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The Role of Data Governance in Food and Nutrition Security: Insights from a Multi-Method approach to Public Policy and Practices in Chile

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Signed declaration

I declare that the thesis has been composed by myself and that the work has not be submitted for any other degree or professional qualification. I confirm that the work submitted is my own, except where work which has formed part of jointly-authored publications has been included. My contribution and those of the other authors to this work have been explicitly indicated below. I confirm that appropriate credit has been given within this thesis where reference has been made to the work of others.

- The work presented in Chapter 3 was previously published in del Valle et al. (2024b) as *Integration and coherence in food governance—a comprehensive analysis of food security public programs in Chile* by *M del Valle M (student), K Shields (supervisor), and S Boza*. This study was conceived by all of the authors. I carried out the conceptualization, methodology, investigation and writing.

- The work presented in Chapter 4 was previously published in *del Valle et al. (2024a)* as *Using Household Dietary Diversity Score and Spatial Analysis to Inform Food Governance in Chile* by *M del Valle M (student), K Shields (supervisor), and S Boza*. This study was conceived by all of the authors. I carried out the conceptualization, methodology, investigation and writing.

- The work presented in Appendix Chapter 1 was previously published in *del Valle et al. (2022)* as *Food governance for better access to sustainable diets: A review by M del Valle M (student), K Shields (supervisor), S Boza, and ASA Vázquez Mellado.* This study was conceived by all of the authors. I carried out the conceptualization, methodology, investigation and writing.

- The work presented in Appendix Chapter 2 was previously published in *del Valle et al. (2025)* as *Co-creating a common language for an agroecological transition through local food governance: lessons learned from discussion and practice in Mashue, Los Ríos, Chile*

by *A review* by *M del Valle M (student), K Shields (supervisor), F Borthwick (supervisor), L Grant (supervisor), S Boza, JP del Valle, JA Luchsinger, R Del Fierro*. This study was conceived by all of the authors. I carried out the conceptualization, methodology, investigation and writing.

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Thesis abstract

Sustainable food systems and their governance, particularly what's related to the role of data and information, are essential for ensuring health, heritage, and environmental sustainability. This thesis investigates how an integrated and diversified data governance approach for food and nutrition security (FNS) can effectively address Chile's double burden of malnutrition. In order to assess these mechanisms and their complexity, this research includes (i) a literature review to explore the emerging debates on data governance within the field of FNS, (ii) a policy integration and coherence analysis at the national level through FNS public programs, (ii) a demographic and spatial food insecurity distribution analysis, and (iii) a reflective piece on multimethod approaches to research and knowledge creation. Key findings indicate that current debates call for integrating diverse data, enhancing data quality and access, and developing robust, ethical, and culturally sensitive governance frameworks. While there is some interministerial governance integration, coherence with the National Policy of Food and Nutrition is insufficient. Vulnerable households in Chile face significant challenges in meeting recommended dietary intakes, with socio-demographic and territorial factors influencing dietary diversity. Effective governance of food systems requires a multi-level approach that integrates national policies, identifies groups most at risk of food insecurity, and adopts a multimethod strategy to enable participatory co-creation and broader dissemination of data and knowledge. These strategies are essential for achieving sustainable diets and addressing food security challenges in diverse contexts. Future research should focus on exploring challenges in program execution, considering contextual variations in policy implementation, expanding the scope to include other government bodies and civil society organizations, and analyzing temporal variations in geospatial analysis to identify differences and interactions in critical food groups.

Lay summary

Data and information governance of sustainable food systems is vital for maintaining health, preserving heritage, and ensuring environmental sustainability. This thesis examines how different data governance strategies can work to establish a strong and effective food governance framework in Chile, especially for vulnerable populations who face high rates of overweight and food insecurity.

The research involved a comprehensive approach, conducting a literature review to identify emerging debates in the intersection between data governance and food and nutrition security (FNS), analyzing policy integration and coherence at the national level through FNS public programs, and mapping food insecurity using geographical data. Also, a reflective piece was carried out to stress the importance of adopting a multi-method approach in food systems research and embracing the knowledge coming from different levels. Key findings indicate that progress is still needed in both data integration and accessibility. While there is some integration between government ministries, alignment with the National Policy of Food and Nutrition is insufficient. Additionally, vulnerable households in Chile struggle to meet recommended dietary intakes due to socio-demographic factors that affect dietary diversity.

To effectively govern food systems, a multi-level strategy is needed. This includes integrating data and information to aligning national policies, identifying and addressing the needs of the most at-risk groups through data-driven decisions, and strengthening community agency through an equitable access to data and information as a public good. These combined efforts are essential for addressing food security challenges in various contexts.

Future research should address the challenges of implementing programs, consider local differences in policy execution, include other government bodies and civil society organizations for a more comprehensive view, and analyze how food insecurity varies over time across different regions.

To my grandmother, “la Bebe”, who always wanted to come to see Scotland.

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List of abbreviations

AET: Agroecological Transition

APPO: Associated Public Programmatic Offer

BIPS: Banco Integrado de Programas Sociales (Integrated Bank of Social Programmes)

DIPRES: Dirección de Presupuestos de Chile

FAO: Food and Agriculture Organization of the United Nations

FNS: Food and Nutrition Security

FOSIS: Fondo Solidario de Inversión Social

FSPFS: Family Support Program of Food Self-Sufficiency

HDDS: Household Dietary Diversity Score

HERC: Human Ethical Review Committee

MAA: Mashue Agroecological Association

NFNP: National Food and Nutrition Policy of Chile

RPPO: Relevant Public Programmatic Offer

UNICEF: United Nations International Children's Emergency Fund

WHO: World Health Organization

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CHAPTER 1: Introduction

While studying my fourth year of agronomy in Chile in 2011, like every winter, Santiago, the country's capital and most populated city, collapsed due to heavy rains that lasted days. It often happens that the news focuses almost exclusively on reporting the situation, informing about closed streets, falling of trees, public transport delays, schools that have had to suspend classes, and, as hours pass, updates on the number of affected families. In this context, a section of the press often visits the *"campamentos"*, as we call slums or favelas in Chile, many of them settlements situated on the outskirts of the city, where families have established themselves due to the lack of housing solutions provided by the state through the years. There, in addition to reporting on the destruction of many homes, digging into the deepest intimacy of the affected families, and the whereabouts of family and community members, journalists often ask head of households to tell the audience about their situation and detail what they have lost to raise social awareness and perhaps motivate various types of donations. In one of those interviews, a reporter asked a woman, telling her she was live for the entire country, to describe her situation, particularly listing the things in her house that the rain and wind had washed away or destroyed, and explain how she was feeling. The woman, completely soaked but with flushed cheeks, physically and emotionally exhausted from what she, her family and neighbors were experiencing, with tears in her eyes, told the warmly-dressed reporter that she didn't know, she had lost count, she had no idea how much clothing was lost, if the appliances were ruined, or if the mattresses could absorb any more water or mud. She didn't know and didn't care. The only thing she couldn't stop thinking about at that moment was that her children had to go to bed "*con la guatita vacía*", this is with empty stomachs, and that was the most painful part of the whole situation.

I remember hearing those words live from my warm and dry living room and began to think about that quote "*la guatita vacía*". Hunger, a phenomenon that in my ignorance I thought completely foreign to Chile, at least compared to what other countries in the region and in the broader southern hemisphere experience daily for various reasons, was present in this emergency. From then on, questions related to hunger, poor food access, and malnutrition began to arise more frequently in my head and made me somewhat uncomfortable as an agronomy student, especially since I was

getting to the end of my degree. Let me explain. Until that year of my study plan, what was most emphasized in my agronomy school was that as future agronomists, we were going to play an important role in ensuring food for a growing population. That we were in charge of ensuring food security and therefore had to become more productive and efficient. Everything seemed very logical: more people, we need to produce more food, and ideally, to be traded in external markets where more competitive prices could be obtained, thereby more resources will enter to the country. However, we talked little, only in optative courses, about food and human health, nutrition, food insecurity, poverty and rurality, biodiversity, or the role that agriculture could have in public health. Why would that be? Why we were so far away from these global discussions?

The next semester I decided to change the study plan I was following at that time to one that I believed could at least better interact with the world of Chilean rurality and the global discussions mentioned above. I decided to do my Minor in Animal Sciences, focusing on studying the small livestock and goat holders, of Chile's central region, with whom I had the opportunity to work, walk, talk, share meals, and listen about their day-to-day life and views on livestock, agriculture, and food. Life and opportunities led me to cross the Atlantic Ocean and live and work with small farmers and goat holders in a rural contexts in northern Mozambique and in urban schools in Kenya, where I saw that food insecurity is a phenomenon with diverse tones and causes, and that overlaps with so many other emergencies that it seemed to go beyond a solution simply focused on producing more and more food to the best taker.

After a few years of going back and forth between Chile and southeastern Africa, where I also had the opportunity to conduct my master's dissertation fieldwork, I decided to stay in Chile to settle down and reflect on how I wanted to continue my career. Thus, I began working in a public program focused on FNS for the most vulnerable families in the country, which was in a transition period, shifting its focus towards agroecology and food systems. During two years, I travelled throughout Chile and visit places I would not have otherwise been able to see, from the Atacama Desert to Patagonia, but most importantly I met and listened to professional teams and families in

the most isolated areas of the country, with views on agriculture and food different from mine, and where the Chilean different public institutions made great efforts to reach.

Those two years were full of questions and debates with colleagues about how we were governing food security in Chile. Why, with the ideal conditions we have for food production, including our natural barriers to pests and diseases, do we seem to be eating so poorly? Why, if our fresh fruit is highly prized in international markets, do we struggle to get it into rural school cafeterias? Is there a gap in the food production chain? Are all participants in the production chain really actively participating? What do the farming families, who produce most of the vegetables we consume, have to add to the debate? I began to think about what I could do contribute to answer these questions, and the possibility of pursuing a PhD began to manifest as an increasingly real and interesting option. I started looking for alternatives in Chile and abroad, gradually leaning towards the latter option. I wanted to see what was happening out there, and although I intended from the beginning to conduct my research "in" and "for" Chile, I wanted to witness how these problems were addressed in other parts of the world and especially what type of professions were involved, as I knew that in other countries and specific territories, food and nutrition insecurity was approached in a more interdisciplinary manner.

This doctoral thesis represents for me the culmination of four years of curiosity, doubts, and deep dedication. Four challenging years in every single dimension of my life. I hope this work is sufficiently questioned by my scientific colleagues working in the field of FNS and others. Nothing proposed in this thesis is the final word or a dogma. I hope Chilean or foreign colleagues come to tell me that they would have done it differently, that they found a limitation I didn't see. I believe that only in this way can this effort contribute to academic knowledge and achieve a tangible impact in the area of sustainable FNS in Chile.

That rainy winter evening in 2011, unknowingly, I began to forge what will become a cause that would give meaning to my career and take me around the world. That evening, I began to understand that what I wanted to do with my life was to be useful in the global effort so that no

child goes to bed *"con la guatita vacía"*, and I firmly believe that what I have learned during this research process has given me greater tools to better understand and hence contribute to these goals.

Martín del Valle Menéndez
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1. Context and background

1.1. The governance challenge in fostering FNS

Different international institutions, including The Food and Agriculture Organization of the United Nations (FAO) and the United Nations International Children's Emergency Fund (UNICEF) (2021) estimated that in 2020 around 800 million people faced hunger, while one third of global population did not have access to adequate food. In addition, according to the World Health Organization (WHO, 2020), in 2016 1.9 billion adults were overweight (34.2% obese) and 39 million children were either overweight or obese in 2020. The same organization also estimated that in 2021 between 1 and 2 billion people had an insufficient intake of essential micronutrients -minerals and vitamins-, or hidden hunger (WHO, 2022). The figures presented in these reports demand interrogation. Are our contemporary food problems strictly due to insufficient production and therefore an exclusive matter of available calories? Are food production systems designed for promoting human health? According to the approach or interests involved, answers will vary. Some groups, such as highly concentrated input, food processors, distributors, and retail companies, will probably embrace a "productivism spirit", which argues that ending world's food problems must do exclusively with producing more food (Howard, 2021). The above obeys to the fact that historically, rising yields, productivity and availability of food have been pursued as the main approach to agricultural policies (Milani-Bonab et al., 2023). However, recent evidence suggest that this is not the way of addressing the problem, especially considering how food production and consumption trends have behaved over time as, for example, worldwide per person food production has been consistently increasing for decades, at a faster rate than the increases in world's total population (Chappell, 2018). Smith and Haddad (2015) confirm the above, by indicating that less than 20% of the decline in child undernutrition between 1970 and 2020 came from increased food production, yield, or availability. Certainly, calories are needed, and efforts must be maintained to keep food production and availability stable. However, the strict focus on calories available risks detracting from other important dimensions of food security, such as access to sustainable diets that not only meet caloric needs but also promote health and environmental sustainability.

Nowadays, the framework used by international institutions indicates that food security exists when “all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food which meets their dietary needs and food preferences for an active and healthy life” (FAO, 1996). Together with this definition, it is possible to identify the classical four dimensions of food security: availability, access, utilization, and stability. However, many have said that this way of understanding FNS is insufficient, as there is a lack of a political dimension in the definition, avoiding talking about the social control of food security (Patel, 2009), and it doesn’t point out the importance of asking “why” when trying to understand the reasons behind hunger and malnutrition (Chappell, 2018).

To consider the control society can have over food systems in terms of inclusion and participation is of a major relevance, as recent approaches indicate that hunger and malnutrition are most usually the consequence of power differentials that result in a “structural violence” (Holmes, 2013), rather than any simple deficit of food and technology (Chappel, 2018; Schnurr, 2017). However, power is managed by institutions, with their own philosophies, values, and interests, which are hard to change and have very strong effects on how we behave. When different institutions are involved in the same subject, tensions appear, making it difficult to act coherently to address a major problem, resulting in a lack of “political ecology”, or a lack of understanding how power dynamics work (Robbins, 2012). From the FNS scope, this is reflected in the fragmentation among the determinants of production, consumption and nutrition that have difficulted a coordinated work for improving food systems performance (Zúñiga-Escobar et al., 2021).

Recognizing the role that power plays in the functioning of food systems has allowed other approaches to understand food security to emerge. The Five A’s of Food Security, developed by the food security economist Cecilia Rocha, and the concept of “food sovereignty”, among others, have come to address the aforementioned. Rocha adds a new food security dimension: “agency”, understood as the requirement that citizens are empowered in defining and securing their own food security, and thus that there are competent sociopolitical systems wherein policies and practices may be brought forth by the will of the citizens and reflected in governance to enable the achievement of overall food security. This includes access to accurate information, the right to such information and to other aspects of food security, and the ability to secure such rights. In a

complementary way, the food sovereignty approach was developed to "address the perceived apolitical nature and inadequate challenge to current structural inequalities represented by food security. It demands a rethinking of the nature of the state in terms of how decisions are made, and communities are involved" (Chappel, 2018), and to ensure "the rights of local people to determine their own agricultural and food policy, organize production and consumption to meet social needs, and secure access to land, water and seed" (Nettle, 2013). The way in which these approaches can be incorporated into the way food systems work will depend on how they are organized, and for that, food governance has a determining role. In addition, the integration of sustainable diets into effective food governance frameworks presents a crucial opportunity to address both current nutritional needs and environmental concerns, aligning food production practices with those that support the health of both the planet and its inhabitants.

1.2. *Data and information accessibility in food governance*[1]

As described above, food governance plays a crucial role in transforming food systems towards sustainability. A key factor in this transformation is the accessibility of data and information (del Valle et al., 2022), which enables evidence-based policymaking, enhances transparency, and fosters coordination among stakeholders (Berry, 2019; Dupouy and Gurinovic, 2020). However, the literature highlights significant challenges.

Firstly, there's a risk of policy fragmentation occurring when different levels of governance collect and use data inconsistently, leading to ineffective decision-making (Lang and Barling, 2013; Balázs et al., 2021). Some authors have also noted a marked exclusion of local knowledge, which limits the integration of traditional sustainable practices into policymaking (Delabre et al., 2021; Sonnino, 2013). Additionally, unequal access to data and information can exacerbate disparities, particularly in rural areas where small-scale producers and consumers often lack the infrastructure to access market and regulatory information (Eakin et al., 2017). Moreover, this uneven data access is sometimes exploited selectively to favor corporate interests, further disadvantaging small producers and vulnerable communities (De Schutter et al., 2020). These overlapping challenges can impede the goal of achieving FNS for all (FAO, 2021; WHO, 2021).

[1] To deepen in this topic, please refer to Appendix Chapter 1 or del Valle et al. (2022).

To address these challenges, the literature suggests diverse strategies:

1. Integrating open-access data systems to enhance cross-sectoral and multilevel coordination (FAO, 2021).
2. Strengthening community participation to incorporate local knowledge into governance structures (Mattioni and Caraher, 2018; Galli et al., 2020).
3. Reframing agricultural governance to position it as a key sector for public health and environmental sustainability (Hawkes and Popkin, 2015; Vermeulen et al., 2020).
4. Ensuring data transparency through auditing mechanisms to prevent selective data use and corporate bias (Kennedy et al., 2021).

The governance challenges involved in fostering FNS, as well as the role that data and information play in achieving a sustainable food system transformation, vary depending on the context. Variables such as climate change, political stability, and disasters, among others, dictate the types of data governance needed to address challenges specific to FNS. The following section will deepen into Chile's unique agroclimatic and nutritional context to better understand its particular setting and to more clearly situate the characteristics of the territory where this doctoral research took place.

1.3. Agroclimatic diversity and nutritional transition in Chile

Chile is a long and narrow country located in southwestern South America which exhibits a highly diverse range of climatic conditions, which significantly influence its agricultural practices. Spanning approximately 4,300 km from north to south, Chile's climates vary dramatically due to latitudinal and geographical factors. The northern region is characterized by one of the driest climates on Earth, while the central and southern areas transition from temperate to cold, hyper-humid environments. As a result, agriculture in Chile is concentrated in the central region (33° 00′ S and 42° 00′ S latitude), where temperate conditions favor crop production and are vital for both socio-economic stability and food security (Piticar, 2019).

The country can be divided into five macro-zones, each with distinct climatic characteristics based on the Köppen–Geiger classification. The Norte Grande macro-zone is dominated by arid (B) and polar (E) climates due to the Atacama Desert and high altitudes. In contrast, the Norte Chico region is predominantly arid but also experiences polar climates at higher elevations. The Zona Central is the primary agricultural zone, where temperate climates (C) cover over 90% of the region. Further south, the Zona Sur maintains a temperate climate with minor tundra zones, while the Zona Austral macro-zone features a mix of polar and temperate climates, reflecting the cold and humid conditions typical of this area (Sarricolea et al., 2017). Details of Köppen–Geiger classification can be found in Table 1.

Table 1. First Order (Main Climate Type) Köppen–Geiger classification (adapted from Sarricolea et al., 2017).

Order	Classification	Description
First Order (Main Climate Type)	A: Tropical	Warm climates with high water availability, typically near the equator.
	B: Arid	Dry climates with low precipitation, includes deserts and semi-arid regions.
	C: Temperate	Moderate climates with distinct seasons, common in mid-latitudes.
	D: Cold	Cold climates with long, harsh winters, usually in higher latitudes.
	E: Polar	Extremely cold climates found in polar regions or high altitudes.

Each one of these macro-zones also is characterized by a specific type of agriculture, as shown in more detail in table 2.

Table 2. Agricultural Production by Macro-zones in Chile (adapted from Meza et al., 2021).

