroecology movement's relationship with Indigenous federations, which became interested in agroecology largely for its potential to support traditional practices and reclaim cultural sovereignty (Gortaire 2016). What constitutes "traditional" food varies vastly across the world, but examples from numerous contexts show TFs to be associated with healthier dietary patterns that hedge against the negative consequences of the nutrition transition (Johns and Sthapit 2004; M.-J. Lee, Popkin, and Kim 2002; Receveur, Boulay, and Kuhnlein 1997). In our research, we were interested in understanding how traditional food practices can be supported in the Ecuadorian highlands. Specifically, we assessed production and consumption of 12 indicator TF products, including several common TFs and several considered to be underutilized, as well as consumption of wild foods. Through this process, we found that the same agricultural pathways relevant to supporting nutrient-rich diets are also relevant to supporting traditional food consumption. Moreover, our attention to TF practices proved to be a rich case study on how these pathways play out when tracing specific TFs from production to consumption.

Through path analysis, we found a strong relationship between farmers' overall production diversity and their TF production diversity. This relationship set off a clean linkage pathway in which greater TF production diversity was associated with greater TF consumption diversity, which in turn was associated with greater TF consumption frequency. As discussed in Section 7.1.1: Mobilization of production diversity, the correlation coefficients and standardized path estimates for these relationships were strong, abetted by the fact that we measured production and consumption on comparable scales (i.e. both were species-based and over a one-year time span). As in our assessment of other food practices, we also found that agroecology and the social capital associated with it plays a likely role in supporting these TF practices. Indeed, agroecological farmers discussed at length how their AFNs supported TF practices and even re-introduced them to TFs that they had previously forgotten. Similarly, we found agroecological farmers to strongly outperform reference farmers on measures of TF production diversity, consumption diversity and consumption frequency. The only TF practice in which the two groups were equivalent was in wild food consumption diversity.

Our attention to TFs also highlighted the variables that did not predict stronger TF practices. Namely, we did not find consistent associations with age, education, income or distance to markets. We found this compelling, because previous research suggests that TF practices are disproportionately the purview of the old, poor, remote and otherwise marginalized (Peñafiel et al. 2016; Keller, Mndiga, and Maass 2005; Smale et al. 2004). That this was not the case in our context is cause for optimism. Possibly, some farmers in the region may be re-valorizing traditional foods in the same way that these foods have gained new breath in other localities, such as has been described in Europe (Balogh et al. 2016). For agroecological farmers in particular, the social capital embedded in the diverse relationships constructed around AFNs seems to be key in supporting this process. This was best expressed by one AFN farmer and market leader who said that, "in the [agroecological] markets, the consumer began to understand and request these [traditional] products, and the farmers also began to assimilate them in their diets. Traditional products are nothing new for the most conscious consumers, and these are the consumers that come to our market." This was remarkably similar to the experience another farmer described in Section 6.2: Article 1 that led her to integrate spring onions—a novel and largely unknown product in this region—into her regular production. In this sense, the same diverse relationships that inspire AFN farmers to reclaim traditional Andean products also lead them to adopt new, globalized ones. Doing so, the promotion of traditional foods in agroecological networks may paradoxically be a form of cosmopolitanism, or a positive expression of globalization.

Studies in other countries also demonstrate how traditional foods have taken on new societal roles and meanings. In Lebanon, wild plants retain their long standing medicinal value, but they have escaped from their role as a means to cope with crop failures and wartime famines; instead, collecting wild plants is valued as a social activity and an enjoyable means of "getting some fresh air" (Marouf et al. 2015). Meanwhile, in Palestine, the production, sale and consumption of traditional foods has emerged as an act of subversion against the hegemony of the oppressive Israeli regime (Nadar and Deaconu 2021)[40]. These examples coincide with our own findings to suggest that, in numerous contexts, TFs are not a mere relic of the most marginalized populations, but rather a dynamic part of "modern" food practices. We believe this subject warrants greater attention in both research and programming; because TF production and consumption practices have been shown to support both environmental (Chivenge et al. 2015; Cook 2018) and human health (Johns and Sthapit 2004), they may present a culturally-appropriate means for supporting sustainable food systems. If so, they belong in the agriculture-nutrition tool box, and deserve to be supported not only by the agroecology movement but also by national food policies and local-level programming.

7.1.6 Nutrient adequacy and dietary moderation



In our assessment of agroecological and reference farmers, we found that agroecology was associated not only with measures of nutrient adequacy, but also of dietary moderation. This is a compelling result in context of the body of agriculture-nutrition linkage literature, which continues to lean heavily toward a focus on nutrient adequacy (Herforth et al. 2019), despite the rapidly growing double burden of malnutrition in rural areas around the world (Popkin 2021). Moreover, the importance of consumption of own-production in mediating pathways from agroecology to both nutrient adequacy as well as dietary moderation underlines the role that agriculture can play, not only in providing access to diverse foods, but in fostering eating patterns that moderate harmful nutrient excesses. The role of foods from social economy and traditional foods in mediating dietary outcomes was less clear; however, plausible

[40] An English version of this publication is provided in Appendix 4.

linkages exist that also make these relevant to initiatives for supporting nutritional health in farming communities.

Dietary diversity

Regardless of the precise mechanisms at play, the potential for Ecuador's agroecological AFNs to promote dietary diversity is very meaningful for health outcomes given that they operate among populations that are disproportionately affected by nutrient deficiencies. Nearly half of Indigenous children in Ecuador are stunted (Ramírez-Luzuriaga et al. 2020), and much of this is connected to an inadequate nutritional environment dominated by starchy staples and with insufficient intake of nutrient-rich foods such as animal-source foods (Freire, Ramírez, and Belmont 2015; Berti, Krasevec, and Cole 2004). We found agroecology to be associated with higher dietary diversity in terms of both individual foods (FVS) and food groups (DDS). With respect to food groups, we found that agroecological farmers were more likely to consume dairy and fruits than their reference neighbours, and they were possibly more likely to also consume pulses, green-leafy vegetables and other vegetables. Any improvement in dietary diversity is associated with stronger probability of nutrient adequacy (Ruel 2003), and these food groups hint at which specific nutrient intake improvements might be expected (WHO 2018). Beyond vitamins and minerals, higher dietary diversity can also contribute beneficial secondary metabolites, such as certain flavonoids that can support cardiometabolic health and other physiological functions (Egert and Rimbach 2011). Downstream, dietary diversity is associated with cognitive function (Wengreen et al. 2009; Yin et al. 2017), lower incidence of cancer (Jansen et al. 2004), lower incidence of metabolic syndrome (Azadbakht, Mirmiran, and Azizi 2005) and lower mortality (Tao, Xie, and Huang 2020; Kobayashi et al. 2020).

Food processing

Given the paucity in the literature on linkages between agriculture and dietary moderation (Herforth et al. 2019), our use of the NOVA food classification system (Monteiro et al. 2018) produced what we consider one of our most compelling findings. In Section 6.4: Article 3, we detected a pathway between agroecological AFN participation and lower consumption of foods from NOVA group 2, or processed culinary ingredients; further, in Section 6.5: Article 4, we found a positive association between consumption of foods from conventional markets and consumption of processed culinary ingredients. Just as our own results found that processed culinary ingredients comprise 12% and 16% of mean daily caloric intake among our agroecological and reference populations, respectively, previous research in Ecuador has identified that such ingredients—including sugars, edible oils and processed seasonings—have become heavily established in rural diets (Gross et al. 2016; Freire, Ramírez, and Belmont 2015) and characterize the state of the nutrition transition among the rural highland population (Gross et al. 2016). In this context, our finding that agroecological AFN participation may mitigate consumption of processed culinary ingredients—whose excess consumption has been implicated as part of unhealthy diets associated with chronic disease (WHO and FAO 2003)—provides a specific and tangible means for agriculture to link to dietary moderation.

Even so, our use of the NOVA food classification system to understand dietary moderation, and particularly our attention to NOVA group 2, was likely also our most provocative methodological decision. Although NOVA-based consumption patterns have been previously studied successfully for their associations with cardiometabolic health and chronic disease, this body of research has focused heavily on NOVA group 4, or ultra-processed foods (Moubarac et al. 2014; Monteiro et al. 2019). In our study population, both NOVA groups 3 (processed foods) and 4 (ultra-processed foods) made only minor contributions to farmers' diets, representing 9% (standard deviation: 10%) and 2% (standard deviation: 5%) of the pooled population's mean caloric intake, respectively. The large standard deviations also suggest that many participants' true intakes are far from these means. For example, the median consumption of NOVA group 4 foods represented 0% percent of caloric intake, meaning that at least half of farmers did not in fact consume any foods from this group during the day that we assessed. As such, our statistical capacity to detect associations between consumption of these two NOVA groups and key study variables (including farmer category) is severely limited. Yet given the reality that these foods are also making inroads into rural settings (Popkin 2014) coupled with the unambiguous negative health outcomes of excessive ultra-processed food consumption (Monteiro et al. 2019) makes it all the more important to understand which factors may be associated with these food categories. Doing so could contribute to efforts to forestall unhealthy food patterns related to ultra-processed food consumption before they become more deeply ingrained in this already vulnerable population.

Links between nutrient adequacy and dietary moderation

Although our study only assessed the diets of adult women, previous research on intrahousehold food distribution in Ecuador's rural highlands (Berti, Leonard, and Berti 1997) provides reason to believe that improvements in women's diets are likely to extend to others in the household. Yet even if that is not the case, maternal dietary diversity can set the stage for intergenerational health. For example, higher maternal dietary diversity is associated with higher infant birth weight and reduced preterm birth (Zerfu, Umeta, and Baye 2016; Saaka 2013), which are in turn associated with healthier cardiometabolic outcomes later in the life course (Z. Yang and Huffman 2013).

It nevertheless remains possible for dietary diversity to create a trade-off with overweight and obesity, for example if increases to diversity lead to excessive intakes of calories, or if the foods contributing to higher dietary diversity measures are unhealthy. This was observed in Guatemala and Malaysia, where higher dietary diversity was associated with body mass indexes indicating overweight and obesity (OW/OB) (J. Lee et al. 2010; Saibul et al. 2009). Responding to such concerns, a growing chorus is beseeching the global community to better understand the double burden of malnutrition in order to promote "double-duty actions" for simultaneously addressing both undernutrition and overweight (WHO 2017; Hawkes et al. 2020); within this chorus, there are also admonitions to, at the very least, "do no harm" to one side of the double burden while attempting to mitigate the other (Popkin 2021) .

In our study, we did not identify any correlation between body mass index and nutrient adequacy measures. However, we also did not find agroecological farmers to perform better on body mass index or diet-related chronic disease, despite their stronger dietary moderation. Our data described OW/OB among 80% of our study population, which is comparable to national data for women of the age group that was most present in our sample (Freire, Ramírez, and Belmont 2015). Section 6.4: Article 3, discusses multiple explanations for agroecology's lack of delivery on healthier body weights and chronic disease, including that some agroecological farmers reported that they had joined their AFN specifically with the intention of improving their pre-existing health conditions. Further, a body of evidence demonstrates that OW/OB is influenced by many life course factors beyond unbalanced diets (Davis, Stange, and Horwitz 2012; R. E. Black et al. 2013; Gluckman and Hanson 2008). It remains to be seen whether, in the longer term, agroecology in Ecuador will succeed as a double-duty action with meaningful improvements to OW/OB among participating farmers, or if potential improvements to OW/OB will be limited to downstream intergenerational linkages precipitated by stronger nutrient adequacy.

7.2 Methodological reflections

This section reflects on the methodology applied in this research. It begins with a discussion of how we operationalized our theoretical framework throughout our study design, then turns to specific limitations and accompanying lessons identified in the application of our study instruments and analyses.

7.2.1 Theoretical framework and study design

For this research, we adopted a salutogenic, strength-based approach operationalized through the deployment of a participatory process involving a sequential, exploratory mixed methods design as well as a deliberative results dissemination and interpretation phase. A mouthful to describe, we nevertheless found the numerous paradigms shaping our research to interact synergistically and together build a rigorous and responsible research project that produced findings relevant to our research goals, to the greater academic community, to research participants and to other local stakeholders.

Salutogenic frameworks, which emphasize understanding the drivers of health rather than those of illness (Antonovsky 1979) are similar to strength-based approaches, which prioritize identification of strengths over that of weaknesses (Brough, Bond, and Hunt 2004). We found that participatory research was an appropriate means for attaining these objectives. In participatory research processes, the aim is for researchers and communities to collaborate on research projects in a way that develops valid, generalizable knowledge, benefits the participating community and improves research protocols (Macaulay et al. 1999). We found that this process enabled the identification of drivers of health (i.e. “salutogens”) as well as the strengths in farmers’ existing practices to reinforce health. The participatory research process, including its deliberative results dissemination component (Gauvin 2009), emerged to be consistent with Indigenous research frameworks (Drawson, Toombs, and Mushquash 2017). Although we had not anticipated an Indigenous framework when planning this research, it would have been prudent to explicitly do so given our study population. Our mixed methods design afforded us the space and flexibility to integrate the multiple research paradigms that we endeavored to respect. Moreover, this design provided opportunity to triangulate qualitative and quantitative results and increase internal and external validity of our findings.

Operationalization of the theoretical framework and study design

Our salutogenic approach began with our interest in agroecology, which we hypothesized to be a driver of health, and extended into our analyses that focused on the mechanisms by which agroecology may support nutritional health. We aimed to emphasize a strength-based approach in our qualitative data collection protocols. In ethnography, our recruitment protocol expressed to farmers that we were interested in learning from their experiences, thereby placing emphasis on the strengths that each participating farmer had to offer. Similarly, our activity protocol for focus group discussions opened a space for farmers to reflect on their agricultural and dietary accomplishments and the pathways that supported them. Our participatory approach was rooted in the depth of experiences and long-standing relationships nurtured between members of the Ekomer study team and the Imbabura AFN community prior to the onset of this research. For example, I first met several of the Imbabura AFN leaders in 2013, and participated in numerous events with them between then and the onset of data collection, in 2017. Other Ekomer members had a much longer and deeper history of involvement in the region. This history of engagement profoundly informed the goals of this research project, as well as the specific hypotheses and methodological approach.

Once this research project formally commenced, we believe that the qualitative instruments deployed in our mixed methods approach—key informant interviews (KIIs), ethnography and focus group discussions (FGDs)—were effective in supporting the objectives of participatory research. Many of our KIIs were with the leaders of the AFNs that comprised the study community. An initial phase of KIIs with AFN leaders served to refine study objectives and develop appropriate protocols. The second phase of KIIs, which culminated the data collection process, were used to share and interpret the preliminary results of our quantitative instrument (the cross-sectional survey), thereby improving the validity of the knowledge obtained. Further, KIIs were also used as a space to reflect on how this research may be relevant to the participating community, and what next steps could support translation of results into practice. In our ethnography protocol, the last day of each ethnographic homestay was utilized to reflect on the ethnographic process, discuss the upcoming phases of the research project[41] and provide input on study instruments. For example, ethnography participants tested the evolving drafts of the cross-sectional survey and provided detailed feedback. Finally, FGDs were instrumental for obtaining study participants' interpretations of our survey results, which also contributed the validity of the knowledge obtained, as well as dedicating a structured space for study participants to collectively reflect on the results shared. This latter element aligns with "formative" participatory research strategies, in which research activities support participants' ability to reflect on or otherwise engage with the subject of interest in such a way that it may provide benefit to them or their communities (CARE 2013).

Section 6.6: Supplementary results describes how sharing and discussing survey results with AFN leaders in KIIs and other study participants in FGDs was not only fruitful from a research perspective, but also obtained an overwhelmingly positive response from the study communities. One AFN leader expressed that although her community had frequently been studied, this was the first time a researcher returned to share results in a way that was accessible for the community. While we believe that our qualitative methods were effective in supporting a participatory research process that included deliberative return of results, we acknowledge that we only applied these methods with agroecological AFN farmers. In the future, we aim to find ways to extend this approach to our entire study population, which in this case also included "reference" farmers who were not involved with agroecological AFNs.

Beside integrating a participatory approach, adopting a mixed methods design further allowed us to triangulate different forms of data and thereby improve the validity of our results. We believe one of the successes of our strategy was our use of qualitative and quantitative data in integrated analyses, rather than analysing the two forms of data in parallel. This is best illustrated by the analyses described in Section 6.4: Article 3, in which we deferred to both our FGD data and our survey data to decide which variables to include in path analysis and in what order to include them; our subsequent

[41] Prior to this reflection day, ethnography participants knew that the researcher aimed to learn about their food and agricultural practices, but were not privy to other details of the study so as not to create bias in their participation.

discussion integrated interpretation of both qualitative and quantitative results. Given the recognized complementary strengths of qualitative and quantitative data (Creswell 2009), we believe integrated, mixed methods approaches deserve stronger protagonism in nutritional health research.

7.2.2 Limitations and lessons learned

Qualitative instruments and analyses

We found the greatest limitation of our qualitative methods to be that they did not also include the reference participant sample, thereby forgoing the possibility of obtaining helpful input and returning results among this group. While we could have, and perhaps should have, also conducted ethnography with families that are not involved with agroecological AFNs, the design of our FGDs precluded the possibility of also including the reference sample. This was because the design of FGDs called on participants to compare agroecological farmers to "other" farmers. Most farmers who are not part of an agroecological association are unlikely to have sufficient awareness (if any) of agroecology to have a basis for making such a comparison. A viable option may have been to adopt a distinct FGD protocol for reference farmers, perhaps through activities to provoke reflection on linkages between agriculture and dietary practices, but not specific to agroecology. We intend to carry this lesson forward into our future research.

Another limitation of our qualitative instruments was the possibility of subjective bias. Such bias could have especially been provoked by our emphasis on the comparison between agroecological AFN farmers and non-agroecological AFN reference farmers. In FGDs, AFN farmers may have been more likely to judge themselves as performing better than a perceived "other." Similarly, KIIs with AFN leaders and with other actors invested in the agroecology movement, such as NGOs, may have also elicited biases in favour of agroecological farmers. In ethnography, there was much potential for social-desirability bias, as participating farmers may wish to be welcoming hosts for the researcher and make a good impression. As part of the ethnography protocol, I aimed to spend enough time with families that they may become accustomed to my presence and let down some of their boundaries, but this inevitably remained a limitation of the instrument. While such subjective biases are difficult to avoid in qualitative research, integration of qualitative and quantitative methods help attenuate this issue (Creswell 2009).

Finally, another limitation to our qualitative data collection was that we did not systematically document KIIs or FGDs through audio recording, and we also did not employ the support of research assistants for note-taking. This likely compromised the completeness of our data, and provided fewer data points for subsequent analyses. We hesitated to implement audio recording so as not to cause discomfort to participants. In future research we may reassess this decision, and would certainly consider soliciting note-taking support.

Quantitative instruments and analyses

We conducted quantitative assessment by deploying a survey with multiple instruments and components. As with surveys in other studies, we had to make careful decisions regarding what information to collect in order to not overly saturate participants. Although we utilized existing literature as well as ethnography and KIIs to inform survey development, there are nevertheless multiple components that could have been improved. This is also the case for the analytical methods used to assess survey data. Many of the limitations we identified and the lessons learned are detailed in previous chapters, and they are also summarized in Table 5, below.

Table 5: Summary of limitations in quantitative research methods	
Topic	**Limitations identified and lessons learned for future research**
Cross-sectional design	The cross-sectional design of our study limited our ability to assess cause-and-effect relationships related to agroecology. We aimed to mitigate this by employing path analysis (which can provide support for cause-and-effect relationships, although it is not conclusive) and by also utilizing qualitative methods (in which farmers could explain cause-and-effect relationships based on their own experiences). However, future studies would benefit from a longitudinal design.
Sample size	We planned for a small sample size in order to facilitate the data collection process. Although our analysis with this sample size succeeded in providing many interesting results, we were nevertheless limited in our capacity to fully assess certain subjects. In particular, this limited the number of variables that we could include in regression-based analyses such as path analysis. In the future, we would aim for a larger sample size.
Social capital	At the time of the study, we did not identify an appropriate instrument and analytical method to assess social capital. However, future studies may consider available tools

	such as social network analysis of people's connections to each other (Valente and Pitts 2017) or the Integrated Questionnaire for the Measurement of Social Capital (Grootaert et al. 2004).
Conceptualization of agroecology	Our conceptualization of agroecology was based on farmers' participation in agroecological AFNs. This decision was based on previous literature and our team's knowledge of the trajectory of agroecology in Ecuador. However, this conceptualization places stronger focus on the social organization element of agroecology than it does on agricultural practices. Our survey would have been capable of bridging this gap by integrating assessment of agricultural practices relevant to agroecology. However, in the interest of limiting participant burden, we only assessed production diversity. Other practices relevant to agroecology in Ecuador that we could have assessed include the use of green manure, agroforestry, crop rotation practices, livestock integration, and application of organic and synthetic inputs (Macas and Echarry 2009; Heifer 2014).
Production diversity	We measured production diversity by using a list to query for all products grown over the past year. When we assessed the relationship between production diversity and dietary outcomes, this created an inconsistency in temporal scales, because our dietary measures were based on a single, 24-hour period. Future research should instead query for the products from the farm that are available for consumption on the day of the 24-hour recall (e.g., either because they are left over from the harvest, or because they are ripe and ready to pick).
Dietary assessment through 24-hour recall	Conducting dietary assessment through a single 24-hour recall has known limitations. Specifically, it can underestimate energy intake and overestimate micronutrients, and does not reflect long-term food intake trends for individuals (Poslusna et al. 2009). We believe this to be one of the most important systematic limitations of our study instruments, affecting the level of confidence in our dietary results. Future research should address this by conducting at least one follow-up 24 hour recall and applying algorithms for dietary corrections to nutrient intake (Jahns et al. 2005) and/or by complementing 24-hour recall with an appropriate food frequency questionnaire for assessing nutrient adequacy and dietary moderation among the study population. The decision on how to proceed with follow-up 24-hour recalls or other dietary methods should also be weighed against the additional burden it presents to participants.
Food frequency questionnaire on traditional foods	We assessed traditional foods consumption using a food frequency questionnaire (FFQ). Because traditional foods are often only available during certain seasons, we attempted to improve the accuracy of our data by asking farmers for the duration that the given food is available to them, and then asking about frequency during that time period. Even so, we believe this did not entirely mitigate the cognitive difficulty of FFQs (i.e. the need to remember and estimate past consumption) (Kristal, Peters, and Potter 2005) nor the complexity of addressing seasonality with FFQs (Tsubono et al. 1995), thereby affecting the reliability of the data on traditional food consumption frequency.

Waist circumference	Although our research protocol collected waist circumference data, we ultimately discarded this information because of the use of corsets among some Indigenous women. Guidelines used for measuring waist circumference (Centers for Disease Control and Prevention 2007) specify the need to wear loose clothing and remove garments that impede measurement; however, doing so felt intrusive. Future studies should make appropriate adjustments to field protocols.
Ethnicity	We did not query for participants' ethnic identity. This could have provided a stronger understanding of the dynamics affecting Indigenous people.
Anthropometric reporting to participants	Participants were told their body weight, height and waist circumference as the measurements were taken. However, participants frequently sought more information, asking whether their body weight was healthy for their size. In the future, it would be helpful to have systematic guidelines for providing participants with feedback on their results. Given that anthropometric cut offs (e.g. BMI, height to waist circumference) have not been thoroughly validated for an Indigenous Andean population, the appropriate individual return of anthropometric results requires careful consideration. Future research may consider applying the cardiometabolic risk cut-off points proposed by Medina-Lezama and colleagues (2010) for Andean populations, which are derived from waist circumference measurements. This would need to be done in conjunction with field protocols that address the cultural use of corsets among some Indigenous women. Although a comparable population-specific BMI has not been proposed to date, it would be worth closely following any advances on this subject.

7.3 Implications for the Ecuadorian context

The sum of our research findings shed light on how agroecological AFNs in Ecuador's highland Imbabura province support women farmers in obtaining healthier dietary outcomes. We found evidence along this pathway to suggest that production diversity, social capital, consumption of foods from own-production and social economy as well as the promotion of traditional foods could be key to supporting healthy diets. For actors working to create a more sustainable and regenerative food system in Ecuador, this evidence supports tangible courses of action. In light of our findings, we outline several recommendations:

Promotion of agroecology should continue. Agroecology in Ecuador has been promoted through the actions of a multitude of organized actors. In Imbabura, these include farmers' associations (e.g. *Asociación de Productores Agroecológicos de Intag*), Indigenous associations and federations (e.g. *Unión de Comunidades Indígenas de Gonzales Suárez, Federación Indígena y Campesina de Imbabura*, among others), NGOs (e.g. *Agrónomos y Veterinarios sin Fronteras, Vibrant Village*, *Fundación Heifer*, among others) and various nationally-active civil-society groups (e.g. *Movimiento de Economía Social y Solidaria del Ecuador*, *Colectivo Agroecológico, Campaña ¡Que Rico Es!*, among others). Moreover, it has been promoted through the actions of certain state authorities, such as parish- and municipal-level *Gobiernos Autónomos Descentralizados* (decentralized autonomous governments). The activities and policies of such a diversity of actors have supported farmer-to-farmer knowledge-sharing, provided technical support and capacity building, supported the creation and continuity of agroecological AFNs, and otherwise contributed to an enabling environment for agroecology. Part of the success in fostering favourable nutritional outcomes may be from the diversity of actors involved. For example, while some actors may focus primarily on agricultural techniques, others may be more concerned with food practices, gastronomy and nutrition. Farmers in our study, and particularly the AFN leadership we interviewed, recognized the importance of these various actors for helping spark agroecology as an organized initiative in their farming communities, and for providing support in key points along each AFN's trajectory (see Section 6.6: Supplementary results).

The pathways connecting agroecology to nutrition outcomes should continue to be strengthened. AFNs and their allies should continue to engage in activities that increase production diversity, create social capital around food, promote consumption of foods from own-production and social economy, as well as promote traditional foods. Because production diversity has received much recognition for its role in creating regenerative agro-environments as well as in providing access to a diversity of foods for own-consumption (Johns and Sthapit 2004; Frison, Cherfas, and Hodgkin 2011; Cook 2018), this pathway has perhaps received unique attention, particularly from NGOs. On the other hand, the construction of social capital is less-established in development literature and it may be more challenging for certain actors to justify it as a programming priority. While activities with other objectives—such as to promote specific agricultural practices, strengthen food literacy or commercialize agroecological products—have served the dual-purpose of also supporting social capital, we believe that the strengthening of social relationships is valuable as an objective in-and-of itself. One positive example of purposefully inserting activities to promote social capital in encounters with multiple other objectives comes from the *Colectivo Agroecológico*: in their meetings, this group has dedicated time and space to both structured bonding activities (e.g. ice-breaker games, youth encounters) as well as unstructured bonding activities (e.g. down-time during farm visits, down-time to get to know each other during lunch breaks) (Colectivo Agroecológico del Ecuador 2018).

In the attempt to strengthen agroecology's positive impacts on nutrition, we believe it is important to simultaneously invest in multiple pathways. Previous research in the Andes on the relationship between agrobiodiversity and nutrition in NGO initiatives concludes that progress toward regenerative agriculture and healthy food is achieved more readily through intensification of experience rather than extensification, with the former referring to diversification and deepening of experiences and the latter referring to scaling in size or number (Natividad et al. 2021). Similarly, our research shows that many pathways interact to connect to a meaningful outcome in dietary quality; the effect of following a single pathway would likely be too small to have any noticeable impact. As such, we also believe that intensification needs to be prioritized before extensification can have any meaningful effect.

Agroecology should remain a social movement. The farmers whom we consulted placed value on the shared identity created through agroecology, and this sense of identity appeared to strengthen their dedication to certain norms around food and agriculture as well as foster a sense of agency in holding and sharing knowledge. Other research in Ecuador has suggested that farmers who feel an affective tie with a broader movement may feel more compelled to share their knowledge and connect others to the movement (Sherwood, Van Bommel, and Paredes 2016). Perhaps part of the success in spreading agroecology as a social movement in Ecuador is because so much of its evolution is closely tied to civil-society organizations such as farmers' associations and Indigenous groups, with which farmers already hold close affective ties. As agroecology gains attention at both a national and international scale (Sherwood et al. 2013; Gortaire 2016; FAO 2018b; HLPE 2019), it is important that it not become institutionalized in such a way as to deteriorate the affective, movement-oriented ties. The agency of respected leaders in the agroecological movement in defining courses of action may be especially important. For NGOs in particular, an approach that may be consistent with these intentions is that of "participatory development." Natividad and colleagues describe how participatory development pays attention to the quality of learning-action processes in order to create trust, build confidence, and enhance local ownership, thereby enabling innovation (Natividad et al. 2021).