Macro-zone	Agricultural production
Norte Grande	Smallholder farming with horticultural crops (corn, lettuce, tomato, bell pepper). Fruit trees like citrus, mangoes, and olives.
Norte Chico	Production intensifies with table grapes, wine grapes, mandarins, avocados, and blueberries.
Zona Central	Dominated by export-oriented agriculture. Main crops include fruits (grapes, apples, berries), vegetables, and forestry products. Large areas of arable soils support diversified farming systems.
Zona Sur	Shift towards export-oriented fruit trees (walnuts, blueberries, hazelnuts, cherries), replacing traditional crops like wheat and barley. Pastures, dairy and beef farming are also significant.
Zona Austral	Limited agricultural activity, with a focus on livestock, primarily sheep, and forestry.

After nearly eradicating malnutrition in the late 1980s, Chile experienced a significant increase in overnutrition rates (Vio del Río, 2007), with 74.2% of the population now classified as overweight, according to the National Health Survey of 2017, and a 66.3% increase in child obesity rates between 2005 and 2017 (EVS, 2020). Nowadays it is one of the Latin American countries with the highest sales of ultra-processed foods and beverages (Popkin and Hawkes, 2016), which has contributed to it being the OECD member with the highest prevalence of overweight and obesity in adults since 2019 (OCDE, 2019). This shift has led to three million Chileans grappling with non-communicable diseases (NCDs) linked to obesity, impacting their overall well-being, productivity, and straining the national healthcare system (Fernández, 2017). Additionally, lockdowns during the pandemic contributed to an increase in food insecurity, primarily low and moderate (Prada et al., 2021). According to the last National Socioeconomic Characterization Survey (2022), 16.3% of households in Chile faced moderate food insecurity, while 3.5% suffered from severe food insecurity, primarily due to financial limitations. This juxtaposition of

overconsumption of unhealthy foods and food insecurity has led to what is often termed the "double burden of malnutrition" (Shrimpton and Rokx, 2012).

2. Research Problem

Due to the increasing prevalence of overnutrition and its associated health impacts alongside persistent food insecurity in Chile, this research investigates how an integrated and diversified data governance approach for FNS can effectively address the country's double burden of malnutrition. In doing so, it focuses on how data management strategies can be optimized to facilitate equitable and sustainable outcomes.

3. Research structure and objectives

To address the research problem, this thesis examines a range of global and national data governance approaches to FNS. It explores emerging international debates, Chile's political and administrative dimensions, demographic and spatial insights, and the lived experiences of family farmers within food systems. The work is organized into a literature review (Chapter 2) two empirical chapters (Chapters 2 to 4) and one reflective chapter (Chapter 5), each with corresponding objectives, as detailed below.

- Chapter 2: to conduct a literature review addressing emerging debates on data governance approaches for food and nutrition security.

- Chapter 3: To analyze the coherence and integration of food governance policies in Chile through the implementation of public programs using open-sourced data.

- Chapter 4: To identify vulnerable areas affected by food insecurity and enhance data-driven decision-making through geospatial tools and data analysis.

- Chapter 5: To reflect on my academic journey from a conventional agronomist trained in quantitative and positivist methods to a researcher embracing mixed-methods and participatory approaches to knowledge creation.

4. Methodology

This thesis employed multiple methodologies for the literature review, and the empirical and reflective chapters, all of them derived from diverse theoretical frameworks which correspond to the specific objectives above.

- For Chapter 2, a literature review was conducted focusing on the emerging debates around data governance for FNS. The review explored existing theoretical frameworks, academic debates, and prior studies to establish a comprehensive foundation. The methodology involved an extensive search across Google Scholar, using keywords related to data, governance, FNS, and food systems. The selection and data extraction were performed using Excel spreadsheets, facilitating the studies review and data organization. Extracted data was organized to systematically compare findings, allowing for the identification of the complexity and plurality within these approaches.

- To analyze the coherence and integration of food governance policies in Chile, Chapter 3 employed the theoretical framework of Relevant Public Programmatic Offer (RPPO) and Associated Public Programmatic Offer (APPO) as defined by DIPRES (Dirección de Presupuestos de Chile). This framework enabled a structured analysis of public programs, categorizing them by their direct or indirect mandates for food security. Methods included a detailed review of program objectives and financial analysis in Excel, alongside the use of ATLAS.ti to systematically categorize and analyze program objectives according to FNS dimensions. Additionally, thematic and content analyses were conducted to assess inter-ministerial integration and alignment with national policies.

- Chapter 4 employed a multifaceted approach, integrating socio-demographic analysis, dietary intake frequency assessment, and the calculation of the Household Dietary

Diversity Score (HDDS). Based on frameworks developed by Kundu et al (2020) and Hossain et al (2020), this methodology included descriptive statistics to analyze socio-demographic variables and dietary patterns among vulnerable households in Chile. The study utilized RStudio and packages like “tidyverse,” “ggplot2,” and “chilemapas” for spatial visualization, developing a warning system to inform governance decisions based on HDDS correlations and spatial data.

- Chapter 5 adopted a reflective approach based on my own academic journey and the review of literature related to creation of local knowledge, positionality and reflexivity, and the subjective nature of research.

Having reviewed the context and background of this doctoral thesis, including the global challenges in food governance, especially regarding data governance and information accessibility, as well as Chile’s current FNS indicators, and having established the research problem, structure, objectives, and methodology, the next chapter aims to present an in-depth literature review. This review will explore emerging debates on data governance in FNS, identify the research gap, and articulate the research questions to be addressed in the next chapters of the thesis.

5. References

Balázs, B., Kelemen, E., Centofanti, T., Vasconcelos, M. W., and Iannetta, P. P. (2021). Integrated policy analysis to identify transformation paths to more sustainable legume-based food and feed value-chains in Europe. Agroecol. Sustain. Food Syst. 45, 931–953. doi: 10.1080/21683565.2021.1884165

Berry, E. (2019). Sustainable food systems and the mediterranean diet. Nutrients 11, 2229. doi:10.3390/nu11092229

Chappell, M. J. (2018). Beginning to end hunger. In Beginning to End Hunger. University of California Press.

De Schutter, O., Jacobs, N., and Clément, C. (2020). A 'common food policy' for Europe: how governance reforms can spark a shift to healthy diets and sustainable food systems. Food Policy 96, 101849. doi: 10.1016/j.foodpol.2020.101849

del Valle M, M., Shields, K., Alvarado Vázquez Mellado, A. S., & Boza, S. (2022). Food governance for better access to sustainable diets: A review. Frontiers in Sustainable Food Systems, 6, 784264.

Delabre, I., Rodriguez, L. O., Smallwood, J. M., Scharlemann, J. P., Alcamo, J., Antonarakis, A. S., et al. (2021). Actions on sustainable food production and consumption for the post-2020 global biodiversity framework. Sci. Adv. 7, abc8259. doi: 10.1126/sciadv.abc8259

DIPRES – Dirección de Presupuestos de Chile. (2021). Evaluación sectorial "Política de Promoción de Exportaciones". División de Control de Gestión Pública, Dirección de Presupuestos.

Dupouy, E., and Gurinovic, M. (2020). Sustainable food systems for healthy diets in Europe and Central Asia: introduction to the special issue. Food Policy 96, 101952. doi: 10.1016/j.foodpol.2020.101952

Eakin, H., Rueda, X., and Mahanti, A. (2017). Transforming governance in telecoupled food systems. Ecol. Soc. 22. doi: 10.5751/ES-09831-220432

EVS (Elige Vivir Sano) (2020). Radiografía de la obesidad infantil. http://eligevivirsano.gob.cl/wp-content/uploads/2020/01/PPT-EVS-15012020-Final.pdf (Accessed on May 03 2021).

FAO. 1996. Report of the World Food Summit.

FAO & UNICEF. (2021). WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO.

Galli, A., Pires, S. M., Iha, K., Alves, A. A., Lin, D., Mancini, M. S., et al. (2020). Sustainable food transition in Portugal: assessing the footprint of dietary choices and gaps in national and local food policies. Sci. Total Environ. 749, 141307. doi: 10.1016/j.scitotenv.2020.141307

Hawkes, C., and Popkin, B. M. (2015). Can the sustainable development goals reduce the burden of nutrition-related non-communicable diseases without truly addressing major food system reforms? BMC Med. 13, 1–3. doi: 10.1186/s12916-015-0383-7

Holmes, S. M. (2013). Fresh fruit, broken bodies. In Fresh Fruit, Broken Bodies. University of California Press.

Hossain, M. J., Das, S., Chandra, H., & Islam, M. A. (2020). Disaggregate level estimates and spatial mapping of food insecurity in Bangladesh by linking survey and census data. PloS one, 15(4), e0230906.

Howard, P. H. (2021). Concentration and power in the food system. Concentration and Power in the Food System, 1-232.

Kennedy, G., Hunter, D., Garrett, J, and Padulosi, S. (2017). Leveraging Agrobiodiversity to Create Sustainable Food Systems for Healthier Diets. UNSCN News. Available online at: https://hdl.handle.net/10568/89400 (accessed June 10, 2021)

Lang, T., and Barling, D. (2013). Nutrition and sustainability: an emerging food policy discourse. Proc. Nutr. Soc. 72, 1–12. doi: 10.1017/S002966511200290X

Mattioni, D., and Caraher, M. (2018). Moving towards ecologically sustainable diets: lessons from an Italian box delivery scheme. Int. J. Consum. Stud. 42, 430–438. doi: 10.1111/ijcs.12437

Meza, F., Gil, P., & Melo, O. (2021). Agricultural uses. Water resources of Chile, 243-258.

Milani-Bonab, A., Kalantari, N., Takian, A., & Haghighian-Roudsari, A. (2023). Food and agriculture, nutrition and health related policy integration in Iran's national development agenda and their alignment with the sustainable development goals. Environment, Development and Sustainability, 25(4), 3353-3378.

National Socioeconomic Characterization Survey. Ministry of Social Development and Family, Government of Chile. Food Insecurity Outcomes. (2022) https://datasocial.ministeriodesarrollosocial.gob.cl/fichaIndicador/814/1 (accessed on 03 May 2024).

Nettle, C. (2013). Hannah Wittman, Annette Aurélie Desmarais, Nettie Wiebe (eds): Food sovereignty: reconnecting food, nature and community. Agriculture and Human Values, 30(2), 313-314.

OCDE. (2019). Estudios de la OCDE sobre Salud Pública en Chile hacia un futuro más sano evaluación y recomendaciones. Ministerio de Salud, Gobierno de Chile. https://www.oecd.org/health/health-systems/Revisi%C3%B3n-ocde-de-Salud-P%C3%BAblica-Chile-Evaluaci%C3%B3n-y-recomendaciones.pdf

Patel, R. (2009). Food sovereignty. The journal of peasant studies, 36(3), 663-706.

Piticar, A. (2019). Changes in agro-climatic indices related to temperature in Central Chile. International journal of biometeorology, 63(4), 499-510.

Popkin, B. M., & Hawkes, C. (2016). Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses. The lancet Diabetes & endocrinology, 4(2), 174-186.

Prada, G. E., Durán-Agüero, S., & Moya-Osorio, J. L. (2021). Confinamiento e inseguridad alimentaria durante la pandemia por covid-19 en Chile. Revista chilena de nutrición, 48(5), 678-686.

Robbins, P. (2019). Political ecology: A critical introduction. John Wiley & Sons.

Sarricolea, P., Herrera-Ossandon, M., & Meseguer-Ruiz, Ó. (2017). Climatic regionalisation of continental Chile. Journal of Maps, 13(2), 66-73.

Schnurr, M. A. (2017). GMOs and poverty: yield gaps, differentiated impacts and the search for alternative questions. Canadian Journal of Development Studies/Revue canadienne d'études du développement, 38(1), 149-157.

Shrimpton, R., & Rokx, C. (2012). The double burden of malnutrition: a review of global evidence.

Smith, L. C., & Haddad, L. (2015). Reducing child undernutrition: past drivers and priorities for the post-MDG era. World Development, 68, 180-204.

Sonnino, R. (2013). Local foodscapes: place and power in the agri-food system. Acta Agric. Scand. B Soil Plant Sci. 63: 2–7. doi: 10.1080/09064710.2013.800130

Vermeulen, S. J., Park, T., Khoury, C. K., and Béné, C. (2020). Changing diets and the transformation of the global food system. Ann. NY Acad. Sci. 1478, 3–17. doi: 10.1111/nyas.14446

Vio del Río, F. The Nutrition Transition in Chile. Food policy for developing countries: the role of government in the global food system. (2007). Case study of the program Food Policy for Developing Countries: The Role of Government in the Global Food System. Cornell University. Edited by Per Pinstrup-Andersen and Fuzhi Cheng.

WHO (2021). Obesity and Overweight. Available online at: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (accessed September 13, 2021).

WHO. 2022. Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight#:~:text=39%20million%20children%20under%20the,Obesity%20is%20preventable. (Accessed on June 6, 2022).

Zúñiga-Escobar, M., Grisa, C., & Coelho-de-Souza, G. (2021). Redes de política pública: un abordaje para analizar la gobernanza de la Seguridad Alimentaria y Nutricional. Saúde e Sociedade, 29.

CHAPTER 2: Data Governance in Food and Nutrition Security - A review of emerging debates and pathways forward

1. Chapter's introduction

Before deepening into the details of the research and examining how the Chilean experience can serve as a case study for the current thesis aims and objectives, it is essential to first review the available literature and current trends. This chapter explores the main topics discussed in the field of data governance and investigates the prevailing discussions related to data for FNS. A primary inquiry of this literature review is to determine what the core themes in data governance are, going from policy frameworks and regulatory environments to the practical challenges of ensuring data integrity, privacy, and accessibility. Concurrently, it seeks to elucidate the state of research on the role of data in FNS, particularly the emerging debates. By addressing these areas, the literature review identifies both established practices and emerging trends, offering an integrated view of two fields.

Ultimately, this literature review serves as the foundation for the subsequent empirical and reflective work of the thesis. By situating the Chilean case study within the broader theoretical frameworks and debates extracted from the literature, it builds a compelling argument for the relevance of this research. In doing so, it clearly defines the research gap and identifies the research questions that will be addressed in the thesis, paving the way for a comprehensive analysis of how integrated data governance can contribute to improved FNS outcomes.

Abstract

Data governance has become an increasingly relevant topic in FNS, as the effective management of diverse data sources plays a crucial role in informing different types of action. However, challenges such as data fragmentation, accessibility gaps, and ethical concerns persist, limiting the potential of data-driven decision-making in the field. This literature review examines those challenges by addressing the research question: *"how do emerging debates and literature on data for food and nutrition security inform the types of data governance necessary for transforming food systems?".* The review is structured into three key sections. First, it explores the concept and scope of data governance, identifying key challenges related to the control and management of data assets. Second, it analyzes emerging debates in the literature focused on FNS, including the integration of heterogeneous data sources, the role of technology and innovation, the need for global coordination, and the advocacy for data as a public good. Thirdly, it discusses implications for action, reviewing governance models, institutional frameworks, and examples that illustrate how data governance principles are being operationalized in the field of FNS. Findings suggest that while data-driven approaches dominate the FNS research landscape, there is a lack of integration, interdisciplinary, and participatory governance strategies that include qualitative insights and local knowledge.

2. Background

Over the past decade, the intersection of data and FNS has gained substantial attention, with researchers and institutions recognizing the transformative potential of robust data systems and analytics to address ongoing challenges of hunger and malnutrition (HLPE, 2022; FAO et al, 2024). However, the proliferation of new data sources, including remote sensing, international data bases publicly available, and social media, has also revealed critical gaps and inconsistencies in how data is collected, governed, and applied across diverse food systems (Jarray et al., 2023). But why is it important to focus on the intersection between data, information and governance in the field of FNS? According to Béné et al. (2019) effective governance is essential for balancing power

and decision-making among diverse stakeholders in the food system, especially when varying interests are present. Thus, providing access to information can assist in several critical areas. First, it empowers stakeholders by equipping them with the knowledge necessary to make informed decisions regarding food related choices and sustainable practices (Lang, 2014; Dupouy and Gurinovic, 2020). Additionally, enhanced access to information facilitates collaboration among different actors within the food system, thereby strengthening collective efforts towards effective food governance (Hawkes and Popkin, 2015; Kennedy et al., 2017). Moreover, when stakeholders have access to relevant data, it fosters accountability and transparency within food governance structures (Galli et al., 2020). Since the field of food systems research and advocacy is quite diverse it means that it necessitates governance processes that incorporate strategies for improved information sharing, which is critical for addressing FNS challenges and promoting sustainability (Lee et al., 2020; Delabre et al., 2021). The conclusion from that review indicate that while many authors discuss the importance of access to data and information within the context of food governance, there is still space to explore on specific methodologies or frameworks to enhance this access (del Valle et al., 2022; Vermeulen et al., 2020).

This chapter presents a literature review that explores the research question *"how do emerging debates and literature on data for food and nutrition security inform the types of data governance necessary for transforming food systems?".* In doing so, it aims to situate this thesis within current academic and policy discussions and provide a theoretical foundation for the subsequent empirical work carried out as part of the PhD. In this regard, for the purpose of this thesis, "*transforming food systems"* is understood as shifting from fragmented and exclusive productivity-driven models toward inclusive, sustainable, and equitable frameworks. This implies ensuring the right to food, integrating social and environmental considerations, promoting participatory approaches, and reconsidering power relations in decision-making processes.

3. Methodology employed

To ensure the quality and academic rigor of this literature review, only scientific articles published in indexed journals were included. Although the initial search was conducted through Google Scholar, the selected studies were verified to belong to journals indexed in Scopus, Web of

Science, or other reputable databases, ensuring they met peer-review standards and scientific quality criteria. Additionally, grey literature from internationally recognized organizations was included, provided that it came from reputable institutions known for their contributions to the field.

For the section on data governance, the keyword *"data governance"* was used. Then, to address emerging debates related to data governance and FNS, the following search strategy was employed:

"Data governance" AND ("food security" OR "food and nutrition security" OR "food systems").

The combination of terms with Boolean operators allowed the search to focus on documents that explicitly connected data governance with aspects of FNS and food systems.

3.1.Inclusion and exclusion criteria

- Document type: Peer-reviewed scientific articles and gray literature from international organizations were included. Conference papers and doctoral dissertations were excluded.
- Language: Only documents in English were included.
- Time range: Initially, only documents published from 2020 onward were considered. However, during the review of references in these texts, earlier sources (particularly those on *data governance*) were identified as relevant and thus included.
- Thematic scope: Only documents that explicitly addressed data governance, food and/or nutrition security, or provided a relevant theoretical or empirical framework for understanding these topics were selected.

3.2.Selection and review process

Titles and abstracts of identified documents were progressively reviewed, with documents being read in detail as they were encountered, to build a solid foundation for the analysis. Throughout this process, inclusion and exclusion criteria (document type, language, thematic scope) were

consistently applied to ensure relevance and coherence with the research objectives. As a result, a total of 27 documents were included in the review.

3.3.Analytical approach

The final set of literature was categorized under two main groups, in accordance with the objectives of this review:

- (1) Data governance: conceptual definitions and key challenges
- (2) Emerging debates and literature around the role of data in Food and Nutrition Security

For each group, an Excel matrix was created to record relevant information from each article (authors, year, objectives, key findings, and main contributions), which served as the basis for interpreting and synthesizing the literature.