7.4 Implications for agriculture-nutrition linkage frameworks

Through our empirical research, we find that predominant agriculture-nutrition linkage frameworks are useful for exploring and understanding how agroecology can relate to farmer health. Our findings further reflect the need to respect heterogeneity of context; among our study population in the Ecuadorian highlands, certain pathways stood out to be more relevant than others. Specifically, we detected a stronger role for pathways linking agriculture to nutrition via own-consumption rather than via agricultural income generation. Even so, within a bounded "context," the pathways that are most relevant for one farmer may be different than those that are most relevant for their neighbour. This became most evident in our qualitative research, where the practices observed for each individual "n=1" did not always align with the broader trends of the "n=90" that we measured using our survey instrument. This may serve to better understand why the magnitude of correlations measured for specific agriculture-nutrition linkages, such as that between production diversity and dietary diversity, often fail to deliver on expectations.

Our findings further explored how two additional components, social capital and social economy, can be relevant to agriculture-nutrition pathways. There is documented evidence from around the world on the importance of social capital in farming communities (Pretty 2003), on how agricultural initiatives can impact social capital (Kansanga et al. 2020) as well as on the importance of social capital to health outcomes (Eriksson 2011), yet its mediating role in agriculture-nutrition literature has been largely neglected. Similarly, social economy has been largely unexplored as a means of obtaining nutritious foods, despite its usage and cultural importance in some populations. In the rural Andes in particular, social economy is an important means of food acquisition, especially among Indigenous communities (Argumedo and Pimbert 2010; Ferraro 2011), and studies in this region are unlikely to form a complete portrait of how people obtain their food without also considering social economy. Such was the case in our exploration of underutilized, traditional foods, wherein social economy was key for certain farmers to obtain products that they neither grew themselves, nor could purchase in conventional markets.

Our research provides empirical support for a link between agroecology and nutritional health among farmers in Imbabura. However, agroecology is a dynamic concept operationalized through distinct agricultural and social experiences across the world (Wezel et al. 2009). As such, there is no guarantee that the experience in Imbabura would be replicated in other countries or even in other provinces of Ecuador. Yet the adherence of our findings to recognized agriculture-nutrition pathways, which have been developed based on findings from numerous localities (Haddad 2000; Arimond et al. 2011; Herforth and Harris 2014; Kadiyala et al. 2014), provides support for this relationship to also be present in other contexts, although not necessarily in all contexts. For example, impact studies of three agroecology initiatives funded by MISEREOR found strong evidence for a positive relationship between agroecology and dietary outcomes in Brazil, modest evidence in India, and very little if any evidence in Senegal (Chappell et al. 2018). Given the support for the notion that agroecology is not just an agricultural intervention, but rather a social movement based in strong relationship networks of farmers and other allies (Wezel et al. 2009), further exploration is needed to understand how agroecology can impact dietary practices, and how this relationship can be leveraged for greater nutritional health impact.

7.5 Key contributions of this research

On a local level, a key contribution of this research was in providing empirical evidence for how agroecology may support farmer nutritional health in the Ecuadorian highlands. The preliminary results of our research informed the development of a much broader study in Ecuador assessing the role of AFNs in supporting nutritional health; to do so, this study will assess not only dietary intake but also physiological outcomes through anthropometry, biochemical assessment of nutritional status and clinical assessment of hypertension and diabetes mellitus (Batal and Paredes 2018). Further, the results dissemination process contributed to the knowledge of Imbabura's AFNs and other stakeholders on the mechanisms by which agroecology can be leveraged for nutritional health.

More globally, this research situated agroecology within an agriculture-nutrition framework and extended this framework's impact pathways to include not only nutrient adequacy but also dietary moderation. Our findings empirically demonstrated that agroecology's promotion of production diversity positions it squarely within predicted pathways, and also uniquely integrated social capital and social economy into this framework. Moreover, we provided an empirical exploration of how traditional foods can also be integrated into agricultural practices to precipitate dietary outcomes that support nutritional health.

From a methodological perspective, this study illustrated the utility of mixed methods for enabling a participatory research process grounded in a salutogenic, strength-based approach. One of the most provocative observations obtained from integrating participatory qualitative methods with more conventional quantitative methods was that participants in qualitative instruments reliably predicted many of the results from our quantitative survey (Section 6.4: Article 3); this served as an important reminder that people know their own realities and do not depend on us, as researchers, to explain their lives to them. Our methods also highlighted specific analytical lessons, including the need to assess the relationship between production diversity and dietary diversity on comparable temporal scales. It is our hope that these contributions will inform ongoing and future practices and programming for multiple actors, including but not limited to the research community.

7.6 Unknowns and future research directions

This research also illuminated many gaps that remain in our understanding. The following section presents several subjects that we believe would support local initiatives aiming to use agroecology to benefit nutritional health, as well as the broader agriculture-nutrition community.

Broadening scope to include other family members: Our assessment focused on adult women due to their stronger presence in agroecological networks as well as their cultural role in food practices. While previous studies assessing intrahousehold dietary dynamics (Berti, Leonard, and Berti 1997) give us reason to believe that the diets of their household may be similar, it is nevertheless worth exploring the dietary outcomes for other members of the household, and particularly for children. Future studies may consider broadening their scope to include other members of the household.

Inquiry on use of income liberated from food purchases: We found that agroecological farmers obtain healthier diets with lower food expenditures, despite equivalent incomes. The question remains of how agroecological farmers utilize the income that is liberated from food purchases, and whether this income supports present and future family well-being. For example, investments in education may have long-term intergenerational impacts (Akresh, Halim, and Kleemans 2018). Moreover, our findings on income and expenditures among agroecological AFN farmers bring into question the longitudinal effects of AFN participation on income: for example, it may be that some farmers began with lower incomes than their neighbours, but AFN participation allowed them to level up. Qualitative instruments, such as interviews with farmers or focus group discussions, may support a stronger understanding of the use of liberated income as well as of income changes related to AFN participation.

Systematic evaluation of agroecology's impact on women's empowerment: Women participating in agroecological AFNs discussed many benefits to their participation; however, they also expressed certain sacrifices, such as strong requirements on their time. This points to the need for further exploration of women's empowerment in agroecology, and careful consideration of whether the requirements on women's time may compromise their well-being or their ability to perform other activities, such as those related to diet or childcare, or time for leisure and physical activities. For example, future studies may consider adapting surveys to apply the Women's Empowerment in Agriculture Index (Alkire et al. 2013).

Enhanced exploration on social capital in the community: Our exploration of social capital focused on agroecological AFN spaces. However, social capital is certainly also present in agroecological farmers' families, village communities and throughout other networks. It would be relevant to understand whether and how the health-promoting practices of AFN farmers spread through their other relationships. For example, is there a trickle-down effect on their neighbours? Social network analysis provides tools (Valente 2010) that can be integrated into surveys to explore this subject.

Improved assessment of land tenure and land surface in use: We identified that agroecological farmers utilized more land surface for production, and that this was relevant to the ability to obtain non-market foods. Agroecological farmers sustained that they did not own more land, but simply utilized more land because they placed higher priority on agriculture. In future surveys, it would be prudent to design questions that more carefully distinguish between land tenure and land use. Further qualitative assessment (e.g. through focus group discussions) would also be helpful to understand how access to land may interact with the ability to participate in agroecological AFNs, as well as with production diversity and consumption from non-market sources.

Longitudinal assessment: Despite a cross-sectional design, both our qualitative and quantitative analyses provide support for a "before" and "after" effect related to agroecology. However, it is possible that there is also a certain degree of bidirectionality. For example, agroecological farmers may have already had higher production diversity or social capital prior to joining the AFN, and this presumably may have even influenced their decision to join. Even if these factors were measurably strengthened through joining agroecology, this does not negate any comparative advantages that they already held. Such bidirectionality was previously detected in a study based in Malawi regarding social capital in agroecology (Kansanga et al. 2020), and this subject would also warrant further attention in the Ecuadorian highlands through a longitudinal study.

Interdisciplinary exploration between ecosystem health and food systems: Agroecology in the Ecuadorian highlands emerged as Indigenous farmers and their allies recognized multiple failures of the trajectory of "modern" industrialized agriculture, including its environmental consequences. Around the world, ecosystem health and abundance play a critical role in the food systems of Indigenous people, and threats to the ecosystem harm people's food (Kuhnlein et al. 2009). It would be valuable to better understand this in the Ecuadorian context through an interdisciplinary exploration of the feedback cycles and other interactions by which environmental change and ecological decline impact the dietary practices and nutritional health of farmers. For example, research on this subject with Indigenous people in the Arctic has highlighted how environmental constraints can create important discrepancies between people's desired diets and their actual diets (Kenny 2017).

8. Concluding remarks: diversity from farm to plate

In many ways, this research affirms what farmers and other actors organized around agroecology in Ecuador had already sensed: that the impacts of agroecology extend far beyond environmental regeneration and occupational well-being (i.e. avoiding pesticides) to include farmers' nutritional health. In a food system where the preponderant conventions for how to grow, commercialize and consume foods converge to ultimately attack people's nutritional health from multiple angles, recognizing, understanding and encouraging healthier alternatives is urgent. In this sense, Ecuador's agroecology movement, rooted in Indigenous people's aim to exert cultural sovereignty and presently tied together by its alternative food networks, presents a compelling example of how the relationships between and around agriculture and food can support both stronger nutrient adequacy and dietary moderation among farmers.

The title of this thesis established the intention to examine the role of "diversity from farm to plate" in agroecology. The bookends to this exploration were the diversity in agricultural production and in dietary intake; however, we found the importance of diversity to also extend into other realms. Social capital rooted in a variety of social relationships enabled farmers to beget other forms of capital that can ultimately support healthy food practices. Similarly, diversifying food acquisition sources to transcend conventional retail outlets supported farmers in accessing healthy products. Meanwhile, an assortment of motivations lead farmers to assert the importance of traditional foods as part of nutritious diets. Numerous societal ills, from unsustainable food systems to loss of cultural sovereignty, have been traced back to a phenomenon of homogenization. In contrast, our research supports the growing understanding that agroecology's contributions to diversity in agriculture and food pave a pathway to a more sustainable food system and healthier society.

9. References to the thesis[42]

Abbott, J Anthony. 2005. "Counting Beans: Agrobiodiversity, Indigeneity, and Agrarian Reform." *The Professional Geographer* 57 (2): 198–212.
AFSSA. 2003. "Evaluation Nutritionnelle et Sanitaire Des Aliments Issus de l'agriculture Biologique." l'Agence française de sécurité sanitaire des aliments. https://www.anses.fr/fr/system/files/NUT-Ra-AgriBio.pdf.
Akresh, Richard, Daniel Halim, and Marieke Kleemans. 2018. "Long-Term and Intergenerational Effects of Education: Evidence from School Construction in Indonesia." 0898–2937. National Bureau of Economic Research.
Alberti, KGMM, Robert H Eckel, Scott M Grundy, Paul Z Zimmet, James I Cleeman, Karen A Donato, Jean-Charles Fruchart, W Philip T James, Catherine M Loria, and Sidney C Smith Jr. 2009. "Harmonizing the Metabolic Syndrome: A Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity." *Circulation* 120 (16): 1640–45.
Alkire, Sabina, Ruth Meinzen-Dick, Amber Peterman, Agnes Quisumbing, Greg Seymour, and Ana Vaz. 2013. "The Women's Empowerment in Agriculture Index." *World Development* 52: 71–91.
Altieri, Miguel A. 1999. "The Ecological Role of Biodiversity in Agroecosystems." In *Invertebrate Biodiversity as Bioindicators of Sustainable Landscapes*, 19–31. Elsevier.
Altieri, Miguel A, and Victor Manuel Toledo. 2011. "The Agroecological Revolution in Latin America: Rescuing Nature, Ensuring Food Sovereignty and Empowering Peasants." *Journal of Peasant Studies* 38 (3): 587–612.
Anderson, Colin Ray, Janneke Bruil, M Jahi Chappell, Csilla Kiss, and Michel Patrick Pimbert. 2020. "Origins, Benefits and the Political Basis of Agroecology." In *Agroecology Now!*, 11–28. Springer.
Antonovsky, A. 1979. *Health, Stress and Coping*. San Francisco, CA: Joseey-Bass.
April-Lalonde, Gabriel, Sara Latorre, Myriam Paredes, María Fernanda Hurtado, Fabián Muñoz, Ana Deaconu, Donald C Cole, and Malek Batal. 2020. "Characteristics and Motivations of Consumers of Direct Purchasing Channels and the Perceived Barriers to Alternative Food Purchase: A Cross-Sectional Study in the Ecuadorian Andes." *Sustainability* 12 (17): 6923.
Arce, Alberto, Stephen Sherwood, and Myriam Paredes. 2015. "Repositioning Food Sovereignty: Between Ecuadorian Nationalist and Cosmopolitan Politics." In *Food Sovereignty in International Context*, 135–52. Routledge.
Argumedo, Alejandro, and Michel Pimbert. 2010. "Bypassing Globalization: Barter Markets as a New Indigenous Economy in Peru." *Development* 53 (3): 343–49.
Arimond, Mary, Corinna Hawkes, MT Ruel, Zeina Sifri, Peter R. Berti, Jef L Leroy, Jan W Low, Lynn R Brown, and Edward A Frongillo. 2011. "Agricultural Interventions and Nutrition: Lessons from the Past and New Evidence." *Eds B. Thompson and L. Amoroso*, 41–75.
Arimond, Mary, and Marie T Ruel. 2004. "Dietary Diversity Is Associated with Child Nutritional Status: Evidence from 11 Demographic and Health Surveys." *The Journal of Nutrition* 134 (10): 2579–85.
Arimond, Mary, Doris Wiesmann, Elodie Becquey, Alicia Carriquiry, Melissa C Daniels, Megan Deitchler, Nadia Fanou-Fogny, Maria L Joseph, Gina Kennedy, and Yves Martin-Prevel. 2010. "Simple Food

[42] Additional references to published or submitted articles (presented in Sections 6.2 through 6.5) are available in their respective reference sections.

Group Diversity Indicators Predict Micronutrient Adequacy of Women's Diets in 5 Diverse, Resource-Poor Settings." *The Journal of Nutrition* 140 (11): 2059S-2069S.

Aschner, Pablo, Richard Buendía, Imperia Brajkovich, Antonio Gonzalez, Rafael Figueredo, Xiomara E Juarez, Felipe Uriza, Ana Maria Gomez, and Carlos I Ponte. 2011. "Determination of the Cutoff Point for Waist Circumference That Establishes the Presence of Abdominal Obesity in Latin American Men and Women." *Diabetes Research and Clinical Practice* 93 (2): 243–47.

Ayala, Guido. 2004. "Aporte de los cultivos 7 andinos a la nutrición humana." In *Raíces Andinas: Contribuciones al conocimiento ya la capacitación.*, 101–12. Lima, Perú: Universidad Nacional Mayor de San Marcos.

Azadbakht, L, P Mirmiran, and F Azizi. 2005. "Dietary Diversity Score Is Favorably Associated with the Metabolic Syndrome in Tehranian Adults." *International Journal of Obesity* 29 (11): 1361–67.

Baiphethi, Mompati N, and Peter T Jacobs. 2009. "The Contribution of Subsistence Farming to Food Security in South Africa." *Agrekon* 48 (4): 459–82.

Balogh, Péter, Dániel Békési, Matthew Gorton, József Popp, and Péter Lengyel. 2016. "Consumer Willingness to Pay for Traditional Food Products." *Food Policy* 61: 176–84.

Barański, Marcin, Leonidas Rempelos, Per Ole Iversen, and Carlo Leifert. 2017. "Effects of Organic Food Consumption on Human Health; the Jury Is Still Out!" *Food & Nutrition Research* 61 (1): 1287333. https://doi.org/10.1080/16546628.2017.1287333.

Batal, Malek, Katherine Gray-Donald, Harriet V Kuhnlein, and Olivier Receveur. 2005. "Estimation of Traditional Food Intake in Indigenous Communities in Denendeh and the Yukon." *International Journal of Circumpolar Health* 64 (1): 46–54.

Batal, Malek, and Elizabeth Hunter. 2007. "Traditional Lebanese Recipes Based on Wild Plants: An Answer to Diet Simplification?" *Food and Nutrition Bulletin* 28 (2_suppl2): S303–11.

Batal, Malek, and Myriam Paredes. 2018. "Evaluating and Bringing to Scale Alternative Food Networks to Address Diabetes Mellitus and Hypertension. IDRC Project # 109101-001, CIHR Project # HA1-164002."

Bellon, Mauricio R., Gervais D. Ntandou-Bouzitou, and Francesco Caracciolo. 2016. "On-Farm Diversity and Market Participation Are Positively Associated with Dietary Diversity of Rural Mothers in Southern Benin, West Africa." Edited by Jacobus van Wouwe. *PLOS ONE* 11 (9): e0162535. https://doi.org/10.1371/journal.pone.0162535.

Berdegué, Julio A, and Ricardo Fuentealba. 2011. "Latin America: The State of Smallholders in Agriculture." In , 24:25.

Berkman, Lisa F, and Thomas Glass. 2000. "Social Integration, Social Networks, Social Support, and Health." *Social Epidemiology* 1: 137–73.

Berti, Peter R. 2015. "Relationship between Production Diversity and Dietary Diversity Depends on How Number of Foods Is Counted." *Proceedings of the National Academy of Sciences* 112 (42): E5656–E5656. https://doi.org/10.1073/pnas.1517006112.

Berti, Peter R., Cynthia Fallu, and Yesmina Cruz Agudo. 2014. "A Systematic Review of the Nutritional Adequacy of the Diet in the Central Andes." *Revista Panamericana de Salud Pública* 36: 314–23.

Berti, Peter R., and Andrew D Jones. 2013. "Biodiversity's Contribution to Dietary Diversity: Magnitude, Meaning and Measurement." In *Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health*, edited by Jessica Fanzo, Danny Hunter, Teresa Borelli, and Federico Mattei, First edition. Issues in Agricultural Biodiversity. London ; New York: Earthscan from Routledge.

Berti, Peter R., Julia Krasevec, and Donald Cole. 2004. "Diet Inadequacies and Neurobehavioural Impairment in Rural Highland Ecuadoreans." Ottawa, Canada: HealthBridge.

Berti, Peter R., Julia Krasevec, and Sian FitzGerald. 2004. "A Review of the Effectiveness of Agriculture Interventions in Improving Nutrition Outcomes." *Public Health Nutrition* 7 (5): 599–609.

Berti, Peter R., William R Leonard, and Wilma J Berti. 1997. "Malnutrition in Rural Highland Ecuador: The Importance of Intrahousehold Food Distribution, Diet Composition, and Nutrient Requirements." *Food and Nutrition Bulletin* 18 (4): 1–11.

Black, Maureen M. 2003. "Micronutrient Deficiencies and Cognitive Functioning." *The Journal of Nutrition* 133 (11): 3927S-3931S.

Black, Robert E, Cesar G Victora, Susan P Walker, Zulfiqar A Bhutta, Parul Christian, Mercedes De Onis, Majid Ezzati, Sally Grantham-McGregor, Joanne Katz, and Reynaldo Martorell. 2013. "Maternal and Child Undernutrition and Overweight in Low-Income and Middle-Income Countries." *The Lancet* 382 (9890): 427–51.

Bogin, B., and R. Keep. 1999. "Eight Thousand Years of Economic and Political History in Latin America Revealed by Anthropometry." *Annals of Human Biology* 26 (4): 333–51. https://doi.org/10.1080/030144699282651.

Borron, Sarah. 2006. "Building Resilience for an Unpredictable Future: How Organic Agriculture Can Help Farmers Adapt to Climate Change." *Food and Agriculture Organization of the United Nations, Rome*.

Bouis, Howarth E. 2000. "Commercial Vegetable and Polyculture Fish Production in Bangladesh: Their Impacts on Household Income and Dietary Quality." *Food and Nutrition Bulletin* 21 (4): 482–87.

Branca, Francesco, and Marika Ferrari. 2002. "Impact of Micronutrient Deficiencies on Growth: The Stunting Syndrome." *Annals of Nutrition and Metabolism* 46 (Suppl. 1): 8–17.

Brassel, Frank, Stalin Herrera, Michel Laforge, and SIPAE, eds. 2008. *¿Reforma Agraria En El Ecuador? Viejos Temas, Nuevos Argumentos*. Quito, Ecuador: Sistema de Investigación sobre la Problemática Agraria en el Ecuador.

Brough, Mark, Chelsea Bond, and Julian Hunt. 2004. "Strong in the City: Towards a Strength-based Approach in Indigenous Health Promotion." *Health Promotion Journal of Australia* 15 (3): 215–20.

Burgos, Gabriela, Walter Amoros, Maximo Morote, James Stangoulis, and Merideth Bonierbale. 2007. "Iron and Zinc Concentration of Native Andean Potato Cultivars from a Human Nutrition Perspective." *Journal of the Science of Food and Agriculture* 87 (4): 668–75.

CARE. 2013. "Formative Research: A Guide to Support the Collection and Analysis of Qualitative Data for Integrated Maternal and Child Nutrition Program Planning." Cooperative for Assistance and Relief Everywhere, Inc. (CARE). https://www.fsnnetwork.org/sites/default/files/Formative%20Research%20Guide%20for%20Nutrition%20Programs%202014.pdf.

Carvajal-Larenas, F. E., A. R. Linnemann, M. J. R. Nout, M. Koziol, and M. A. J. S. van Boekel. 2016. "Lupinus Mutabilis: Composition, Uses, Toxicology, and Debittering." *Critical Reviews in Food Science and Nutrition* 56 (9): 1454–87. https://doi.org/10.1080/10408398.2013.772089.

Centers for Disease Control and Prevention. 2007. "National Health and Nutrition Examination Survey: Anthropometry Procedures Manual." *Centers for Disease Control and Prevention (CDC): Atlanta, GA, USA*.

Chamorro, Antonio. 2011. "Dieta y Agrobiodiversidad Durante La Modernización de Las Chakras En La Sierra Central Ecuatoriana." MSc Thesis, Wageningen University.

Chan, Laurie, Malek Batal, Tonio Sadik, Constantine Tikhonov, Harold Schwartz, Karen Fediuk, Amy Ing, et al. 2019. "FNFNES Final Report for Eight Assembly of First Nations Regions: Draft Comprehensive Technical Report." Assembly of First Nations, University of Ottawa, Université

de Montréal.
Chappell, M Jahi, Annelie Bernhart, Lorenz Bachmann, André Luiz Gonçalves, Sidy Seck, Phanipriya Nandul, and Alvori Cristo dos Santos. 2018. "Agroecology as a Pathway towards Sustainable Food Systems." MISEREOR IHR Hilfswerk.
Child Health Epidemiology Reference Group Small-for-Gestational-Age/Preterm Birth Working Group. 2015. "Short Maternal Stature Increases Risk of Small-for-Gestational-Age and Preterm Births in Low-and Middle-Income Countries: Individual Participant Data Meta-Analysis and Population Attributable Fraction." *The Journal of Nutrition* 145 (11): 2542–50.
Chivenge, Pauline, Tafadzwanashe Mabhaudhi, Albert Modi, and Paramu Mafongoya. 2015. "The Potential Role of Neglected and Underutilised Crop Species as Future Crops under Water Scarce Conditions in Sub-Saharan Africa." *International Journal of Environmental Research and Public Health* 12 (6): 5685–5711.
Christakis, Nicholas A. 2007. "The Spread of Obesity in a Large Social Network Over 32 Years." *N Engl j Med*, 10.
Cole, Donald C, Fernando Carpio, Jim Julian, Ninfa Leon, Ramona Carbotte, and Hipatia De Almeida. 1997. "Neurobehavioral Outcomes among Farm and Nonfarm Rural Ecuadorians." *Neurotoxicology and Teratology* 19 (4): 277–86.
Cole, Donald C., Fernando Carpio, and Ninfa León. 2000. "Economic Burden of Illness from Pesticide Poisonings in Highland Ecuador." *Revista Panamericana de Salud Pública* 8 (3): 196–201. https://doi.org/10.1590/S1020-49892000000800007.
Cole, Donald C, Stephen Sherwood, Charles Crissman, Victor Barrera, and Patrico Espinosa. 2002. "Pesticides and Health in Highland Ecuadorian Potato Production: Assessing Impacts and Developing Responses." *International Journal of Occupational and Environmental Health* 8 (3): 182–90.
Colectivo Agroecológico del Ecuador. 2018. "El Futuro Es Agroecológico: Memoria de La IV Jornadas Agroecológicas 2017." https://colectivoagroecologicoec.files.wordpress.com/2018/04/memoria_ivjornadas_agroecologicas2017.pdf.
Colucci, Erminia. 2007. "'Focus Groups Can Be Fun': The Use of Activity-Oriented Questions in Focus Group Discussions." *Qualitative Health Research* 17 (10): 1422–33. https://doi.org/10.1177/1049732307308129.
Contreras Díaz, Jackeline, Myriam Paredes Chauca, and Sandra Turbay Ceballos. 2017. "Circuitos Cortos de Comercialización Agroecológica En El Ecuador." *Idesia (Arica)* 35 (3): 71–80.
Cook, Seth. 2018. "The Spice of Life: The Fundamental Role of Diversity on the Farm and on the Plate." Discussion Paper. London and The Hague: IIED and Hivos.
Cordero-Ahiman, Otilia Vanessa, Jorge Leonardo Vanegas, Christian Franco-Crespo, Pablo Beltrán-Romero, and María Elena Quinde-Lituma. 2021. "Factors That Determine the Dietary Diversity Score in Rural Households: The Case of the Paute River Basin of Azuay Province, Ecuador." *International Journal of Environmental Research and Public Health* 18 (4): 2059.
Córdoba, Diana, Ana Maria Peredo, and Paola Chaves. 2021. "Shaping Alternatives to Development: Solidarity and Reciprocity in the Andes during COVID-19." *World Development* 139: 105323.
Cornwall, Andrea, and Rachel Jewkes. 1995. "What Is Participatory Research?" *Social Science & Medicine* 41 (12): 1667–76.
Creswell, John W. 2009. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 3rd ed. Thousand Oaks, Calif: Sage Publications.
Danton, Heather, and Sarah Titus. 2018. "Taking Action: Five Ways to Improve Nutrition through

Agriculture Now.” *Global Food Security* 18: 44–47.
Davis, Esa M, Kurt C Stange, and Ralph I Horwitz. 2012. “Childbearing, Stress and Obesity Disparities in Women: A Public Health Perspective.” *Maternal and Child Health Journal* 16 (1): 109–18.
Deaconu, Ana, Ross Borja, and Pedro Oyarzún. 2015. “The Space Between Production and Consumption in Agroecological Food: A Case Study from an Organized Consumer-Organized Producer Market Channel in Chimborazo, Ecuador.” Quito, Ecuador: Fundación EkoRural.
Deharveng, G, UR Charrondiere, N Slimani, DAT Southgate, and E Riboli. 1999. “Comparison of Nutrients in the Food Composition Tables Available in the Nine European Countries Participating in EPIC.” *European Journal of Clinical Nutrition* 53 (1): 60–79.
Deurenberg, Paul, Mabel Yap, and Wija A Van Staveren. 1998. “Body Mass Index and Percent Body Fat: A Meta Analysis among Different Ethnic Groups.” *International Journal of Obesity* 22 (12): 1164–71.
Drawson, Alexandra S, Elaine Toombs, and Christopher J Mushquash. 2017. “Indigenous Research Methods: A Systematic Review.” *International Indigenous Policy Journal* 8 (2).
Egert, Sarah, and Gerald Rimbach. 2011. “Which Sources of Flavonoids: Complex Diets or Dietary Supplements?” *Advances in Nutrition* 2 (1): 8–14. https://doi.org/10.3945/an.110.000026.
El Mabchour, Asma, Hélène Delisle, Colette Vilgrain, Philippe Larco, Roger Sodjinou, and Malek Batal. 2015. “Specific Cut-off Points for Waist Circumference and Waist-to-Height Ratio as Predictors of Cardiometabolic Risk in Black Subjects: A Cross-Sectional Study in Benin and Haiti.” *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 513. https://doi.org/10.2147/DMSO.S88893.
Ericksen, Polly J. 2008. “Conceptualizing Food Systems for Global Environmental Change Research.” *Global Environmental Change* 18 (1): 234–45. https://doi.org/10.1016/j.gloenvcha.2007.09.002.
Eriksson, Malin. 2011. “Social Capital and Health – Implications for Health Promotion.” *Global Health Action* 4 (1): 5611. https://doi.org/10.3402/gha.v4i0.5611.
Espinosa, Patricio, Rocio Vaca, Jorge Abad, and Charles C Crissman. 1997. *Raíces y Tubérculos Andinos Cultivos Marginados En El Ecuador: Situación Actual y Limitaciones Para La Producción*. International Potato Center.
Estrella, Eduardo. 1986. *El Pan de América: Etnohistoria de Los Alimentos Aborígenes En El Ecuador*. Publicaciones Del C.S.I.C. Conmemorativas Del V Centenario Del Descubrimiento de América. Madrid: Consejo Superior de Investigaciones Científicas, Centros de Estudios Históricos.
FAO. 1994. *Neglected Crops: 1492 from a Different Perspective*. Edited by J. Esteban Hernández Bermejo and J. León. FAO Plant Production and Protection Series, no. 26. Rome: Food and Agriculture Organization of the United Nations.
———, ed. 2014. *The State of Food and Agriculture: Innovation in Family Farming*. The State of Food and Agriculture 2014. Rome.
———. 2015. “Final Report for the International Symposium on Agroecology for Food Security and Nutrition.”
———. 2018a. “Dietary Assessment: A Resource Guide to Method Selection and Application in Low Resource Settings.” Rome: Food and Agriculture Organization of the United Nations. http://www.fao.org/3/i9940en/I9940EN.pdf.
———. 2018b. “FAO’s Work on Agroecology: A Pathway to Achieving the SDGs.” Rome: FAO. http://www.fao.org/3/I9021EN/i9021en.pdf.
———. 2018c. “Sustainable Food Systems, Concept and Framework.” http://www.fao.org/3/ca2079en/CA2079EN.pdf.
FAO, and FHI 360. 2016. “Minimum Dietary Diversity for Women: A Guide for Measurement. 2016.”

Rome: FAO.
FAO, FIDA, OPS, WFP, and UNICEF. 2020. “Panorama de la seguridad alimentaria y nutricional en América Latina y el Caribe 2020.” Santiago de Chile. https://doi.org/10.4060/cb2242es.
FAO, IFAD, and WFP. 2015. “The State of Food Insecurity in the World 2015: Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress. Rome: FAO, 2015.” http://www.fao.org/3/a-i4646e.pdf.
FAO, OPS, WFP, and UNICEF. 2019. “Panorama de la seguridad alimentaria y nutricional en América Latina y el Caribe 2019.” FAO, OPS, WFP and UNICEF. https://doi.org/10.4060/CA6979ES.
Fernández, Andrés, Rodrigo Martínez, Ignacio Carrasco, and Amalia Palma. 2017. “Impacto Social y Económico de La Malnutrición: Modelo de Análisis y Estudio Piloto En Chile, El Ecuador y México.” CEPAL and WFP. http://www.codajic.org/sites/www.codajic.org/files/Impacto%20social%20y%20econ%C3%B3mico%20de%20la%20malnutrici%C3%B3n%20.pdf.
Ferraro, Emilia. 2011. “Trueque: An Ethnographic Account of Barter, Trade and Money in Andean Ecuador.” *The Journal of Latin American and Caribbean Anthropology* 16 (1): 168–84.
Flores, LA Martinez. 2015. *Seeds, Food Networks and Politics: Different Ontologies in Relation to Food Sovereignty in Ecuador*. Wageningen University.
Fonte, Steven J, Steven J Vanek, Pedro Oyarzun, Soroush Parsa, D Carolina Quintero, Idupulapati M Rao, and Patrick Lavelle. 2012. “Pathways to Agroecological Intensification of Soil Fertility Management by Smallholder Farmers in the Andean Highlands.” In *Advances in Agronomy*, 116:125–84. Elsevier.
Force, UNEP-UNCTAD Capacity-building Task. 2008. *Organic Agriculture and Food Security in Africa*. United Nations New York, NY.
Francis, C., G. Lieblein, S. Gliessman, T. A. Breland, N. Creamer, R. Harwood, L. Salomonsson, et al. 2003. “Agroecology: The Ecology of Food Systems.” *Journal of Sustainable Agriculture* 22 (3): 99–118. https://doi.org/10.1300/J064v22n03_10.
Freire, Wilma B, MJ Ramírez, and P Belmont. 2015. “Tomo I: Encuesta Nacional de Salud y Nutrición de La Población Ecuatoriana de Cero a 59 Años, ENSANUT-ECU 2012.” *Revista Latinoamericana de Políticas y Acción Pública Volumen 2, Número 1-Mayo 2015* 2 (1): 117.
Freire, Wilma B, Katherine M Silva-Jaramillo, María J Ramírez-Luzuriaga, Philippe Belmont, and William F Waters. 2014. “The Double Burden of Undernutrition and Excess Body Weight in Ecuador–.” *The American Journal of Clinical Nutrition* 100 (6): 1636S-1643S.
Freire, Wilma B, William F Waters, Diana Román, Elisa Jiménez, Estefania Burgos, and Philippe Belmont. 2018. “Overweight, Obesity, and Food Consumption in Galapagos, Ecuador: A Window on the World.” *Globalization and Health* 14 (1): 1–9.
Frison, Emile A, Jeremy Cherfas, and Toby Hodgkin. 2011. “Agricultural Biodiversity Is Essential for a Sustainable Improvement in Food and Nutrition Security.” *Sustainability* 3 (1): 238–53.
Frison, Emile A and IPES-Food. 2016. “From Uniformity to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems.”
Frison, Emile A., Ifeyironwa Francisca Smith, Timothy Johns, Jeremy Cherfas, and Pablo B. Eyzaguirre. 2006. “Agricultural Biodiversity, Nutrition, and Health: Making a Difference to Hunger and Nutrition in the Developing World.” *Food and Nutrition Bulletin* 27 (2): 167–79. https://doi.org/10.1177/156482650602700208.
Gauvin, François-Pierre. 2009. “What Is a Deliberative Process?” 1193. National Collaborating Centre for Healthy Public Policy. https://www.ncchpp.ca/docs/DeliberativeDoc1_EN_pdf.pdf.
Gibson, Rosalind S, U Ruth Charrondiere, and Winnie Bell. 2017. “Measurement Errors in Dietary

Assessment Using Self-Reported 24-Hour Recalls in Low-Income Countries and Strategies for Their Prevention.” *Advances in Nutrition* 8 (6): 980–91.
Gliessman, Stephen R. 1990. “Agroecology: Researching the Ecological Basis for Sustainable Agriculture.” In *Agroecology*, 3–10. Springer.
Gliessman, Steve, and Pablo Tittonell. 2015. “Agroecology for Food Security and Nutrition.” *Agroecology and Sustainable Food Systems* 39 (2): 131–33. https://doi.org/10.1080/21683565.2014.972001.
Gluckman, PD, and MA Hanson. 2008. “Developmental and Epigenetic Pathways to Obesity: An Evolutionary-Developmental Perspective.” *International Journal of Obesity* 32 (7): S62–71.
Godfrey, Keith M, Peter D Gluckman, and Mark A Hanson. 2010. “Developmental Origins of Metabolic Disease: Life Course and Intergenerational Perspectives.” *Trends in Endocrinology & Metabolism* 21 (4): 199–205.
Gómez, Georgina, Ágatha Nogueira Previdelli, Regina Mara Fisberg, Irina Kovalskys, Mauro Fisberg, Marianella Herrera-Cuenca, Lilia Yadira Cortés Sanabria, Martha Cecilia Yépez García, Attilio Rigotti, and María Reyna Liria-Domínguez. 2020. “Dietary Diversity and Micronutrients Adequacy in Women of Childbearing Age: Results from ELANS Study.” *Nutrients* 12 (7): 1994.
Gómez, Miguel I, and Katie D Ricketts. 2013. “Food Value Chain Transformations in Developing Countries: Selected Hypotheses on Nutritional Implications.” *Food Policy* 42: 139–50.
Goodman, David, and Michael Goodman. 2009. “Alternative Food Networks.” In *International Encyclopedia of Human Geography*, 208–20.
Goodwin, Geoff. 2021. “Fictitious Commodification and Agrarian Change: Indigenous Peoples and Land Markets in Highland Ecuador.” *Journal of Agrarian Change* 21 (1): 3–24. https://doi.org/10.1111/joac.12368.
Gortaire, Roberto. 2016. “Agroecología En El Ecuador. Proceso Histórico, Logros, y Desafíos.” *Antropología Cuadernos de Investigación*, no. 17: 12–38.
Grandjean, Philippe, Raul Harari, Dana B Barr, and Frodi Debes. 2006. “Pesticide Exposure and Stunting as Independent Predictors of Neurobehavioral Deficits in Ecuadorian School Children.” *Pediatrics* 117 (3): e546–56.
Greenhalgh, Trisha, Glenn Robert, Fraser Macfarlane, Paul Bate, and Olivia Kyriakidou. 2004. “Diffusion of Innovations in Service Organizations: Systematic Review and Recommendations.” *The Milbank Quarterly* 82 (4): 581–629.
Grivetti, Louis E, and Britta M Ogle. 2000. “Value of Traditional Foods in Meeting Macro-and Micronutrient Needs: The Wild Plant Connection.” *Nutrition Research Reviews* 13 (1): 31–46.
Grootaert, Christiaan, Deepa Narayan, Veronica Nyhan Jones, and Michael Woolcock. 2004. *Measuring Social Capital: An Integrated Questionnaire*. The World Bank.
Gross, Joan, Carla Guerrón Montero, Michaela Hammer, and Peter R. Berti. 2017. “Creating Healthy Bodies in Rural Ecuador at a Time of Dietary Shift.” In *Food, Agriculture and Social Change*, edited by Stephen Sherwood, Alberto Arce, and Myriam Paredes, 1st ed., 34–47. Routledge. https://doi.org/10.4324/9781315440088-3.
Gross, Joan, Carla Guerrón Montero, Peter R. Berti, and Michaela Hammer. 2016. “Moving Forward, Looking Back: On the Frontlines of Dietary Shift in Rural Ecuador.” *Íconos-Revista de Ciencias Sociales*, no. 54: 49–70.
Guenther, Patricia M., Kellie O. Casavale, Jill Reedy, Sharon I. Kirkpatrick, Hazel A.B. Hiza, Kevin J. Kuczynski, Lisa L. Kahle, and Susan M. Krebs-Smith. 2013. “Update of the Healthy Eating Index: HEI-2010.” *Journal of the Academy of Nutrition and Dietetics* 113 (4): 569–80. https://doi.org/10.1016/j.jand.2012.12.016.

Guerrero, Andrés. 1975. “La Hacienda Precapitalista y La Clase Terrateniente En América Latina y Su Inserción En El Modo de Producción Capitalista: El Caso Ecuatoriano.”
Ha, Myung-Hwa, Duk-Hee Lee, and David R Jacobs Jr. 2007. “Association between Serum Concentrations of Persistent Organic Pollutants and Self-Reported Cardiovascular Disease Prevalence: Results from the National Health and Nutrition Examination Survey, 1999–2002.” *Environmental Health Perspectives* 115 (8): 1204–9.
Habte, Ted Y, and Michael Krawinkel. 2016. “Dietary Diversity Score: A Measure of Nutritional Adequacy or an Indicator of Healthy Diet.” J Nutr Health Sci 3 (3): 303.
Haddad, Lawrence. 2000. “A Conceptual Framework for Assessing Agriculture–Nutrition Linkages.” *Food and Nutrition Bulletin* 21 (4): 367–73. https://doi.org/10.1177/156482650002100405.
Halfon, Neal, Kandyce Larson, Michael Lu, Ericka Tullis, and Shirley Russ. 2014. “Lifecourse Health Development: Past, Present and Future.” *Maternal and Child Health Journal* 18 (2): 344–65.
Hatløy, A., L. E. Torheim, and A. Oshaug. 1998. “Food Variety—a Good Indicator of Nutritional Adequacy of the Diet? A Case Study from an Urban Area in Mali, West Africa.” *European Journal of Clinical Nutrition* 52 (12): 891–98. https://doi.org/10.1038/sj.ejcn.1600662.
Hawkes, Corinna, and Marie T Ruel. 2008. “From Agriculture to Nutrition: Pathways, Synergies and Outcomes.”
Hawkes, Corinna, Marie T Ruel, Leah Salm, Bryony Sinclair, and Francesco Branca. 2020. “Double-Duty Actions: Seizing Programme and Policy Opportunities to Address Malnutrition in All Its Forms.” *The Lancet* 395 (10218): 142–55.
Heifer. 2014. “La Agroecología Está Presente. Mapeo de Productores Agroecológicos y Del Estado de La Agroecología En La Sierra y Costa Ecuatoriana.” Quito, Ecuador: Fundación Heifer Ecuador, MAGAP.
Herforth, Anna, and Jody Harris. 2014. “Understanding and Applying Primary Pathways and Principles Brief#1.” Improving Nutrition through Agriculture Brief Series. Arlington, VA: USAID/Strengthening Partnerships, Results and Innovations in Nutrition Globally (SPRING) Project.
Herforth, Anna, Timothy Johns, Hilary M Creed-Kanashiro, Andrew D Jones, Colin K Khoury, Timothy Lang, Patrick Maundu, Bronwen Powell, and Victoria Reyes-García. 2019. “Agrobiodiversity and Feeding the World: More of the Same Will Result in More of the Same.” In *Agrobiodiversity: Integrating Knowledge for a Sustainable Future*, edited by Karl S. Zimmerer and Stef De Haan, 185–211. Strüngmann Forum Reports Book 24. The MIT Press.
Hernandez-Diaz, S, KE Peterson, S Dixit, B Hernandez, S Parra, S Barquera, J Sepulveda, and JA Rivera. 1999. “Association of Maternal Short Stature with Stunting in Mexican Children: Common Genes vs Common Environment.” *European Journal of Clinical Nutrition* 53 (12): 938–45.
Hidrobo, Melissa, John Hoddinott, Amber Peterman, Amy Margolies, and Vanessa Moreira. 2014. “Cash, Food, or Vouchers? Evidence from a Randomized Experiment in Northern Ecuador.” *Journal of Development Economics* 107: 144–56.
Hirvonen, Kalle, and John Hoddinott. 2017. “Agricultural Production and Children’s Diets: Evidence from Rural Ethiopia.” *Agricultural Economics* 48 (4): 469–80.
HLPE. 2017. “Nutrition and Food Systems. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security.” Rome: FAO. http://www.fao.org/3/a-i7846e.pdf.
———. 2019. “Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition.” Rome: High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security.

http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-14_EN.pdf.
Hsieh, Hsiu-Fang, and Sarah E Shannon. 2005. “Three Approaches to Qualitative Content Analysis.” *Qualitative Health Research* 15 (9): 1277–88.
Hudda, Mohammed T, Claire M Nightingale, Angela S Donin, Mary S Fewtrell, Dalia Haroun, Sooky Lum, Jane E Williams, Christopher G Owen, Alicja R Rudnicka, and Jonathan CK Wells. 2017. “Body Mass Index Adjustments to Increase the Validity of Body Fatness Assessment in UK Black African and South Asian Children.” *International Journal of Obesity* 41 (7): 1048–55.
INEC. 2006. “La Población Indígena Del Ecuador.” Quito, Ecuador: Instituto Nacional de Estadística y Censos. http://www.acnur.org/fileadmin/Documentos/Publicaciones/2009/7015.pdf.
———. 2010. “Fascículo Provincial Imbabura. Resultados Del Censo 2010.” Quito, Ecuador: Instituto Nacional de Estadística y Censos. http://www.ecuadorencifras.gob.ec/censo-de-poblacion-y-vivienda/.
———. 2014. “Anuario de Estadísticas Vitales, Nacimientos y Defunciones 2014.” Ecuador: Instituto Nacional de Estadística y Censos. https://www.ecuadorencifras.gob.ec/documentos/web-inec/Poblacion_y_Demografia/Nacimientos_Defunciones/Publicaciones/Anuario_Nacimientos_y_Defunciones_2014.pdf.
———. 2016. “Reporte de Pobreza Por Consumo Ecuador 2006-2014.” Quito, Ecuador: Instituto Nacional de Estadística y Censos.
Jacobsen, Kathryn H, Priscila S Ribeiro, Bradley K Quist, and Bruce V Rydbeck. 2007. “Prevalence of Intestinal Parasites in Young Quichua Children in the Highlands of Rural Ecuador.” *Journal of Health, Population, and Nutrition* 25 (4): 399.
Jahns, Lisa, Lenore Arab, Alicia Carriquiry, and Barry M Popkin. 2005. “The Use of External Within-Person Variance Estimates to Adjust Nutrient Intake Distributions over Time and across Populations.” *Public Health Nutrition* 8 (1): 69–76. https://doi.org/10.1079/PHN2004671.
Jansen, Margje CJF, H Bas Bueno-de-Mesquita, Edith JM Feskens, Martinette T Streppel, Frans J Kok, and Daan Kromhout. 2004. “Quantity and Variety of Fruit and Vegetable Consumption and Cancer Risk.” *Nutrition and Cancer* 48 (2): 142–48.
Jayawardena, Ranil. 2016. “Comparison Dietary Assessment Methods in Sri Lankan Adults: Use of 24-Hour Dietary Recall and 7-Day Weighed Intake.” *BMC Nutrition* 2 (1): 1–4.
Johns, Timothy, Bronwen Powell, Patrick Maundu, and Pablo B Eyzaguirre. 2013. “Agricultural Biodiversity as a Link between Traditional Food Systems and Contemporary Development, Social Integrity and Ecological Health: Traditional Food Systems, Agricultural Biodiversity and Sustainable Development.” *Journal of the Science of Food and Agriculture* 93 (14): 3433–42. https://doi.org/10.1002/jsfa.6351.
Johns, Timothy, and Bhuwon R Sthapit. 2004. “Biocultural Diversity in the Sustainability of Developing-Country Food Systems.” *Food and Nutrition Bulletin* 25 (2): 143–55.
Jones, Andrew D. 2017. “Critical Review of the Emerging Research Evidence on Agricultural Biodiversity, Diet Diversity, and Nutritional Status in Low- and Middle-Income Countries.” *Nutrition Reviews* 75 (10): 769–82. https://doi.org/10.1093/nutrit/nux040.
Jones, Andrew D., Aditya Shrinivas, and Rachel Bezner-Kerr. 2014. “Farm Production Diversity Is Associated with Greater Household Dietary Diversity in Malawi: Findings from Nationally Representative Data.” *Food Policy* 46 (June): 1–12. https://doi.org/10.1016/j.foodpol.2014.02.001.
Kadiyala, Suneetha, Jody Harris, Derek Headey, Sivan Yosef, and Stuart Gillespie. 2014. “Agriculture and Nutrition in India: Mapping Evidence to Pathways.” *Ann NY Acad Sci* 1331 (1): 43–56.

Kahma, Nina, Johanna Mäkelä, Mari Niva, and Thomas Bøker Lund. 2014. "Associations between Meal Complexity and Social Context in Four Nordic Countries." *Anthropology of Food*, no. S10 (November). https://doi.org/10.4000/aof.7666.

Kahneman, Daniel. 2003. "Maps of Bounded Rationality: Psychology for Behavioral Economics." *American Economic Review* 93 (5): 1449–75.

Kansanga, MM, I Luginaah, R Bezner Kerr, E Lupafya, and L Dakishoni. 2020. "Beyond Ecological Synergies: Examining the Impact of Participatory Agroecology on Social Capital in Smallholder Farming Communities." *International Journal of Sustainable Development & World Ecology* 27 (1): 1–14.

Karnes, Daniel A. 2008. "To grow or to buy : food staples and cultural identity in the Southern Ecuadorian Andes." Oregon State University.

Katona, Peter, and Judit Katona-Apte. 2008. "The Interaction between Nutrition and Infection." *Clinical Infectious Diseases* 46 (10): 1582–88.

Kegel, Hannah. 2003. "The Significance of Subsistence Farming in Georgia as an Economic and Social Buffer." *Subsistence Agriculture in Central and Eastern Europe: How to Break the Vicious Circle*, 147–60.

Keller, Gudrun B., Hassan Mndiga, and Brigitte L. Maass. 2005. "Diversity and Genetic Erosion of Traditional Vegetables in Tanzania from the Farmer's Point of View." *Plant Genetic Resources* 3 (3): 400–413. https://doi.org/10.1079/PGR200594.

Kelly, Bridget, and Enrique Jacoby. 2018. "Public Health Nutrition Special Issue on Ultra-Processed Foods." *Public Health Nutrition* 21 (1): 1–4.

Kenny, Tiff-Annie M. 2017. "Ecological, Environmental, and Economic Dimensions of the Nutrition Transition." Doctoral dissertation, University of Ottawa.

King, Steven R., and Stanley N. Gershoff. 1987. "Nutritional Evaluation of Three Underexploited Andean Tubers:Oxalis Tuberosa (Oxalidaceae),Ullucus Tuberosus (Basellaceae), AndTropaeolum Tuberosum (Tropaeolaceae)." *Economic Botany* 41 (4): 503–11. https://doi.org/10.1007/BF02908144.

Knibbs, Kristin, Jane Underwood, Mary MacDonald, Bonnie Schoenfeld, Melanie Lavoie-Tremblay, Mary Crea-Arsenio, Donna Meagher-Stewart, Lynnette Leeseberg Stamler, Jennifer Blythe, and Anne Ehrlich. 2012. "Appreciative Inquiry: A Strength-Based Research Approach to Building Canadian Public Health Nursing Capacity." *Journal of Research in Nursing* 17 (5): 484–94.

Kobayashi, Minatsu, Shizuka Sasazuki, Taichi Shimazu, Norie Sawada, Taiki Yamaji, Motoki Iwasaki, Tetsuya Mizoue, and Shoichiro Tsugane. 2020. "Association of Dietary Diversity with Total Mortality and Major Causes of Mortality in the Japanese Population: JPHC Study." *European Journal of Clinical Nutrition* 74 (1): 54–66.

Korpe, Poonum S, and William A Petri Jr. 2012. "Environmental Enteropathy: Critical Implications of a Poorly Understood Condition." *Trends in Molecular Medicine* 18 (6): 328–36.

Krebs-Smith, Susan M., TusaRebecca E. Pannucci, Amy F. Subar, Sharon I. Kirkpatrick, Jennifer L. Lerman, Janet A. Tooze, Magdalena M. Wilson, and Jill Reedy. 2018. "Update of the Healthy Eating Index: HEI-2015." *Journal of the Academy of Nutrition and Dietetics* 118 (9): 1591–1602. https://doi.org/10.1016/j.jand.2018.05.021.

Kristal, Alan R., Ulrike Peters, and John D. Potter. 2005. "Is It Time to Abandon the Food Frequency Questionnaire?" *Cancer Epidemiology Biomarkers & Prevention* 14 (12): 2826–28. https://doi.org/10.1158/1055-9965.epi-12-ed1.

Kuhnlein, Harriet V., Bill Erasmus, Dina Spigelski, and FAO, eds. 2009. *Indigenous Peoples' Food Systems: The Many Dimensions of Culture, Diversity and Environment for Nutrition and Health*.

Reprinted. Rome: Food and Agriculture Organization of the United Nations.
Kumar, Neha, Samuel Scott, Purnima Menon, Samyuktha Kannan, Kenda Cunningham, Parul Tyagi, Gargi Wable, Kalyani Raghunathan, and Agnes Quisumbing. 2018. “Pathways from Women’s Group-Based Programs to Nutrition Change in South Asia: A Conceptual Framework and Literature Review.” *Global Food Security* 17: 172–85.
Lachat, Carl, Jessica E. Raneri, Katherine Walker Smith, Patrick Kolsteren, Patrick Van Damme, Kaat Verzelen, Daniela Penafiel, et al. 2018. “Dietary Species Richness as a Measure of Food Biodiversity and Nutritional Quality of Diets.” *Proceedings of the National Academy of Sciences* 115 (1): 127–32. https://doi.org/10.1073/pnas.1709194115.
Larrea, Carlos, and Ichiro Kawachi. 2005. “Does Economic Inequality Affect Child Malnutrition? The Case of Ecuador.” *Social Science & Medicine* 60 (1): 165–78.
Lee, Duk-Hee, Michael W Steffes, Andreas Sjödin, Richard S Jones, Larry L Needham, and David R Jacobs Jr. 2011. “Low Dose Organochlorine Pesticides and Polychlorinated Biphenyls Predict Obesity, Dyslipidemia, and Insulin Resistance among People Free of Diabetes.” *PloS One* 6 (1): e15977.
Lee, Jounghee, Robert F Houser, Aviva Must, Patricia Palma de Fulladolsa, and Odilia I Bermudez. 2010. “Disentangling Nutritional Factors and Household Characteristics Related to Child Stunting and Maternal Overweight in Guatemala.” *Economics & Human Biology* 8 (2): 188–96.
Lee, Min-June, Barry M Popkin, and Soowon Kim. 2002. “The Unique Aspects of the Nutrition Transition in South Korea: The Retention of Healthful Elements in Their Traditional Diet.” *Public Health Nutrition* 5 (1a): 197–203. https://doi.org/10.1079/PHN2001294.
Leonard, W. R., T. L. Leatherman, J. W. Carey, and R. B. Thomas. 1990. “Contributions of Nutrition versus Hypoxia to Growth in Rural Andean Populations.” *American Journal of Human Biology* 2 (6): 613–26. https://doi.org/10.1002/ajhb.1310020605.
Leporati, Michel, Salomón Salcedo, Byron Jara, Verónica Boero, and Mariana Muñoz. 2014. “La Agricultura Familiar En Cifras.” In *Agricultura Familiar En América Latina y El Caribe: Recomendaciones de Política*, edited by Salomón Salcedo and Lya Guzmán, 35–56. Santiago de Chile: FAO. http://www.fao.org/3/i3788s/i3788s.pdf.
Macas, Benjamin, and Koldo Echarry. 2009. “Caracterización de Mercados Locales Agroecológicos y Sistemas Participativos de Garantía Que Se Construyen En El Ecuador.” *Quito: Coordinadora Ecuatoriana de Agroecología*.
Macaulay, Ann C, Laura E Commanda, William L Freeman, Nancy Gibson, Melvina L McCabe, Carolyn M Robbins, and Peter L Twohig. 1999. “Participatory Research Maximises Community and Lay Involvement.” *Bmj* 319 (7212): 774–78.
Madden, J Patrick, S Jane Goodman, and Helen A Guthrie. 1976. “Validity of the 24-Hr. Recall. Analysis of Data Obtained from Elderly Subjects.” *Journal of the American Dietetic Association* 68 (2): 143–47.
Madison, D Soyini. 2005. “Introduction to Critical Ethnography: Theory and Method.” *Critical Ethnography: Method, Ethics & Performance*, 1–16.
Mann, Charles C. 2005. *1491: New Revelations of the Americas before Columbus*. Alfred a Knopf Incorporated.
Marouf, Maysan, Malek Batal, Sara Moledor, and Salma N Talhouk. 2015. “Exploring the Practice of Traditional Wild Plant Collection in Lebanon.” *Food, Culture & Society* 18 (3): 355–78.
Martin-Prével, Yves, Pauline Allemand, Doris Wiesmann, Mary Arimond, Terri Ballard, Megan Deitchler, Marie-Claude Dop, Gina Kennedy, Warren TK Lee, and Mourad Moursi. 2015. “Moving Forward on Choosing a Standard Operational Indicator of Women’s Dietary Diversity.”
Mataira, Peter J. 2019. “Transforming Indigenous Research: Collaborative Responses to Historical

Research Tensions." *International Review of Education* 65 (1): 143–61.
McCormack, Lacey Arneson, Melissa Nelson Laska, Nicole I Larson, and Mary Story. 2010. "Review of the Nutritional Implications of Farmers' Markets and Community Gardens: A Call for Evaluation and Research Efforts." *Journal of the American Dietetic Association* 110 (3): 399–408.
McCrory, Megan A, Paul J Fuss, Joy E McCallum, Manjiang Yao, Angela G Vinken, Nicholas P Hays, and Susan B Roberts. 1999. "Dietary Variety within Food Groups: Association with Energy Intake and Body Fatness in Men and Women." *The American Journal of Clinical Nutrition* 69 (3): 440–47.
McKay, Ben. 2012. "A Socially Inclusive Pathway to Food Security: The Agroecological Alternative." International Policy Centre for Inclusive Growth.
McMichael, Philip. 2009. "Banking on Agriculture: A Review of the World Development Report 2008." *Journal of Agrarian Change* 9 (2): 235–46.
Medina-Lezama, J., C. A. Pastorius, H. Zea-Diaz, A. Bernabe-Ortiz, F. Corrales-Medina, O. L. Morey-Vargas, D. A. Chirinos, et al. 2010. "Optimal Definitions for Abdominal Obesity and the Metabolic Syndrome in Andean Hispanics: The PREVENCION Study." *Diabetes Care* 33 (6): 1385–88. https://doi.org/10.2337/dc09-2353.
Melby, Christopher L, Fadya Orozco, Jenni Averett, Fabián Muñoz, Maria José Romero, and Amparito Barahona. 2020. "Agricultural Food Production Diversity and Dietary Diversity among Female Small Holder Farmers in a Region of the Ecuadorian Andes Experiencing Nutrition Transition." *Nutrients* 12 (8): 2454.
Mialon, Melissa, Neha Khandpur, Mais Amaral Laís, and Ana Paula Bortoletto Martins. 2020. "Arguments Used by Trade Associations during the Early Development of a New Front-of-Pack Nutrition Labelling System in Brazil."
Monteiro, Carlos A., Geoffrey Cannon, Mark Lawrence, ML da Costa Louzada, and P Pereira Machado. 2019. "Ultra-Processed Foods, Diet Quality, and Health Using the NOVA Classification System." *Rome, FAO*.
Monteiro, Carlos A., Geoffrey Cannon, Jean-Claude Moubarac, Renata Bertazzi Levy, Maria Laura C Louzada, and Patrícia Constante Jaime. 2018. "The UN Decade of Nutrition, the NOVA Food Classification and the Trouble with Ultra-Processing." *Public Health Nutrition* 21 (1): 5–17.
Morris, E Kathryn, Tancredi Caruso, François Buscot, Markus Fischer, Christine Hancock, Tanja S Maier, Torsten Meiners, Caroline Müller, Elisabeth Obermaier, and Daniel Prati. 2014. "Choosing and Using Diversity Indices: Insights for Ecological Applications from the German Biodiversity Exploratories." *Ecology and Evolution* 4 (18): 3514–24.
Mottet, Anne, Abram Bicksler, Dario Lucantoni, Fabrizia De Rosa, Beate Scherf, Eric Scopel, Santiago Lopez-Ridaura, Barbara Gemmil-Herren, Rachel Bezner Kerr, and Jean-Michel Sourisseau. 2020. "Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE)." *Frontiers in Sustainable Food Systems* 4: 252.
Moubarac, Jean-Claude, Diana C. Parra, Geoffrey Cannon, and Carlos A. Monteiro. 2014. "Food Classification Systems Based on Food Processing: Significance and Implications for Policies and Actions: A Systematic Literature Review and Assessment." *Current Obesity Reports* 3 (2): 256–72. https://doi.org/10.1007/s13679-014-0092-0.
MSP and FAO. 2020. "Documento Técnico de Las Guías Alimentarias Basadas En Alimentos (GABA) Del Ecuador." Quito, Ecuador: Ministerio de Salud Pública del Ecuador y la Organización de las Naciones Unidas para la Alimentación y la Agricultura. https://doi.org/10.4060/ca9928es.
Murimi, Mary W, Michael Kanyi, Tatenda Mupfudze, Md Ruhul Amin, Teresia Mbogori, and Khalid Aldubayan. 2017. "Factors Influencing Efficacy of Nutrition Education Interventions: A Systematic Review." *Journal of Nutrition Education and Behavior* 49 (2): 142-165. E1.