4. Data governance: conceptual definitions and key challenges

Multiple authors converge on defining data governance as a structured exercise of authority and control over data management, with the common objective of maximizing data value and minimizing risks or associated costs. Abraham et al. (2019) and Machado Ribeiro et al. (2022) highlight this central idea by focusing on power and control as mechanisms to safeguard data while extracting its maximum benefit. Complementing these perspectives, Yebenes and Zorrilla (2019) emphasize the assignment of decision-related rights and duties for treating data as an organizational asset, highlighting the importance of shared decision-making. In a similar way, Panian (2010) and Alhassan et al. (2016) describe frameworks designed to clarify responsibilities, encourage desirable behaviors, and implement organization-wide policies for consistent data handling. Newlands (2020) takes a broader approach by describing data governance as encompassing structures, systems, and practices that guide decision-making and strategic direction, including the management of information and communication technology.

There are some studies that highlight data quality, privacy, standardization, and non-equitable access as critical challenges that obstruct effective data governance in the context of FNS. For

instance, Abraham et al. (2019) underline persistent difficulties in integrating big data with traditional systems, calling attention to the need for standardized metrics to evaluate data value. Durrant et al. (2021) and Serfilippi et al. (2022) similarly emphasize the inequalities that arise from inadequate data quality, limited transparency, and weak interoperability—factors that exacerbate power imbalances. Canfield and Ntambirweki (2024) add that concerns over data accuracy, security, and usability often overlap with broader social inequalities, while Kebede et al. (2024) highlight institutional capacity as a key factor in facing challenges such as difficulties in access, standardization, and data privacy. Related to this, Kumar et al. (2024) identify the gap in knowledge transfer as an emerging barrier, and Machado Ribeiro et al. (2022) highlight the urgent need for updated data policies to address regulatory compliance and issues related to data quality.

Regardless of these obstacles, a recurring theme is the call for global coordination and ethical frameworks to guide data sharing and usage. Zeb et al. (2021) and Matchaya et al. (2023) both underline the importance of cross-border partnerships to ensure consistent standards and equitable access, whereas Pisa et al. (2020) see the alignment of data protection authorities as vital to dealing with sensitive privacy concerns, using as an example the beginning of COVID-19. Smith et al. (2022) argue that balancing open data principles with the protection of vulnerable groups demands careful ethical supervision. Meanwhile, Marvin et al. (2022) and Yarime (2017) highlight that data governance intersects with broader political economy issues, such as conflicting stakeholder interests, or institutional arrangements for promoting open data, underscoring how technological innovations are shaped by and reshape existing power structures. Across these studies, the consensus is that without robust governance, grounded in ethics and collaborative regulatory frameworks, the transformative potential of data for FNS will remain constrained.

The literature reviewed indicates that data governance is not neutral, as it takes place in a context where different actors—governments, companies, and communities—have different levels of power. Choices about who can access or control data involve political negotiations that can reinforce, or sometimes change, existing inequalities. Recognizing these power relationships is key to understanding how data governance can either maintain unfair food systems or help make them more just. By acknowledging these imbalances, data governance approaches can attempt to redistribute decision-making power among multiple stakeholders and better serve vulnerable

populations. In this regard, civil society (e.g. local groups, cooperatives, and community networks) can play a big part in data governance, as they can help demand transparency, ensure that data is treated as a public good pushing then for more equitable access, and bring in local knowledge that policymakers often overlook. However, for their participation, open communication channels, skill-building resources, and institutional commitment are needed to ensure inclusive and transparent data management through collaborative and participatory approaches (del Valle et al., 2022). Considering the above, for the purpose of this thesis, data governance will be understood as *"the principles, rules, and actions that shape how data is collected, shared, and used in food systems"*. This understanding will guide the analysis in the following chapters, as it suggests a participatory view, where decisions about data—such as who owns it, how it is stored, and who can see it—are made by a range of actors.

5. Emerging debates and literature around the role of data in Food and Nutrition Security

In recent years, the growing complexity of agri-food systems and the challenges related to hunger and malnutrition have highlighted the need for more accurate, accessible, and multidimensional data (HLPE, 2022; FAO et al, 2024). The strategic use of information has become a key factor in designing policies and practices that improve FNS on a global scale (Tian et al., 2016). However, data heterogeneity, lack of common standards, and unequal access remain substantial barriers (Jarray et al., 2023). In this context, various authors have identified a set of emerging debates around the role of data, which can guide a roadmap for more effective decision-making and interventions.

As shown in Table 1, the most recurrent debates found in the literature focus on the integration of diverse data sources, data gaps and challenges in data availability, and the growing demand for data-driven decision-making (HLPE, 2022; Deléglise et al., 2022; Jarray et al., 2023; Restrepo et al., 2022; FAO et al., 2024; Tao et al., 2020; Tian et al., 2016). These discussions highlight the urgency of coordinating information from public, private, and civil society institutions, as well as from emerging technologies (e.g., satellite data and machine learning), to more accurately characterize food systems. Among the main findings, there is also a focus on the role of technology,

innovation, and advanced methods (FAO et al., 2024; Tao et al., 2020; Tian et al., 2016) and a growing interest in understanding consumer behavior and acceptance (Tao et al., 2020; Tian et al., 2016; Wan et al., 2021). In addition, some studies also highlight the need for global coordination (HLPE, 2022; Tian et al., 2016) and for recognizing data as a public good, which calls for stronger political and regulatory commitment (HLPE, 2022; FAO et al., 2024). Another group of topics includes the application of machine learning, the complexity of measuring FNS and generating reliable data, and the policy implications of using data to design and evaluate interventions (Deléglise et al., 2022; Restrepo et al., 2022; Tian et al., 2016).

Table 1. Most frequent debates on data for FNS.

Debate	Studies mentioning it	Occurrences
Integration of diverse/heterogeneous data sources *(includes data from the public sector, private sector, civil society, remote sensing, open data, etc.)*	HLPE (2022); FAO et al. (2024); Deléglise et al. (2022); Jarray et al. (2023); Restrepo et al. (2022); Tao et al. (2020)	6
Data gaps, availability, quality, and collection challenges	HLPE (2022); FAO et al. (2024): Jarray et al. (2023); Restrepo et al. (2022)	4
Demand for data-driven decision making	HLPE (2022); Tian et al. (2016); Tao et al. (2020)	3
Role of technology, innovation, and advanced methods	FAO et al. (2024); Tian et al. (2016); Tao et al. (2020)	3
Consumer behavior, acceptance, and demand	Wan et al. (2021); Tao et al. (2020); Tian et al. (2016)	3
Global coordination/collaboration and data sharing	HLPE (2022); Tian et al. (2016)	2
Machine learning and advanced analytics applications	Deléglise et al. (2022); Restrepo et al. (2022)	2
Complexity/multidimensional approach to measuring FNS	Deléglise et al. (2022); Restrepo et al. (2022)	2
Policies, regulation, and implications	Restrepo et al. (2022); Tian et al. (2016)	2

Data as a public good/advocacy for data Collection as a global public good	HLPE (2022); FAO et al (2024)	2

In addition, there are debates that were found in only one study, compiled in Table 2, which does not diminish their relevance and that can set the direction for future research. Examples include data fusion strategies and the importance of temporal dynamics in predicting food security (Deléglise et al., 2022). Some authors also highlight alignment with the Sustainable Development Goals (SDGs) (Jarray et al., 2023), while others emphasize the need for standardized definitions and measurements (FAO et al., 2024). This set also includes more specialized topics, such as data related to introducing alternative proteins to strengthen FNS (Wan et al., 2021), data on protein quality measurement, food safety and surveillance, and data on food loss and waste (Tao et al., 2020; Tian et al., 2016).

Table 2. Less frequent debates in data for FNS.

Debates	Studies mentioning it
Data fusion strategies	Deléglise et al. (2022)
Temporal dynamics	Deléglise et al. (2022)
Data complexity and processing	Jarray et al. (2023)
Alignement with the SDGs	Jarray et al. (2023)
Need for standardization (definitions, measurements)	FAO et al. (2024)
Inequalities in data access	FAO et al. (2024)
Alternative proteins as a solution	Wan et al. (2021)
Protein quality measurement	Wan et al. (2021)
Integration of nutritional quality into food policy	Wan et al. (2021)
Quantitative connection between food security and nutritional quality	Wan et al. (2021)
Food safety and surveillance	Tao et al. (2020)
Challenges in data credibility and relevance	Tao et al. (2020)
Food waste and loss	Tian et al. (2016)

Nutritional deficiencies	Tian et al. (2016)
Impact of COVID-19 and conflicts	HLPE (2022)

6. Implications for action, examples and research gap

Building on the definitions and emerging debates discussed in the previous sections, it is crucial to explore how governance frameworks and initiatives are being translated into actionable strategies for FNS. For instance, FAO et al. (2024) have developed guidelines emphasizing transparent data-sharing practices, capacity building, and the importance of ethical oversight in digital agriculture programs. In a similar way, initiatives like the Global Strategy to Improve Agricultural and Rural Statistics (GSARS) and 50x2030 (Matchaya et al., 2023) exemplify efforts to establish common standards and robust data systems, while promoting collaboration among governments, donors, and the private sector. Practical approaches range from Data Trusts (Durrant et al., 2021) to Data Governance Councils implemented by The Kenyan Ministry of Agriculture (Canfield & Ntambirweki, 2024) and "Findable, Accessible, Interoperable, and Reusable" (FAIR) data management ecosystems (Kumar et al., 2024). Such mechanisms aim to support sustainable, evidence-based policy decisions that enhance FNS (Machado Ribeiro et al., 2022; Marvin et al., 2022). Studies have also highlighted the value of public-private partnerships, such as collaborative platforms linking humanitarian organizations with open data resources (Smith et al., 2022), and large-scale projects like the Data Integration and Analysis System (DIAS) to promote urban sustainability (Yarime, 2017). Taken together, these examples illustrate a growing alignment between theoretical debates on data governance and tangible, on-the-ground efforts to enable equitable access and responsible data practices.

Finally, it is important to acknowledge that most of the literature reviewed relies heavily on quantitative data governance approaches, focusing on large-scale indicators while leaving less room for mixed methods and strictly qualitative approaches. This methodological imbalance limits the ability to capture the social, cultural, and institutional dimensions of FNS governance. Expanding research that incorporates participatory and qualitative approaches is crucial for

developing more inclusive, context-sensitive, and actionable strategies that address both structural and localized challenges in FNS governance.

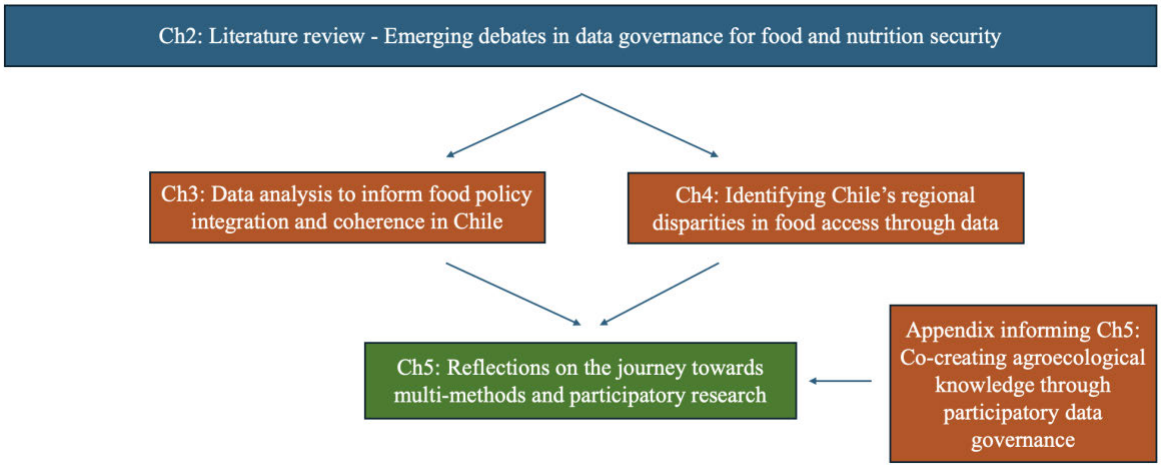
6.1. Clarifying the research gap

While many studies have discussed the potential of data to improve FNS, few have provided practical guidelines on implementing these ideas in a manner that is fair, ethical, and inclusive. This thesis addresses that gap by using Chile as a case study to explore how integrated and evidence-based approaches to data governance can enhance FNS, thereby offering actionable insights to overcome the country's double burden of malnutrition.

7. Linking this review with the subsequent chapters

The results of this literature review establish the foundational themes for the thesis, identifying key challenges such as data gaps, inequities, and the need for participatory governance frameworks. It emphasizes the importance of integrating diverse data sources and contextualizing governance models to address FNS challenges. These debates serve as a theoretical lens that informs both empirical and reflective work carried out. The connections between the literature review, empirical chapters, and the reflective chapter are illustrated in Figure 1, with a subsequent detail of each just below.

Figure 1. Connections between the literature review and the subsequent thesis chapters.



Note: The text linked to each chapter does not correspond to the chapter titles, but rather to the main themes they cover.

- Chapter 3: Data analysis to inform food policy integration and coherence in Chile.

  Related to the emerging debate "coordination/collaboration in data sharing", this chapter addresses the research question *"how does data analysis contribute to the integration and coherence of food policies in Chile?"*. By analyzing both quantitative and qualitative data, it operationalizes the literature's emphasis on governance integration and coherence by discussing gaps in policy alignment, programmatic objectives, and budget allocations.

- Chapter 4: Identifying Chile's regional disparities in food access through data.

  The chapter applies data governance principles through the use of Household Dietary Diversity Scores (HDDS) and spatial visualization to answer the research question "*how can data analysis support evidence-based decisions to reduce inequalities in food access in Chile?"* It aligns with the literature's focus on "demand for data-driven decision making" for addressing regional disparities in food access.

- Chapter 5: Reflections on the journey towards multi-methods and participatory research.

This chapter addresses the need to connect my personal journey—from conventional agronomy to agroecology, and from strictly positivist quantitative methods to mixed qualitative and participatory approaches—with the findings and discussions presented in this thesis. I reflect on the question "*how does my position as a researcher—and my transition from conventional agronomy to a participatory, multi-method approach—shape the knowledge produced about food and nutrition security in Chile?"*. More than a methodological note, it is a space to examine how my understanding of what counts as knowledge in agronomy and food systems governance has changed, and to recognize the importance of local knowledge, lived experience, and community collaboration. A case study, taken from an appendix chapter included in this thesis, grounds these reflections in a practical example carried out between December 2022 and February 2023 in the Mashue sector of the Los Ríos Region, Chile.

- Appendix chapter 1: Co-creating knowledge through participatory data governance.

  This chapter serves as an informing piece of work for informing Chapter 5. It addresses the research question *"how can participatory data governance foster the co-creation of agroecological knowledge in southern Chile?"*, reflecting the literature's call for inclusive governance and "data as a public good" by integrating local knowledge and fostering collaboration to address socio-ecological challenges in food systems.

8. References

Abraham, R., Schneider, J., & Vom Brocke, J. (2019). Data governance: A conceptual framework, structured review, and research agenda. *International journal of information management*, *49*, 424-438.

Alhassan, I., Sammon, D., & Daly, M. (2016). Data governance activities: an analysis of the literature. Journal of Decision Systems, 25(sup1), 64-75.

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I., de Haan, S., Prager, S., Khoury, C. (2019). When food systems meet sustainability–Current narratives and implications for actions. World Development, 113, 116-130. https://doi.org/10.1016/j.worlddev.2018.08.011

Canfield, M., & Ntambirweki, B. (2024). Datafying African Agriculture: From data governance to farmers' rights. Development, 1-9.

del Valle M, M., Shields, K., Alvarado Vázquez Mellado, A. S., & Boza, S. (2022). Food governance for better access to sustainable diets: A review. Frontiers in Sustainable Food Systems, 6, 784264.

Delabre, I., Rodriguez, L. O., Smallwood, J. M., Scharlemann, J. P., Alcamo, J., Antonarakis, A. S., ... & Stenseth, N. C. (2021). Actions on sustainable food production and consumption for the post-2020 global biodiversity framework. Science Advances, 7(12). DOI: 10.1126/sciadv.abc8259

Deléglise, H., Interdonato, R., Bégué, A., d'Hôtel, E. M., Teisseire, M., & Roche, M. (2022). Food security prediction from heterogeneous data combining machine and deep learning methods. Expert Systems with Applications, 190, 116189.

Dupouy, E., and Gurinovic, M. (2020). Sustainable food systems for healthy diets in Europe and Central Asia: introduction to the special issue. Food Policy 96, 101952. doi: 10.1016/j.foodpol.2020.101952

Durrant, A., Markovic, M., Matthews, D., May, D., Leontidis, G., & Enright, J. (2021). How might technology rise to the challenge of data sharing in agri-food?. Global Food Security, 28, 100493.

FAO, IFAD, UNICEF, WFP and WHO. 2024. The State of Food Security and Nutrition in the World 2024 – Financing to end hunger, food insecurity and malnutrition in all its forms. Rome. https://doi.org/10.4060/cd1254en

Galli, A., Pires, S. M., Iha, K., Alves, A. A., Lin, D., Mancini, M. S., et al. (2020). Sustainable food transition in Portugal: assessing the footprint of dietary choices and gaps in national and local food policies. Sci. Total Environ. 749, 141307. doi: 10.1016/j.scitotenv.2020.141307

Hassoun, A., Marvin, H. J., Bouzembrak, Y., Barba, F. J., Castagnini, J. M., Pallarés, N., ... & Regenstein, J. M. (2023). Digital transformation in the agri-food industry: recent applications and the role of the COVID-19 pandemic. Frontiers in Sustainable Food Systems, 7, 1217813.

Hawkes, C., and Popkin, B. M. (2015). Can the sustainable development goals reduce the burden of nutrition-related non-communicable diseases without truly addressing major food system reforms? BMC Med. 13, 1–3. doi: 10.1186/s12916-015-0383-7

HLPE. 2022. Data collection and analysis tools for food security and nutrition: towards enhancing effective, inclusive, evidence-informed, decision making. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

Jarray, N., Abbes, A. B., & Farah, I. R. (2023). Machine learning for food security: current status, challenges, and future perspectives. Artificial Intelligence Review, 56(Suppl 3), 3853-3876.

Kebede, E. A., Abou Ali, H., Clavelle, T., Froehlich, H. E., Gephart, J. A., Hartman, S., ... & Davis, K. F. (2024). Assessing and addressing the global state of food production data scarcity. Nature Reviews Earth & Environment, 5(4), 295-311.

Kennedy, G., Hunter, D., Garrett, J, and Padulosi, S. (2017). Leveraging Agrobiodiversity to Create Sustainable Food Systems for Healthier Diets. UNSCN News. Available online at: https://hdl.handle.net/10568/89400

Kumar, P., Hendriks, T., Panoutsopoulos, H., & Brewster, C. (2023). Investigating Fair Data Management Practices in Eu-Funded Agri-Food and Rural Development Multi-Actor Projects.

Lang, T. I. M. (2014). Sustainable Diets: Hairshirts or a better food future?. Development, 57(2), 240-256. https://doi.org/10.1057/dev.2014.73

Lee, A. J., Cullerton, K., & Herron, L. M. (2020). Achieving food system transformation: insights from a retrospective review of nutrition policy (in) action in high-income countries. International Journal of Health Policy and Management. 10.34172/IJHPM.2020.188

Machado Ribeiro, V. H., Barata, J., & da Cunha, P. R. (2022). Sustainable data governance: A systematic review and a conceptual framework.

Marvin, H. J., Bouzembrak, Y., Van der Fels-Klerx, H. J., Kempenaar, C., Veerkamp, R., Chauhan, A., ... & Tekinerdogan, B. (2022). Digitalisation and Artificial Intelligence for sustainable food systems. Trends in Food Science & Technology, 120, 344-348.