Muthoni, Jane, and DO Nyamongo. 2010. “Traditional Food Crops and Their Role in Food and Nutritional Security in Kenya.” Journal of Agricultural & Food Information 11 (1): 36–50.
Nadar, Danya, and Ana Deaconu. 2021. “Conversaciones Sin Fronteras: ¿Qué Podemos Aprender de Alimentos Tradicionales En Redes Alternativas de Palestina y Ecuador?” In *Distribución, Comercialización y Acceso a Alimentos de Calidad En América Latina*, edited by Sebastián Grenoville, Julie Le Gall, and Julien Noel, 22–42. Buenos Aires, Argentina: INTA Ediciones.
Natividad, Patricia, María Cristina Omonte Ferrufino, María Mayer de Scurrah, and Stephen Sherwood. 2021. “Enabling More Regenerative Agriculture, Food, and Nutrition in the Andes: The Relational Bio-Power of ‘Seeds.’” In *Routledge Handbook of Sustainable and Regenerative Food Systems*, edited by Jessica Duncan, Michael Carolan, and Johannes S.C. Wiskerke, 304. London and New York: Earthscan from Routledge.
Nyéléni. 2015. “Declaration of the International Forum for Agroecology.” Nyéléni, Mali. http://www.foodsovereignty.org/forum-agroecology-nyeleni-2015/.
Orozco, Fadya, Donald C Cole, Verónica Muñoz, Ana Altamirano, Susitha Wanigaratne, Patricio Espinosa, and Fabian Muñoz. 2007. “Relationships among Production Systems, Preschool Nutritional Status, and Pesticide-Related Toxicity in Seven Ecuadorian Communities: A Multi-Case Study Approach.” *Food and Nutrition Bulletin* 28 (2_suppl2): S247–57.
Oyarzun, Pedro J, Ross Mary Borja, Stephen Sherwood, and Vicente Parra. 2013. “Making Sense of Agrobiodiversity, Diet, and Intensification of Smallholder Family Farming in the Highland Andes of Ecuador.” *Ecology of Food and Nutrition* 52 (6): 515–41.
Padulosi, S., T. Hodgkin, J.T. Williams, and N. Haq. 2002. “Underutilised Crops: Trends, Challenges and Opportunities in the 21st Century.” In Managing Plant Genetic Diversity, edited by J. Engels, V.R. Rao, and M. Jackson, 323–38. CAB International. https://eprints.soton.ac.uk/53786/.
Padulosi, S, J Thompson, and P Rudebjer. 2013. “Fighting Poverty, Hunger and Malnutrition with Neglected and Underutilized Species (NUS): Needs, Challenges and the Way Forward.” Rome: Bioversity International. https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Fighting_poverty__hunger_and_malnutrition_with_neglected_and_underutilized_species__NUS__1671.pdf.
PAHO. 2015. “Ultra-Processed Food and Drink Products in Latin America: Trends, Impact on Obesity, Policy Implications.” Washington, DC: Pan American Health Organization.
Pellegrini, Lorenzo, and Luca Tasciotti. 2014. “Crop Diversification, Dietary Diversity and Agricultural Income: Empirical Evidence from Eight Developing Countries.” Canadian Journal of Development Studies/Revue Canadienne d’études Du Développement 35 (2): 211–27.
Peñafiel, Daniela, Celine Termote, Carl Lachat, Ramon Espinel, Patrick Kolsteren, and Patrick Van Damme. 2016. “Barriers to Eating Traditional Foods Vary by Age Group in Ecuador With Biodiversity Loss as a Key Issue.” *Journal of Nutrition Education and Behavior* 48 (4): 258-268.e1. https://doi.org/10.1016/j.jneb.2015.12.003.
Penafiel, Dolores, Holger Cevallos-Valdiviezo, Ramón Espinel, and Patrick Van Damme. 2019. “Local Traditional Foods Contribute to Diversity and Species Richness of Rural Women’s Diet in Ecuador.” *Public Health Nutrition* 22 (16): 2962–71.
Pera, Megan F, Beth NH Katz, and Margaret E Bentley. 2019. “Dietary Diversity, Food Security, and Body Image among Women and Children on San Cristobal Island, Galapagos.” *Maternal and Child Health Journal* 23 (6): 830–38.
Peralta, I. 2016. *El Chocho En Ecuador “Estado Del Arte.”* Quito, Ecuador: INIAP, PRONALEG. https://repositorio.iniap.gob.ec/handle/41000/3938.
Perry, Elsie Azevedo, Heather Thomas, H Ruby Samra, Shannon Edmonstone, Lyndsay Davidson, Amy

Faulkner, Lisa Petermann, Elizabeth Manafò, and Sharon I Kirkpatrick. 2017. "Identifying Attributes of Food Literacy: A Scoping Review." *Public Health Nutrition* 20 (13): 2406–15.

Peterman, Amber, Benjamin Schwab, Shalini Roy, Melissa Hidrobo, and Daniel O Gilligan. 2015. "Measuring Women's Decisionmaking: Indicator Choice and Survey Design Experiments from Cash and Food Transfer Evaluations in Ecuador, Uganda, and Yemen."

Pomeroy, Cheryl. 1988. "The Salt of Highland Ecuador: Precious Product of a Female Domain." *Ethnohistory* 35 (2): 131–60. https://doi.org/10.2307/482700.

Popkin, Barry M. 1993. "Nutritional Patterns and Transitions." *Population and Development Review* 19 (1): 138. https://doi.org/10.2307/2938388.

———. 2014. "Nutrition, Agriculture and the Global Food System in Low and Middle Income Countries." *Food Policy* 47 (August): 91–96. https://doi.org/10.1016/j.foodpol.2014.05.001.

Popkin, Barry M. 2015. "Nutrition Transition and the Global Diabetes Epidemic." *Current Diabetes Reports* 15 (9): 64.

———. 2021. "To Assist the Large Number of Countries Facing the Double Burden of Malnutrition We Must Understand Its Causes and Recognize the Need for Policies That Do No Harm." *The American Journal of Clinical Nutrition*.

Popkin, Barry M, Linda S Adair, and Shu Wen Ng. 2012. "Global Nutrition Transition and the Pandemic of Obesity in Developing Countries." *Nutrition Reviews* 70 (1): 3–21. https://doi.org/10.1111/j.1753-4887.2011.00456.x.

Poslusna, Kamila, Jiri Ruprich, Jeanne HM de Vries, Marie Jakubikova, and Pieter van't Veer. 2009. "Misreporting of Energy and Micronutrient Intake Estimated by Food Records and 24 Hour Recalls, Control and Adjustment Methods in Practice." *British Journal of Nutrition* 101 (S2): S73–85.

Powell, Bronwen, Shakuntala Haraksingh Thilsted, Amy Ickowitz, Celine Termote, Terry Sunderland, and Anna Herforth. 2015. "Improving Diets with Wild and Cultivated Biodiversity from across the Landscape." *Food Security* 7 (3): 535–54.

Prefectura de Imbabura. 2017. "PLAN PROVINCIAL DE RIEGO Y DRENAJE DE IMBABURA 2017-2037.Pdf." Gobierno Autónomo Descentralizado de Imbabura. https://www.imbabura.gob.ec/phocadownload/K-Planes-programas/PLAN%20PROVINCIAL%20DE%20RIEGO%20Y%20DRENAJE%20DE%20IMBABURA%202017-2037.pdf.

Pretty, Jules. 2003. "Social Capital and the Collective Management of Resources." *Science* 302 (5652): 1912–14.

Pretty, Jules, A. D. Noble, D. Bossio, J. Dixon, R. E. Hine, F. W. T. Penning de Vries, and J. I. L. Morison. 2006. "Resource-Conserving Agriculture Increases Yields in Developing Countries." *Environmental Science & Technology* 40 (4): 1114–19. https://doi.org/10.1021/es051670d.

Ramírez-Luzuriaga, María J, Philippe Belmont, William F Waters, and Wilma B Freire. 2020. "Malnutrition Inequalities in Ecuador: Differences by Wealth, Education Level and Ethnicity." *Public Health Nutrition* 23 (S1): s59–67.

Ramírez-Luzuriaga, María J., MK Silva-Jaramillo, Philippe Belmont, and Wilma Freire. 2014. "Tabla de Composición de Alimentos Del Ecuador: Compilación Del Equipo Técnico de La ENSANUT-ECU 2012." Quito, Ecuador: Ministerio de Salud Pública del Ecuador.

Ramirez-Zea, Manuel, Maria F Kroker-Lobos, Regina Close-Fernandez, and Rebecca Kanter. 2014. "The Double Burden of Malnutrition in Indigenous and Nonindigenous Guatemalan Populations." *The American Journal of Clinical Nutrition* 100 (6): 1644S-1651S. https://doi.org/10.3945/ajcn.114.083857.

Rebaï, Nasser, and Julio A Alvarado Vélez. 2018. "Trajectories of Vulnerability of Rural Territories in the Ecuadorian Andes: A Comparative Analysis." *Journal of Alpine Research| Revue de Géographie Alpine*, no. 106–3.
Receveur, O., M. Boulay, and H. V. Kuhnlein. 1997. "Decreasing Traditional Food Use Affects Diet Quality for Adult Dene/Métis in 16 Communities of the Canadian Northwest Territories." *The Journal of Nutrition* 127 (11): 2179–86. https://doi.org/10.1093/jn/127.11.2179.
Robelly Espinoza, Alegria. 2019. "Barter, Old Fashioned or a Modern Alternative?" MSc Thesis, Wageningen University. https://edepot.wur.nl/509772.
Rosenbaum, Paula F, Ruth S Weinstock, Allen E Silverstone, Andreas Sjödin, and Marian Pavuk. 2017. "Metabolic Syndrome Is Associated with Exposure to Organochlorine Pesticides in Anniston, AL, United States." *Environment International* 108: 11–21.
Ruel, Marie T. 2003. "Operationalizing Dietary Diversity: A Review of Measurement Issues and Research Priorities." *The Journal of Nutrition* 133 (11): 3911S-3926S. https://doi.org/10.1093/jn/133.11.3911S.
Ruel, Marie T. 2015. "From the WDDS to the MDD-W: Get to Know the New Indicator for Measuring Women's Dietary Diversity Http://A4nh.Cgiar.Org/2015/09/22/Get-to-Know-the-New-Indicator-for-Measuring-Womens-Dietary-Diversity/." September 22, 2015. http://a4nh.cgiar.org/2015/09/22/get-to-know-the-new-indicator-for-measuring-womens-dietary-diversity/.
Ruel, Marie T, Harold Alderman, and Maternal and Child Nutrition Study Group. 2013. "Nutrition-Sensitive Interventions and Programmes: How Can They Help to Accelerate Progress in Improving Maternal and Child Nutrition?" *The Lancet* 382 (9891): 536–51.
Saaka, Mahama. 2013. "Maternal Dietary Diversity and Infant Outcome of Pregnant Women in Northern Ghana." *International Journal of Child Health and Nutrition* 1 (2): 148–56.
Saibul, Nurfaizah, Zalilah Mohd Shariff, Khor Geok Lin, Mirnalini Kandiah, Abdul Ghani Nawalyah, and Abdul Rahman Hejar. 2009. "Food Variety Score Is Associated with Dual Burden of Malnutrition in'Orang Asli'(Malaysian Indigenous Peoples) Households: Implications for Health Promotion." *Asia Pacific Journal of Clinical Nutrition* 18 (3): 412.
Salomon, Frank. 1980. *Los Señores Étnicos de Quito En La Época de Los Incas*. Vol. 10. Instituto otavaleño de antropología Otavalo.
Seufert, Verena, and Navin Ramankutty. 2017. "Many Shades of Gray—The Context-Dependent Performance of Organic Agriculture." *Science Advances* 3 (3): e1602638. https://doi.org/10.1126/sciadv.1602638.
Sherwood, Stephen. 2009. "Learning from Carchi: Agricultural Modernisation and the Production of Decline." S.l.: s.n.]. https://library.wur.nl/WebQuery/wurpubs/fulltext/7207.
———. 2019. "Strengthening Impact of the Healthy Food Consumption Campaign: 250,000 Families in Ecuador. Final Technical Report: January 2016-June 2019." Fundación EkoRural. https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/59373/IDL-59373.pdf.
Sherwood, Stephen, Alberto Arce, Peter R. Berti, Ross Borja, Pedro Oyarzun, and Ellen Bekkering. 2013. "Tackling the New Materialities: Modern Food and Counter-Movements in Ecuador." *Food Policy* 41 (August): 1–10. https://doi.org/10.1016/j.foodpol.2013.03.002.
Sherwood, Stephen, Alberto Arce, and Myriam Paredes. 2018. "Affective Labor's 'Unruly Edge': The Pagus of Carcelen's Solidarity & Agroecology Fair in Ecuador." *Journal of Rural Studies* 61 (July): 302–13. https://doi.org/10.1016/j.jrurstud.2018.02.001.
Sherwood, Stephen, Ana Deaconu, and Myriam Paredes. 2017. "250 Thousand Families Campaign: The Existence of Flavor and Taste." In *Food, Agriculture and Social Change*, edited by Stephen

Sherwood, Alberto Arce, and Myriam Paredes, 1st ed., 198–210. Routledge. https://doi.org/10.4324/9781315440088-15.
Sherwood, Stephen, Cees Leeuwis, and Todd Crane. 2012. “Development 3.0: Development Practice in Transition.” *Farming Matters* 28 (4): 40–41.
Sherwood, Stephen, and Myriam Paredes. 2014. “Dynamics of Perpetuation: The Politics of Keeping Highly Toxic Pesticides on the Market in Ecuador.” *Nature and Culture* 9 (1): 21–44. https://doi.org/10.3167/nc.2014.090102.
Sherwood, Stephen, Severine Van Bommel, and Myriam Paredes. 2016. “Self-Organization and the Bypass: Re-Imagining Institutions for More Sustainable Development in Agriculture and Food.” *Agriculture* 6 (4): 66.
Sibhatu, Kibrom T. 2019. “Farm-Level Agricultural Biodiversity Is Not the Principal Contributor to Diverse and Micronutrient-Rich Diets, nor to Overall Food Consumption in Smallholder Farm Households.” *The Journal of Nutrition* 149 (8): 1482–83.
Sibhatu, Kibrom T., Vijesh V. Krishna, and Matin Qaim. 2015. “Production Diversity and Dietary Diversity in Smallholder Farm Households.” *Proceedings of the National Academy of Sciences* 112 (34): 10657–62. https://doi.org/10.1073/pnas.1510982112.
Sibhatu, Kibrom T, and Matin Qaim. 2018a. “Meta-Analysis of the Association between Production Diversity, Diets, and Nutrition in Smallholder Farm Households.” *Food Policy*.
Sibhatu, Kibrom T., and Matin Qaim. 2018b. “Farm Production Diversity and Dietary Quality: Linkages and Measurement Issues.” *Food Security* 10 (1): 47–59. https://doi.org/10.1007/s12571-017-0762-3.
Silventoinen, Karri. 2003. “Determinants of Variation in Adult Body Height.” *Journal of Biosocial Science* 35 (2): 263–85.
Singh, Ranjay K, Anamika Singh, and Amish K Sureja. 2007. “Traditional Foods of Monpa Tribe of West Kameng, Arunachal Pradesh” 6 (1): 12.
Smale, Melinda, Mauricio R. Bellon, Devra Jarvis, and Bhuwon Sthapit. 2004. “Economic Concepts for Designing Policies to Conserve Crop Genetic Resources on Farms.” *Genetic Resources and Crop Evolution* 51 (2): 121–35. https://doi.org/10.1023/B:GRES.0000020678.82581.76.
Smith, Kirsten P., and Nicholas A. Christakis. 2008. “Social Networks and Health.” *Annual Review of Sociology* 34 (1): 405–29. https://doi.org/10.1146/annurev.soc.34.040507.134601.
Soto, Michelle. 2014. “PRÁCTICAS ALIMENTARIAS: GÉNERO Y GLOBALIZACIÓN EN CUATRO COMUNIDADES DE SAQUISILÍ.” FLACSO-Ecuador. https://repositorio.flacsoandes.edu.ec/xmlui/handle/10469/8676.
Souverein, OW, AL Dekkers, A Geelen, J Haubrock, JH De Vries, MC Ocké, U Harttig, H Boeing, and P Van’T Veer. 2011. “Comparing Four Methods to Estimate Usual Intake Distributions.” *European Journal of Clinical Nutrition* 65 (1): S92–101.
Stein, Aryeh D., Angela M. Thompson, and Ashley Waters. 2005. “Childhood Growth and Chronic Disease: Evidence from Countries Undergoing the Nutrition Transition.” *Maternal and Child Nutrition* 1 (3): 177–84. https://doi.org/10.1111/j.1740-8709.2005.00021.x.
Steyn, Neila P, Johanna Helena Nel, Guy Nantel, Gina Kennedy, and Demetre Labadarios. 2006. “Food Variety and Dietary Diversity Scores in Children: Are They Good Indicators of Dietary Adequacy?” *Public Health Nutrition* 9 (5): 644–50.
Stigter, CJ, Zheng Dawei, LOZ Onyewotu, and Mei Xurong. 2005. “Using Traditional Methods and Indigenous Technologies for Coping with Climate Variability.” In *Increasing Climate Variability and Change*, 255–71. Springer.
Swinburn, Boyd A, Vivica I Kraak, Steven Allender, Vincent J Atkins, Phillip I Baker, Jessica R Bogard,

Hannah Brinsden, Alejandro Calvillo, Olivier De Schutter, and Raji Devarajan. 2019. “The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission Report.” *The Lancet* 393 (10173): 791–846.

Tao, Liyuan, Zheng Xie, and Tao Huang. 2020. “Dietary Diversity and All-Cause Mortality among Chinese Adults Aged 65 or Older: A Community-Based Cohort Study.” *Asia Pacific Journal of Clinical Nutrition* 29 (1): 152.

Tapia-Armijos, María Fernanda, Jürgen Homeier, Carlos Iván Espinosa, Christoph Leuschner, and Marcelino de la Cruz. 2015. “Deforestation and Forest Fragmentation in South Ecuador since the 1970s–Losing a Hotspot of Biodiversity.” *PloS One* 10 (9): e0133701.

Timmermann, Cristian, and Georges F Félix. 2015. “Agroecology as a Vehicle for Contributive Justice.” *Agriculture and Human Values* 32 (3): 523–38.

Tittonell, Pablo. 2014. “Food Security and Ecosystem Services in a Changing World: It Is Time for Agroecology.”

Toledo, Álvaro, and Barbara Burlingame. 2006. “Biodiversity and Nutrition: A Common Path toward Global Food Security and Sustainable Development.” *Journal of Food Composition and Analysis* 19 (6–7): 477–83. https://doi.org/10.1016/j.jfca.2006.05.001.

Torres Guevara, Juan, and Fabiola Parra Rondinel. 2005. “De Los Sachas, Las Chacras y La Vida Silvestre En Los Andes Del Perú.” *LEISA Revista de Agroecología* 20 (4): 24–26.

Torres, Nataly, Mónica Vera, Francisco Gachet, and Laura Boada. 2016. “Balance de La Situación Alimentaria y Nutricional En Ecuador - Informe 2015.” FIAN Ecuador.

Trijsburg, Laura, Elise F. Talsma, Jeanne HM De Vries, Gina Kennedy, Anneleen Kuijsten, and Inge D. Brouwer. 2019. “Diet Quality Indices for Research in Low-and Middle-Income Countries: A Systematic Review.” *Nutrition Reviews* 77 (8): 515–40.

Tsubono, Yoshitaka, Yoshikazu Nishino, Akira Fukao, Shigeru Hisamichi, and Shoichiro Tsugane. 1995. “Temporal Change in the Reproducibility of a Self-Administered Food Frequency Questionnaire.” *American Journal of Epidemiology* 142 (11): 1231–35. https://doi.org/10.1093/oxfordjournals.aje.a117582.

Ubelaker, D. H., and L. A. Newson. 2002. “Patterns of Health and Nutrition in Prehistoric and Historic Ecuador.” *The Backbone of History: Health and Nutrition in the Western Hemisphere*, 343–75.

Urrutia, Rocío, and Mathias Vuille. 2009. “Climate Change Projections for the Tropical Andes Using a Regional Climate Model: Temperature and Precipitation Simulations for the End of the 21st Century.” *Journal of Geophysical Research: Atmospheres* 114 (D2).

USDA. 2019. “FoodData Central.” U.S. Department of Agriculture, Agricultural Research Service. 2019. fdc.nal.usda.gov.

Valente, Thomas W. 2010. *Social Networks and Health: Models, Methods, and Applications*. Oxford University Press. https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780195301014.001.0001/acprof-9780195301014.

Valente, Thomas W, and Stephanie R Pitts. 2017. “An Appraisal of Social Network Theory and Analysis as Applied to Public Health: Challenges and Opportunities.” *Annual Review of Public Health* 38: 103–18.

Van den Eynden, Veerle, Eduardo Cueva, and Omar Cabrera. 2003. “Wild Foods from Southern Ecuador.” *Economic Botany* 57 (4): 576–603. https://doi.org/10.1663/0013-0001(2003)057[0576:WFFSE]2.0.CO;2.

Vandenbrink, D, E Pauzé, and M Potvin Kent. 2020. “Strategies Used by the Canadian Food and Beverage Industry to Influence Food and Nutrition Policies.” *International Journal of Behavioral*

Nutrition and Physical Activity 17 (1): 3.
Vandermeer, John, and Ivette Perfecto. 2013. *Breakfast of Biodiversity: The Political Ecology of Rain Forest Destruction*. Food First Books.
Verano, John W. 1997. “Advances in the Paleopathology of Andean South America.” *Journal of World Prehistory* 11 (2): 237–68. https://doi.org/10.1007/BF02221205.
Villa, Tania Carolina Camacho, Nigel Maxted, Maria Scholten, and Brian Ford-Lloyd. 2005. “Defining and Identifying Crop Landraces.” *Plant Genetic Resources* 3 (3): 373–84. https://doi.org/10.1079/PGR200591.
Visser, Sanne Siete, Inge Hutter, and Hinke Haisma. 2016. “Building a Framework for Theory-Based Ethnographies for Studying Intergenerational Family Food Practices.” *Appetite* 97 (February): 49–57. https://doi.org/10.1016/j.appet.2015.11.019.
Vorster, Ineke, Willem Jansen van Resnsburg, Zijl Van, and Sonja Venter. 2007. “The Importance of Traditional Leafy Vegetables in South Africa.” *African Journal of Food, Agriculture, Nutrition and Development* 7 (4): 1–13.
Waijers, Patricia M. C. M., Edith J. M. Feskens, and Marga C. Ocké. 2007. “A Critical Review of Predefined Diet Quality Scores.” *British Journal of Nutrition* 97 (2): 219–31. https://doi.org/10.1017/S0007114507250421.
Waller, Lisa. 2018. “Indigenous Research Methodologies and Listening the Dadirri Way.” In *Ethical Responsiveness and the Politics of Difference*, 227–42. Springer.
Waters, William F. 2007. “Indigenous Communities, Landlords, and the State: Land and Labor in Highland Ecuador, 1950-1975.” In *Highland Indians and the State in Modern Ecuador*, edited by A. Clark and M. Becker, 120–38.
Weigel, MM, A Calle, RX Armijos, IP Vega, BV Bayas, and CE Montenegro. 1996. “The Effect of Chronic Intestinal Parasitic Infection on Maternal and Perinatal Outcome.” *International Journal of Gynecology & Obstetrics* 52 (1): 9–17.
Wengreen, Heidi J, Chailyn Neilson, Ron Munger, and Chris Corcoran. 2009. “Diet Quality Is Associated with Better Cognitive Test Performance among Aging Men and Women.” *The Journal of Nutrition* 139 (10): 1944–49.
Wezel, Alexander, S. Bellon, T. Doré, C. Francis, D. Vallod, and C. David. 2009. “Agroecology as a Science, a Movement and a Practice. A Review.” *Agronomy for Sustainable Development* 29 (4): 503–15. https://doi.org/10.1051/agro/2009004.
Wezel, Alexander, Marion Casagrande, Florian Celette, Jean-François Vian, Aurélie Ferrer, and Joséphine Peigné. 2014. “Agroecological Practices for Sustainable Agriculture. A Review.” *Agronomy for Sustainable Development* 34 (1): 1–20.
Wezel, Alexander, Barbara Gemmill Herren, Rachel Bezner Kerr, Edmundo Barrios, André Luiz Rodrigues Gonçalves, and Fergus Sinclair. 2020. “Agroecological Principles and Elements and Their Implications for Transitioning to Sustainable Food Systems. A Review.” *Agronomy for Sustainable Development* 40 (6): 1–13.
WHO. 2000. “Physical Status: Use and Interpretation of Anthropometry.” Geneva: World Health Organization.
———. 2017. “Double-Duty Actions for Nutrition: Policy Brief.” World Health Organization.
———. 2018. “Healthy Diet Fact Sheet No. 394.” World Health Organization. https://www.who.int/en/news-room/fact-sheets/detail/healthy-diet.
WHO and FAO. 2003. “Diet, Nutrition and the Prevention of Chronic Diseases: Report of a Joint WHO/FAO Expert Consultation.” World Health Organization.
Wilkie, David S, Bryan Curran, Richard Tshombe, and Gilda A Morelli. 1998. “Modeling the Sustainability

of Subsistence Farming and Hunting in the Ituri Forest of Zaire." *Conservation Biology* 12 (1): 137–47.
Willett, Walter, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, et al. 2019. "Food in the Anthropocene: The EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems." *The Lancet* 393 (10170): 447–92. https://doi.org/10.1016/S0140-6736(18)31788-4.
Willett, Walter, Laura Sampson, Meir J Stampfer, Bernard Rosner, Christopher Bain, Jelia Witschi, Charles H Hennekens, and Frank E Speizer. 1985. "Reproducibility and Validity of a Semiquantitative Food Frequency Questionnaire." *American Journal of Epidemiology* 122 (1): 51–65.
Wong, William W, Garrett Strizich, Moonseong Heo, Steven B Heymsfield, John H Himes, Cheryl L Rock, Marc D Gellman, Anna Maria Siega-Riz, Daniela Sotres-Alvarez, and Sonia M Davis. 2016. "Relationship between Body Fat and BMI in a US Hispanic Population-based Cohort Study: Results from HCHS/SOL." *Obesity* 24 (7): 1561–71.
World Health Organization. 2015. "Improving Nutrition Outcomes with Better Water, Sanitation and Hygiene: Practical Solutions for Policies and Programmes." https://apps.who.int/iris/bitstream/handle/10665/193991/9789241565103_eng.pdf.
Yang, Jin-Hoon, Yu-Mi Lee, Sang-Geun Bae, David R Jacobs Jr, and Duk-Hee Lee. 2012. "Associations between Organochlorine Pesticides and Vitamin D Deficiency in the US Population." *PLoS One* 7 (1): e30093.
Yang, Zhenyu, and Sandra L Huffman. 2013. "Nutrition in Pregnancy and Early Childhood and Associations with Obesity in Developing Countries." *Maternal & Child Nutrition* 9: 105–19.
Yates, Luke, and Alan Warde. 2015. "The Evolving Content of Meals in Great Britain. Results of a Survey in 2012 in Comparison with the 1950s." *Appetite* 84 (January): 299–308. https://doi.org/10.1016/j.appet.2014.10.017.
Yin, Z, Z Fei, C Qiu, MS Brasher, VB Kraus, Wenhua Zhao, Xiaoming Shi, and Yi Zeng. 2017. "Dietary Diversity and Cognitive Function among Elderly People: A Population-Based Study." *The Journal of Nutrition, Health & Aging* 21 (10): 1089–94.
Zamosc, León. 1990. "Luchas Campesinas y Reforma Agraria: La Sierra Ecuatoriana y La Costa Atlántica Colombiana En Perspectiva Comparativa." *Revista Mexicana de Sociología*, 125–80.
———. 1994. "Agrarian Protest and the Indian Movement in the Ecuadorian Highlands." *Latin American Research Review* 29 (3): 37–68.
Zanello, Giacomo, Bhavani Shankar, and Nigel Poole. 2019. "Buy or Make? Agricultural Production Diversity, Markets and Dietary Diversity in Afghanistan." *Food Policy* 87: 101731.
Zerfu, Taddese A, Melaku Umeta, and Kaleab Baye. 2016. "Dietary Diversity during Pregnancy Is Associated with Reduced Risk of Maternal Anemia, Preterm Delivery, and Low Birth Weight in a Prospective Cohort Study in Rural Ethiopia." *The American Journal of Clinical Nutrition* 103 (6): 1482–88.
Zimmerer, Karl S. 1997. *Changing Fortunes: Biodiversity and Peasant Livelihood in the Peruvian Andes*. Vol. 1. Univ of California Press.