Matchaya, G. C., Makombe, T., & Mihaylova, N. G. (2023). Data challenges and opportunities for food systems transformation in Africa.

Newlands, N. K. (2020). Big Data Governance, Technology, and Implementation in Climate-Resilient Societies. The Palgrave Handbook of Climate Resilient Societies, 1-20.

Panian, Z. (2010). Some practical experiences in data governance. World Academy of Science, Engineering and Technology, 62(1), 939-946.

Pisa, M., Dixon, P., Ndulu, B., & Nwankwo, U. (2020). Governing data for development: trends, challenges, and opportunities. CGD Policy Paper, 190, 1-61.

Restrepo, D. S., Pérez, L. E., López, D. M., Vargas-Cañas, R., & Osorio-Valencia, J. S. (2022). Multi-dimensional dataset of open data and satellite images for characterization of food security and nutrition. Frontiers in Nutrition, 8, 796082.

Serfilippi, E., Giovannucci, D., Ameyaw, D., Bansal, A., Wobill, T. A. N., Blankson, R., & Mishra, R. (2022). Benefits and Challenges of Making Data More Agile: A Review of Recent Key Approaches in Agriculture. Sustainability, 14(24), 16480.

Smith, N., Idris, M. Y., Schüür, F., & Ko, R. (2022). Data for Good, What Is It Good For?: Challenges, Opportunities, and Data Innovation in Service of Refugees.

Tao, D., Yang, P., & Feng, H. (2020). Utilization of text mining as a big data analysis tool for food science and nutrition. Comprehensive reviews in food science and food safety, 19(2), 875-894.

Tian, J., Bryksa, B. C., & Yada, R. Y. (2016). Feeding the world into the future–food and nutrition security: the role of food science and technology. Frontiers in life science, 9(3), 155-166.

Vermeulen, S. J., Park, T., Khoury, C. K., & Béné, C. (2020). Changing diets and the transformation of the global food system. Annals of the New York Academy of Sciences, 1478(1), 3–17. https://doi.org/10.1111/nyas.14446

Wan, A. C., Tai, B. C., & Du, C. (2021). Food security and nutrition-a systematic approach. Trends in Food Science & Technology, 109, 738-745.

Yarime, M. (2017). Facilitating data-intensive approaches to innovation for sustainability: opportunities and challenges in building smart cities. Sustainability Science, 12, 881-885.

Yebenes, J., & Zorrilla, M. (2019). Towards a data governance framework for third generation platforms. Procedia Computer Science, 151, 614-621.

Zeb, A., Soininen, J. P., & Sozer, N. (2021). Data harmonisation as a key to enable digitalisation of the food sector: A review. Food and Bioproducts Processing, 127, 360-370.

9. Chapter's conclusions

This literature review examined a total of 27 documents to address the research question: *"how do emerging debates and literature on data for FNS inform the types of data governance necessary for transforming food systems?"*. The results were analyzed in two main sections. The first reviewed the definitions and key challenges related to "data governance", while the second explored the emerging debates on data governance within the field of FNS. Based on this analysis, the review discussed the implications for action, provided illustrative examples, and identified the research gap that this thesis seeks to fill.

The results have shown that current debates converge on the importance of integrating heterogeneous data, addressing persistent gaps in data quality and accessibility, and establishing robust governance frameworks that balance openness with ethical, equal, and cultural considerations (HLPE, 2022; Tian et al., 2016). From discussions of machine learning and advanced analytics to new institutional mechanisms such as Data Trusts or dedicated Data Governance Councils, researchers and practitioners alike point to the necessity of aligning data usage with transparent, participatory models that ensure equitable benefits for food-insecure populations (Durrant et al., 2021; Canfield and Ntambirweki, 2024). Thus, this review highlights a key principle: data must be viewed as an asset that demands careful management, ethical guidelines should be embedded in all stages of data use, and collaborative frameworks are essential for scaling successful practices. While promising initiatives exist, more empirical evidence is needed to determine which governance models translate effectively into diverse regional and cultural contexts.

The analysis and conclusions presented in this literature review pave the way for the next phase of the thesis, which introduces the empirical and reflective chapters. The first empirical chapter offers a concise examination of coordination and collaboration in data sharing within Chile's food security framework. The chapter integrates both quantitative and qualitative open-source data from the Chilean Integrated Database of Social Programs to analyze public programs related to food security. Utilizing a methodology developed by Chile's Budget Directorate, the chapter categorizes

these programs into two distinct groups, thereby assessing inter-ministerial governance of food policies.

CHAPTER 3: Integration and coherence in food governance - a comprehensive analysis of food security public programs in Chile

* This chapter is based on:

Del Valle M, M., Shields, K., Boza, S. (2024). *Integration and coherence in food governance—a comprehensive analysis of food security public programs in Chile*. Frontiers in Sustainable Food Systems, 8:1431969. Doi: 10.3389/fsufs.2024.1431969

Supplementary information is available online, accessible via the doi.

1. Chapter's introduction

The first empirical chapter of this thesis examines the emerging debate on "coordination/collaboration in data sharing" as presented in the literature review. Guided by the thesis sub-research question, "*how does data analysis contribute to the integration and coherence of food policies in Chile?*", the chapter integrates quantitative and qualitative open-source data from the Chilean Integrated Database of Social Programs (*Banco Integrado de Programas Sociales*) to investigate n=70 public programs affecting FNS. It assesses inter-ministerial governance in food policies by using a methodology previously applied by the Budget Directorate of Chile (*Dirección de Presupuestos de Chile*), which categorizes the public programs offer into Relevant Public Programs Offer (RPPO) and Associated Public Programs Offer (APPO). The analysis evaluates the alignment between the Social Determinants of Health and the National Food and Nutrition Policy, identifies disparities in resource allocation among ministries, and reviews inter-ministerial collaboration in food security initiatives.

Although not the primary emerging debate highlighted in the literature for this chapter, the content also intersects with the discussion on the "demand for data-driven decision making." The results presented here can be instrumental in informing decisions that foster integrative and coherent food policies. In doing so, this chapter begins to illustrate that the debates uncovered in the literature

review are not mutually exclusive; rather, they naturally overlap when examining the specific realities of a country or territory.

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Abstract

This study critically examines Chilean food governance. In particular it focuses on two aspects of inter-ministerial governance: policy 'integration' and policy 'coherence'. It does so by evaluating the alignment between two key policy objectives within the Chilean government; the Social Determinants of Health (SDH) and National Food and Nutrition Policy (NFNP) objectives. It does so by using publicly available data at the Integrated Bank of Social Programs (*BIPS – Banco Integrado de Programas Sociales*) collected in 2021. Utilizing mixed methods including content analysis, program review, and financial analysis, 245 public programs were scrutinized. Only 0.042% of the 2021 national budget for public programs was allocated to n=70 key programs directly addressing food and nutrition security (FNS), highlighting significant resource disparities among ministries. While some inter-ministerial integration was observed, overall coherence with NFNP objectives, particularly in “health integration and intersectorality”, was lacking. Since disparities in resource allocation and neglect of stability and agency within food security across ministries are identified, indicating a variegated approach to food security with differing emphases on availability, utilization, and access, this study calls for a collaborative, multi-sectoral strategy to bridge policy gaps and enhance coherence in addressing food security challenges. Its findings contribute to the discourse on food governance, offering insights into policy implementation gaps and suggesting avenues for enhancing inter-ministerial integration and coherence. This research underscores the importance of a comprehensive approach to policy formulation and execution in achieving NFNP goals and addressing the complex challenges of food security in Chile.

Keywords: Chile, Coherence, Food Security, Governance, Integration, Public Programs.

2. Background

Despite global advances in agricultural science and technology development, hunger and malnutrition continue to affect millions of people around the world. Fragmented policy responses and lack of coordination have often exacerbated these issues, as seen in various international contexts (Kushitor et al., 2022), meaning that inclusive multi-stakeholder processes to effectively address these issues (Duncan and Claeys, 2018). It is estimated that between 720 and 811 million people faced hunger in 2020, 118 million more than in 2019, while one in three people did not have access to adequate food during the same period (FAO & UNICEF, 2021). In 2016, 1.9 billion adults were overweight, 650 million of these obese, and 39 million children under the age of 5 were overweight or obese in 2020 (WHO, 2022), with diet-related non-communicable diseases rising sharply (Hawkes and Popkin, 2015; Hawkes et al., 2020) In addition, the number of people suffering from “hidden hunger” (insufficient intake of essential minerals and vitamins required in small amounts by the body for proper growth and development) was likely to be between 1 and 2 billion in 2021 (WHO, 2022).

Chile's case reveals the dual challenge of undernutrition and overnutrition, since the country experienced a classic post-nutritional transition stage by nearly eradicating malnutrition in the late 1980s and subsequently witnessing an increase in its rates of overnutrition (Vio del Río, 2007). Over the course of almost forty years, this shift has led to an alarming statistic: an estimated 74.2% of the Chilean population is now classified as overweight (National Health Survey, 2017). Furthermore, the period between 2005 and 2017 saw a 66.3% increase in child obesity rates (EVS, 2020). This reality has meant that three million Chileans are now dealing with non-communicable diseases (NCDs) linked to obesity, impacting their overall well-being, productivity, and straining the national healthcare system (Fernández et al., 2017). On the other hand, according to the last National Socioeconomic Characterization Survey (2022), around 16.3% of households in Chile faced moderate food insecurity, while 3.5% suffered from severe food insecurity, primarily due to financial limitations. This juxtaposition of overconsumption of unhealthy foods and food insecurity has led to what is often termed the "double burden of malnutrition” (Shrimpton and Rokx, 2012).

In response to these complex challenges, the Chilean government introduced in 2017 the "National Policy of Food and Nutrition" (NFNP) (NFNP, 2017). The NFNP's vision is to contribute to improving the health status and quality of life of the national population through the development of regulations, strategies, plans, programs, and projects in the field of food and nutrition. This comprehensive policy comprises six approaches and eight components designed to address the multifaceted dimensions of nutrition and health disparities. These approaches and components, found in Table 1, range from promoting healthy eating and improving food environments to enhancing nutritional care and citizen participation. One of the approaches are the “Social Determinants of Health” (SDH), defined by the World Health Organization (WHO) as “the conditions in which people live, encompassing factors such as local governance, public policies, housing and land, culture and social values, social class, gender, and ethnicity, all of which collectively shape their health status” (WHO, 2013). Chile is no exception to this pattern, as in the context of both undernutrition and overweight, being a woman, residing in rural areas, and having less than eight years of formal education exemplify social determinants of health that significantly impact food and nutrition insecurity in the country (National Health Survey, 2017; National Socioeconomic Characterization Survey, 2023).

Table 1. NFNP approaches and components.

Approaches	Components
Human rights	Humanizing nutrition and promote the right to adequate food
Social determinants of health	Improving the configuration of food environments and systems
Commercial and political determinants of health	Monitoring food and nutrition and evaluating public policies
Gender	Promoting citizen participation and social control
Indigenous peoples and interculturality	Promoting healthy eating
Age and lifecourse	Strengthening food and nutrition security: availability, access, food utilization and stability
	Strengthening nutritional care at the different levels of health care

	Deepening intersectoriality and health in all policies

Source: National Policy of Food and Nutrition (2017).

The incorporation of the SDH within the NFNP reflects an understanding of the factors influencing health outcomes. By recognizing the impact of socio-economic status, gender, and education on nutritional well-being, the policy acknowledges that addressing health disparities requires a holistic approach that goes beyond dietary recommendations. This integration of social determinants underscores the policy's commitment to tackling the root causes of both food insecurity and malnutrition. Thus, to better address both global and Chilean food challenges, it is necessary to understand the broader mechanisms and structures that influence food and nutrition security. In this regard, the concept of "food governance" emerges as a pivotal framework for analysis and intervention.

Food governance is a comprehensive concept that encompasses the formal and informal rules, interactions, institutions, and mechanisms governing decisions and actions related to food and nutrition security at local, national, and global levels (Candel, 2014, del Valle et al., 2022). It involves the exercise and balance of power within specific institutional contexts, which are designed to direct, control, and regulate activities related to food security, emphasizing the need for these institutions to be perceived as legitimate, accountable, and transparent (Candel, 2014). Furthermore, the scope of food governance extends to shaping the entire food system, influencing actors, processes, and outcomes in the production, distribution, and consumption of food, fostering sustainability in health, heritage, and natural environments (Moragues-Faus et al., 2017). Moreover, the significance of food governance becomes even more evident when considering its complex interconnection with climate change, an area in which the food and agricultural sector not only contributes significantly but is also highly vulnerable to adverse effects, as noted by Clapp et al. (2018). Within this framework, food governance plays a crucial role in both the genesis and mitigation of food insecurity. Suboptimal governance, present within conflicts, institutional deficiencies, inadequate policy design, and delays in implementation, can significantly hinder the production and equitable distribution of healthy foods. In contrast, effective governance is essential to ensure the sustainability, resilience, and equity of food systems, thereby guaranteeing universal access to safe, nutritious, and culturally appropriate food (Candel, 2014). In this sense, that

effectiveness can be achieved when certain characteristics, including policy integration and coherence, are found to play a crucial role in shaping effective and resilient food systems necessary for fostering food security.

Integration in food governance is defined as the coordination of policies, actions, and stakeholders to address interconnected challenges in the food system (Sibbing et al., 2021). It involves recognizing the interdependence of various food system aspects, necessitating coordinated governance to mitigate duplications and contradictions, thereby enhancing the overall efficacy of related governance objectives. By leveraging different agricultural policy levers, it is possible to promote healthier diets and address the growing prevalence of obesity and diet-related chronic diseases. For instance, crop diversification and targeted subsidies can enhance the availability and affordability of nutritious foods, aligning agricultural production with public health goals (Hawkes, 2007). Candel and Biesbroek (2016) also acknowledge the complexity of food security challenges, suggesting that horizontal, vertical, and stakeholder integration are key elements that enhance policy implementation, reduce fragmentation, and foster stakeholder participation and ownership, thus improving the effectiveness of food governance. Moreover, Candel (2019) indicates the importance of addressing externalities and trade-offs through institutional alignment at the policy domain level, which promotes consistency and collaboration. Similarly, Chinseu et al. (2018) emphasize the need for integration to embed social, economic, and environmental objectives into national policy, ensuring coordination, and mutual support among policies, leading to better resource use efficiency, improved food security and nutrition outcomes, and increased resilience of food systems, all while addressing the diverse needs and perspectives of stakeholders.

Coherence in food governance refers to the coordinated alignment of policies across sectors and ministries to support food security goals, ensuring they complement rather than undermine each other (Brooks, 2014; Thow et al., 2018). It involves promoting mutually reinforcing policies while avoiding negative spillovers, aiming for a harmonious balance between health, environmental, social, and economic objectives within the food system (Monticone et al., 2023). This concept involves ensuring that at a national level, policies across sectors and ministries work in a coordinated manner, supporting one another to optimize the collective impact, thereby enhancing policy effectiveness and resource allocation efficiency while minimizing waste and preventing

unintended negative consequences (Brooks, 2014; Monticone et al., 2023). Thow et al. (2018) also advocate for the importance of fostering synergistic relationships and averting adverse effects among different policy areas. From a broader view, coherence aims for policy alignment within the entire food system to find a balance among health, environmental, social, and economic objectives, thus avoiding undermining efforts in one area while enhancing another (Monticone et al., 2023). The adoption of a coherent approach in food governance is instrumental in mitigating policy conflicts and trade-offs, leading to more equitable and efficient outcomes that address the multifaceted challenges of food governance. This approach enhances sustainability through the promotion of positive policy synergies and by cultivating trust and cooperation among stakeholders—key elements for food security (Brooks, 2014). Coherence also improves nutrition outcomes and supports the pursuit of health, environmental, and socio-economic objectives, ensuring that policies are not just efficient but also effective over the long term (Thow et al., 2018). Furthermore, a coherent approach fosters transparency and accountability, aiding stakeholders in understanding how policies align with broader goals and thereby strengthening the legitimacy and effectiveness of food systems governance (Monticone et al., 2023).

In this sense, public programs are crucial for informing food governance policies by providing essential resources, facilitating inclusive decision-making, and promoting stakeholder participation. Candel (2014) and Moragues-Faus et al. (2017) highlight their roles in offering financial support and crucial data for evidence-based policy decisions on food security and sustainability. The effectiveness of these programs, however, is influenced by political contexts, engagement levels, and resource availability as noted by Candel and Biesbroek (2016). Thow et al. (2018) stress the need for increased civil society involvement to enhance policy coherence. Additionally, public programs contribute to policy-making by delivering research and analysis, engaging stakeholders in identifying priorities, and promoting cross-sector learning, crucial for cohesive governance as discussed by Chinseu et al. (2018).

Considering what’s been described around the Chilean food security challenges, effective governance through policy integration and coherence, and the role of public programs as policy informers, this study aims to highlight the significance of policy 'integration and coherence' to meeting food security objectives. It does so through a case-study on Chilean food governance, in

particular by *"assessing the integration and coherence of Chilean ministerial food governance related to the Social Determinants of Health (SDH) with the Chilean National Food and Nutrition Policy (NFPN)".*

3. Methods

Program Objective Review and Financial Analysis: A detailed review of program objectives was conducted to discern the presence of Food and Nutrition Security (FNS) dimensions. Following the framework by DIPRES (2021), programs were categorized into Relevant Public Programmatic Offer (RPPO) and Associated Public Programmatic Offer (APPO). The RPPO was defined previously by these authors as the "set of programs executed by organizations and agencies that play a leading role, since they have clear and explicit legal mandates, an institutional mission, a functional structure at their service, strategic products, as well as the participation of the program and operating budgets provided". On the other hand, the APPO refers to those "actions that have an indirect impact or implicit objectives to the Chilean food security purpose, such as money transfers, scholarships, microcredits, financial education, conservation of ecosystems, entrepreneurship, and labor insertion" (DIPRES, 2021). For both groups, it was established as an initial selection criterion for further analysis that: (1) programs should have had an allocated budget for the 2021 period; (2) reference to at least one of food security dimensions provided by FAO (1996) and Chappell (2018) - (availability: *physical presence of food, which is determined by the quantity of food produced and imported into a country, as well as the efficiency of the food distribution system*; access: *it refers to individuals' ability to obtain food and depends on economic and physical means, which include income, prices, and purchasing power, as well as the physical distance to food sources*; utilization: *involving the proper use of food, which encompasses the nutritional value and safety of the food consumed, including also factors such as food preparation, dietary practices, and overall health, which affect the body's ability to absorb and use nutrients*; stability: *refering to the consistency of the availability, access, and utilization of food over time and emphasizing the need to prevent fluctuations that could jeopardize food security, such as seasonal shortages or economic shocks;* and agency: *as the requirement that citizens are empowered in defining and securing their own food security, and thus that there are competent sociopolitical systems wherein policies and practices may be brought forth by the will of the*

citizens and reflected in governance to enable the achievement of overall food security) described in their objectives.

Information was organized using a Microsoft Excel spreadsheet in which each social program had associated content related to their objectives, their budget, the ministry to which they belong and the food security reference(s) in their objectives. The software 'ATLAS.ti' was utilized to systematically organize the objectives of each program and to categorize them according to the various dimensions of food security, thereby facilitating comprehensive analysis and coding of program objectives. With the aim of identifying patterns in food security emphasis, the number and distribution of programs across the selected ministries were quantified and a further financial analysis entailed the calculation of the total budget for 2021, juxtaposed with the national budget to contextualize the proportion dedicated to food security. Programs details, including objectives and budget was obtained at the Integrated Bank of Social Programs (*BIPS – Banco Integrado de Programas Sociales* - https://programassociales.ministeriodesarrollosocial.gob.cl/).