10. Annexes

10.1 Description of the annexes

Annex 1: Ethics certificates:

This contains the initial project ethics certificate obtained from the Université de Montréal review board, as well as yearly renewals.

Annex 2: Ethnography protocol:

This contains the protocol followed for ethnographic homestays (in Spanish).

Annex 3: Cross-sectional survey:

This contains the cross-sectional survey (in Spanish).

Annex 4: "Conversations without borders" book chapter:

This contains an English version of the following Spanish-language book chapter published in 2021:

> Nadar, Danya, and Ana Deaconu. 2021. "Conversaciones Sin Fronteras: ¿Qué Podemos Aprender de Alimentos Tradicionales En Redes Alternativas de Palestina y Ecuador?" In *Distribución, Comercialización y Acceso a Alimentos de Calidad En América Latina*, edited by Sebastián Grenoville, Julie Le Gall, and Julien Noel, 22–42. Buenos Aires, Argentina: INTA Ediciones.

The chapter was co-authored with equal contributions from Danya Nadar and myself, and is a cross-cultural comparison between Palestine and Ecuador on traditional food practices. The results pertaining to Ecuador were obtained through the research for this thesis.

Annex 5: Lay report:

This contains a Spanish-language report on study findings, prepared for a lay audience.

Annex 6: Summary flyer:

This contains a Spanish-language flyer on key study findings, prepared for a lay audience.

10.2 Annexes

Annex 1: Ethics certificates

Université de Montréal

Comité d'éthique de la recherche en santé

2 May 2017

Objet: Approbation éthique – « Diversity from farm to plate: Nutrition and food relationships among agroecological farmers in Ecuador »

Mme Ana Deaconu,

Le Comité d'éthique de la recherche en santé (CERES) a étudié le projet de recherche susmentionné et a délivré le certificat d'éthique demandé suite à la satisfaction des exigences précédemment émises. Vous trouverez ci-joint une copie numérisée de votre certificat; copie également envoyée à votre directeur/directrice de recherche et à la technicienne en gestion de dossiers étudiants (TGDE) de votre département.

Notez qu'il y apparaît une mention relative à un suivi annuel et que le certificat comporte une date de fin de validité. En effet, afin de répondre aux exigences éthiques en vigueur au Canada et à l'Université de Montréal, nous devons exercer un suivi annuel auprès des chercheurs et étudiants-chercheurs.

De manière à rendre ce processus le plus simple possible et afin d'en tirer pour tous le plus grand profit, nous avons élaboré un court questionnaire qui vous permettra à la fois de satisfaire aux exigences du suivi et de nous faire part de vos commentaires et de vos besoins en matière d'éthique en cours de recherche. Ce questionnaire de suivi devra être rempli annuellement jusqu'à la fin du projet et pourra nous être retourné par courriel. La validité de l'approbation éthique est conditionnelle à ce suivi. Sur réception du dernier rapport de suivi en fin de projet, votre dossier sera clos.

Il est entendu que cela ne modifie en rien l'obligation pour le chercheur, tel qu'indiqué sur le certificat d'éthique, de signaler au CERES tout incident grave dès qu'il survient ou de lui faire part de tout changement anticipé au protocole de recherche.

Nous vous prions d'agréer, Madame, l'expression de nos sentiments les meilleurs,

Dominique Langelier, présidente
Comité d'éthique de la recherche en santé (CERES)
Université de Montréal

DL/GP/gp
c.c. Gestion des certificats, BRDV
Malek Batal, professeur agrégé, Faculté de médecine - Département de nutrition
p.j. Certificat #17-053-CERES-P

adresse postale
C.P. 6128, succ. Centre-ville
Montréal QC H3C 3J7

3744 Jean-Brillant
4e étage, bur. 430-11
Montréal QC H3T 1P1

Téléphone : 514-343-6111 poste 2604
ceres@umontreal.ca
www.ceres.umontreal.ca

Université de Montréal

N^O de certificat
17-053-CERES-P

Comité d'éthique de la recherche en santé

CERTIFICAT D'APPROBATION ÉTHIQUE

Le Comité d'éthique de la recherche en santé (CERES), selon les procédures en vigueur, en vertu des documents qui lui ont été fournis, a examiné le projet de recherche suivant et conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal.*

Projet	
Titre du projet	**Diversity from farm to plate: Nutrition and food relationships among agroecological farmers in Ecuador**
Étudiante requérante	**Ana Deaconu** (ND), Candidate au Ph. D. en nutrition, Faculté de médecine - Département de nutrition
Sous la direction de	Malek Batal, professeur agrégé, Faculté de médecine - Département de nutrition, Université de Montréal

Financement	
Organisme	EkoRural
Programme	
Titre de l'octroi si différent	
Numéro d'octroi	
Chercheur principal	
No de compte	

MODALITÉS D'APPLICATION

Tout changement anticipé au protocole de recherche doit être communiqué au CERES qui en évaluera l'impact au chapitre de l'éthique.

Toute interruption prématurée du projet ou tout incident grave doit être immédiatement signalé au CERES

Selon les règles universitaires en vigueur, un suivi annuel est minimalement exigé pour maintenir la validité de la présente approbation éthique, et ce, jusqu'à la fin du projet. Le questionnaire de suivi est disponible sur la page web du CERES.

[redacted]

Dominique Langelier, présidente
Comité d'éthique de la recherche en santé
Université de Montréal

2 mai 2017
Date de délivrance

1er juin 2018
Date de fin de validité

adresse postale
C.P. 6128, succ. Centre-ville
Montréal QC H3C 3J7

3744 Jean-Brillant
4e étage, bur. 430-11
Montréal QC H3T 1P1

Téléphone : 514-343-6111 poste 2604
ceres@umontreal.ca
www.ceres.umontreal.ca

Université de Montréal

Comité d'éthique de la recherche en santé

12 juin 2018

Objet: Certificat d'approbation éthique - 1er renouvellement – « Diversity from farm to plate: Nutrition and food relationships among agroecological farmers in Ecuador »

Mme Ana Deaconu,

Le Comité d'éthique de la recherche en santé (CERES) a étudié votre demande de renouvellement pour le projet de recherche susmentionné et a délivré le certificat d'éthique demandé suite à la satisfaction des exigences qui prévalent. Vous trouverez ci-joint une copie numérisée de votre certificat; copie également envoyée à votre directeur/directrice de recherche et à la technicienne en gestion de dossiers étudiants (TGDE) de votre département.

Notez qu'il y apparaît une mention relative à un suivi annuel et que le certificat comporte une date de fin de validité. En effet, afin de répondre aux exigences éthiques en vigueur au Canada et à l'Université de Montréal, nous devons exercer un suivi annuel auprès des chercheurs et étudiants-chercheurs.

De manière à rendre ce processus le plus simple possible et afin d'en tirer pour tous le plus grand profit, nous avons élaboré un court questionnaire qui vous permettra à la fois de satisfaire aux exigences du suivi et de nous faire part de vos commentaires et de vos besoins en matière d'éthique en cours de recherche. Ce questionnaire de suivi devra être rempli annuellement jusqu'à la fin du projet et pourra nous être retourné par courriel. La validité de l'approbation éthique est conditionnelle à ce suivi. Sur réception du dernier rapport de suivi en fin de projet, votre dossier sera clos.

Il est entendu que cela ne modifie en rien l'obligation pour le chercheur, tel qu'indiqué sur le certificat d'éthique, de signaler au CERES tout incident grave dès qu'il survient ou de lui faire part de tout changement anticipé au protocole de recherche.

Nous vous prions d'agréer, Madame, l'expression de nos sentiments les meilleurs,

Guillaume Paré
Conseiller en éthique de la recherche.
Comité d'éthique de la recherche en santé (CERES)
Université de Montréal

c.c. Gestion des certificats, BRDV
Malek Batal, professeur agrégé, Faculté de médecine - Département de nutrition
p.j. Certificat #17-053-CERES-P(1)

adresse postale
C.P. 6128, succ. Centre-ville
Montréal QC H3C 3J7

3333 Queen-Mary
2e étage, bur. 220-3
Montréal QC H3V 1A2

Téléphone : 514-343-6111 poste 2604
ceres@umontreal.ca
www.ceres.umontreal.ca

Université de Montréal

Comité d'éthique de la recherche en santé

N^{O} de certificat
17-053-CERES-P(1)

CERTIFICAT D'APPROBATION ÉTHIQUE

- 1er renouvellement -

Le Comité d'éthique de la recherche en santé (CERES), selon les procédures en vigueur et en vertu des documents relatifs au suivi qui lui a été fournis conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal*

Projet	
Titre du projet	**Diversity from farm to plate: Nutrition and food relationships among agroecological farmers in Ecuador**
Étudiante requérante	**Ana Deaconu** (ND), Candidate au Ph. D. en nutrition, Faculté de médecine - Département de nutrition
Sous la direction de	Malek Batal, professeur agrégé, Faculté de médecine - Département de nutrition, Université de Montréal

Financement	
Organisme	EkoRural
Programme	
Titre de l'octroi si différent	
Numéro d'octroi	
Chercheur principal	
No de compte	

MODALITÉS D'APPLICATION

Tout changement anticipé au protocole de recherche doit être communiqué au CERES qui en évaluera l'impact au chapitre de l'éthique. Toute interruption prématurée du projet ou tout incident grave doit être immédiatement signalé au CERES.

Selon les règles universitaires en vigueur, un suivi annuel est minimalement exigé pour maintenir la validité de la présente approbation éthique, et ce, jusqu'à la fin du projet. Le questionnaire de suivi est disponible sur la page web du CERES.

[redacted]

Guillaume Paré
Conseiller en éthique de la recherche.
Comité d'éthique de la recherche en santé
Université de Montréal

12 juin 2018 Date de délivrance du renouvellement ou de la réémission*	**1er juillet 2019** Date du prochain suivi
2 mai 2017 Date du certificat initial	**1er juillet 2019** Date de fin de validité

*Le présent renouvellement est en continuité avec le précédent certificat

adresse postale
C.P. 6128, succ. Centre-ville
Montréal QC H3C 3J7

3333 Queen-Mary
2e étage, bur. 220-3
Montréal QC H3V 1A2

Téléphone : 514-343-6111 poste 2604
ceres@umontreal.ca
www.ceres.umontreal.ca

Université de Montréal

Comité d'éthique de la recherche en sciences et en santé (CERSES)

26 Février 2020

Objet: Certificat d'approbation éthique - 2ième renouvellement – « Diversity from farm to plate: Nutrition and food relationships among agroecological farmers in Ecuador »

Mme Ana Deaconu,

Le Comité d'éthique de la recherche en sciences et en santé (CERSES) a étudié votre demande de renouvellement pour le projet de recherche susmentionné et a délivré le certificat d'éthique demandé suite à la satisfaction des exigences qui prévalent. Vous trouverez ci-joint une copie numérisée de votre certificat; copie également envoyée à votre directeur/directrice de recherche et à la technicienne en gestion de dossiers étudiants (TGDE) de votre département.

Notez qu'il y apparaît une mention relative à un suivi annuel et que le certificat comporte une date de fin de validité. En effet, afin de répondre aux exigences éthiques en vigueur au Canada et à l'Université de Montréal, nous devons exercer un suivi annuel auprès des chercheurs et étudiants-chercheurs.

De manière à rendre ce processus le plus simple possible et afin d'en tirer pour tous le plus grand profit, nous avons élaboré un court questionnaire qui vous permettra à la fois de satisfaire aux exigences du suivi et de nous faire part de vos commentaires et de vos besoins en matière d'éthique en cours de recherche. Ce questionnaire de suivi devra être rempli annuellement jusqu'à la fin du projet et pourra nous être retourné par courriel. La validité de l'approbation éthique est conditionnelle à ce suivi. Sur réception du dernier rapport de suivi en fin de projet, votre dossier sera clos.

Il est entendu que cela ne modifie en rien l'obligation pour le chercheur, tel qu'indiqué sur le certificat d'éthique, de signaler au Comité tout incident grave dès qu'il survient ou de lui faire part de tout changement anticipé au protocole de recherche.

Nous vous prions d'agréer, Madame, l'expression de nos sentiments les meilleurs,

Insaf Salem Fourati
Responsable à l'évaluation éthique continue de la recherche
Comité d'éthique de la recherche en sciences et en santé (CERSES)
Université de Montréal

c.c. Gestion des certificats, BRDV
Malek Batal, professeur agrégé, Faculté de médecine - Département de nutrition
p.j. Certificat #17-053-CERES-P(2)

adresse postale
C.P. 6128, succ. Centre-ville
Montréal QC H3C 3J7

3333 Queen-Mary
2e étage, bur. 220-9
Montréal QC H3V 1A2

Téléphone : 514-343-6111 poste 33346
cerses@umontreal.ca
www.cerses.umontreal.ca

Université de Montréal

N^O de certificat
17-053-CERES-P(2)

Comité d'éthique de la recherche en sciences et en santé (CERSES)

CERTIFICAT D'APPROBATION ÉTHIQUE

\- 2ième renouvellement -

Le Comité d'éthique de la recherche en sciences et en santé (CERSES), selon les procédures en vigueur et en vertu des documents relatifs au suivi qui lui a été fournis conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal*

Projet	
Titre du projet	**Diversity from farm to plate: Nutrition and food relationships among agroecological farmers in Ecuador**
Étudiante requérante	**Ana Deaconu** (ND), Candidate au Ph. D. en nutrition, Faculté de médecine - Département de nutrition
Sous la direction de	Malek Batal, professeur agrégé, Faculté de médecine - Département de nutrition, Université de Montréal
Note :	Ajout de groupes de discussion (19 mars 2019)//Ajout d'un financement (bourse d'études doctorales du FRQS) (26 février 2020)

Financement	
Organisme	EkoRural//Bourse d'études doctorales (FRQS)
Programme	
Titre de l'octroi si différent	
Numéro d'octroi	
Chercheur principal	
No de compte	

MODALITÉS D'APPLICATION

Tout changement anticipé au protocole de recherche doit être communiqué au Comité qui en évaluera l'impact au chapitre de l'éthique. Toute interruption prématurée du projet ou tout incident grave doit être immédiatement signalé au Comité.

Selon les règles universitaires en vigueur, un suivi annuel est minimalement exigé pour maintenir la validité de la présente approbation éthique, et ce, jusqu'à la fin du projet. Le questionnaire de suivi est disponible sur la page web du Comité.

[redacted]

Insaf Salem Fourati
Responsable à l'évaluation éthique continue de la recherche
Comité d'éthique de la recherche en sciences et en santé (CERSES)
Université de Montréal

26 février 2020 Date de délivrance du renouvellement ou de la réémission*	**1er mars 2021** Date du prochain suivi
2 mai 2017 Date du certificat initial	**1er mars 2021** Date de fin de validité

*Le présent renouvellement est en continuité avec le précédent certificat

Université de Montréal

Comité d'éthique de la recherche en sciences et santé (CERSES)

02 Février 2021

OBJET : **Rapport annuel- renouvellement et approbation de modifications**

Étudiante requérante : Ana Deaconu
Sous la direction de: Malek Batal, professeur agrégé
Titre du projet: « Diversity from farm to plate: Nutrition and food relationships among agroecological farmers in Ecuador »
Projet 17-053-CERES-P, 3ième renouvellement.
Source de financement : 1) EkoRural; 2) Bourse d'études doctorales (FRQS); 3) Centre de recherche en développement du Canada et Instituts de recherche en santé du Canada, titre original: "Evaluating and bringing to scale alternative food networks to adress diabetes mellitus and hypertension"
Nature des modifications: Ajout de groupes de discussion (19 mars 2019)//Ajout d'un financement (bourse d'études doctorales du FRQS) (26 février 2020)//Ajout d'un nouveau financement (02-02-21)

Bonjour,

Vous avez présenté au Comité d'éthique de la recherche en sciences et santé (CERSES) de l'Université de Montréal, en date du 25 janvier 2021, un rapport d'étape annuel ainsi qu'une demande de modification à votre projet cité en objet.

Suite à l'évaluation de cette demande, il me fait plaisir de vous confirmer que le CERSES est satisfait du rapport d'étape annuel et en conséquence que **l'approbation éthique est renouvelée** pour **un an**, à compter du **01-03-2021** jusqu'au **01-03-2022.**

Comme votre approbation éthique arrive à échéance le 1er mars 2021, le Comité a procédé à son renouvellement. Veuillez noter que la nouvelle approbation entrera en vigueur à compter du 1er mars 2021. Entre-temps, le projet de recherche est couvert par l'approbation éthique émise en date 26 février 2020 et qui expire le 1er mars 2021.

Également, suite à l'évaluation des modifications proposées, le tout étant jugé satisfaisant et en conséquence j'ai le plaisir de vous informer que votre demande de modification est approuvée par le Comité.

Mesures de suivi éthique continu
Le CERSES demeure responsable de l'acceptabilité éthique des activités de recherche menées sous son autorité. Une fois l'approbation éthique initiale obtenue, une évaluation éthique minimalement annuelle est requise. L'évaluation éthique continue sera effectuée par le CERSES à partir des notifications qui lui seront transmises par l'équipe de recherche pendant le

déroulement de la recherche. À cette fin, je vous rappelle que le CERSES a arrêté lors de l’approbation initiale les mesures suivantes de suivi éthique continu de votre projet de recherche :

- La soumission d’un r**apport d’étape annuel,** à soumettre un mois avant l’échéance de la date d’approbation afin de renouveler l’approbation éthique.
- La soumission de toute **modification au projet de recherche qui touche les participants**; une modification ne peut être mise en œuvre sans l’approbation du CERSES.
- La soumission dans les meilleurs délais d’un rapport de tout **évènement indésirable, de tout accident ou de tout incident** lié à la réalisation du projet de recherche.
- La soumission d’un rapport sur toute **déviation au protocole** de recherche susceptible d’augmenter le niveau de risque ou susceptibles d’influer sur le bien-être du participant ou son consentement.
- La notification de toute **cessation prématurée, interruption temporaire ou suspension**, qu’elle soit temporaire ou permanente.
- La soumission d’un **rapport de fin de projet.**

Ces notifications doivent être transmises au CERSES en complétant le questionnaire de suivi disponible sur la page web du CERSES à la section « Modifications envisagées à un projet de recherche » et en le retournant par courriel à suivi-ethique@umontreal.ca avec la mention « Suivi éthique – [no d’approbation éthique] – date de complétion » dans le champ « Objet ».
Tout défaut de respecter une de ces mesures de suivi éthique pourrait résulter en une suspension ou une révocation de l’approbation.

Cadre normatif

Le CERSES de l’Université de Montréal est désigné par le ministre de la Santé et des Services Sociaux aux fins de l’application de l’article 21 du Code civil du Québec. Il exerce ses activités en conformité avec la *Politique sur la recherche avec des êtres humains* (60.1) de l’Université de Montréal ainsi que l'Énoncé de politique des trois conseils (EPTC). Il suit également les normes et règlements applicables au Québec et au Canada.

La présente lettre d’approbation est une décision officielle du CERSES.

Nous vous remercions de votre collaboration et nous vous souhaitons bon succès pour la suite de votre projet.

Pour le CERSES

Insaf Salem Fourati
Responsable de l'évaluation éthique continue
Bureau de la conduite responsable en recherche
Université de Montréal

Comités desservis :
Pour le Comité d’éthique de la recherche clinique (CERC)
Pour le Comité d’éthique de la recherche en sciences et santé (CERSES)
Pour le Comité d’éthique de la recherche en éducation et en psychologie (CEREP)

Annex 2: Ethnography protocol

Protocolo de Investigación para Etnografía en el Proyecto: "Strengthening impact on the Healthy Food Consumption Campaign “250.000 Families in Ecuador"

<u>Selección de Familias:</u> Se utilizará un enfoque basado en los actores (actor-oriented approach) para escoger un mínimo de 3 y un máximo de 6 familias de cada cuenca alimentaria (Riobamba, Quito, Ibarra). Los criterios para escoger las familias serán los siguientes: (1) productores agroecológicos; (2) participación activa en organizaciones o redes sociales que promueven la agroecología y el consumo responsable, por ejemplo el Movimiento de Economía Social y Solidaria de Ecuador (MESSE) o el Colectivo Agroecológico. En trabajo etnográfico, es importante tomar en cuenta las relaciones que se mantienen con los y las participantes, y es imprescindible que la familia esté de acuerdo con participar.

Para escoger y contactar las familias, se van a movilizar las relaciones que existen entre el grupo de investigación con el MESSE, el Colectivo Agroecológico, y otras redes. Se les va a preguntar a las familias si están dispuestas a (1) participar en el estudio y (2) recibir a la investigadora en su hogar por aproximadamente una semana. Es necesario avisar a las familias que este proyect es para aprender más sobre las prácticas de alimentación en la comunidad, y que es importante que las familias no cambien sus hábitos alimentarios durante el tiempo que esté la investigadora. La investigadora no es huéspeda en el sentido convencional de la palabra, y no se debe preparar nada especial para ella.

<u>Etnografía:</u> La investigadora Ana Deaconu, estudiante de doctorado, se quedará con cada familia por un tiempo de 4 a 6 días. Posiblemente, un otro estudiante participará como asistente. En este caso, el asistente se quedará con otras familias desde el grupo seleccionado. Los dos investigadores no se quedarán con las mismas familias. Preferiblemente, los días de estancia con cada familia serán secuenciales, y los días precisas se van a anotar en los cuadernos de campo. Siempre cuando sea posible, la investigadora se quedará a vivir con la familia. Caso contrario, pasará la mayor parte de las horas del día con la familia. Cada periódo de etnografía va a culminar en tres días de pensar, escribir notas, organizar información, reflexionar, y relajar.

Se van a compensar a las familias participantes con $5 por día, pagados al final de la estancia. Esto es para cubrir los costos incurridos por el hecho de hospedar y alimentar a la investigadora. Se intentará de no alterar el estado económico de la familia, ni tampoco sus hábitos alimentarios durante el tiempo de observación etnográfica.

La investigadora utilizará un pequeño cuaderno de campo para anotar observaciones al rato que ocurren, o poco tiempo después. Usará estos apuntes para hacer una sistematización todas las noches. Comenzando el primer día, la investigadora debe ofrecer su ayuda en la cocina, para estar en contacto directo con la persona quien prepara la comida. Además, debe averiguar si hay algún evento social o reunión durante el tiempo que está presente, y pedir si puede asistir, siempre cuando no vaya a incomodar a la familia o los demás de la reunión. También debe averiguar si es que se realizará alguna actividad agrícola durante el tiempo que esté, y procurar visitar los sembrillos. En el primer día, la investigadora debe hacerse amigos y comenzar a comprender los papeles de cada miembro de la familia. Debe escuchar y observar, y tomar apuntes.

Una de las tareas principales de la investigadora es de documentar que se consume, de donde se consigue, como se prepara, y otras acciones, relaciones o conversaciones que giren entorno a la alimentación. La otra tarea es de comprender el entorno social de la familia -- con quien se relacionan, de donde toman sus influencias sobre la alimentación, con quien comparten sus ideas sobre la alimentacion, posiciones políticas o éticas sobre temas de alimentación, etc. Mientras en la primera tarea el papel de la investigadora es netamente como observante, en la segunda tarea puede ser necesario hacer preguntas claves para abrir el tema de conversación. Es importante anotar si una información es de segunda mano (e.g. la esposa cuenta sobre los opiniones de su esposo).

Otras actividades que la investigadora debe completar durante su estadía con cada familia

1. Implementar la encuesta de hogar.
2. Dibujar un árbol de parentesco de los miembros del hogar, e incluír las edades de cada miembro.
3. Dibujar un árbol de relaciones sociales dentro de la información que se ofrece sobre otras personas de la comunidad. Recolectar información sobre redes sociales, incluyendo formales (e.g. participation en asociaciones, grupos religiosos, otras organizaciones) e informal (e.g. relaciones con vecinos).
4. Preguntar qué es que la familia ha aprendido sobre la alimentación y nutrición, y de donde aprendió.
5. Preguntar qué es los que la familia considera como comida “sana”, y como “consumo responsable” si el término es dentro de su léxico.
6. Si hay una madre lactante o madre de hijos menos de cinco años, prestar atención especial sobre las prácticas de amamantar o de alimentar.
7. Pasar mucho tiempo en la cocina con la persona quien prepara la comida. Se puede ayudar en la preparación. Anotar las prácticas de cocinar. Que ingredientes se combina? Que estilo de preparación su usa (hervir, freír, asar, etc.). Se hace algo especial para preparar los alimentos de niños pequeños? Notar las prácticas de higiene. Se lavan las manos e los implementos de cocinar? El agua para los alimentos está hervida? Por cuánto tiempo? De donde viene el agua?
8. Prestar atención a las prácticas de usar el baño. Donde está ubicado el baño? Se lavan las manos?
9. Pregunta sobre temas de enfermedades y salud, y profundizar en temas que puedan estar relacionadas con la alimentación (e.g. diabetes, hipertensión).
10. Acompañar en las compras o en otras maneras de procurar alimentos (cosecha, intercambio, etc). Anotar todo lo comprado y de donde. Preguntar sobre los productos que ya están en la casa -- de donde vienen, desde cuando los tienen. Preguntar qué se compra en las tiendas o mercados cercanos, y que les gustaría poder comprar y porque no pueden. Cuáles son las barreras para conseguir los alimentos que desean? Preguntar donde más compran, y donde más consiguen alimentos. Preguntar a dónde van para conseguir alimentos para los animales.
11. Visitar la tienda más cercana. Que venden? Preguntar a la persona quien atiende donde consiguen los productos.
12. El último día, conseguir alimentos de los que se consumen frecuentemente en el hogar. Pedir a la madre y a cada uno de los hijos mayores que clasifiquen los productos en grupos diferentes. Ellos tienen que describir los criterios con que clasifican cada grupo, y darle un nombre a cada grupo. Dejar los alimentos con la familia como agradecimiento.