Content Analysis of Food Security Integration: A systematic content analysis was conducted to explore how ministries integrate food security dimensions—'availability,' 'utilization,' 'access,' 'stability,' and 'agency'—into their RPPOs. This involved scrutinizing program documentation and classifying each program according to the relevant food security dimensions. A matrix was devised to map programs against these dimensions, facilitating a list of programs that addressed each one, thereby ascertaining the focal points of each ministry's efforts.

Thematic Analysis of Inter-Ministerial Integration: The third phase of the study undertook a thematic analysis to evaluate the inter-ministerial integration of food security within RPPO objectives. RPPO objectives were extracted, categorized into 18 distinct categories, and coded to assess the thematic concentration of objectives across ministries. This process highlighted the distribution of focus areas and the extent of multi-sectoral objectives, suggesting the level of collaboration or overlap among ministerial responsibilities.

Content Analysis of Alignment with National Policy: Finally, the alignment of RPPO objectives with the NPFN was evaluated. Through content analysis, each RPPO was assessed for its

adherence to the NPFN components, creating a co-occurrence table for quantification. By using Atlas.ti, this table was later visualized through a Sankey diagram with particular attention to identifying and documenting gaps in RPPO objectives that lacked correspondence with any NPFN component.

Figure 1 shows the methodological approach followed.

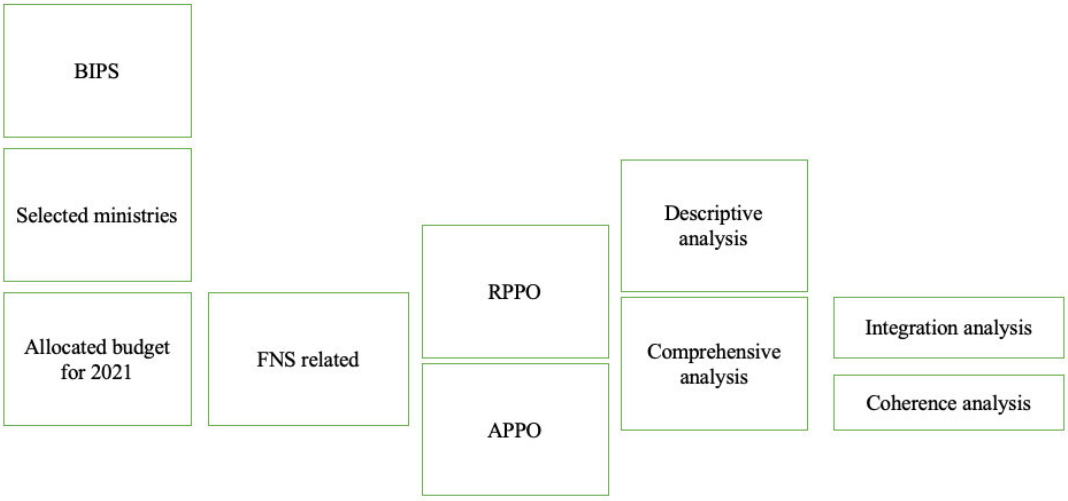

Figure 1. Methodological approach scheme.

4. Results

4.1.Program Objective Review and Financial Analysis.

(*Average conversion rate for 2021 was $759.27 CLP/USD, (Banco Central de Chile, 2021)).

4.1.1. Food security related programs: RPPO vs APPO.

A total of n=245 public programs programs were retrieved from the selected ministries of Agriculture, Health, Social Development and Family, Women and Gender Equality, and Education. Of them, n=229 were found to have an associated budget for the 2021 period. When analyzing the existence of FNS dimensions references in their objectives, we found that a total of n=70 programs, of which n=35 belonged to the RPPO and n= 35 to the APPO. The total budget allocated for 2021 was kMM CLP $10,804.5, being kMM CLP $5,342.41 from RPPO, and kMM CLP $5,462.04

from APPO. If it's considered that for 2021a total of kMM CLP $26,044,875 was directed to public programs, the budget allocated for both RPPO and APPO represents a 0.042% of the national budget. Budget details for RPPO and APPO across selected Chilean Ministries can be found in Supplementary Material, N2 and N3.

4.1.2. RPPO & APPO distribution across the selected Chilean ministries.

The Ministry of Social Development and Family (n=24) and the Ministry of Education (n=18) are those with the largest number of programs as a whole. The Ministry of Agriculture presented the largest number of RPPO (n=12), and Social Development and Family the largest number of APPO (n=16). No RPPO at the Ministry of Women and Gender Equality. More details can be found in Figure 2.

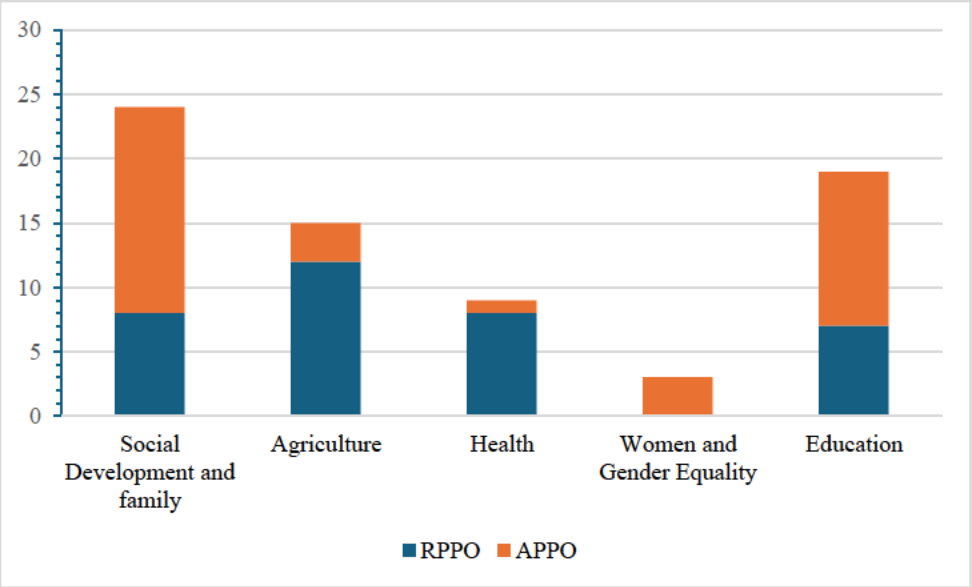

Figure 2. RPPO & APPO distribution across the pre-selected Chilean ministries.

4.1.3. RPPO & APPO budget across the selected ministries.

In terms of the total budget allocated per ministry (Figure 3), Social Development and Family (kMM CLP $4,160; 38.5%) and Education (kMM CLP $ 3,661.74; 33.9%) concentrated most of the resources. From the RPPO side, Education (kMM CLP $1,941.93; 36.3%) had the majority of

the resources and Agriculture (kMM CLP $454.98; 8.5%) the fewest. From the APPO side, Social Development and Family (kMM CLP $2,759.82; 50.5%) had most of the budget, whereas Agriculture the lowest (kMM CLP $25.63; 0.5%). Finally, Woman and Gender Equality only got budget for APPO (kMM CLP $301.78).

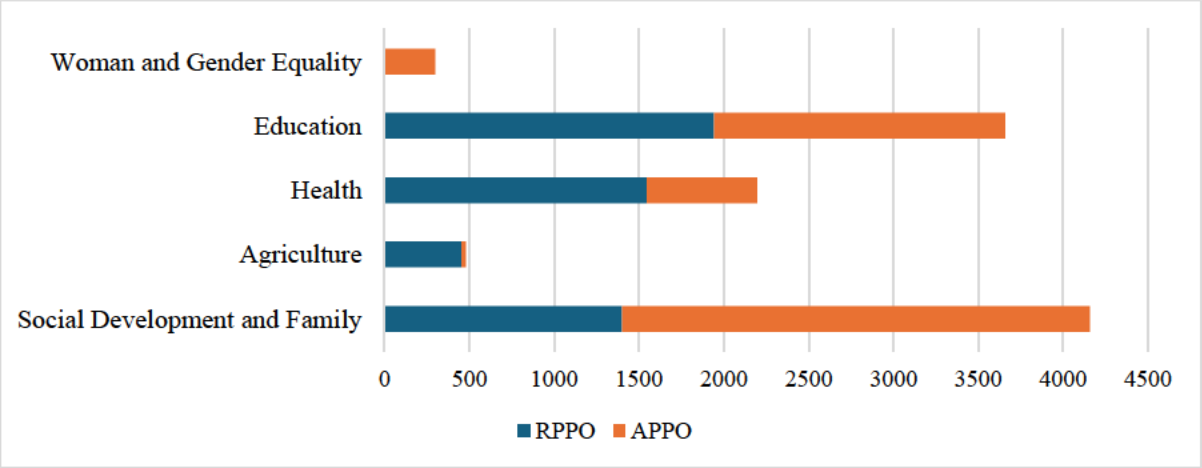

Figure 3. 2021 allocated budget (kMM CLP$) for FNS related public programs.

4.2. Content Analysis of Food Security Integration

Food security dimensions and priorities are emphasized differently in the RPPO of selected Chilean ministries. For example, when it comes to the Ministry of Agriculture, they put more focus on the "availability" of food, with n=11 programs. The Ministry of Health tends to focus on how food is "utilized" or used for health, having n=7 programs in their offer. Meanwhile, the Ministry of Social Development and Family seems to care most about both "access" to food (n=5) and its "availability" (n=6). The idea of "stability" in food supply is more of a concern for the Ministry of Agriculture (n=5) but less so for the other ministries. Lastly, the concept of "agency" or having control over food decisions is not given as much attention, except for the Ministry of Agriculture and the Ministry of Social Development and Family, both with n=2 programs in their RPPO. The detail of each food security dimension in selected ministries can be found in supplementary Table 2. The visual representation of such differences can be found in figure 4.

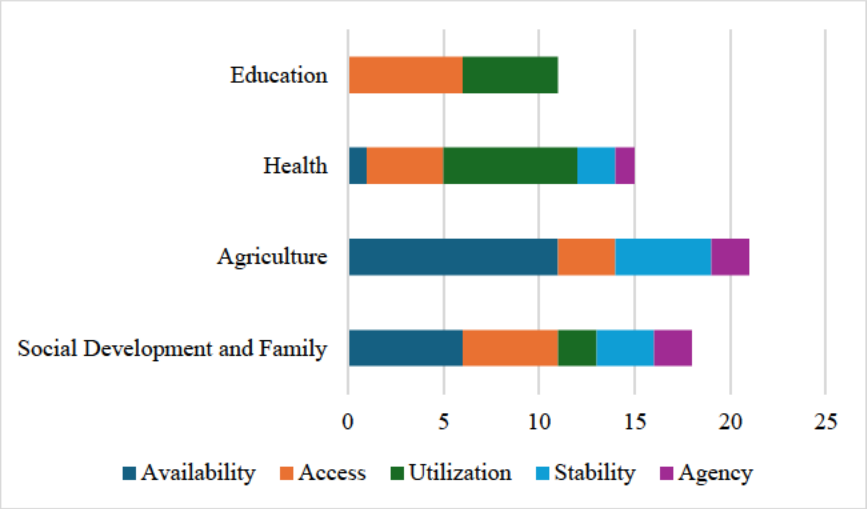

Figure 4. Incorporation of food security dimensions in RPPO across Chilean selected ministries.

4.3. Thematic Analysis of Inter-Ministerial Integration

A total of n=18 categories of objectives were created after analyzing the RPPO, as shown in Table 2. Except from "food service delivery" and "training and productive technical assistance", most objectives were found up to 3 times. Figure 5 shows the number of times each category of objectives is present in the RPPO according to the selected ministries. Four types of objectives were found in more than one ministry: "training and productive technical assistance", "nutritional food education", "food service delivery", and "funding of productive infrastructure". Related to the above, only the Ministry of Social Development and Family was presented in all of these cases, while the ministries of Agriculture and Health had participation in two cases, and the ministry of education in one. Finally, it is also possible to see that there are, for these four cases, attempts of integrating the "essence" of different ministries into RPPO. However, four cases over a total of eighteen may not seem like there is fully integration in the Chilean strategy of food security.

Table 2. RPPO objectives across selected Chilean ministries.

Objective category	Social Development and Family	Agriculture	Health	Education	Total
Food service delivery	2	0	3	5	10
Training and productive technical assistance	4	4	0	0	8
Funding of productive infrastructure	1	2	0	0	3
Protection and improvement of the agricultural resources of the country	0	3	0	0	3
Nutritional food education	1	0	1	0	2
Access to water	2	0	0	0	2
Generation of income from production surpluses	0	2	0	0	2
Food scholarship	0	0	0	2	2
Basic care for the newborn	1	0	0	0	1
Delivery of basic food equipment	1	0	0	0	1
Productive chain	0	1	0	0	1
Studies for the agricultural sector	0	1	0	0	1
Productive investments with a gender approach	0	1	0	0	1
Food safety improvement	0	0	1	0	1
Improvement of food environments	0	0	1	0	1
Nutritional evaluation in minors	0	0	1	0	1
Reduction of risk factors for overweight and obesity	0	0	1	0	1
Local policies in health promotion	0	0	1	0	1

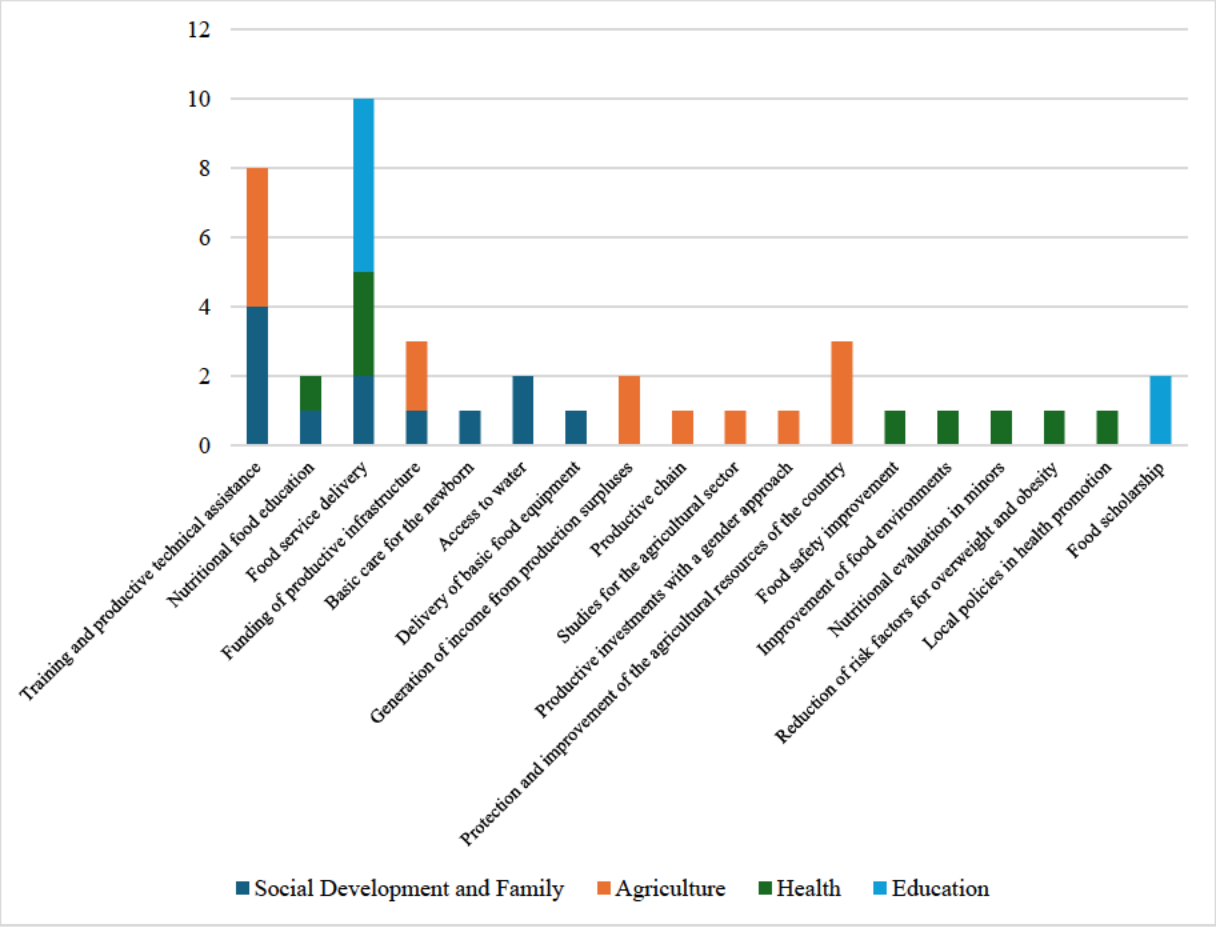

Figure 5. Integration of RPPO objectives across selected Chilean ministries.

4.4.Evaluating the alignment of food security programs with the national policy framework

Except for the component "Deepening intersectoriality and health in all policies", all NPFN components (found in supplementary Table 1) were found in at least one RPPO. At the same time, all ministries have programs related to the component "Strengthening food and nutrition security: availability, access, food utilization and stability".

The most frequent NPFN components were "Strengthening food and nutrition security: availability, access, food utilization and stability" (n=36), ["*The programme finances productive investments by accredited rural women who are in the second year of the Rural Women's Programme (PRODEMU)*"]; "Improving the configuration of food environments and systems" (n=18) *["The programme seeks to improve the food environment to which children from two to*

fourteen years of age are exposed, through surveillance, monitoring and education regarding the supply, availability, marketing and information of food"], and "Promoting healthy eating" [*"...the programme distributes free of charge fortified complementary foods, linked to other health promotion and disease prevention actions"]*, and "Humanizing nutrition and promote the right to adequate food" ["*Children are cared for throughout the day at the different levels of care: nursery, middle school and transition level, providing them with comprehensive care that involves: educational service, food and extended hours"*], both with n=11 co-occurrences.

The ministry whose programs have more presence in the NPFN components were the Ministry of Health with n=30 co-occurrences, the Ministry of Agriculture with and n=27 occurrences, and the Ministry of Social Development and Family with and n=20. At the same time, the Ministry of Health was the institution whose programs have presence in more NPFN components and (n=7), followed by the Ministry of Social Development and Family with n=5. The co-occurrence relationship between the RPPO and NFPN components can be found in table 3 and in the Sankey diagram in Figure 6.

Table 3. Co-occurrence relationship between RPPO and NFNP components.

NFNP component	Agriculture	Education	Health	Social Development and Family	Total
Strengthening food and nutrition security: availability, access, food utilization and stability	13	7	8	8	36
Improving the configuration of food environments and systems	12	0	1	5	18
Humanizing nutrition and promote the right to adequate food	0	6	2	3	11
Promoting healthy eating	0	0	8	3	11
Strengthening nutritional care at the different levels of health care	0	1	6	0	7
Promoting citizen participation and social control	2	0	1	1	4
Monitoring food and nutrition and	0	0	3	0	3

evaluating public policies					
Deepening intersectoriality and health in all policies	0	0	0	0	0

Figure 6. Co-occurrence scheme between RPPO and NFNP components.

Note: Components "Monitoring food and nutrition and evaluating public policies" and "Promoting citizen participation and social control" have been condensed to "Monitoring F&N and evaluating PP" and "Citizen participation and social control" respectively to accommodate the space limitations of the Sankey diagram.

5. Discussion

In this study, a total of n=245 programs were identified, of which 70 had references to FNS dimensions in their objectives, evenly distributed between RPPO and APPO, with an allocated budget of $10,804.5 million CLP for 2021. This represents only 0.042% of the national budget, indicating a modest investment in food security. Literature demonstrates a clear correlation between the allocation of national budget resources to food security programs and improved food security outcomes. However, the way resources are spent, however, is directly related to an improved access to healthy food and resilience to food crises (Thow et al., 2018), sustainable agriculture promotion and monitoring and evaluation (Candel and Briesbroek, 2018), nutritional education (Candel, 2014), and reducing significantly instances of hunger, malnutrition, and overall food insecurity (Milani-Bonab et al. 2023).

The results also indicate a prioritization of overall food security programs within the Social Development and Family sector, closely followed by Agriculture. Conversely, the Health, Women and Gender Equality, and Education sectors showed less emphasis, presenting a scope for enhanced integration. This distribution is critical for the efficacy of national food security strategies, and the literature suggests that uncoordinated efforts may lead to fragmented and inefficient initiatives. Thow et al. (2018) and Milani-Bonab et al. (2023) highlight the risks of isolated operations, including policy incoherence and coverage gaps that fail to address complex food security challenges. Candel (2014) further identifies the detrimental effects of dispersed accountability on program evaluation and impact. To mitigate these issues, experts recommend the establishment of formal mechanisms, such as inter-ministerial committees and policy coherence, to ensure aligned objectives and consolidate efforts across different governmental sectors involved in food security. In this sense, public policies could redirect more financial resources towards food security programs, especially in those critical aspects identified as deficient in coverage or effectiveness.

Related to the content analysis, the results showed that different ministries prioritize different aspects of food security according to their specific roles. The Education and Agriculture ministries seem to focus more on the supply side ('Availability' and 'Access'), while the Health ministry also

gives weight to the 'Utilization' aspect, which can relate to nutrition. The Social Development and Family ministry appears to address food security in a more holistic manner. Prioritizing certain dimensions of food security, like availability or access, over others can result in a fragmented policy landscape that fails to address the root causes of food insecurity in a comprehensive manner (Thow et al., 2018). Such an imbalanced focus may inadvertently exacerbate inequities, disproportionately affecting vulnerable groups and perpetuating cycles of food insecurity (Candel and Biesbroek, 2018). For example, if policies and strategies only focus on increasing food production without addressing issues of access, distribution, and utilization, vulnerable groups may continue to face barriers in accessing nutritious and affordable food. At the same time, a lack of attention to the social, economic, and environmental dimensions of food security can perpetuate cycles of food insecurity by failing to address the root causes of vulnerability and inequity. Additionally, a narrow approach can undermine the resilience of food systems, making them less capable of resist various shocks and stresses; whereas, a holistic strategy that considers all dimensions—including stability and agency—promotes sustainable outcomes (Candel and Biesbroek, 2018). In this sense, Moragues-Faus et al., (2017) indicate that to achieve sustainable food security, strategies should foster empowerment, support varied agricultural practices, bolster local markets, and enhance community resilience, ensuring inclusivity and adaptability to future shocks. For instance, greater collaboration between the Ministries of Education and Agriculture could be encouraged to jointly address aspects of food availability and access, while the Ministry of Health could lead inter-ministerial initiatives focused on food utilization and nutrition.

Results also showed that inter-ministerial integration was partial, with some programs addressing multiple dimensions of food security, but there was a general lack of cohesion and coordination among ministries, limiting the effectiveness of the food security response. Coordination is essential in unifying government departments like agriculture, trade, health, and environment to enhance policy coherence for the multi-dimensional challenges of food security. As Moragues-Faus et al. (2017) note, synchronized strategies improve resource allocation, reduce redundancy, and form comprehensive policies that cover production to nutrition and sustainability. Policy integration mechanisms, as advocated by Thow et al (2018), and capacity building, suggested by Candel and Biesbroek (2018), reinforce inter-ministerial cooperation. Robust monitoring and evaluation frameworks are also critical, assessing impacts and refining policies based on evidence, as pointed

out by Moragues-Faus et al. (2017). Same authors indicate that including a diverse set of stakeholders, from non-governmental to community actors, enriches strategies and promotes sustainable food security initiatives.

In the coherence analysis, although all ministries showed programs related to the 'Strengthening food security and nutrition' component, the lack of alignment with the 'Deepening intersectorality and health in all policies' component indicates a missed opportunity to more comprehensively integrate health into food security policies. To enhance the efficacy of national food and nutrition policies, literature suggests strategies that bridge the gap from policy formulation to execution. Multi-stakeholder partnerships are essential, as detailed by Milani-Bonab et al. (2022), promoting inclusive policymaking through diversified stakeholder engagement. The Processual Policy Integration Framework proposed by the same authors encourages understanding the interconnections between policy dimensions—frames, subsystems, goals, and instruments—to foster aligned implementation. Thow et al. (2018) further advocate for an extensive policy content analysis, scrutinizing policy across sectors to resolve inconsistencies and better meet actual needs. However, implementing these policies faces challenges, notably resource constraints, such as limited political commitment, human capital, and institutional capabilities, which impede the effective application of public nutrition policies. Debie et al. (2022) emphasize the importance of adequately and equitably distributing financial resources within health systems to address disparities in access to health services and promote health equity. For instance, Japan's Universal Health Coverage ensures coherent health policies to achieve better access for its population (OECD, 2016). Similarly, the "Health in All Policies" framework in Finland, Sweden, and Norway focuses on coherent health policies and budget allocation to address these challenges (WHO, 2014).The engagement of civil society is also crucial; their exclusion poses a barrier to nutrition policy action, thus affecting health promotion program success (Thow et al., 2018). Lastly, regional differences in social, economic, and political contexts significantly shape the design and implementation of nutrition policies, creating disparities in health program outcomes Milani-Bonab et al. (2022). The identification of this gap indicates an opportunity to review and modify existing programs, as well as to design new initiatives that integrate health more effectively into food security policies.

Future research in the field of FNS could address several key areas to enhance understanding and effectiveness of these initiatives. One approach could involve evaluating the accuracy and quality of public information regarding the goals and budget allocations of the food security public programs, including a comparative analysis between stated objectives and actual program implementation. Another important line of research could be the exploration of operational and logistical challenges faced by the food security public programs, possibly through case studies or analysis of barriers to achieving program objectives (Brownhill & Hickey, 2012). Additionally, investigating how contextual variations affect the implementation and effectiveness of programs (Di Prima, 2022) within the RPPO could offer valuable insights, considering socioeconomic, cultural, and political factors. Expanding the scope to include other governmental bodies and civil society organizations in the analysis could provide an intersectoral or multisectoral perspective on collaboration for food security (Caviedes et al. 2023). Finally, employing broader interdisciplinary approaches and advanced mixed methods, such as geospatial analysis (Hossain, 2020; Swati & Kavita, 2021) or qualitative methods (del Valle et al. 2023) to capture program beneficiaries' experiences, could significantly enrich the understanding of food security programs.

Finally, while this study employs a mixed methodology involving both qualitative content analysis and quantitative assessment, there are certain limitations to consider. In the first, the analysis relies on publicly available information regarding FNS objectives and budget allocations, which depends on how clear the available information is and its quality. Any potential discrepancies between publicly stated objectives and actual program implementation are not addressed in this analysis. Moreover, the study does not deepen into the difficulties of program execution, focusing primarily on objective alignment. In addition, the assessment of NFNP components within the RPPO is based on the information available in the programs' stated objectives, and any further contextual variations are not explored. The study's scope is also confined to the identified ministries and does not include other relevant government bodies, such as other ministries and public services and/or societal organizations that might contribute to food security efforts.

6. Conclusions

This study aimed to assess the inter-ministerial integration and coherence of ministerial food governance in Chile in relation to the Social Determinants of Health (SDH) and the objectives and components of the National Food and Nutrition Policy (NFNP). Through a mixed-methodology approach, we analyzed food security programs in selected Chilean ministries using content, financial, and program reviews to assess their alignment and integration with the NFNP objectives.

Findings reveal a modest investment in food security, accounting for only 0.042% of the national budget, highlighting a significant opportunity to increase resources dedicated to this crucial area. Although various ministries address aspects of food security, a lack of cohesion and coordination among ministries limits the effectiveness of the response to food insecurity.

A key conclusion that emerges from this study is the insufficient inter-ministerial coordination. While some ministries prioritize specific dimensions of food security according to their institutional roles, a clear gap in alignment with critical components of the NFNP, particularly concerning the deepening of "intersectorality and the integration of health in all policies", is evident. This lack of coordination raises several critical questions: Are the existing programs in Chile, and the agencies and ministries responsible for them, forming a cohesive strategy? If not, why is this the case? What steps should be taken to improve this situation? These questions highlight the necessity for a more integrated approach and a strategic framework that aligns the efforts of various stakeholders.

The absence of inter-ministerial coordination translates into a fragmented and less effective strategy for addressing food insecurity and related issues such as obesity, which has a severe impact on healthcare costs. According to the Organization for Economic Co-operation and Development (OECD, 2019), obesity-related healthcare costs in Chile accounted for around 2.4% of total healthcare spending in 2016. Moreover, projections indicate that reducing obesity rates by 20% by 2030 could potentially decrease obesity-related healthcare spending by about 7% by that year. These findings underscore the importance of addressing these questions to bridge the gap between ministries and foster intersectoral collaboration to address obesity as a critical component of the NFNP, ultimately leading to more effective public health outcomes.

Finally, the practical and theoretical implications of this study are many. They underscore the urgent need for increased investment in food security and the importance of robust mechanisms for inter-ministerial integration. The identification of gaps in alignment with the NFNP suggests opportunities for reviewing existing programs and developing new initiatives that more effectively integrate health considerations into food security policies. This study also points to future research directions, including the assessment of the accuracy and quality of public information on food security programs, the exploration of challenges in program execution, and the consideration of contextual variations in policy implementation. Expanding the scope to include other government bodies and civil society organizations could offer richer and more holistic perspectives on food security in Chile.

7. Author Contributions

MdV, KS and ASVM: conceptualization and methodology; MdV: investigation and writing; KS, SB: supervision, review and editing; ASVM: review and editing.

8. References

Banco Central de Chile. 2021. Indicadores diarios 2021- Dólar observado. https://si3.bcentral.cl/Indicadoressiete/secure/Serie.aspx?gcode=PRE_TCO&param=RABmAFYAWQB3AGYAaQBuAEkALQAzADUAbgBNAGgAaAAkADUAVwBQAC4AbQBYADAARwBOAGUAYwBjACMAQQBaAHAARgBhAGcAUABTAGUAdwA1ADQAMQA0AE0AawBLAF8AdQBDACQASABzAG0AXwA2AHQAawBvAFcAZwBKAEwAegBzAF8AbgBMAHIAYgBDAC4ARQA3AFUAVwB4AFIAWQBhAEEAOABkAHkAZwAxAEEARAA%3d. (Accessed in May 28, 2024).

Brooks, J. (2014). Policy coherence and food security: The effects of OECD countries' agricultural policies. Food Policy, 44, 88-94.

Brownhill, L., & Hickey, G. M. (2012). Using interview triads to understand the barriers to effective food security policy in Kenya: a case study application. Food Security, 4, 369-380.

Candel, J. J. (2014). Food security governance: A systematic literature review. Food Security, 6, 585-601.

Candel, J. J. L. (2019). The expediency of policy integration. Policy Studies, 42(4), 346–361.

Candel, J. J., & Biesbroek, R. (2016). Toward a processual understanding of policy integration. Policy Sciences, 49, 211-231.

Candel, J. J., & Biesbroek, R. (2018). Policy integration in the EU governance of global food security. Food security, 10, 195-209.

Caviedes, J., Ibarra, J. T., Calvet-Mir, L., & Junqueira, A. B. (2023). "Listen to us": small-scale farmers' understandings of social-ecological changes and their drivers in Important Agricultural Heritage Systems. Regional Environmental Change, 23(4), 158.

Chappell, M. J. (2018). Beginning to end hunger. In Beginning to End Hunger. University of California Press.

Chinseu, E., Stringer, L., & Dougill, A. (2018). Policy integration and coherence for conservation agriculture initiatives in Malawi. Sustainable Agriculture Research, 7(4), 51-62.

Clapp, J., Moseley, W. G., Burlingame, B., & Termine, P. (2022). The case for a six-dimensional food security framework. Food Policy, 106, 102164.

Debie, A., Khatri, R. B., & Assefa, Y. (2022). Successes and challenges of health systems governance towards universal health coverage and global health security: a narrative review and synthesis of the literature. Health research policy and systems, 20(1), 50.

Del Valle M, M., Shields, K., Alvarado Vazquez Mellado, A. S., & Boza, S. (2022). Food governance for better access to sustainable diets: A review. Frontiers in Sustainable Food Systems, 6, 784264.

Del Valle M, M., Hernández, R., Boden, L., & Riveros, J. L. (2023). Redefining Food Sources: Exploring the Disconnect between Goat Farming and Its Perceived Sustainability—A Case Study in Chitima, Mozambique. Sustainability, 15(14), 11071.

DIPRES – Dirección de Presupuestos de Chile. (2021). Evaluación sectorial "Política de Promoción de Exportaciones". División de Control de Gestión Pública, Dirección de Presupuestos.

Di Prima, S., Wright, E. P., Sharma, I. K., Syurina, E., & Broerse, J. E. (2022). Implementation and scale-up of nutrition-sensitive agriculture in low-and middle-income countries: a systematic review of what works, what doesn't work and why. Global Food Security, 32, 100595.

Duncan, J., Claeys, P. (2018). Politicizing food security governance through participation: Opportunities and opposition. Food Security, 10(6), 1411-1424.

National Food and Nutrition Policy. 2017. Ministry of Health, Government of Chile. http://www.bibliotecaminsal.cl/wp/wp-content/uploads/2018/01/BVS_POL%C3%8DTICA-DE-ALIMENTACI%C3%93N-Y-NUTRICI%C3%93N.pdf. (accessed on 08 February 2021).

EVS (Elige Vivir Sano) (2020). Radiografía de la obesidad infantil. http://eligevivirsano.gob.cl/wp-content/uploads/2020/01/PPT-EVS-15012020-Final.pdf (Accessed on May 03 2021).

FAO. 1996. Report of the World Food Summit.

FAO & UNICEF. (2021). WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO.

Fernández A., Martínez, R., Carrasco, I., Palma, A. (2017). Impacto Social y Econo´mico de la Malnutricio´n: Modelo de Análisis y Estudio Piloto en Chile, el Ecuador y México [Social and Economic Impact of Malnutrition: Analysis Model and Pilot Study in Chile, Ecuador and Mexico], at 86, 102, U.N. Doc. LC/TS.2017/32.

Hawkes, C. (2007). Promoting healthy diets and tackling obesity and diet-related chronic diseases: what are the agricultural policy levers?. Food and nutrition bulletin, 28(2_suppl2), S312-S322.

Hawkes, C., & Popkin, B. M. (2015). Can the sustainable development goals reduce the burden of nutrition-related non-communicable diseases without truly addressing major food system reforms?. BMC medicine, 13, 1-3.

Hawkes, C., Ruel, M. T., Salm, L., Sinclair, B., & Branca, F. (2020). Double-duty actions: seizing programme and policy opportunities to address malnutrition in all its forms. The Lancet, 395(10218), 142-155.

Hossain, M. J., Das, S., Chandra, H., & Islam, M. A. (2020). Disaggregate level estimates and spatial mapping of food insecurity in Bangladesh by linking survey and census data. PloS one, 15(4), e0230906.

Kushitor, S. B., Drimie, S., Davids, R., Delport, C., Hawkes, C., Mabhaudhi, T., ... & Pereira, L. M. (2022). The complex challenge of governing food systems: The case of South African food policy. Food security, 14(4), 883-896.

Milani-Bonab, A., Kalantari, N., Takian, A., & Haghighian-Roudsari, A. (2023). Food and agriculture, nutrition and health related policy integration in Iran's national development agenda and their alignment with the sustainable development goals. Environment, Development and Sustainability, 25(4), 3353-3378.

Monticone, F., Barling, D., Parsons, K., & Samoggia, A. (2023). Identifying food policy coherence in Italian regional policies: The case of Emilia-Romagna. Food Policy, 119, 102519.

Moragues-Faus, A., Sonnino, R., & Marsden, T. (2017). Exploring European food system vulnerabilities: Towards integrated food security governance. Environmental Science & Policy, 75, 184-215.

National Socioeconomic Characterization Survey. Ministry of Social Development and Family, Government of Chile. Food Insecurity Outcomes. (2022) https://datasocial.ministeriodesarrollosocial.gob.cl/fichaIndicador/814/1 (accessed on 03 May 2024).

OECD. Organization for Economic Co-operation and Development. (2016). Universal Health Coverage and Health Outcomes. https://www.oecd.org/els/health-systems/Universal-Health-Coverage-and-Health-Outcomes-OECD-G7-Health-Ministerial-2016.pdf (Accessed on June 3, 2024).

OECD. Organization for Economic Co-operation and Development. (2019). The heavy burden of obesity: The economics of prevention. (Accessed on May 03, 2024).

Robbins, P. (2019). Political ecology: A critical introduction. John Wiley & Sons.

Shrimpton, R., & Rokx, C. (2012). The double burden of malnutrition: a review of global evidence.

Sibbing, L., Candel, J., & Termeer, K. (2021). A comparative assessment of local municipal food policy integration in the Netherlands. International Planning Studies, 26(1), 56-69.

Swati, R., & Kavita, A. (2021). Measuring and mapping the state of food insecurity in Rajasthan, India. Geography, Environment, Sustainability, 14(1), 33-40.

Thow, A. M., Greenberg, S., Hara, M., Friel, S., duToit, A., & Sanders, D. (2018). Improving policy coherence for food security and nutrition in South Africa: a qualitative policy analysis. Food Security, 10, 1105-1130.

Vio del Río, F. The Nutrition Transition in Chile. Food policy for developing countries: the role of government in the global food system. (2007). Case study of the program Food Policy for Developing Countries: The Role of Government in the Global Food System. Cornell University. Edited by Per Pinstrup-Andersen and Fuzhi Cheng.

WHO. 2013. Determinantes sociales de la salud. WHO. Retrieved from http://www.who.int/social_determinants/es/ (Accessed on March 3, 2021).

WHO. 2014. Health in all policies: Helsinki statement. Framework for country action.

WHO. 2022. Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight#:~:text=39%20million%20children%20under%20the,Obesity%20is%20preventable. (Accessed on June 6, 2022).

Zúñiga-Escobar, M., Grisa, C., & Coelho-de-Souza, G. (2021). Redes de política pública: un abordaje para analizar la gobernanza de la Seguridad Alimentaria y Nutricional. Saúde e Sociedade, 29.

9. Chapter's conclusions

Responding to the sub-research question "*how does data analysis contribute to the integration and coherence of food policies in Chile?*", this chapter uses open-sourced data to demonstrate the value of adopting a "coordination/collaboration in data sharing" approach among Chilean state institutions. The study highlights significant disparities in funding for food security programs among various ministries and identifies limited inter-ministerial coordination in addressing food security policies. It reveals misalignments between health and nutrition policy objectives, with only 0.042% of the national budget allocated to food security programs. Since different ministries focus on various aspects of food security, improved data sharing and enhanced collaboration are essential. The findings advocate for a multi-sectoral approach to effectively address food security challenges and recommend establishing formal mechanisms for inter-ministerial collaboration to enhance policy coherence.