Annex 3: Cross-sectional survey

NOID:___________________

Diversidad de la Mata a la Olla: Nutrición y Relaciones Alimentarias de los Productores Agroecológicos Ecuatorianos
Encuesta para productores en las ferias agroecológicas

A. Datos iniciales

Consentimiento: Da usted su consentimiento para participar?	□ Si (Continúa) □ No (termina la entrevista)
Fecha	
Hora	

Nombres y Apellidos	
Comunidad	
Parroquia	
Canton	
Feria	

Latitud	
Longitud	

Nombres y Apellidos de la No-Feriante vinculada _____________________________

B. CONSUMO B1. Recordatorio 24 horas. ***Si mencionan algún alimento/ingrediente sorprendente, preguntar de como llegó a conocerlo y comerlo!***

Momento	Plato	Cant. porción	Ingredientes principales [tipo, preparación, procesamiento, marca]	Cantidad ingrediente	Orígen

***PP** = producción propia; **TF** = trueke en feria; **TC** = trueke en comunidad o con otros; **RP** = regalado de la producción propia de otro; **R** = regalado (no de prod propia, o no se sabe orígen del regalo) **CF** = comprado en la feria; **CP** = comprado directo de productores en la comunidad, otro mercado de compra directa, u otro directo de productor; **CM** = comprado en un mercado, supermercado o tienda convencional, o comprado en la calle de intermediarios. **PC** = plato entero comprado (especificar de donde). **E** = encontrado en el monte, bosque, quebrada, etc.*

0 = antes del desayuno, 1 = desayuno, 2 = refrigerio AM, 3 = almuerzo, 4 = refrigerio PM, 5 = merienda, 6 = refrigerio post-merienda, 7 = otro

Momento	Plato	Cant. porción	Ingredientes principales [tipo, preparación, procesamiento, marca]	Cantidad ingrediente	Orígen

***PP** = producción propia; **TF** = trueke en feria; **TC** = trueke en comunidad o con otros; **RP** = regalado de la producción propia de otro; **R** = regalado (no de prod propia, o no se sabe orígen del regalo) **CF** = comprado en la feria; **CP** = comprado directo de productores en la comunidad, otro mercado de compra directa, u otro directo de productor; **CM** = comprado en un mercado, supermercado o tienda convencional, o comprado en la calle de intermediarios. **PC** = plato entero comprado (especificar de donde). **E** = encontrado en el monte, bosque, quebrada, etc.*

0 = antes del desayuno, 1 = desayuno, 2 = refrigerio AM, 3 = almuerzo, 4 = refrigerio PM, 5 = merienda, 6 = refrigerio post-merienda, 7 = otro

Tal vez tomó alguna vitamina o otro suplemento alimentario? (*detallar*)_________

Ayer hubo algo especial en su día que pudo haber afectado su alimentación normal (*ej. fiesta, enfermedad*)? ____________

B2. Productos tradicionales. Ahora me gustaría preguntarle sobre algunos alimentos específicos que tal vez coma, cada cuánto los come, y de donde los consigue.

	v/ día	v/ sem	v/ mes	v/ año	Muy raro	nunca	No conoce producto	Duración temporada	Dónde consigue
Hoja de quinua									
Quinua (grano)									
Hoja de ataco/Sangorache									
Amaranto/Sangorache/ataco (grano)									
Chocho									
Melloco									
Mashua (comida o remedio)									
Oca									
Zanahoria blanca									
Jicama									
Chulpi									
Camote									

***PP** = producción propia; **TF** = trueke en feria; **TC** = trueke en comunidad o con otros; **RP** = regalado de la producción propia de otro; **R** = regalado (no de prod propia, o no se sabe orígen del regalo) **CF** = comprado en la feria; **CP** = comprado directo de productores en la comunidad, otro mercado de compra directa, u otro directo de productor; **CM** = comprado en un mercado, supermercado o tienda convencional, o comprado en la calle de intermediarios. **PC** = plato entero comprado (específicar de donde). **E** = encontrado en el monte, bosque, quebrada, etc.*

En el último año, tal vez ha consumido alguna de las siguientes hierbas de monte o frutas de monte? .....Tal vez consume alguna otra?

	bledo		Lengua de vaca (wagrahayu)		Uvilla de lobo		*Otros:*
	nabo de monte		Quinua de monte (allpa quinua)		Taxo de monte		
	Rábano de monte		Mora de monte (mora silvestre)		Chimbalo		
	Berro de monte		Uvilla de monte		Mortiño		

B3. Hábitos alimentación y compra

Más o menos cuánto gasta su familia cada mes (o semana o quincena) para comprar alimentos? ___________/mes

Cuánto tiempo se demora en llegar al lugar donde más hace sus compras? Caminando____________ + Transporte __________

Qué transporte toma? *Círcula el principal.* •Carro propio. •Taxi o carro contratado. •Bus/taxi colectivo. •Pie. •Otro_________

Cada cuánto compran [productos de matriz debajo] **para el consumo en la casa**? Y cuánto compran?

Producto	Compra cada.... semana/mes/año/etc.	Cantidad	Producto	Compra cada.... semana/mes/año/etc.	Cantidad
Azúcar			Aceite (no incluír oliva)		
Azúcar morena			Margarina (mantequilla pesada)		
Panela			Mantequilla (de leche)		
Sal			Manteca vegetal		
Cubo maggi, ajinomoto, ranchero			Manteca de animal (chancho, pollo, vaca)		

****Si compran sal para hacer queso para vender, o azúcar para mermeladas para vender (etc.), pregunta cuánto se ocupa para el* consumo *en la casa.*

C. Redes Sociales.

Ahora le quiero preguntar sobre su participación en las ferias. En que ferias nomás participa ahora? Y antes ha participado en alguna otra feria?

	Feria ______________________	Feria ______________________	Feria ______________________
Cuánto tiempo ha participado en la feria?		•Ya no participa	•Ya no participa
Ocupa alguna posición de liderazgo en la feria?	•No. •Sí___	•No. •Sí___	•No. •Sí___
Más antes ha ocupado alguna posición de liderazgo?	•No. •Sí___	•No. •Sí___	•No. •Sí___
Más o menos cada cuánto va a vender en esta feria?	_______/________	_______/________	_______/________
Cómo es que llegó a participar en esta feria?			

Usted conoce el término *agroecología*, o usa este término en su feria? •No. •Si. •Ha escuchado pero no sabe que es.

Ahora quiero preguntarle sobre algunos procesos sociales que tal vez conozca, o tal vez no conozca.

Conoce al MESSE (El Movimiento de Economía Social y Solidaria de Ecuador, con Rosita Murillo? Asista a las reuniones o encuentros o otras actividades del MESSE?	•No. •Sí: •No. •Sí: • Siempre que haya. •A veces. •Raras veces. •Una vez. *Explique:*
Conoce al Colectivo Agroecológico (con el compañero Roberto Gortaire)? Asista a las reuniones o encuentros o otras actividades del Colectivo Agroecológico?	•No. •Sí: •No. •Sí: • Siempre que haya •A veces. •Raras veces. •Una vez. *Explique:*
Conoce a la CEA (Coordinadora Ecuatoriana de Agroecología, con el compañero Pepe Rivadeneira)? Asista a las reuniones o encuentros o otras actividades de la CEA?	•No. •Sí: •No. •Sí: • Siempre que haya. •A veces. •Raras veces. •Una vez. *Explique:*
Conoce la Campaña Que Rico Es, también conocida como las 250,000 familias?	•No. •Sí: *Explique:*
Escucha uno de los siguientes programas de radio: Minga por la Pachamama, Poder del Cucharón, Mama Cuchara?	•No. •Sí: • Regularmente. •A veces. •Raras veces. •Una vez.
Ha participado con algún otro grupo, asociación, o fundación que promueve la agroecología? Con cuáles?	•Swiss aid. •Oxfam. •Heifer. •Vibrant village. •Ayuda en Acción. •AVSF •FICI. •UNORCAC. •CARE •Otros:
Con su participación en la feria o en [MESSE, Colectivo, CEA, fundaciones de la agroecología...]	
...Ocupa o alguna vez ocupó alguna posición de **liderazgo** o puesto de trabajo u otra responsabilidad especial? (e.g. dinamizadora, promotora...) (aparte del liderazgo ya anotado para la feria)	•No. •Sí____ •Antes Sí_____
...Alguna vez ha ***dado o ayudado en dar*** un taller, o hecho promoción, de uno de los siguientes temas? Consumo responsable: Alimentación sana o nutrición:	*Detalles:*

Cocinar o preparar comidas, o hacer transformados (mermeladas, yogurt, cremas, jabón...): Prácticas de producción natural o de agroecología: Otro relacionado (soberanía alimentaria...):	
...Alguna vez ha ***recibido*** un taller de uno de estos temas? Consumo responsable: Alimentación sana o nutrición: Cocinar o preparar comidas, o hacer transformados (mermeladas, yogurt, cremas, jabón...): Prácticas de producción natural o de agroecología: Otro relacionado (soberanía alimentaria...):	*Detalles:*
...Alguna vez ha participado en una **actividad política para las semillas o para la alimentación**? (Por ejemplo marcha contra transgénicos, o la ley de semillas?	•No. •Sí: *Explique:*

Aparte de lo que ya hemos conversado, alguna vez ha recibido un taller de nutrición o de alimentación sana de algún otro grupo (*con la escuela, del municipio...*)? *Explique.*

D. PRODUCCION

Más o menos cuánto terreno utiliza usted para sembrar y criar animales? •<1 ha. •1-3 ha. •3-5 ha. •5-10 ha. •>10 ha.

Tiene riego? •Sí •No

De los siguientes animales, cuáles tiene, aunque sea unito?

Vacas para leche	Alpacas	Codornizes
Ganado para carne	Gallinas que dan huevos	Tilapia
Chanchos	Pollos para carne	Trucha
Borregos	Patos	Cuyes
Chivos/ Cabras	Ganzos	Conejos
Llamas	Palomas	*Otros:*

De los siguientes productos, que nomás tiene sembrado, o tenía sembrado este año pero ya se acabó? Aunque sea un poquitito, solo una matita?

	Acelga		Cebolla perla		Fresa /frutilla		Mora de castillo		Romanezco		Berro (puede ser en quebrada)		Guanábana
	Achojchas		Cebolla paiteña		Granadilla		Mora (otras)		Rúcula		Nabo		Arazá
	Aguacate		Cebolla puerro		Guabas		Mortiño		Ruibarbo		Nabo chino/extranjero/kale		Achotillo
	Ají		Cebollín		Guayaba		Naranja		Sábila		Plantas aromáticas/medicinales		Cúrcuma
	Ajo		Cereza (maribel)		Haba		Naranjilla		Penko				
	Albahaca		Cidra		Higos		Níspero		Sambo		***De climas cálidas:***		
	Alcachofa		Chía		Hinojo / eneldo		Oca		Taxo		Yuca		
	Alfalfa		Chirimoya		Jícama		Orégano		Tomate de árbol		Cacao		
	Amaranto		Chochos		Lechuga repollo		Paico		Tomate riñón		Café		
	Ataco / Sangorache		Cilantro		Lech. crespa		Papa		Toronja		Mango		
	Apio		Col		Lech. otras		Papa china		Trigo		Mangostino		
	Arveja		Col morada		Limón		Papanabo		Tunas		Maní		
	Avena		Col de bruselas		Lima		Pepinillo		Uvas		Piña		
	Babaco		Coliflor		Linaza		Pepino		Uvilla		Plátano verde		
	Chamburo		Cúrcuma		Hierba Maggi		Peras		Vainita		Soya		
	Chihualcán		Durazno		Maíz		Perejil		Zanahoria amarilla		Tamarindo		
	Brócoli		Espárrago		Mandarina		Pimiento		Zanahoria blanca		Banano / guineo		
	Camote		Espinaca		Manzana		Quinoa		Zapallo		Orito		
	Capulí		Estevia		Maracuya		Rábano		Zapote		Caimito		
	Cebada		Frambuesa		Mashua		Reina Claudia		Zuquini / calabacín		Caña de azúcar		
	Cebolla larga		Fréjol		Melloco		Remolacha		Lechuga limón/acedera/vinagre		Jengibre		

Ahora quisiera saber las variedades que dispone de unos ciertos productos (en el caso que los tenga): *Se puede anotar solo #, o por colores o nombres inventados.*

Producto	Variedades que tiene sembradas ahora	# Variedades
Maíz		
Frejol		
Papa		

Su producción es primero para: •el consumo en el hogar? •o para la venta? •o para los dos igualmente?

En la(s) feria(s), regala o intercambia (comparte, truekea) productos? •Sí. •No Cada cuánto más o menos _______ v/ ________

La última vez que hizo **trueke** en la feria, que productos **recibió**?

En su comunidad, regala o intercambia (comparte, truekea) sus productos? •Sí. •No. Cada cuánto más o menos? _______ v/ _____

La última vez que **regaló o intercambió** a otros en su comunidad, **que les dió** (a otros)?

Aquí en su comunidad, **vende** de sus productos a otros? •Sí. •No. Cada cuánto más o menos? _______ v/ ________

_______La última vez que ***vendió*** de sus productos en la comunidad, **que vendió**?

Cuáles son los últimos productos que usted **recibió** de otros ***en su comunidad***, sea porque le vendieron o porque le compartieron o cambiaron?

E. SALUD Alguna vez le ha dicho un médico que usted tiene...: •Nunca ha ido al médico

	Sí	No		Sí	No
La presión arterial alta o hipertensión arterial?			Enfermedad cardiovascular o enfermedad de corazón?		
Nivel alto de colesterol o de los triglicéridos de la sangre?			Anemia?		
Nivel alto de azúcar en la sangre o diabetes?			Cancer? Sí? Cuál ____________________________		
Gastritis?					

F. SOCIOECONOMICO Y DEMOGRAFICO

Cuántas personas viven en la casa, contando también a usted? ______________

Cuántos años tiene?   Me puede por favor decir la edad de cada miembro del hogar, y que relación tienen para usted? De estos, quienes son los que más trabajan en su terreno, sea para sembrar o cuidar los animales?

Edad entrevistada			Trabajo en terreno (entrevistada)?		
HOMBRES: Relación a entrevistada	Edad	Trabaja terreno?	MUJERES: Relación a entrevistada	Edad	Trabaja terreno?
H1. H2. H3. H4. H5. H6.			M1. M2. M3. M4. M5. M6.		

Que nivel de educación tiene usted?	Guardería o nada Parte de primaria Primaria Parte de secundaria Completó secundaria Universidad o pos-secundaria	Cuál es el nivel más alto de educación que tiene alguien en el hogar? Quién (#)?_______________	Guardería o nada Parte de primaria Primaria Parte de secundaria Completó secundaria Universidad o pos-secundaria

Comparando con otros en la comunidad, Usted considera que tienen •más ingresos (más rico), •menos ingresos (más pobre), •o igual?

Tomando en cuenta los trabajos y actividades económicas de todos en el hogar, de qué nomás ganan dinero para su hogar? (*Marque todos)*

•Vender en la feria •Vender productos agrícolas en otro lado •Vender productos transformados •Trabajar de jornalero/peón

•Otros:__

Cuántas personas aportan dinero al hogar a través de sus trabajos o de lo que venden? ________

De estos, alguien recibe un pago cada mes (un trabajo salariado), aunque sea un poquito? •No •Sí. Cuántas personas? ______

Alguien les manda dinero de otro lado, por ejemplo un familiar quien vive en la ciudad o en otro país? •No •Sí. Detalle____

Alguien en su hogar recibe el Bono de Desarrollo Humano? •No •Sí. Cuántos?___

Sumando todos los ingresos de todos los miembros del hogar, cuál es más o menos el ingreso mensual total de su hogar? ____________

Anotar BDH aparte (ej. $100 + 2 x BDH). También se puede anotar por salario básico (ej. 2 x básico).

F. ANTROPOMETRICO

Si desea, puedo medir su estatura, peso y perímetro de la cintura. Está de acuerdo con hacer esto?

Se encuentra embarazada o dando leche? •Embarazada •Amamantando •Ninguna

Entrevistada: Peso medido en kg__________ Altura medida en cm________ Perímetro de la cintura en cm_________

Tal vez alguien más en la familia quisiera saber su peso y su talla?

Relación a entrevistada (ej. nieta)	Edad	Peso (KG)	Talla (CM)	Perim. (CM)	Nota (ej. embarazada)

Agradecer y buscar No-Feriante en la comunidad.

Annex 4: “Conversations without borders” book chapter

This text is an English adaptation of the following Spanish-language book chapter:

> *Nadar, Danya, and Ana Deaconu. 2021. “Conversaciones Sin Fronteras: ¿Qué Podemos Aprender de Alimentos Tradicionales En Redes Alternativas de Palestina y Ecuador?” In Distribución, Comercialización y Acceso a Alimentos de Calidad En América Latina, edited by Sebastián Grenoville, Julie Le Gall, and Julien Noel, 22–42. Buenos Aires, Argentina: INTA Ediciones.*

Conversations without borders: What can we learn from Palestinian and Ecuadorian experiences with traditional foods in alternative networks?

Danya Nadar and Ana Deaconu

Abstract

This chapter presents lessons from a dialogue on traditional foods in Palestine and Ecuador, based on the qualitative studies conducted by the two authors in these locations. We found that, in both locations, traditional foods constitute responses to hegemonic threats toward cultural identity. In Ecuador, the oppressor is the agri-food industry. In Palestine, it is the Israeli occupation. In this sense, traditional foods become components in a subversive practice that depends largely on alternative mechanisms for production, distribution and commercialization. We sustain that these mechanisms are consolidated in alternative food networks in both locations, although they take on distinct forms. Despite the need to pass through multiple alternatives and at times dangerous mechanisms, in both regions there exist actors who ascribe sufficient value to traditional foods to seek out creative solutions throughout the commercial value chain.

Key words: traditional foods, alternative food networks, Palestine, Ecuador

Introduction

In a great socioeconomic paradox, smallholder family farmers produce 70-80% of the world’s food, but they face concerningly high levels of food insecurity (FAO 2014). Traditional smallholder farmers and pastoralists are essential contributors to food and nutrition security in the Global South (Altieri 2008; FAO 2014). Much of their crops and animal products are consumed locally and regionally, and they provide a diversity of nutrient-rich and culturally relevant foods (Johns et al. 2013). This has been placed at odds with global food security concerns: efforts to satiate a swelling urban population drove the agenda for agricultural intensification and increased production of cereal crops. Now, 75% of all plant-based foods are derived from only 12 crops (FAO 1999; Johns et al 2013). Meanwhile, industrial agriculture is considered one of the major generators of greenhouse gas emissions globally. The literature is at a crossroads: how do we simultaneously feed a planet that is expected to reach 9 billion by the year 2050, decrease the carbon footprint, and keep smallholder farmers growing nutrient-dense foods on their own land?

The authors of this paper believe there is no silver bullet to solving the malnutrition and food security crisis, but rather a toolbox. As such, we explore the decisions farmers make in order to engage in traditional foods systems. We are interested in traditional products for their potential to promote biodiverse agriculture, which is coherent with environmental values, resilient in the face of global climate change and does not generate dependencies on external inputs nor holds the health consequences associated with modern pesticide use (Padulosi et al. 2013; Chivenge et al. 2015; Cook 2018). For these characteristics, family farming based on traditional products is recognized for its capacity to protect and strengthen farmer livelihoods (ibid). Further, we are interested in the foods derived from traditional products for their potential to promote culturally relevant and nutritionally healthy food (Kuhnlein et al. 2009; Padulosi et al. 2013). Finally, the production and consumption of traditional foods recognizes and strengthens Indigenous knowledge in a global context in which much of this knowledge has been neglected and undervalued (Padulosi and Frison 1999; Kuhnlein et al. 2009).

We explore these themes from a perspective that purposefully ignores regional frontiers with the intention of contribution to knowledge exchange in the Global South. We seek points of intersection between the research conducted with Indigenous communities in Bethlehem, Palestine and Imbabura, Ecuador. Our use of the term “Indigenous” is not intended to collectivize distinct histories that have endured their own struggles against colonialism and capitalism, but rather to internationalize an Indigenous peoples’ network toward the survival of traditional food systems (Smith 2008). Additionally, we do not apply a definition for what counts as a "traditional" product and instead defer to each individual's definition according to their own sociocultural and biocultural context within their own historical continuum (Johns et al. 2013). Further, while we use the terms "producer", "distributor" and "consumer" for clarity, we recognize that these fixed prototypes are false, given that we are all consumers, that producers can also be distributors, and vice-versa. Finally, we take this opportunity to add to the literature on AFNs operating in the Global South.

This chapter emerged from the two authors' interest in exploring Indigenous and traditional food systems. This common interest led us to exchange knowledge and observations from our study regions, Palestine and Ecuador, through conversations prior to and following our respective data collection forays. Because of the geographic distance and political and cultural realities that separate Palestine and Ecuador, we at first viewed the two locations as drastically different spaces, and we were only united by our shared methodological interests. Yet eventually, we began to identify strong intersections that entered into conversation with the global discourse on alternatives to the hegemony in food systems. When Nadar proposed this comparative angle in a 2019 Latin American conference on food sovereignty, she was met with both curiosity and skepticism: what is the relationship between the food systems of two such distant places?

We thus recognized the value of juxtaposing the knowledge and experiences around traditional foods in Palestine and Ecuador, not only for ourselves, but for a broader audience. In this chapter, we therefore tell the stories of traditional foods in these two countries, as we understand them, by integrating literature review on historic and political perspectives with observations gained from our own experiences conducting qualitative research.

1. Methods

Nadar's research in Palestine is phase two of a larger study on community biodiversity management in the West Bank. The first phase (June-August 2018) focused on community seed saving models and their impact on agrobiodiversity and farmer autonomy in the West Bank. The second phase (June-August 2019), which provided the data for this chapter, utilized ethnographic methods and direct participant observation to explore traditional food systems (including production, distribution, access and consumption) in the Bethlehem region. Interviews were conducted with: 30 producers (28 of whom produced on less than 2 hectares of land), 15 consumers and distributors (including small businesses, traders, wholesalers), three key informants, and five young people involved in organizing various initiatives for creating awareness among consumers. While we apply these categories to organize the data, in reality there is very little differentiation between what constitutes a producer, consumer, distributor, informant and the youth movements, as many of these roles intersect in their everyday lives.

Deaconu conducted qualitative research as part of a mixed method, multi-phase project in Ecuador's highland Imbabura province. The general objective of this project was to explore the relationships between agroecology and nutritional health among farmers that participated in agroecology-based alternative food networks. This chapter is based on data obtained between February and April 2019. Eight focus group discussions with a total of 128 farmers who sell in agroecological markets were used to explore perceptions on production, consumption and sale of traditional foods. Eight semi-structured interviews with the leaders of each market inquired in further detail on the same subjects.

2. The stories of traditional foods in two locations

2.1 Palestine

2.1.1 Traditional crops as the carriers of the DNA of resistance

Palestinians are among the original people of the West Bank (Salhani 2016; Erakat 2019), and they are currently fighting for liberty against modern colonialism (Khalidi 2020). The occupation of the West Bank since 1967 has resulted in the territory's lack of autonomy over its own resources, such as land and water, and its own borders, including the movement of people and goods (Isaac and Gasteyer 1995). In this context, we focus on the Bethlehem governorate to document an economy at risk of extinction. We trace the effects of occupation on the struggle for survival of traditional crops and associated knowledge, and on the struggle of the farmers that grow them. Further, we explore a nascent youth movement working to revalorize its own food heritage. As one local food activist puts it: "traditional crops carry the DNA of Palestinian history and existence under Israel's occupation."

2.1.2 The history, value and network of* baladi *crops in the Bethlehem region

The Bethlehem region is nestled in the West Bank highlands and contains two agricultural production zones: the eastern slopes are dry, traditionally used for ruminant grazing; the central highlands in the western section of the governorate (the focus of our study) is hilly and lush with fertile land, scattered with pockets of natural water springs. The latter is an ideal climate for the harvest of traditional fruits, vegetables, and olives (Aquastat 2008; UNCTAD 2015; CBD 2015). Most farmers in our studied region are smallholders, farming on less than 2 hectares of land (relative to Palestine's average of 4 ha) and depend on 300mm-600mm of annual rains and natural springs for irrigation.

Agriculture originated in the Fertile Crescent sometime between 13,000 – 11, 500 BC, and Palestine is home to several native species of wheat, barley, lentil, and chickpea (CBD 2015; Ceccarelli 2015). Beyond static definitions of traditional foods based on concepts of "centers of origin" (Ceccarelli et al. 1995; Shrestha et al. 2013), many Palestinian farmers interviewed expressed that what "localizes" the diversity of traditional crops is their management by local farmers (Fieldnotes 2018). Rather than referring directly to "traditional" products, Palestinians use the term *baladi*, which literally translates from Arabic to mean "my country". In the

Bethlehem region, baladi has multiple definitions, each of which depends on the context in which it is used (Fieldnotes 2019). For example, baladi crops could refer to those that have been historically grown in the region and that were used to make traditional meals. Some Palestinian farmers, baladi refers to crops that are cultivated using natural farming methods, without the use of synthetic agricultural inputs. Many baladi crops have a cultural and historical connection to a specific village, such as the white cucumber from Beit Sahour, or the *Battiri* eggplant from Battir village. Some people use the term baladi to refer to heirloom crops, while others make the distinction that they are non-hybrid and non-Israeli produced crops. When traditional crops are abundant in the summer months, sellers in Bethlehem's dense central market shout "baladi tomatoes! baladi cauliflower!" signaling to buyers in earshot that they are selling a product that is high-quality, flavourful, unique, traditional and locally grown. Market clients are willing to pay a small premium for these products because they value buying and consuming baladi products, especially when they come directly from the people whom they identify as farmers—even though that is not always the case. Households visited while conducting this study shaped their meals according to the season of baladi crops: zucchinis, stuffed grapevine leaves, stuffed bottle gourd, mallow stew, Armenian cucumber, grapes, among others.

However, few Palestinian farmers continue growing baladi. Among those who do, one expressed preferring to cultivate these farmers "because what's healthy for the soil, is healthy for our bodies, and healthy for my family" (Interview 2019). *Baladi* seeds are still found among farmers and they are exchanged regionally; baladi crops not sold in the market are found in home gardens and gifted to neighbors and visitors. Some farmers value the seeds' adaptability to a changing climate and sporadic rains, while others describe the importance of maintaining a heritage crop (Nadar fieldnotes 2018 & 2019). Almost all invoke the distinct flavour of a baladi crop and consider this to be a flavour that Israeli crops cannot offer (Fieldnotes 2018 & 2019).

Conversations on baladi crops interweave with the stories of each territory. For example, the famous apricot from Beit Jala (*mishmish Bajajly)* was historically called the mother of the family (*om el 'eila*), making reference to abundance and family security. During its short 10- to 14-day season, Beit Jala households drove truckloads of *mishmish* to the market and earned enough money to sustain a family for an entire year. It is becoming increasingly rare to find these apricots sold in the market today: some farmers lamented that the trees had lower yields, while others recounted that the trees were cut to make room for an urbanizing community (Fieldnotes 2019). However, many home garden plots and farmer fields continue to maintain this variety of apricot, and people who have them gift their surplus to families and friends.

The Sahouri white cucumber still exists in farmers' fields: sometimes, it dots patches of hybrid cucumbers, but it is mostly found among a small number of farmers who grow only baladi products. One farmer, who grows enough of the white cucumber for his family and sells his surplus to villagers, lamented that his crop yields much less than it used to because of soil degradation caused by the increased pressure on the land and runoff from neighboring Israeli settlements (Interview 2019). This farmer's land is in a part of Palestine designated as "Area C", a designation that is directly under Israel's military control. As a result, whenever he needs to dig, build, or make renovations to his land, he is required to seek authorization from Israel's military administration, which only approves 1% of requests (OCHA 2015).

To understand this farmer's reality, it is necessary to understand the political and territorial context of Palestine. According to the Oslo Accords[1], the West Bank is divided into three zones: Zone A contains Palestinian cities under autonomous Palestinian control; Zone B is under shared control between the Palestinian Authority and the Israeli military administration; and, Zone C is under total Israeli military control. The Bethlehem governorate is fragmented by these zones. Approximately 220,000 Palestinians live in the urban Zones A and B, which comprise 13% of the region. Approximately 26,000 Palestinians who live in Zone B have access to agricultural land in Zone C. They find themselves affected by illegal Israeli settlements and run the risk of having their land annexed (NAD 2017; PCBS 2017). An 87% of the Bethlehem governorate is designated as Zone C; this area is split between land occupied by Israeli settlers in gated and heavily guarded communities, designated military zones, and environmental protectorates that prohibit access to Palestinians (Clarno 2017; OCHA 2015).