While this chapter employs both qualitative and quantitative methods, the following chapter adopts a distinct methodological approach and utilizes data from a different origin. If in the current chapter open-source data from the Chilean Integrated Database of Social Programs (*Banco Integrado de Programas Sociales*) was used, the next chapter relies exclusively on quantitative analysis based on data procured through a confidentiality agreement with the responsible government entity, as it pertains to vulnerable families. This shift not only represents a change in methodology but also introduces a different data source, thereby incorporating an ethical component into the thesis discussion regarding the responsible use and protection of sensitive information in research.

CHAPTER 4: Using Household Dietary Diversity Score and Spatial Analysis to inform Food Governance in Chile

* This chapter is based on:

Del Valle M, M., Shields, K., Boza, S. (2024). Using Household Dietary Diversity Score and Spatial Analysis to Inform Food Governance in Chile. Nutrients,16,2937. Doi.org/10.3390/nu16172937

Supplementary information is publicly available online, accessible via the doi.

1. Chapter's introduction

Building on the debate presented in the literature review regarding the "demand for data-driven decision making", this chapter addresses the sub-research question *"how can data analysis support evidence-based decisions to reduce inequalities in food access in Chile?*". Unlike the previous chapter, which relied on open-source data, this analysis is based on data obtained through a collaboration and confidentiality agreement with Chile's Ministry of Social Development and Family. Under this agreement, access was granted to a database containing the annual execution data for 2019 and 2020 from the Family Support Program for Self-Sufficiency (FSPFS). This database includes socio-demographic information and food frequency data for over 4,000 households identified as socially vulnerable. This allowed for an analysis to characterize the consumption of 12 food groups in these households and to determine which groups were consumed in excess or were insufficient. Additionally, a spatial analysis was conducted to visualize potential differences in the consumption of these food groups across the country's various agroclimatic macro-zones. Beyond the research findings and their potential utility for ministerial decision-making, this chapter also illustrates the ethical considerations involved in working with data on socially vulnerable families—data that, for these reasons, cannot be made publicly available. Moreover, this section serves as an example of coordination and collaboration in data sharing between government departments and academic institutions, enhancing the visibility of existing information that many government agencies cannot fully exploit due to budgetary constraints.

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Abstract

This study explores how the Household Dietary Diversity Score (HDDS) and spatial visualization can inform food governance in Chile, focusing on socio-demographic and geographical determinants affecting food consumption patterns. A national household database (n=4,407), including households from 2019 (n=3,967; 98.02%) and 2020 (n=80; 1.98%), provided by the "Family Support Program of Food Self-Sufficiency" (FSPFS) of the Ministry of Social Development and Family was analyzed. The findings revealed that Chilean vulnerable households were led mostly by women (86.6%), with an age average of 55.9 ± 15.6 years old, versus 68.9 ± 12.9 years in the case of men. The intake frequency analysis showed that dairy, fruits, and vegetables were below the recommended values in at least half of the households, and that fats and sugars were above recommended levels. Regarding the HDDS [0-189], the national average was of 91.4 ± 20.6 and was significantly influenced by the number of minors in the households, water access, food access issues, and residing in the Zona Sur. Finally, the spatial visualization showed that the Zona Central had higher consumption of fruits and vegetables, while the extreme zones Norte Grande and Zona Austral showed higher intakes of fats and sugars. These findings emphasize the importance of leveraging data insights like HDDS and spatial visualization to enhance food security and inform food governance strategies.

Key words: Chile; Food Security; Food Governance; Household Dietary Diversity Score; Spatial Visualization.

2. Background

2.1. Household dietary diversity as an indicator of food security

Household dietary diversity is commonly defined as a qualitative measure of food consumption at the household level that reflects access to a variety of foods and serves as a proxy for nutrient adequacy (Muthini *et al.,* 2020; Larson *et al.,* 2019; Kennedy, 2011), micronutrient adequacy in resource-poor settings (Ruel *et al.,* 2010) and encompasses a range methodologies provided by different approaches related to the number of food groups and to whom is directed. For example, Muthini *et al.,* (2020) highlight the Household Diet Diversity Score (HDDS), Child Dietary Diversity Score (CDDS), and Women Dietary Diversity Score (WDDS). Ruel et al., (2010) and Larson et al. (2019) introduced the Minimum Dietary Diversity for Women (MDD-W) score, which is based on the consumption of ten specific food groups. Kundu et al. (2020) and Bezner Kerr et al. (2019) provided the Household Dietary Diversity Score (HDDS), focusing on 12 food groups for assessment. Pritchard et al. (2019) adapted the MDD-W methodology by using ten food groups as a basis for their measurement. The Food and Agriculture Organization suggests a dietary diversity questionnaire underlining the importance of considering various food groups to gauge the extent of dietary diversity in individuals or households (Kennedy, 2011).

The HDDS can be assessed through various indicators and components, each shedding light on the variety and quality of foods consumed within a household. Some authors (Arimond et al., 2010) indicate that these methodologies need to be simple to better predict micronutrients adequacy. According to Muthini et al. (2020), the HDDS is a commonly utilized indicator, calculated based on the number of food groups consumed by the household over specific timeframes, typically within either 24 hours or 7 days. This score has proven to be a reliable predictor of nutrient adequacy in the diet and typically consists of 12 food groups, including cereals, vegetables, fruits, meat, poultry, eggs, legumes, milk, oils, sweets, spices, and beverages. Another approach, highlighted by Bezner Kerr et al. (2019), involves assessing the number of different food groups or types of food consumed by household members over a specified period. The HDDS is a valuable tool in this regard, ranging from 0 to 15, reflecting the number of food groups consumed. Households are categorized based on their dietary diversity, generally classifying those consuming

at least four different food groups (DDS ≥ 4) as having medium dietary diversity. Pritchard et al. (2019) discuss an adapted version of the Minimum Dietary Diversity for Women (MDD-W) methodology, focusing on ten defined food groups to assess dietary diversity. Respondents recall their food consumption over a 24-hour period, and enumerators categorize the foods into these ten groups, ultimately assigning a dietary diversity score out of ten. Similarly, Larson et al. (2019) use the Minimum Dietary Diversity for Women (MDD-W) score, assessing whether women have consumed foods from five or more of the ten defined food groups in the previous day. These food groups encompass a wide range, including grains, pulses, dairy, meat, poultry, eggs, and various fruits and vegetables. However, these methodologies also present limitations, as stated by Arimond et al. (2010) like small sample sizes in some data sets and potential underreporting and overreporting of dietary intakes, or food groups misreported when adding foods in small quantities to sauces (Martin-Prevel et al., 2010).

A diverse diet that includes a variety of food groups is generally associated with better nutrient intake and overall health (Martin-Prevel et al., 2010; Moursi et al. 2009). These chosen dietary diversity indicators, such as the HDDS are intrinsically linked to food security by quantifying the variety and quality of food consumed. Muthini et al. (2020) emphasize the vital role of policies and programs aimed at bolstering household dietary diversity to ensure access to a diverse array of foods, ultimately improving food security. Verger et al., (2019) demonstrate positive correlations between dietary diversity indicators and macro/micronutrient adequacy in various age groups. Strategies like enhancing market access for farm produce and generating off-farm employment are recognized as effective means to boost dietary diversity, thus positively impacting food security. Additionally, dietary diversity indicators serve as invaluable monitoring tools to assess the efficacy of food security interventions. Kundu et al. (2020) highlight the practical utility of HDDS in identifying vulnerable households requiring targeted food security interventions, particularly during crises like the COVID-19 pandemic. Bezner Kerr et al. (2019) emphasize the role of their HDDS in enhancing dietary diversity, which contributes to improved food security and nutrition, while also promoting agricultural sustainability through diverse crop cultivation. Becquey and Martin-Prevel (2010) showed in Burkina Faso that higher intakes of organ meat, flesh foods, vitamin A- and vitamin C-rich fruits and vegetables, and legumes and nuts were significantly associated with a lower risk of micronutrient inadequacy. Pritchard et al. (2019) further underscore

the connection between dietary diversity and food security, advocating for the incorporation of dietary diversity into policymaking to enhance nutritional quality and overall well-being.

2.2. Spatial visualization food insecurity warning systems

Spatial visualization is a crucial tool in addressing food insecurity, providing a geospatial lens to understand its distribution and severity. Hossain et al. (2020) and Leroy et al. (2015) highlight the value of spatial visualization in identifying high-risk areas, thereby supporting effective intervention targeting. Similarly, Wauchope and Ward (2012) emphasize the utility of spatial analysis, particularly mapping, in identifying unmet needs, facilitating a comprehensive understanding of the relationship between poverty, population density, and food access. Swati and Kavita (2021) underscore the practical significance of visualizing food insecurity in prioritizing interventions, as evidenced by their research in Rajasthan, India. These tools enhance the targeting of vulnerable populations, facilitating effective decision-making and resource allocation (Hwang and Smith, 2010; Hossain et al., 2020; Davis et al., 2022). By mapping spatial patterns, these tools offer visual representations of food insecurity across regions (Mathengue et al., 2022; Hossain et al., 2020), aiding policymakers in targeting interventions and understanding local geographic influences (Mathengue et al., 2022; Nica-Avram et al., 2020). Additionally, these tools reveal spatial disparities, informing sustainable territorial-based agriculture and food security policies (Mathengue et al., 2022). They also highlight significant household and individual level variations, capturing diverse factors influencing food security and dietary quality (Davis et al., 2022). Indeed, these tools prevent oversimplification of food insecurity, enhancing the depth and accuracy of information (Davis et al., 2022). The integration of geo-referenced data collection via handheld devices has reduced costs, enabling better data collection and targeted interventions in urban areas (Davis et al., 2022; Hossain et al., 2020). Finally, spatial visualization tools enable comparison of different geographic resolutions, offering new perspectives for policy research and providing a comprehensive view of deprivation and food insecurity (Nica-Avram et al., 2020). They aggregate summaries of food stores, food banks, and bus stops, contextualizing the entrenched issues of food insecurity.

There are several successful case studies and applications that showcase the effectiveness of different spatial visualization tools and methodologies in addressing food insecurity. For example, Hossain et al. (2020) highlight the Integrated Food Security Phase Classification (IPC) system by the World Food Programme (WFP), a standardized approach employed in over 30 countries. The IPC system classifies food security outcomes at different geographic levels, allowing for cross-country comparisons and targeted interventions. Hwang and Smith (2010) describe a successful web-based prototype developed in Bogota, Colombia, which integrated diverse data sources such as census, socioeconomic, and accessibility data to visualize community kitchens and food resources. This prototype aided in the spatial exploration of food security challenges in specific neighborhoods. Mathengue et al. (2022) and Davis et al. (2022) emphasize the use of GIS-based indicators and spatially explicit methodologies for mapping local spatial interactions and identifying geographically deprived areas and clusters with high concentrations of food insecurity hotspots. Furthermore, Mathengue et al. (2022) discuss the integration of spatially targeted interventions to combat inequalities and improve household livelihoods and welfare, particularly in western Kenya. The application of small area estimation (SAE) is highlighted by Hossain et al. (2020) as a successful method for estimating food insecurity indicators at the district level in Bangladesh, providing precise and representative estimates that are valuable for resource allocation and policy-making. Additionally, Davis et al. (2022) showcase the efficiency and cost-effectiveness of tablet-based data collection, as demonstrated by Leisher (2014) in conservation projects, achieving cost reductions of up to 75% compared to traditional paper-based surveys. Finally, Leroy et al. (2015) conducted a critical review and mapping of indicators to measure the food access dimension of food security, providing valuable insights for assessing and addressing food insecurity.

Despite the advantages highlighted before, spatial visualization also faces important limitations. One of the main restrictions is the limited availability of high-quality subnational data, especially in low-income countries, which can affect the accuracy of spatial analysis (Hossain et al., 2020). Additionally, there is the potential for misinterpretation of spatial data, particularly by users unfamiliar with data acquisition methods, and the possibility of spatial bias due to non-representative data or poorly defined spatial units. In addition, spatial visualization tools rely heavily on limited data sources and require continuous updates to maintain their accuracy. These

tools are primarily based on census and survey data collected at infrequent intervals, which can restrict the timeliness and precision of the information (Hwang and Smith, 2010; Nica-Avram et al., 2020). The validity and accuracy of data based on self-reported measures by households, and the need for additional validation through local surveys, highlight significant challenges (Mathengue et al., 2022; Nica-Avram et al., 2020). Furthermore, the high costs associated with collecting spatially disaggregated data, especially through in-person surveys using electronic devices, further complicate their implementation and the complex socio-ecological interactions involved in food insecurity require a precision approach tailored to individual and neighborhood-level factors, which can be challenging to execute (Davis et al., 2022). There is also a notable bias towards those with access to the platform originating the observed data and significant difficulties in linking heterogeneous data sources to enhance insights (Nica-Avram et al., 2020). Also, potential differences in food insecurity experiences between urban and rural areas, driven by the clustering of emergency food assistance and supermarkets around population centers, need to be considered (Nica-Avram et al., 2020). Lastly, the risk of misinterpretation of maps by policymakers and the need for continuous updates to ensure the accuracy and relevance of spatial information pose further limitations (Hossain et al., 2020).

2.3. Research rationale and objectives

The most recent "Report on Food Consumption in Chile" (EVS, 2021) highlighted a concerning trend: all income quintiles are consuming healthy food groups below the recommended levels, with the lowest income quintile being the most affected. In an average household of 3.3 people, monthly consumption includes 23.4 liters of sweetened beverages, 17.5 kg of bread, and 5.1 kg of sweets, whereas the intake of fruits, vegetables, and legumes barely reaches 24.7 kg (EVS, 2021). Furthermore, the latest National Socioeconomic Characterization Survey (2022) indicates that 16.3% of Chilean households face moderate food insecurity, with 3.5% experiencing severe food insecurity, largely due to financial constraints. These statistics underscore the pressing challenges faced by vulnerable households, particularly those in the lower income quintile, in achieving the recommended dietary intake. Understanding the dietary diversity, food security status, and geographical location of these households is crucial, as they encounter the most significant barriers to consuming essential food groups such as fruits, vegetables, and legumes.

This research aims to provide a comprehensive assessment of the dietary habits, socio-demographic characteristics, and geographical distributions of these vulnerable households. The insights gained will be vital for informing strategies and interventions to address food insecurity and enhance the well-being of the most marginalized segments of the Chilean population.

Thus, the main objective of this study is "*to analyze the interplay between socio-demographic factors, food consumption patterns, and food security in Chile's most vulnerable households, and to develop a spatial visualization information system that visually identifies and warns about areas of food insecurity across different food groups at both national and regional levels"*. In order to deepen the analysis, the following secondary objectives have been proposed:

- To describe the socio-demographic characteristics of Chile's most vulnerable households, represented by the "Family Support Program of Food Self-Sufficiency (FSPFS)" diagnostic survey.

- To calculate the intake frequency of different food group in Chile's vulnerable households at the national and macro-zones level.

- To calculate a national and regional HDDS and analyze its association with socio-demographic characteristics, food security determinants, and geographical macro-zones.

- To develop a geospatial warning system based on spatial visualization of food insecure areas for different food groups.

3. Methods

The current research received ethical approval from the Human Ethical Review Committee (HERC) of the Royal (Dick) School of Veterinary Studies at the University of Edinburgh, with approval number HERC_2022_148 on October 31, 2022. The approval letter is available in Supplementary Material, N4, and it was granted on the condition that the research is conducted according to the description provided in the application and the assurances made.

The methodological framework for this chapter was designed to dissect the socio-demographic and nutritional contours of Chile's most vulnerable households, based in the work done by Kundu et al. (2020) focused on the determinants of household food security and dietary diversity during the covid-19 pandemic in Bangladesh. Segregated into four strategic objectives, this chapter evaluates household composition, dietary intake patterns, the HDDS, and the development of a Spatial Warning System, each section providing a critical lens on different facets of food security. For the purposes of this research, the HDDS methodology was chosen due to its generality over other more specific methods of measuring dietary diversity in households, such as methodologies focused on women suggested by Larson et al. (2019) and Muthini et al. (2020), or on children (Muthini et al., 2020). For the spatial visualization of food security, Hossain et al. (2020) was used as a reference; however, spatial clustering analysis was not conducted due to concerns about low representativeness and high sensitivity to small data variations, which could hinder the identification of significant spatial patterns. Additionally, data scarcity could lead to unstable and biased clusters, limiting the reliability of the analysis.

Households' information was gathered from a database that contains the results of the diagnostic survey for the Family Support Program of Food Self-Sufficiency (FSPFS) (*Programa de apoyo a familias para el autoconsumo)* of the Ministry of Social Development and Family of Chile and the Solidary Fund of Social Innovation (FOSIS), which was obtained through a request for transparency and confidentiality agreement to the Secretary of Social Services of said ministry. The households invited to participate in this program are those belonging to the 40% most vulnerable population in Chile, according to the socio-economic characterization survey conducted nationwide. This program seeks to increase the availability of healthy food for vulnerable families, through education and self-provision to supplement their food needs and improve their living conditions. It mainly considers support to production activities (cultivation and breeding of small livestock) and, secondarily, to activities aimed at the preservation, processing, and correct preparation of food. It also has an educational component as it aims to provide information, promote learning, and reinforce knowledge associated with eating habits and, complementarily, with healthy lifestyles. The diagnostic questionnaire is applied to all households that will be part of the program in order to get information from three main areas: family group socio-demographic

characteristics, general food security determinants, and food diagnosis. We selected the items of each area that best matched this study's aims, as shown in Table 1.

Table 1. Diagnostic questionnaire resume.

Area	No of Items	Items
Family group socio-demographic characteristics	11	Region; commune; head of household (Hoh) gender; (Hoh) age; (Hoh) main work activity; 0–5 years old; 6–9 years old; 10–17 years old; 18–64 years old; 65+ years old; total family members.
General food security determinants	4	Food access issues; food availability issues; water access issues.
Food diagnosis	24	"Weekly intake frequency" and "below recommended/recommended/above recommended" for the following food groups: vegetables, fruits, dairy, white meat, red meat, eggs, legumes, water, bread, cereals, fat, sugar.

Until 2013, the FSPFS was focused on increasing family savings and security through self-production of food. Following an evaluation of the programme, it was concluded that the saving capacity was difficult to measure and that it should shift focus to peoples' "right to food", paralleling a broader change of prioritization among those working in food security. Thus, from 2013 onwards, the program focused on safeguarding the consumption and diversity of food in the most vulnerable families in the country through the improvement of the availability of healthy foods and food education.

Each family responds to a specific diagnosis regarding their frequency of consumption for 12 food groups, which then derive in three types of recommendations; "below-recommended", "recommended", and "above-recommended". Although the dietary recommendations for the Chilean population for the year 2009/2010 were taken as a reference, most are the result of the program's own creation. For each of the 12 food groups, a frequency of consumption is defined in order to approximate, over a period of one-month, dietary intake, and thus determine whether to work on a production technology if the consumption is below what is recommended, or focus on dietary education if consumption is above recommendations. The three categories mentioned above were created based on international standards and the previously mentioned dietary guidelines for the Chilean population and seek to make it easier for the executor, who is the figure that works directly with the families, the job of uploading the information to the centralized system. However, the program recognizes that this type of question never provides information that is

100% accurate, since food guidelines should also be based on the territory, realities, and integrating cultural aspects. A total standardization can, among other things, end up suggesting a culturally- or otherwise- inappropriate way of asking about culinary or consumption patterns. Finally, one of the most recent modifications of the diagnostic instrument involved adding information on the consumption of the different food groups in terms of "quantity", improving the accuracy provided by the information associated with the frequency of consumption.