In fact, 87% of the Bethlehem governorate is considered Area C providing nominal access to Palestinians, and the more than 220,000 Palestinians live scattered on the remaining 13% of the region (Clarno, 2017; PCBS, 2016; PCBS, 2017).

2.1.3 The effect of the occupation on **baladi** *production, distribution and access*

Illegal Israeli settlements[2] in the Bethlehem region constitute 12% of the governorate with a population of 130,000 Israeli settlers (NAD 2017). In recent years, settlement building has expanded downward, teetering over the valleys where Palestinians farm their land (ibid). Since 2017, the Israeli ministry of tourism has been distributing maps to Israeli settlers and encouraging them to explore the valleys, go camping, and swim in natural springs near where

[1] In September 1993, the Government of Israel and the Palestine Liberation Organization signed the Oslo Accords, a set of agreements defining territorial and administrative borders for the occupied Palestinian territories (Taghdisi Rad 2015; Roy 1999).

[2] Israeli settlements are illegal under the UN Security Council resolution 2334 (reaffirmed in 2016) (Office of the EU Representative, 2019)

Palestinian farmers cultivate their land (Interviews & field observations 2019; Haaretz, 2019, Clarno, 2017). Palestinian farmers have observed tourists bathing in their water sources, destroying crops and damaging agricultural infrastructure. Instead of making efforts to protect Palestinian agriculture, the new trend of “exploration” of the region has received institutional support in the form of confiscation of natural springs for exclusive Israeli use. This is the case in Al-Wallajeh village, where Palestinian farmers have lost access to the springs on which they depend for irrigation (ibid). Israeli settlements and outposts have also set up near to or surrounding Palestinian agricultural land. This is the case for the villagers of Husan, who require special permits to access their fruit and olive trees, and for the landowners in Al-Khader, who find themselves monitored and questioned by Israeli settlers (LRC, 2017; Clarno, 2017; Interviews, 2019).

Palestinian farmers struggle to preserve traditional crops is linked to their lack of autonomy over their borders and weak local governance. Israel treats its boundary with the West Bank as an international border, and it treats the regions as a captive market that it can utilize for Israeli benefits (UNCTAD, 2015). For example, it only “imports” specific crops from the West Bank when Israel has a shortage, and it does so according to strict and unreciprocal sanitary and phytosanitary regulations. Moreover, it “exports” its subsidized lower-quality crops (which are considered too low of a quality to be consumed in Israel) into the West Bank, flooding the market and eliminating any Palestinian-produced competition (ibid; World Bank 2017). Moreover, the production, distribution and sale of agricultural goods in the Bethlehem governorate lacks protective laws and regulatory oversight by the local Palestinian authorities. Farmers incur all costs associated with the production, distribution and sale of their crops, and receive no compensation for losses or market irregularities. No regulations exist to organize extension agents and monitor inputs sold to farmers. There are no sanitary and phytosanitary standards available to protect Palestinian consumers. The local Palestinian authorities’ sole responsibility at every step of the value chain is acting as tax collector.

This regulatory vacuum and market unpredictability narrow the options for traditional crop farmers. When choosing which baladi crops to produce, they prefer those with no hybrid equivalent. This is because market prices of hybrid crops are so low that the baladi equivalent would not be able to compete. Further, consumers do not always know how to distinguish between a baladi product and a hybrid equivalent and thus prefer to purchase the cheaper option. For example, traditional tomatoes have virtually gone extinct from the market due to the influx of cheaper hybrid vine tomatoes with which baladi tomatoes cannot compete. Because it does not make economic sense to produce baladi tomatoes for sale, farmers only grow them for their own consumption or for the gifting and barter economies. On the other hand, traditional crops such as Battiri eggplant, bottle gourd, grapevine leaves, and mulberries, among others, do not have a hybrid equivalent and are therefore also sold in the central market. However, to obtain a better price point, farmers prefer to sell these products directly to consumers or to several specific wholesalers, creating an informal short food supply chain.

2.1.4 Access and sales of traditional crops

Gendered divisions exist from the production to the sale of baladi crops. In general, men are in charge of saving seeds and deciding what to cultivate and they also involve the young men in the household in the harvest. Meanwhile, their wives and daughters manage the packaging, marketing, sales and the relationships with customers and wholesalers. The women usually maintain their own home garden where they grow baladi to supplement household needs. One such baladi farmer has managed to organize her own market circuit: she takes her neighbors' orders, then prepares the products and sets a price at a small premium over the market price, and delivers it to them (Interview 2019). She explains: "I want to benefit from the sale but not give the impression we are taking advantage. We are known in the community for our good quality crops. We want our neighbors to keep coming back so we keep a fair price: fair for us, and fair for them." Nadar (2019) observed that rural families' access to fresh seasonal *baladi* crops, either from their own home gardens or from their neighbors' field, increases their access to dietary diversity.

Entirely female-led farming is often found among the *hajjat*[3]. The hajjat that were interviewed were typically older women that have either inherited the profession from their mothers-in-laws, or who work to supplement their husbands' income. The hajjat buy or lease land for agricultural use, and they are the primary decision makers from seeds to production to sale, without intervention from their husbands. Historically, the hajjat lined the alleyways of Bethlehem's central market selling their harvest, but today they are spread thin and only a handful of them sell their own cultivated goods. Those who do grow traditional products from their own production find various means to sell directly to their clients, without intermediaries. Arriving from villages near Bethlehem, some hajjat sit in the same part of the central market each day until they finish selling their products. Every morning, the hajjat establish a price at a small premium over that of the intermediaries that surround them. Their loyal customers often buy from them in bulk because they appreciate the consistent quality of their products and also want the hajjat to benefit directly. However, the hajjat cannot always set their own price because they compete with deflated market prices, and because certain customers who do not value the distinction between baladi and conventional products try to negotiate for a lower price (Fieldnotes, 2018-2019).

---

[3] *Hajjat* is the plural form of *hajja*. It literally means a woman that has performed Islamic pilgrimage in Mecca (*haj*) but it is colloquially used when speaking or referring to an older woman.

Some hajjat interviewed have stopped selling in the market altogether, considering it undignified to sit in alleyways for 10-hour days that end at unpredictable hours. They prefer to pack their car with their crops three days a week and visit their customers in their homes or places of work. Sometimes they take pre-orders, but usually their customers expect them to show up on a certain schedule so that they can choose what to buy. These hajjat have the luxury of choosing who to sell to, and they prefer regular clients who value the quality of their products and do not attempt to reduce the price. As one hajjat remarks, “I have my autonomy, my dignity and a lucrative farming business. I have peace of mind” (Interview 2019).

Bethlehem’s historic, religious and economic relationship to Jerusalem was severed in the year 2000 when the Apartheid Wall was built (Clarno, 2017; NAD, 2017). This has affected many farmers including the hajjat, most of whom used to sell in Jerusalem (Fieldnotes, 2019). The Wall acts as a physical barrier that limits the access of Palestinians under the age of 65 to Jerusalem and historic Palestine. Similarly, it hinders the entry of Palestinian crops. There remain a few hajjat, typically those over 65 years-old, that manage to smuggle their traditional crops into Jerusalem to sell to Arab Jerusalemites (Clarno, 2017; Fieldnotes 2019). A combination of the high cost of food, the rare access to these crops, and the building of trusting relationships with these hajjat have created a climate where Arab Jerusalemites are willing to pay a premium to obtain baladi crops. However, for younger Jerusalemites, the Apartheid Wall has caused a psychological and cultural shift interrupting the knowledge of and interest in baladi crops across generational lines. When Nadar asked young Arab Jerusalemites about baladi crops, she was met with a puzzled reaction, “what are baladi crops?” Meanwhile, when mothers of a generation that was only slightly older found a *ratl* (3 kilos) of Battiri eggplants, they responded with excitement and glee. This reality differs drastically from Bethlehemite shoppers on the other side of the Apartheid Wall only 10 kilometers away: while their knowledge and ability to recognize baladi is diminishing because of the occupation, they nevertheless continue to seek, eat, and value seasonal traditional crops.

2.1.5 Revalorizing* Baladi *in the Bethlehem region

The growing extinction of baladi foods is what inspired an emergence of various youth groups seeking to revalorize baladi crops and traditional cooking, and mobilize Bethlehem’s Palestinian society to reconnect with farmers and the land. Many youth-led initiatives have emerged across the Bethlehem governorate since 2014 (Fieldnotes, 2018 & 2019). These initiatives organized in response to concerns regarding the diminishing access to traditional foods in Palestinian cooking, in the market, and in the fields. They exist to fill the regulatory vacuum in support of farmers and to engage Palestinian society in a conversation on their food heritage. As one youth leader put it, their initiative exists “to bring biodiversity back into the fields, and onto our dinner tables.” The Palestinian Heirloom Seed Library, led by a young woman, focuses its activity on seed saving and sharing among farmers and community members to recover and revive agrobiodiversity. In another example, a group of youth from Battir village concerned with Israeli settlers squatting farmland and hilltops organized and lobbied for UNESCO World Heritage Site recognition of the village’s traditional community farming systems. Another initiative, *Farayek*, shares its name with the Bethlehem pastry. It is led by two young women (one Bethlehemite and one Jerusalemite) who aim to “stimulate rich food experiences” by offering culinary tours of Bethlehem’s central market to both locals and visitors. They support their participants in experiencing traditional regional cuisine and arrange visits to nearby farmers’ fields. These visits serve to stimulate a visceral experience of picking baladi crops, reconnecting with the land, and strengthening connections and trust relationships with farmers.

Municipal and village councils are also starting to collaborate with their community centres to organize crop festivals, such as the lettuce festival in Artas and the eggplant festival in Battir. Moreover, alternative food networks in the form of farmers’ markets have begun to emerge in the West Bank, supporting baladi producers in revitalizing the agricultural heritage of the region before it disappears. Such is the case in the Beit Jala municipality, which is creating a formal sales location where baladi producers can sell their organic products.

One initiative deserving special mention is a farmer-led association working to support the village’s producers that depend on farming for their household income. Together, the association members discuss their needs and concerns and make decisions on finances (e.g., starting a seedling nursery to generate income or applying for funding), marketing and distribution, group activities and advocacy (e.g., cleaning the spring canals or writing a collective letter to the regional government). They also share sales opportunities. For example, when consumers are looking for a specific product, the producers help direct them to the producer who has it. They also work to document and report Israeli settler violence on their land and have filed complaints to Israel’s Military Administration and the Israeli courts to issue injunctions against settlers’ expansions of buildings. These new initiatives provide reason for optimism around the possibility of promoting baladi products rather than leaving them to be forgotten.

2.2 Ecuador

2.2.1 The traditional as a reaction to the modern

Many of the traditional agricultural practices that persist to date in Ecuador originated before the arrival of the Incas. These practices, including the *chakra andina, wachu rozado, chakra amazonica, aja shuar, finca montubia, huerto palta*, *finca pasto, canoero, colino,* and *cantero*, among others, show creative adaptations to the country's unique and often complex biogeographic regions, including to its high-altitude Andean mountains, coastal mangroves, dry forests, and Amazonian river banks (Gortaire 2016). Such traditional practices, which depended largely on leveraging beneficial biotic relationships and optimizing biodiversity, are coherent with the tenets of the modern concept of agroecology. Drawing on traditional knowledge from around the world and modern, multi-disciplinary science, agroecology applies ecological principles to create self-sustaining and regenerative agricultural environments (HLPE 2019).

As anywhere, what is recognized today as traditional agricultural practice has been shaped by processes of change. Traditional agriculture in the Andean region was threatened by the arrival of the Spanish and the ensuing changes in agrarian structures. In the period after Spanish conquest, agricultural labor was much displaced to favor mining and textile industries. The subsequent fall of these industries in the 1800s heralded an economic return to agriculture, and the rise of two dominant agrarian patterns: on the Pacific coast, the cacao boom (and later the banana boom) formed an agro-exportation model that favored monocultures and displaced family farms; in the Andean highlands, haciendas, known in Ecuador as *huasipungos*, assured an Indigenous labor force to large property owners through feudal coercion systems; meanwhile, the Amazon was largely left alone, its landscape perceived as inhospitable and its inhabitants as "savages" (Gortaire 2016; Zamosc 1989).

In the highland region, which this chapter will focus on primarily, the *huasipungo* feudal system "gave permission" to Indigenous people to live on, and cultivate, small plots of land in exchange for free labor to the property owner (Zamosc 1989; Waters 2007). This coercive system nevertheless meant that indigenous farmers continued to implement the traditional self-sustaining, resource-efficient, and biodiverse farming practices on their plots of land, albeit under constrained conditions. Given that their primary source of food was what they produced on their own plots, or through trade within the community, farmers in the highlands had to maintain a large diversity of domestic animals, food crops, and medicinal plants (Gortaire 2016).

Agrarian reform policies beginning in the 1950s formally dismantled the feudal systems in the highlands and redistributed land to the people who were actually using it—that is, Indigenous farmers. However, this process largely favored the landowners, who received large sums of money for land that was no longer economically viable, and relegated Indigenous farmers to small plots in marginal spaces, including high altitude, sloped lands with no irrigation system

(Waters 2007). Further, they were left indebted due to land procurement expenses. The need to pay off debt and the desire to integrate into markets led many farmers to shift away from traditional practices and toward novel agricultural trends: specifically, crop specialization and the use of newly available Green Revolution technologies (Gortaire 2016).

Despite these changes, many highland farmers maintained their traditional practices by implementing a double-strategy: on part of their land, they produced for the market using "modernized" approaches including application of agrochemicals; simultaneously, they produced for home consumption, using organic traditional agroecological practices based on biodiversity and efficient use of natural resources (Gortaire 2016). For many families, this double-strategy was gendered, wherein men would primarily manage cash-crops and women would primarily manage the diverse crops for home consumption (Heifer 2014). Over time, many farming families that had invested in the Green Revolution began losing revenue on cash crops as their soils became depleted. Finding themselves indebted to agrochemical companies and burdened by health consequences of pesticides, many abandoned the project of modernization almost entirely and returned to the safer route of traditional agriculture approaches.

By the 1980s, these production shifts were accompanied by rhetoric and social movement organizing in favor of an "alternative" to market capitalism (Peña 2013). While state and agroindustry discourse sustained that traditional practices were obsolete, small landholders found that the technocratic "modern" practices demanded resources and infrastructure beyond their possibilities in order to be successful, and the use of agrochemicals took an unreasonable toll on their physical health (Gortaire 2016; Deaconu et al. 2019). Meanwhile, certain scientific and academic organizations became concerned with the environmental impacts of agricultural modernization and began promoting the reintegration of plant and animal agrobiodiversity, soil conservation practices, appropriate water use, native reforestation, and organic fertilizers (Gortaire 2016; Deaconu et al. 2019). By 2003, the sum of these concerns led 10,000 farmers in Northern Ecuador to block the Panamerican highway in protest (Sherwood and Paredes 2014).

In parallel to this evolving discourse, farmer groups and urban consumers increasingly organized around "alternative" farming embodying various practices and concepts—organic, solidary, healthy—until these interrelated concepts convened around agroecology as a unifying vision (Gortaire 2016; Sherwood et al. 2013). To distinguish their farming strategies from others and to promote economic viability, farmers groups—often with the support of the Indigenous movement or in partnerships with NGOs—began commercializing their specialized products in alternative food networks (AFNs). Most often, these took on the form of farmers' markets, but also included food boxes, solidarity stores and other formats that reduced market chain lengths and created relationships between producers and consumers (Gortaire 2016). AFNs adopted different structures and internal regulations largely defined by their identities, the most common of which are agroecological markets and “solidarity” (direct-sale, but not necessarily agroecological) markets. By 2013, at least 210 such AFNs were documented across the country (Heifer 2014), and networks of AFNs had consolidated their role as a social movement with the power to influence national policy, including by integrating ideals around food sovereignty and social and solidarity-based economy in Ecuador's new 2008 constitution (Sherwood et al. 2013).

2.2.2 Traditional foods in the identity and practice of Imbabura province's alternative food networks

In Imbabura province, the close ties between AFNs and traditional agricultural practices meant that AFNs also became homes to crops that were culturally perceived as traditional. Nevertheless, the definition of what counts as a traditional crop varies widely even among farmers of the same AFN. For some, it includes all endemic Andean foods. For others, it includes only the endemic Andean foods for which decades of marginalization from modern agriculture have won a title as “traditional.” This generally also includes products that were once marginalized but are now enjoying a surge in popularity, most notably quinoa. For still others, traditional crops are those that were largely enjoyed by previous generations but have lost popularity over recent years, particularly outside of rural, Indigenous communities. This definition also includes certain Eurasian crops, such as barley (Focus group discussions 2019). What is defined as traditional also depends on variety. For example, native potato varieties are considered traditional, but "improved" varieties are not. Further, traditional foods are distinguished by their preparation, such as in the case of "Indigenous" bread, which is considered traditional, and "mestizo" bread, which is not (Fieldnotes 2019).

Despite the diversity in definitions of traditional foods, there is nevertheless predominant consensus on the role of traditional foods in AFNs, and the role of AFNs in promoting traditional foods. AFN farmers see the production of traditional crops as integral to their agricultural strategy because endemic crops tend to be better adapted to their soil and climatic conditions, and are more resistant to droughts, pests and other shocks (Interview 2019). Further, they see AFNs as a space where there is market demand for traditional crops. Some believe that AFN sale of traditional foods catalysed consumer demand for traditional foods. Others believe it to be the other way around, such as one farmer who states: “We farmers, we sell our ancestral products, and the consumers are the ones who eat them more than we do.

The clients seek products that even I did not know about, like black *oka, sidra, jicama, chamburo, achogcha...*" (Focus group discussion 2019).

Many farmers express that their participation in AFNs has led them to revalorize traditional foods, both for sale and for their own consumption. One association leader explains this from her own personal history: "Long ago, we ate quinoa leaves two or three times a week, we ate quinoa soup, quinoa gruel with milk... but back then, quinoa did not sell well in markets, so we reduced our production. But now, in the [agroecological] market, we know that quinoa is a very important food, and we are rescuing it in these markets" (Interview 2019). Another farmer recounts: "With the market, we value traditional products more. Before, we were not like that. Before, we did not eat them (Focus group discussion 2019). In fact, for some farmers, their AFN has also re-introduced them to traditional crops or crop varieties that were largely lost to their generation. This is the case of one elderly farmer who recounts that he remembered jicama (*Smallanthus sonchifolius*) from his early childhood, but he then forgot about this product until joining his AFN. He has now been selling jicama in the agroecological market for the past six years. Another farmer from the same association expresses that for her, jicama is an altogether new food in her life (Focus group discussion, 2019). Despite the existence of such "new" traditional foods, farmers view most traditional products as a continuous part of their lives, not as a novelty. One farmer states: "We grow traditional products because we are already used to growing these, because we live from these" (Focus group discussion 2019). Regardless of their personal histories with traditional foods, AFN farmers discuss traditional foods as a key part of their current identity, and the rescue of traditional products or varieties becomes a status symbol (Deaconu et al 2019; Focus group discussions 2019: Interviews 2019).

While agroecological AFNs were not created expressly for the intention of promoting traditional foods, farmers express that the AFN affords them unique access to seeds for growing traditional crops, which therefore allows them to also consume them more than non-AFN farmers (Focus group discussions 2019). Given that many traditional crops were largely ignored by modern agriculture, some seeds are not readily available in conventional channels for seed purchase. AFN farmers instead rely on barter to obtain seed and to promote the production of less common varieties. Seed barter occurs both informally, among neighbors, fellow AFN members or other acquaintances, as well as through formal gatherings that are often organized by the Indigenous federation, NGOs or local state entities, often in conjunction with AFNs (ibid). Moreover, AFN farmers express that they barter for the traditional products that do not grow in their own climatic niche, thereby increasing the diversity of foods in their diets (ibid).

Much of the interest in traditional foods revolves around perceptions of their health benefits. One farmer states: “Ancestral products are important because they are medicinal, and they also give us energy. They are important for health and for nutrition. This is why we eat them." Several farmers allude to a sense of resilience and food security, stating that traditional grains and tubers grow, and can be consumed, even when drought, pests or other shocks come along. Others find that traditional practices are integral to maintaining overall wellbeing: "The people who migrate to the city do not find a good life. This is why we recover our ancestral way of life and look for ways to live in the countryside, valuing the land and our own lives" (Focus group discussion 2019).

In all focus group discussions, farmers discussed traditional foods in an intergenerational context. While many invoked their grandparents, others expressed a sense of responsibility toward the health of their children and future generations. As one young farmer says, "I value ancestral practices because, as a mother, it gives me more peace to slaughter an animal that I myself raised and to feed it to my children than to buy it in the market. I know what this animal ate and how it lived." The concern that younger generations are not interested in consuming traditional products resonates widely among AFN farmers.

2.2.3 Women as stewards of traditional products in AFNs

Although women are primarily responsible for food preparation, in Imbabura AFNS, both men and women raise concern for the future of their children regarding traditional food consumption. Similarly, AFN farmers do not volunteer any comments that would suggest traditional foods as having a gendered role. Nevertheless, 82% of farmers that we encountered through AFNs were women (Focus group discussions 2019). If AFN spaces are so critical for promoting traditional foods, then it is necessary to recognize the role of women in these spaces. Moreover, it is worthwhile to explore what may have created this gender dynamic in which AFNs are primarily composed of women.

Gender roles in Ecuadorian agriculture frequently lead to men managing cash crops and women managing smaller, more diverse plots of land intended primarily for home consumption. Given this situation, our previous research in the region found that agroecological AFN participation resonated with women, as their diverse home production was already largely consistent with agroecological practices (Deaconu et al. 2019). Moreover, market participation allowed them to gain control of income, albeit a small amount. Prior to joining AFNs, women did not have many opportunities to sell to intermediaries or in other commercial market channels because these channels required them to sell each product in bulk, and women only had small quantities of each product. Instead, the format of the AFN uniquely allowed women to monetize small surpluses of diverse products (ibid). Besides this new control of income, women found AFNs to be a space that allowed them to form new social relationships, strengthen and demonstrate their knowledge and leadership, and articulate values to create a shared identity. Notably, one of the central values to this shared identity was the promotion of traditional foods (ibid).

2.2.4 Traditional foods as a point of pride

At the beginning of our research on traditional foods among AFN farmers in Imbabura, we had taken hints from existing literature (e.g., Peñafiel et al. 2016; Keller et al. 2005; Smale et al. 2004) to hypothesize that traditional foods would be more commonly consumed as a coping strategy by the most vulnerable farmers, specifically elderly farmers living in poverty and far from markets. Yet upon assessing this hypothesis with a survey on traditional food consumption, we found that none of these conditions—age, poverty or market distance—was associated with the diversity or frequency of traditional food consumption (Deaconu et al. 2020). This quantitative result is consistent with farmers' discourse in interviews and focus group discussions, in which farmers clarified that traditional foods are a source of pride rather than a marker of struggle. More strikingly, we had also found this to be true when we stratified data to only assess non-AFN farmers, who are not necessarily involved in social environments that promote traditional foods. This suggests that, more generally, traditional foods are not the mere relics of the old, remote, and poor in Imbabura province (Deaconu et al. 2020).

Nevertheless, we did find that AFN farmers produced and consumed a greater diversity of traditional foods than their neighbours, and they consumed them more frequently (Deaconu et al. 2019). This result corroborates the perspectives of the farmers that claim AFNs to have increased the importance of traditional foods in their lives. In both quantitative and qualitative data, we found that AFNs are important spaces for the promotion of traditional foods in Imbabura province. While we do not have data on this subject for other parts of the country, agroecological AFNs in Imbabura share many aspects with those in other provinces. In fact, in national meetings that bring together leaders of AFNs from nearly all of the country's provinces, it is common to open or close the events by creating a ceremonial mandala of traditional grains, tubers and fruits (Deaconu et al. 2019). This suggests that the affinity between AFNs and traditional products is a phenomenon that extends more broadly throughout Ecuador.

3. Dialogue between the traditional foods of Palestine and Ecuador

When we first spoke of our respective experiences around producers and sellers of traditional foods in Palestine and Ecuador, we remarked how farmers in both regions knew as facts what interdisciplinary sciences are only recently recognizing: first, that traditional crops are better adapted to challenging land; and second, that foods grown in traditional ways (i.e., non agro-industrial) are better for human health.

Curiously, Palestinian and Ecuadorian farmers arrived on this common understanding despite having experienced very distinct histories shaping their relationships to traditional foods. Although Ecuadorian farmers' definitions of "traditional" are varied, there is a strong sense that the traditional stands in opposition to modernity, and that the value around traditional practices is tied to the value of Indigenous identity. In contrast, Palestinian traditional foods are perhaps less tied to a sense of time passing and the world changing, as they are tied to an identity that resists political and economic hegemony. Yet for both, adhering to the traditional is a means of resisting oppression: in Ecuador, the oppressor is the agri-food industry; in Palestine, the oppressor is Israel. In Ecuador in particular, the strength of organization in alternative food networks seems to be a step moving from an act of "resistance" to an act of asserting "existence", as discussed by Sherwood and colleagues (2017). In Palestine, alternative food sales largely remain informal and independent, perhaps lacking the "network" element that is so strong in Ecuador. However, budding efforts to organize may be fruitful in creating a social environment to consolidate values around traditional agriculture and food.

In both Ecuador and Palestine, traditional foods are primarily sold by women. While in Palestine, women sell the products grown by their husbands, in Ecuador's AFNs, women are often both the primary producer and the seller of traditional foods. However, the differences are not so homogeneous. For example, in Palestine, the hajjat women have economic autonomy and can determine the terms of production, distribution and sale of baladi products. These distinctions are critical for understanding both women's role as stewards of traditional foods, as well as for understanding how traditional food sales can specifically impact women's livelihoods.

We find it interesting that in both regions traditional foods, representing an “alternative” to the foods that dominate conventional markets, require multiple alternative mechanisms to advance in each step from production to consumption. To obtain seed, they require barter. To grow, they rely on practices that contradict agro-industrial productivity dogma. To get in the market, they require self-organized market spaces or even uncomfortable informal transactions in the margins of conventional markets. To be sold, they rely on human relationships between producers and consumers, built on trust and exchange of knowledge. Yet despite the need to pass through "alternative" mechanisms at every step, in both locations there are producers, vendors and consumers that recognize sufficient value in traditional foods to find creative solutions throughout the market chain.

Rather than end on a clichéd (and arrogant) summary of what people in Ecuador and Palestine can learn from each other regarding traditional foods, the true conclusion of our conversation is regarding our own learning process as scholars. We came to understand how histories, circumstances and cultures as different as those of Palestine and Ecuador can breed similar wisdom, practices and adaptations. Moving forward, we hope that this will serve us as a reminder that the specific contexts of our research experiences—to which we are so endeared—do not exist in a vacuum delineated by geographic locations.

References

Altieri M, & Toledo VM (2011). The Agroecological Revolution in Latin America: Rescuing Nature, Ensuring Food Sovereignty and Empowering Peasants. The Journal of Peasant Studies 3(38): 587–612.

Aquastat (2008). Irrigation in the Middle East region in figures. The Food and Agriculture Organization of the United Nations, Roma, pp 1–20.

Ceccarelli S (2015). Seeds of Future. In: Veca, S (ed) Laboratorio Expo: The Many Faces of Sustainability, Giangiacomo Feltrinelli Editore, Roma, pp 177-197.

Ceccarelli S, Grando S, van Leur JAG (1995). Barley landraces of the Fertile Crescent offer new breeding options for stress environments. Diversity 11:112–113.

Chivenge P, Modi A, Mafongoya P (2015). The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa. International Journal of Environmental Research and Public Health 12(6): 5685–5711.

Clarno A (2017). Neoliberal apartheid: Palestine/Israel and South Africa after 1994. The University of Chicago Press, Chicago.

Cook S (2018). The spice of life: The fundamental role of diversity on the farm and on the plate In: Hivos and IIED. Sustainable Diets for All. https://pubs.iied.org/pdfs/G04305.pdf, acceso 10 enero 2020.

Deaconu A, Mercille G, Batal M (2019). The Agroecological Farmer’s Pathways from Agriculture to Nutrition: A Practice-Based Case from Ecuador’s Highlands. Ecology of Food and Nutrition 58(2): 142–165.

Deaconu A, Mercille G, Batal M (2020). Promoting traditional foods for human and environmental health: Lessons from agroecology and Indigenous communities in Ecuador. Manuscript Submitted for Publication.

Environmental Quality Authority (2015). State of Palestine: Fifth National Report to the Convention on Biological Diversity.

Erakat N (2019). Justice for Some: Law and the question of Palestine. Stanford University Press, San Francisco.

FAO (1999). Women: Users, preservers, and managers of agrobiodiversity. www.fao.org/FOCUS/E/Women/Biodiv-e.htm, acceso 22 diciembre 2019.

FAO (2014). The State of Food and Agriculture: Innovation in Family Farming. The Food and Agriculture Organization (FAO) of the United Nations, Roma.

Goltaire R (2014). Respuestas del pasado para la agricultura del futuro—Sistemas ingeniosos de Patrimonio Agrícola. SIPAN/FAO/Ministerio de Cultura y Patrimonio del Ecuador, Quito.

Heifer (2014). La agroecología está presente: Mapeo de productores agroecológicos y del estado de la agroecología en la sierra y costa ecuatoriana. Heifer Ecuador Foundation, Quito.

HLPE (2019). Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-14_EN.pdf, acceso 14 diciembre 2019.

Isaac J, Gasteyer S (1995). The Issue of Biodiversity in Palestine. The Applied Research Ins- titute – Jerusalem (ARIJ).

Johns T, Powell B, Mandu P, Eyzaguirre P (2013). Agricultural biodiversity as a link between traditional food systems and contemporary development, social integrity and ecological heal- th: Traditional food systems, agricultural biodiversity and sustainable development. Journal of the Science of Food and Agriculture 93(14): 3433–3442.

Khalel S (2017). Israel to move checkpoint deeper into West Bank, cutting off Palestinian access to spring. Mondoweiss https://mondoweiss.net/2017/11/checkpoint-cutting-palesti- nian/, acceso 7 noviembre 2019.

Khalidi R. (2020). The Hundred Years War on Palestine: A History of Settler Colonial Con- quest and Resistance. Profile Books , New York.

Kuhnlein H, Erasmus B, Spigelski D (2009). Indigenous peoples' food systems: The many dimensions of culture, diversity and environment for nutrition and health. FAO, http://www. fao.org/3/i0370e/i0370e.pdf, acceso 10 enero 2020.

LRC (2017). Israeli Occupation Forces close agricultural road in Bethlehem village of Husan. The Land Research Center. http://poica.org/2017/01/israeli-occupation-forces-close-agricultu-ral-road-in-bethlehem-village-of-husan/, acceso 09 noviembre 2019.

Levy G, Levac A (2019). "This place is only for Jews": The West Bank's Apartheid Springs. https://www.haaretz.com/israel-news/.premium.MAGAZINE-this-place-is-only-for-jews-the-west-bank-s-apartheid-springs-1.7767344.

Ministry of Agriculture (2016). National Agricultural Sector Strategy (2017-2022) Resilience and Sustainable Development, Ministry of Agriculture - State of Palestine. http://www.lacs.ps/documentsShow.aspx?ATT_ID=31791, acceso 18 octubre 2019.

NAD (2016). Bethlehem 2017: Facts and Figures. Negotiations Affairs Department - State of Palestine, Gaza.

NAD (2017). Bethlehem 2016: Facts and Figures (Media Briefs). NAD, Gaza.

Office of the European Union Representative (2019). Six-Month Report on Israeli settle- ments in the occupied West Bank, including East Jerusalem). West Bank and Gaza Strip, UN- RWA, Reporting period: July-December 2018, Bruselas.

Padulosi S, Thompson J, Rudebjer P (2013). Fighting poverty, hunger and malnutrition with neglected and underutilized species (NUS): Needs, challenges and the way forward. Bioversity International. https://www.bioversityinternational.org/fileadmin/_migrated/uploads/ tx_news/Fighting_poverty__hunger_and_malnutrition_with_neglected_and_underutilized_ species NUS 1671.pdf, acceso 17 marzo 2020.

PCBS (2017). The Results of the Labour Force Survey in Palestine. PCBS - The Palestinian Central Bureau of Statistics,

Peña K (2013). Institutionalizing Food Sovereignty in Ecuador. Food Sovereignty - A Critical Dialogue Conference Papers. Transnational Institute, Amsterdam.

Penafiel D, Termote C, Lachat C, Espinel R, Kolsteren P, Van Damme P (2016). Barriers to Eating Traditional Foods Vary by Age Group in Ecuador With Biodiversity Loss as a Key Issue. Journal of Nutrition Education and Behavior 48(4): 258–268.

Renting, H, Marsden, TK, Banks, J (2003). Understanding Alternative Food Networks: Ex- ploring the Role of Short Food Supply Chains in Rural Development. Environment and Plan- ning A: Economy and Space 35(3): 393–411.

Roy S (1999). De-Development Revisited: Palestinian Economy and Society since Oslo. The Journal of Palestine Studies 28(3): 64–82.

Salhani J (2016). The struggle for indigenous rights extends to Palestine. Think Progress https:// archive.thinkprogress.org/palestine-israel-indigenous-216dddd16c59/, acceso 01 febrero 2020.

Shrestha P, Shrestha P, Subedi A, Peroni N, de Boef, W (2013). Community biodiversity ma- nagement: Defined and contextualized. In: Peroni N, de Boef W, Thijssen M, Subedi A (eds). Community Biodiversity Management Promoting resilience and the conservation of plant ge- netic resources. Routledge & Taylor Francis Group, London, pp. 19-25

Smale M, Lipper L, Koundouri P (2006). Scope, Limitations and Future Directions (MRPA Paper). University Library, Munich.

Smith L T (2008). Decolonizing methodologies: Research and Indigenous people. ZED Books, London.

Taghdisi Rad S (2015). Political Economy of Aid in Conflict: An Analysis of Pre- and Post-In- tifada Donor Behaviour in the Occupied Palestinian Territories. Stability: International Journal of Security & Development 4(1): 1–18.

The World Bank Social and Economic Development Group (2008). The Economic Effects of Restricted Access to Land in the West Bank. https://www.ochaopt.org/sites/default/files/ocha_ opt_other_orgnization_report_eera_world_bank.pdf, acceso 09 octubre 2019.

The World Bank Group (2017). Unlocking the trade potential of the Palestinian economy: Immediate Measures and a Long-Term Vision to Improve Palestinian Trade and Economic Out- comes. http://documents1.worldbank.org/curated/en/960071513228856631/pdf/ACS22471-RE- VISED-Palestine-Trade-Note-Web.pdf, acceso 07 noviembre 2019.

UNCTAD (2012). The Palestinian economy: Macroeconomic and trade policymaking under occupation. United Nations Conference on Trade and Development.

UNCTAD (2015). The Besieged Palestinian Agricultural Sector. https://unctad.org/en/Publi- cationsLibrary/gdsapp2015d1_en.pdf, acceso 09 septiembre 2019.

Vaggi G, Baroud S (2005). Asymmetries and economic interaction between Israel and Pa- lestin. Quaderni di

Dipartimento - EPMQ, 173, 2-26.

Waters WF (2007). Indigenous Communities, Landlords, and the State: Land and Labor in Highland Ecuador, 1950-1975. In: Clark K, Becker M (eds). Highland Indians and the state of modern Ecuador, The Press University, Pittsburgh, pp 120-138.

Zamosc L (1994). Agrarian protest and the Indian movement in the Ecuadorian highlands. Latin American Research Review 29(3): 37–68.

Annex 5: Lay report

Diversidad de la Tierra al Plato

Resultados de un estudio comparativo entre productoras agroecológicas y convencionales en su dieta, producción y salud

¿De que se trata el estudio?

El objetivo del estudio es de explorar los impactos de la **agroecología** sobre la dieta, la producción y la salud campesina.

Entre 2017 y 2018 se levantaron datos para comparar a mujeres productoras que practican la agroecología y sus vecinas productoras en la provincia Imbabura. A las vecinas las llamamos productoras "convencionales," ya que si bien practican la agricultura familiar campesina, no están vinculadas a la agroecología.

¿Qué es la agroecología?

La agroecología se reconoce como una estrategia productiva que se basa en conocimientos científicos y ancestrales para mejorar la producción, regenerar la tierra, cuidar la salud humana, respetar las tradiciones culturales y valorar el trabajo campesino.

La agroecología se ha popularizado como manera de producir y comer rico, sano y de nuestra tierra. Las experiencias positivas vividas han impulsado la formación de asociaciones campesinas, consumidores organizados y otros grupos que practican y promueven la agroecología en Ecuador y en otros países.

¿Quienes participaron?

61 productoras agroecológicas

Vinculadas a las ferias: Kurimikuy, Imbabío, Frutos de la Pachamama, Sumak Pacha, Sumak Muyu, Sisamakiarte, Ayllukunapak, La Choza y el Trueke

En promedio han participado con la agroecología durante 4 años

30 vecinas productoras convencionales

Entrevistar a las vecinas nos permite mantener los mismos factores locales, tanto ecológicos que sociales, culturales y económicos

¡PAY!

¡¡Gracias a todas las participantes!!

Preparado por: Ana Deaconu, 2019

Por favor citar: Deaconu, Ana. *Diversidad de la tierra al plato: resultados de un estudio comparativo entre productoras agroecológicas y convencionales en su dieta, producción y salud.* Que Rico Es, 2019.

Este informe también se encuentra en: www.quericoes.org
Para más información, está bienvenido/a a contactarse con:

Ana Deaconu: [redacted]
Stephen Sherwood: ssherwood@ekorural.org; [redacted]

Este estudio se realizó por parte del equipo de investigación Ekomer, en que participan: Fundación EkoRural, Centro Colaborador de la Organización Mundial de Salud Transnut, Facultad Latinoamericana de Ciencias Sociales, Pontífica Universidad Católica del Ecuador, Université de Montréal, University of Toronto, y HealthBridge. Ekomer trabaja en conjunto con la Campaña ¡Que Rico Es!, el Movimiento de Economía Social y Solidaria del Ecuador, y el Colectivo Agroecológico del Ecuador.

¡Qué rico es comer sano y de nuestra tierra!
www.quericoes.org

COLECTIVO AGROECOLÓGICO DEL ECUADOR

messe

APRENDIZAJES CLAVES PARA LA ACCIÓN

La agroecología tiene potencial para enfrentar la desnutrición crónica.

La agroecología está asociada con una dieta de mejor contenido nutricional. Aunque el impacto no es muy grande, es relevante dado el corto tiempo en que la agroecología ha estado presente en este espacio. A largo plazo, puede ser que los beneficios serán más grandes aún. Hay que continuar con las prácticas de promoción de las dietas variadas, basadas en alimentos frescos o mínimamente procesados.

¿Quiéres saber más? Vaya a "Dieta" - p.3

La agroecología aporta más diversidad a la tierra.

Al sembrar más diversidad, las productoras agroecológicas tienen un mejor acceso a alimentos variados desde su propia producción, y además regeneran los suelos y los ecosistemas. Al seguir con los procesos de intercambio de semillas y conocimientos, se puede seguir fortaleciendo esta diversidad de distintos productos y variedades.

¿Quiéres saber más? Vaya a "Producción" - p.4

Las prácticas tradicionales ancestrales están más presentes en la agroecología.

Al producir y consumir alimentos tradicionales, las productoras agroecológicas no solo fortalecen su cultura, sino también pueden evitar los cambios alimentarios que llevan a la obesidad. Las redes agroecológicas están haciendo un trabajo importante en re-valorar estas tradiciones. Esto se debe continuar y fortalecer.

¿Quiéres saber más? Vaya a "Prácticas Tradicionales Ancestrales" - p.4

Los alimentos de la producción propia y de la economía social son los más sanos.

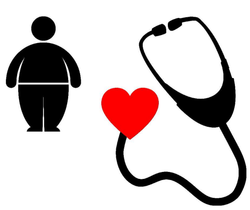
Favorecer el consumo de alimentos de la producción propia y de la economía social y solidaria es una manera para promover una alimentación más nutritiva. En cambio, el consumo de alimentos de la economía convencional aporta más “calorías vacías” que contribuyen a la obesidad.

¿Quiéres saber más? Vaya a "¿De Dónde Consiguen los Alimentos?" - p.5

Se puede comer más barato y más sano a la vez.

Al consumir productos de su propia producción y de la economía social, las productoras agroecológicas logran tener una alimentación más sana gastando menos dinero. El siguiente paso es asegurar que el dinero que se ahorra tenga un buen uso para toda la familia.

¿Quiéres saber más? Vaya a "Dieta - gastos mensuales en alimentos" - p.3



Queda a mejorar el tema de la obesidad y las enfermedades relacionadas.

La gravedad del problema de obesidad y las enfermedades relacionadas merece una respuesta inmediata. Además de seguir con la promoción de la alimentación variada y de los alimentos tradicionales, las redes agroecológicas deberían trabajar para reducir el uso de azúcar y panela, sal, aceite y manteca, y de granos blancos como el arroz.

¿Quiéres saber más? Vaya a "Índices de Salud" - p.5-6

Las redes agroecológicas son fundamentales para promover la salud.

Los beneficios vistos en la alimentación relacionados a la agroecología no son tan solo un resultado de las prácticas de producción. Es el entorno social de las redes agroecológicas que tiene la mayor importancia en promover la salud. Es importante fortalecer las asociaciones, ferias, encuentros y otros espacios de la agroecología para seguir promoviendo los beneficios y aumentar su impacto.

¿Quiéres saber más? Vaya a "Rol de la Agroecología en la Alimentación" - p.6

Diversidad en la dieta por grupo de alimentos:


Granos, raíces y tubérculos blancos, plátano verde


Leguminosas


Nueces y semillas


Lácteos


Cárnicos


Huevos


Verduras de hoja verde oscura


Frutas y verduras con contenido alto en Vitamina A


Otras verduras


Otras frutas

Evaluamos el consumo de 10 grupos diferentes de alimentos reconocidos a nivel internacional por sus aportes distintos en nutrientes, es decir vitaminas y minerales. Mientras más grupos se consumen en un día, más probable es que el grupo está cumpliendo con sus necesidades nutritivas. Esto ayuda a enfrentar problemas de salud como anemia. Para los niños, comer más diverso ayuda a crecer.

¿Cuántos grupos de alimentos consumen?

convencionales:
Promedio de 5 grupos al día (−)

agroecológicas:
Promedio de 6 grupos al día (+)

Consumen más frutas y lácteos, y posiblemente más leguminosas, verduras de hoja verde oscura y otras verduras.

★ Al consumir más diversidad en la dieta, las productoras agroecológicas tienen más probabilidad de cumplir con sus necesidades en nutrientes.

Cantidad de comida:
Las productoras convencionales y agroecológicas consumen la misma cantidad total de comida, en términos de calorías.

Gastos mensuales en alimentos:

convencionales: En promedio gastan $87 mensuales por hogar — 1/3 De sus ingresos mensuales (+)

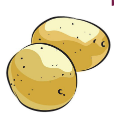
agroecológicas: En promedio gastan $67 mensuales por hogar — 1/4 De sus ingresos mensuales (−)

★ Las productoras agroecológicas gastan menos dinero para tener una alimentación más nutritiva.

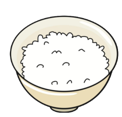
El día de la entrevista, ¿quiénes comieron estos productos?


azúcar o panela

convencionales: casi todas
agroecológicas: casi todas


papas

convencionales: 8 de cada 10
agroecológicas: 9 de cada 10


arroz

convencionales: 8 de cada 10 (+)
agroecológicas: 5 de cada 10 (−)


fideo

convencionales: 4 de cada 10 (+)
agroecológicas: 2 de cada 10 (−)

aliños o cubos sazonadores

convencionales: 2 de cada 10 (+)
agroecológicas: casi nadie (−)

★ Comparadas con las productoras convencionales, las agroecológicas no consumen tanto arroz o fideos, ni tampoco aliños. Esto puede ser resultado de los conocimientos que se comparten en los espacios de la agroecología.

★ Sin embargo, el uso de alimentos blancos es alto para las agroecológicas tanto que para las convencionales. Estos productos tienen poco valor nutritivo y su consumo excesivo contribuye al sobrepeso y obesidad.

PRODUCCIÓN

Diversidad de distintos productos:

El número promedio de distintas plantas comestibles cosechadas y animales criados durante el último año

convencionales: 25 ⊖

agroecológicas: 39 ⊕

Diversidad de variedades de cada producto:

convencionales: Promedio de
- 3 tipos de maíz
- 5 tipos de frejol
- 2 tipos de papas

⊖

agroecológicas: Promedio de
- 6 tipos de maíz
- 8 tipos de frejol
- 4 tipos de papas

⊕

★ Al tener más diversidad en la producción, las productoras agroecológicas pueden acceder a más diversidad de alimentos durante todo el año. Además regeneran a la tierra, y se protegen de problemas imprevistos ecológicos y económicos.

PRÁCTICAS TRADICIONALES ANCESTRALES

Evaluamos el consumo y la producción de productos tradicionales ancestrales. Además de tener una importancia cultural, en muchos espacios se encuentra que el consumo de productos tradicionales protege en contra a patrones de alimentación nuevos que podrían ser dañinos. La siembra de productos tradicionales no solo provee para el consumo sino protege a la tierra, ya que los productos tradicionales son mejor adaptados para las condiciones locales.

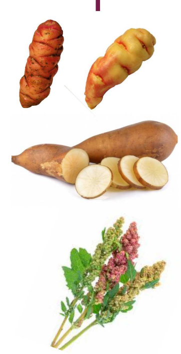
Consumo de productos tradicionales:

En base a una lista de productos tradicionales, evaluamos los promedios de diversidad y frecuencia de consumo.

convencionales: consumen 6 productos, 144 veces al año ⊖

agroecológicas: consumen 8 productos, 259 veces al año ⊕

Además, consumen productos menos comunes, como hoja de quinua, amaranto, mashua, oca, jícama y chulpi.



Siembra de productos tradicionales

De la lista de productos tradicionales, evaluamos el promedio de distintos productos que siembran.

convencionales: siembran 3 productos ⊖

agroecológicas: siembran 6 productos ⊕

Lista de productos tradicionales estudiados:

quinua, hoja de quinua, ataco, amaranto, chocho, melloco, mashua, oca, jícama, chulpi, camote y zanahoria blanca

Consumo de productos silvestres:

Tanto las productoras **convencionales** como **agroecológicas** consumen productos silvestres. En promedio consumen 7 productos distintos, y los más comunes son las frutas de monte, el berro, el bledo, el nabo de chagra, el rábano yuyu y la wagrahayu.

★ Las productoras agroecológicas siembran y consumen más diversidad de productos tradicionales, y los consumen con más frecuencia. Esto abre la oportunidad de tener una dieta sana, que apoya a la tierra y a la cultura.

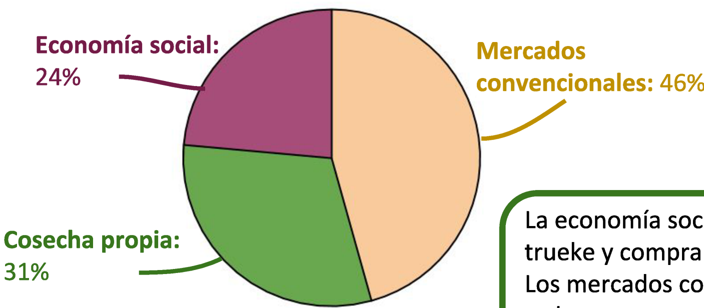
¿DE DÓNDE CONSIGUEN LOS ALIMENTOS?

Aporte de distintas fuentes a la energía en la dieta:

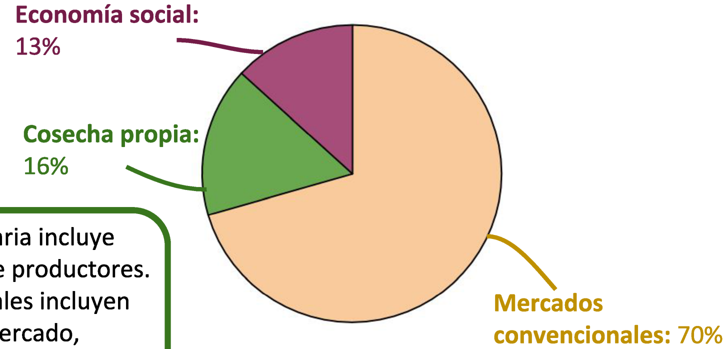
calorías

Alerta: el exceso de calorías lleva al sobrepeso y obesidad.

agroecológicas:



convencionales:



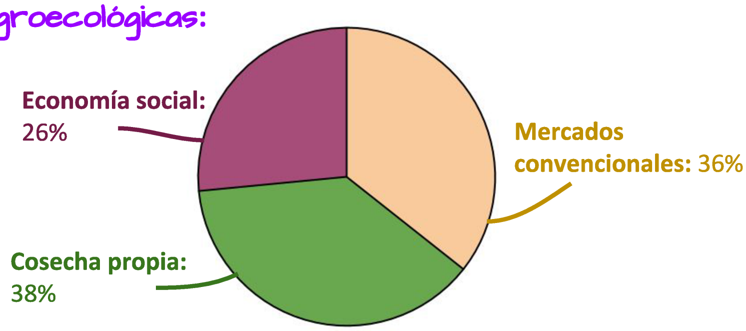
La economía social y solidaria incluye trueke y compra directa de productores. Los mercados convencionales incluyen toda otra compra (supermercado, mercado popular, tienda, restaurante, entre otro).

Aporte de distintas fuentes a los nutrientes:

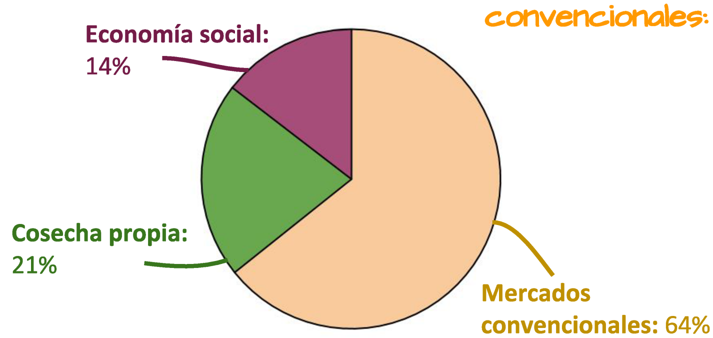
vitaminas y minerales

Aporte a: hierro, calcio, vitamin A, vitamina C, zinc, folatos, tiamina, niacina y riboflavina.

agroecológicas:



convencionales:

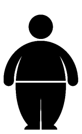


★ Comparadas con las convencionales, las agroecológicas consiguen más alimentos de la economía social y de su propia cosecha, tanto en términos de calorías y de nutrientes.

★ En ambos grupos, la economía social y la cosecha propia contribuyen más al consumo de alimentos sanos. Es decir, aportan más nutrientes que calorías. Al contrario, en los mercados convencionales se proveen de productos menos sanos que tienen más calorías que nutrientes.

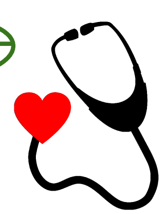
ÍNDICES DE SALUD

La falta de nutrientes no es la única forma de malnutrición. El sobrepeso y obesidad también es una forma de malnutrición, y puede llevar a varias enfermedades crónicas. La obesidad puede ocurrir al mismo tiempo que la falta de nutrientes. Al no encontrar ninguna diferencia entre las productoras agroecológicas y convencionales en el sobrepeso y obesidad o en las enfermedades relacionadas, reportamos los datos en conjunto.



80% del grupo estudiado tiene sobrepeso o obesidad

La mitad del grupo estudiado reporta tener al menos una enfermedad crónica relacionada al sobrepeso



27% reportan tener presión alta
23% reportan tener colesteról alto
10% reportan tener diabetes
8% reportan tener enfermedad cardíaca
2% reportan tener cáncer

★ El sobrepeso y obesidad se ha vuelto epidémico y merece una atención especial, ya que lleva a muchas enfermedades. El sobrepeso resulta cuando se consume más comidas y bebidas de lo que el cuerpo necesita utilizar, y los productos altos en azúcares, grasas y sal contribuyen a estos excesos.

¿Por qué no encontramos diferencias en obesidad y en las enfermedades relacionadas?

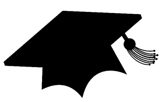
Vimos que las productoras agroecológicas tienen dietas más nutritivas. Sin embargo, al igual que las compañeras convencionales, tienen problemas de obesidad y de las enfermedades relacionadas. Pensamos que hay algunas cosas que explican esto:

- La agroecología todavía es nueva en las vidas de las participantes del estudio, ya que han estado vinculadas con la agroecología en promedio de tan sólo 4 años. Puede ser que se demora más tiempo en detectar cambios mayores al nivel de la obesidad y las enfermedades relacionadas, ya que estas son enfermedades de largo plazo.
- Además, sólo sabemos cuáles enfermedades tiene cada persona según lo que ellas nos dijeron. No hicimos análisis médicos para tener un diagnóstico completo o para entender los niveles de enfermedad.
- Finalmente, algunas mujeres cuentan que se vincularon a la agroecología justo porque ya tenían enfermedades crónicas, y buscan mejorarse con la agroecología.

FACTORES SOCIALES Y ECONÓMICOS

Estos factores nos ayudan a entender el contexto de las productoras en el estudio y además a entender mejor por qué hay diferencias en la dieta y en la producción. Como no encontramos diferencias entre las productoras agroecológicas y convencionales en estos factores, presentamos los datos en conjunto.

Educación



9% pos-secundaria
9% secundaria
31% primaria
44% no terminaron la educación primaria

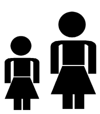
Economía

57% viven en pobreza o pobreza extrema, según sus ingresos

Distancia al mercado

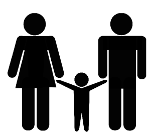
En promedio se demoran 47 minutos para llegar al mercado, pero unas se demoran más de 3 horas

Edad



De 20 a 79 años de edad, con el promedio 45 años

Tamaño del hogar



De 1 a 15 personas, con el promedio de 5 personas

★ Sabemos que estos factores no son la causa de las diferencias en la dieta o en la producción entre las agroecológicas y las convencionales, ya que los dos grupos están iguales.

ROL DE LA AGROECOLOGÍA EN LA ALIMENTACIÓN

El entorno social de la agroecología...

... promueve el consumo de la producción propia

... promueve más diversidad en la producción, tanto de productos y de variedades de productos

... lo que mejora el **acceso** a alimentos diversos y nutritivos

... promueve la producción y consumo de alimentos tradicionales

... lo que mejora el **acceso** y el **interés** por consumir productos tradicionales

... promueve la importancia de comer con diversidad y de evitar productos chatarra o poco nutritivos

... lo que mejora el **conocimiento** de la alimentación sana

¡Gracias por haber leído! Este estudio se realizó por parte del equipo de investigación Ekomer, con el apoyo del International Development Research Centre, Ottawa, Canada. Las opiniones expresadas en el presente no necesariamente representan los del IDRC o de su Junta de Gobernadores. El estudio además recibió el apoyo del Fonds de Recherche en Santé du Québec.

Annex 6: Summary flyer

Las familias agroecológicas...

¡Qué rico es comer sano y de nuestra tierra!

www.quericoes.org

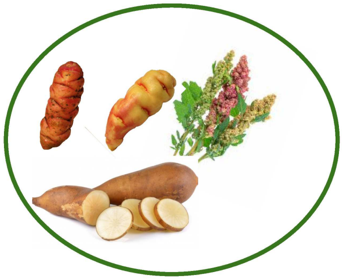
Comemos más variado

lo que es rico y bueno para nuestra salud

Sembramos más variado

lo que nos alimenta a nosotros y a la tierra

Comemos más alimentos tradicionales ancestrales



lo que aporta a la cultura y a la tierra y le da sabor al plato

Gastamos menos dinero en comprar comida

ya que nuestra tierra y el trueke nos dan de comer

¡Las familias agroecológicas comemos rico, sano y de nuestra tierra!

COLECTIVO AGROECOLÓGICO DEL ECUADOR

messe

Todas las familias podemos mejorar nuestra salud con la comida

Debemos comer menos azúcar y panela, menos sal, menos grasas, y menos granos blancos como el arroz.

Tratemos de llenarnos más con verduras, menestras y frutas que con papas y granos. Usemos hierbitas para dar sabor.

Comamos más frutas enteras en vez de solo en jugo. Pongamos más verduras en las comidas. Comamos ensaladas frescas, siempre lavando bien las verduras en agua hervida. Y comamos bastantes menestras.

Es mejor comer las papas con su cáscara y comer granos variados como quinua, amaranto, cebada, maíz, y trigo. Para no siempre comer papa, también comamos mashua, melloco, oca y camote.

Las hojas verdes son ricas y buenas para la salud. Comamos acelga, hoja de quinua, nabo de chagra, berro, y otras hojitas.

Estos pasos nos ayudan a evitar el sobrepeso y obesidad y protegernos de enfermedades.
¡Así vivimos sanos y felices!

Este volante se basa en un estudio que compara a las productoras agroecológicas con sus vecinas convencionales en Imbabura. Si desea saber más, lea el informe completo, "Diversidad de la Tierra al Plato" en www.quericoes.org.