In order to add the geographical characteristics to this study, we added to our dataset a column with the five Chilean macro-zones: Norte Grande, Norte Chico, Zona Central, Zona Sur, and Zona Austral, due to climate differences between each macro-zone. We wanted to see if there were territorial differences regarding the intake of the food groups amongst the macro-zones. Thus, each macro-zone groups the following regions, climate type according to the Köppen-Geiger classification, and agricultural production, as shown in Table 2.

Table 2. Chilean regions grouped in macro-zones (adapted from Sarricolea et al., 2017 and Meza et al., 2021).

Macro-Zone	Regions	Climate Type	Agricultural Production
Norte Grande	Arica y Parinacota, Tarapacá, Antofagasta	Arid and polar climates due to the Atacama Desert and high altitude.	Smallholder farming: horticultural crops (corn, lettuce, tomato, bell pepper). Fruit trees: citrus, mangoes, olives
Norte Chico	Atacama, Coquimbo	Arid but also experiences polar climates at higher elevations.	Table grapes, wine grapes, mandarins, avocados, blueberries.
Zona Central	Valparaíso, Metropolitana, O'Higgins, Maule, Ñuble, Biobío	The primary agricultural zone, where temperate climates cover over 90% of the region.	Export-oriented agriculture: fruits (grapes, apples, berries), vegetables. Large-scale farming systems with diverse crops.
Zona Sur	La Araucanía, Los Lagos, Los Ríos	Temperate climate with minor tundra zones.	Transition to export-oriented fruit trees: walnuts, blueberries, hazelnuts, cherries. Traditional crops: pastures, wheat, barley. Dairy and beef farming.
Zona Austral	Aysén, Magallanes	Mix of polar and temperate climates, reflecting the cold and humid conditions.	Limited agricultural activity. Focus on livestock, mainly sheep, and forestry.

3.1. Methods employed by objective

Objective 1 - Socio-Demographic Analysis of Vulnerable Households: The first step involved a comprehensive analysis of the FSPFS survey, focusing on households identified in 2019 and expanded to include additional data from 2020. The investigation centered around socio-

demographic characteristics, such as household headship, its gender, and number of underaged family members. The analysis further deepen into food security determinants, including food availability issues, food access issues and water access, and territorial determinants, including all macro-regions.

Objective 2 - Dietary Intake Frequency Assessment: For the evaluation of dietary habits, a quantitative approach was adopted, which was based on categorizing the intake frequency of n=12 food groups, shown in Table 3, according to national dietary guidelines and intake recommendations. The assessment stratified households based on “below recommended”, “recommended” and “above recommended” intake levels, further dissecting consumption patterns into weekly intake frequencies (never [0 times/week]; sometimes [0.5 times/week]; [1-2 times/week]; [3-5 times/week]; everyday [7 times/week]) to provide a detailed portrayal of the dietary landscape among Chile's vulnerable populations.

Table 3. Food groups included in the FSPFS.

Vegetables
Fruits
Dairy
White meat
Red meat
Eggs
Legumes
Water
Bread
Cereals
Fat
Sugar

Objective 3 - Dietary Diversity Score Calculation and Analysis: The HDDS served as a pivotal metric in this phase, calculated for a sizable cohort to explore correlations with socio-demographic variables, food security determinants, and regional disparities. This objective employed descriptive

statistics for a national-level dietary diversity overview, while regional scores were scrutinized to pinpoint macro-zone dietary patterns. Multivariate regression techniques were applied to assess the impact of various socio-demographic and food security factors, alongside geographical considerations, on HDDS.

The calculation of the HDDS for each household was conducted in several steps utilizing the data on weekly intake frequencies of n=12 food groups from the FSPFS diagnosis. The methodology employed is outlined as follows:

a. **Quantification of Intake Frequencies**: The weekly intake frequency of each food group was recorded as $HWFfgi$ (Household Weekly Frequency), where i represents each of the 12 food groups. The frequency was quantified on a scale based on the reported intake:

- Never [0 times/week] = 0
- Twice per month [0.5 times/week] = 0.5
- 1-2 times/week = 1.5
- 3-5 times/week = 4
- Everyday [7 times/week] = 7

b. **Weighting of Food Groups**: Each $HWFfgi$ was then multiplied by a weight factor Wi specific to each food group to reflect its importance in the diet and shown in Table 4. The weight factors Wi were derived from WFP (2009) nutritional guidelines which emphasize the relative nutritional contribution of each food group:

$$Weighted\_HWFfgi = HWFfgi \times Wi$$

Table 4. Weight factors per Food Group.

Food Group	Weight Factor
Vegetables	1.0
Fruits	1.0
Dairy	4.0
White meat	4.0

Red meat	4.0
Eggs	4.0
Legumes	3.0
Water	1.0
Bread	2.0
Cereals	2.0
Fat	0.5
Sugar	0.5

c. **Calculation of HDDS**: The HDDS for each household was calculated by summing the weighted frequencies of all 12 food groups:

$$HDDS = \sum_{i=1}^{12} Weighted\_HWFfgi$$

The final HDDS is a summative score that indicates the dietary diversity of the household, serving as a proxy for nutritional adequacy. Higher HDDS values suggest greater dietary diversity and, potentially, better household nutritional status.

Using the "lm" function in R, a multilinear regression model with HDDS as the dependent variable was constructed. The model included Head of Household Age, Gender, Underaged family members, Food Access Issues, Food Availability Issues, Water Access, and Macro-zone as independent variables. To assess the collinearity among the variables in the dataset, Variance Inflation Factor (VIF) test was employed. By calculating the VIF values for each predictor using the "vif" function from the "car" package. A VIF value exceeding 5 was considered indicative of significant collinearity.

Objective 4 - Development of a Spatial Warning System: The data for this objective analysis were extracted from the diagnostic surveys from the FSPFS database. Based on Objective 2 of our preliminary analysis, which identified problematic food group intakes, five critical food groups were selected: fruits, vegetables, dairy products, sugars, and fats. These groups were chosen due to their significant deviation from the recommended intake levels—fruits, vegetables, and dairy intake were typically under the recommended thresholds, while sugars and fats were consumed above the recommended thresholds.

Descriptive statistics were computed for each of the five critical food groups across all macro-zones. For the data analysis, the RStudio environment was utilized with its packages "tidyverse", "chilemapas", "sf", "ggplot2", and "dplyr". The monthly intake averages were calculated to determine the mean number of days each food group was consumed. To capture the variability in consumption patterns, we identified the highest and lowest intake frequencies, along with the corresponding number and percentage of households. The mode, representing the most common reported intake frequency, was also calculated along with its prevalence among the households. To quantify the degree of intake deficiency, we determined the percentage of households consuming at/below/above the recommended levels for each food group.

The spatial visualization analysis of the five critical food groups' intakes across macro-zones in Chile involved the following steps of data processing and geographical mapping:

a. Conversion of Weekly Intake Frequency to Monthly Frequency:

Since the data provided by the FSPFS diagnosis survey considered a weekly intake, the function $MonthlyIntake(i)$ was defined to convert weekly frequency intake to monthly frequency intake.

$$\begin{cases} 30\ if\ Everyday \\ 16\ if\ 3-5\ times\ per\ week \\ 6\ if\ 1-2\ times\ per\ week \\ 2\ if\ Sometimes \\ 0\ if\ Never \end{cases}$$

b. Calculation of Commune-Level Averages

For each commune, i.e. the smallest administrative division in Chile, the average monthly frequency intake, defined as $CommuneAverage(i)$ was calculated, by aggregating individual household monthly frequency intakes for a given food group i and then dividing by the total number of households in the commune.

$$CommuneAverage(i) = \frac{\sum MonthlyIntake(i)}{Total\ number\ of\ households\ in\ the\ commune}$$

Each commune's CommuneAverage(i) was georeferenced using its coordinates provided by the "chilemapas" package in RStudio. This process involved associating the calculated average intake values with their respective spatial locations on the Chilean map.

A Choropleth map was applied to represent the average intake values. Communes with higher average intakes of a particular food group are displayed in darker shades, while those with lower average intakes are shown in lighter shades. This gradient visually represents the distribution of intake frequencies across different communes and macro-zones.

We identified and grouped communes within the macro-zones based on the proportion of households with intake levels below the recommended threshold for fruits, vegetables, and dairy, and above the recommended threshold for fats and sugars. The benchmark for categorization was set at 50% or more of households deviating from the recommended intake levels.

For visual representation, we employed a horizontal barplot with a red gradient fill, where the intensity of the red color corresponded to the proportion of households in each commune with above or below the recommended dietary intake. The gradient provided a visual scale of adherence to dietary recommendations, with darker shades indicating a higher percentage of households not meeting the recommended intake. The analysis was designed to yield both visual and quantitative interpretations of dietary patterns, facilitating the development of targeted nutritional interventions. The formula employed for determining the thresholds was:

$$Threshold\ Proportion = \frac{Number\ of\ households\ not\ meeting\ recommendations}{Total\ number\ of\ households\ in\ the\ commune}\ X\ 100$$

Where a proportion equal to or greater than 50% indicated a significant deviation from recommended dietary patterns. The proportion of households not meeting the recommendations per food group in different macro-regions can be found in Supplementary Material, N6.

4. Results

4.1. Socio-Demographic Analysis of Vulnerable Households

4.1.1. Household composition, size, and type

It was found that all necessary data were available for n=3,967 households, from a total of n=3,996 households initially included, meaning an inclusion rate of 99.3%. In addition, six communes from 2020 were incorporated in the analysis, resulting in a total of n=4,047 households and n=12,534 individuals. Of these, n=3,505 (86.6%) households had a woman as head, whereas n=542 households (13.4%) were led by men. On average, each household had 3.05 members: 3.2 members when the household was led by a woman, and 2.15 members when it was led by a man. When analyzing this variable in the different macro-zones, while in all cases there were more female head of households, in the Norte Grande, the difference was 77.0% vs 23.0%, whereas the largest difference was found in the Zona Central, with 89.2% vs 10.8%. At the national level, it was found that small households were the most frequent, comprising 63.8% of the total, followed by medium-sized households (32.9%), and large households (3.3%). Small households consist of up to 3 members, medium-sized households consist of 4-6 members, and large households consist of 7 or more members. This trend was consistent across all macro-zones, although with variations. For example, in the most extreme zones (i.e. northern and southern regions), Norte Grande and Zona Austral, smaller households accounted for 86.6% and 78.6% of the total, while larger households constituted only 1.7% and 2%, respectively. Refer to Table 5 for detailed statistics on household composition, headship by gender, and size across different macro-zones in Chile.

Table 5. Household Composition, headship by gender and size across Chilean macro-Zones, 2019-2020*.

Macro-Zone	Households Analyzed	Households with Female Head	Households with Male Head	Average Household Size	Small Households	Medium-Size Households	Large Households
Norte Grande	178 (4.4%)	137 (77.03%)	41 (23.03%)	3.1	111 (62.36%)	56 (31.46%)	11 (6.18%)

Norte Chico	298 (7.4%)	265 (88.93%)	33 (11.07%)	3.1	180 (60.4%)	105 (35.23%)	13 (4.36%)
Zona Central	1668 (41.2%)	1488 (89.21%)	180 (10.79%)	3.1	1052 (63.07%)	565 (33.87%)	51 (3.06%)
Zona Sur	1805 (44.6%)	1533 (84.93%)	272 (15.07%)	3.1	1163 (64.43%)	585 (32.41%)	57 (3.16%)
Zona Austral	98 (2.3%)	82 (83.67%)	16 (16.33%)	2.5	77 (78.57%)	19 (19.39%)	2 (2.04%)

*Note: Percentages may not sum to 100 due to rounding.

4.1.2. Age and Regional Variations

The national average age for men was 68.9 +-12.1 years, and for women, it was 55.9 +- 15,6 years, representing a difference of 13 years. The highest average ages were found in the Zona Austral, while the lowest were in the Norte Chico. It is notable that the groups aged 18 to 64, often considered the workforce group, were the most frequent, followed by individuals older than 64 years. Regional variations in age distributions should be noted as well. Refer to Table 6 For detailed information on the average age of household heads by gender and the distribution of age groups across different Chilean macro-zones.

Table 6. Average Age of Household Heads and Age Group Distribution by Gender in Chilean Macro-Zones*

Macro-Zone	Average Age of Male Heads (Years)	Average Age of Female Heads (Years)	Percentage of Workforce Age Group (%)	Percentage of Elderly (65+)
Norte Grande	67.9	51.2	39.6	18.6
Norte Chico	66.5	54.1	50.6	13.7
Zona Central	69.3	55.2	51.1	16.4
Zona Sur	68.5	57	49.5	20.8
Zona Austral	76.5	61.1	42.9	29

*Note: The workforce age group is defined as individuals aged 18 to 64 years.

4.1.3. Employment status and main work activities

Regarding the employment status of household heads, there was a noticeable difference between households led by women and men. It was found that 25.4% (796 individuals) of women who were household heads were employed, while 37.45% (298 individuals) of men who were household heads were employed. When analyzing the main work activities of the family representative, it was found that, for women, the main activities were homemaker (59.86%), pensioner (12.21%), and farmer/food production (9.64%). In the case of households headed by men, the primary activities were pensioner (42.25%), farmer/food production (29.52%), and other occupations (17.34%). For the purposes of this study, homemaker and unemployed were considered mutually

exclusive categories. Refer to Table 7 for more details on occupation according to head of household.

Table 7. Occupation according to head of household.

Head of Household Gender	Occupation					
	Farmer/Food Production	**Homemaker**	**Pensioner**	**Unemployed**	**Other**	**No Information**
Female	338 (9.64%)	2098 (59.86%)	428 (12.21%)	54 (1.54%)	558 (15.92%)	29 (0.83%)
Male	160 (29.52%)	43 (7.93%)	229 (42.25%)	5 (0.92%)	94 (17.34%)	11 (2.03%)

4.2. Dietary Intake Frequency Assessment

4.2.1. Intake of different food groups amongst Chilean vulnerable households at the national level

When analyzing the intake of different food groups amongst Chilean vulnerable households according to the "recommendation" categories, it was possible to highlight different tendencies (Supplementary material, N5), all shown schematized in figure 1. First, it was found that recommended intake of food groups such as bread, cereals, eggs, legumes, sugar, water, and white meats were each met or exceeded by at least 75% of the households. Secondly, not all food groups had intakes in the "above recommended" category; these food groups included vegetables, fruits, dairy and water. In addition, only in the case of vegetables, fruits and dairy, households with the "below recommended" intake were more in comparison with "recommended" and "above recommended". Finally, the only food groups that were regularly over consumed were fats and sugars.

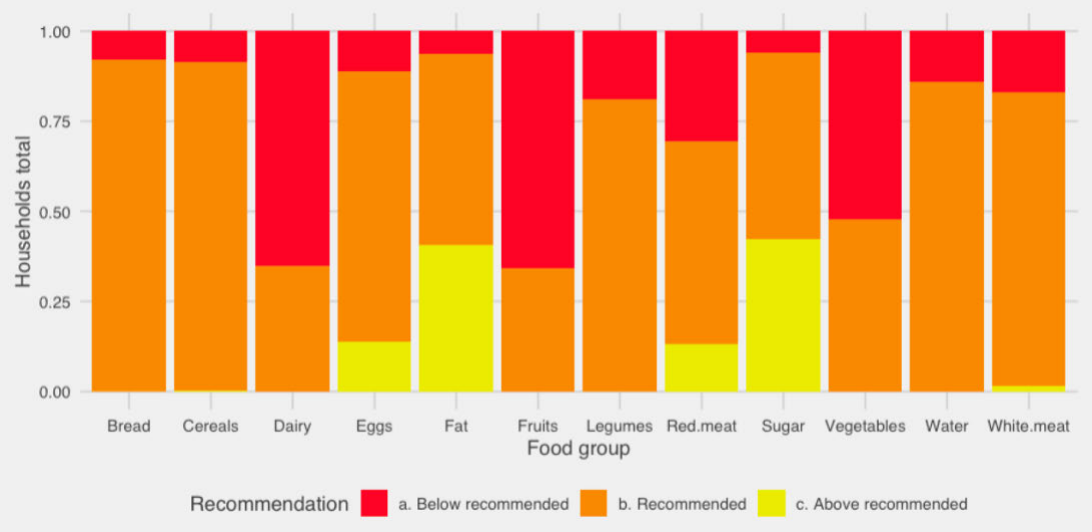


Figure 1. Recommended intake of different food groups in vulnerable Chilean households.

However, the above describe the proportion of households within each recommendation categories and do not give any detail regarding the frequency of intake for the different food groups. Thus, figure 2 shows how this is according to the intake frequency detailed in Supplementary Material, N5. One of the main findings in this analysis is related to the bread intake, which is consumed daily by the 92% of households. It was also found that nearly half of the households consumed vegetables and cereals on a daily basis. Also, fats and sugar were consumed at least once a week for all households. Most households consumed protein at least once per week, mainly through white meat and/or legumes. Finally, most members of households consumed water daily.

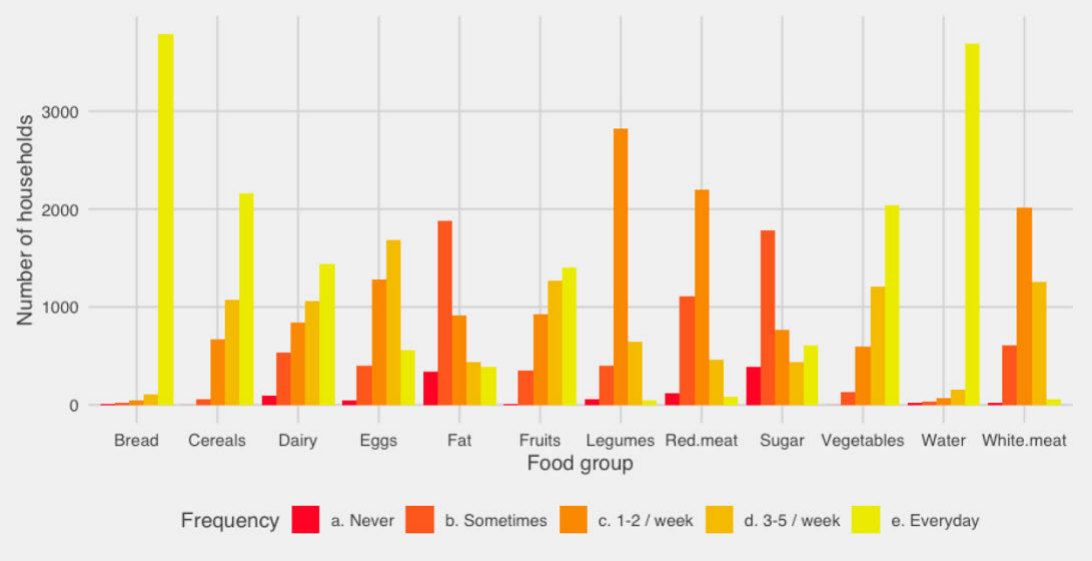


Figure 2. Frequency intake of different food groups in vulnerable Chilean households.

4.3. HDDS Calculation and Analysis

4.3.1. Chilean vulnerable HDDS

National level

The 4,047 observations of the HDDS showed a mean value of 91.4 ± 20.63, indicating a noticeable variability in the dietary diversity across households. The median value of 91.75 closely aligns with the mean, suggesting a symmetric distribution. The range from a minimum score of 20 to a maximum of 163.25 showcases considerable variability in dietary diversity scores. The slight negative skewness of -0.064 indicates that the distribution is slightly skewed to the left, although this skewness is minimal. The HDDS histogram in available in figure 3.

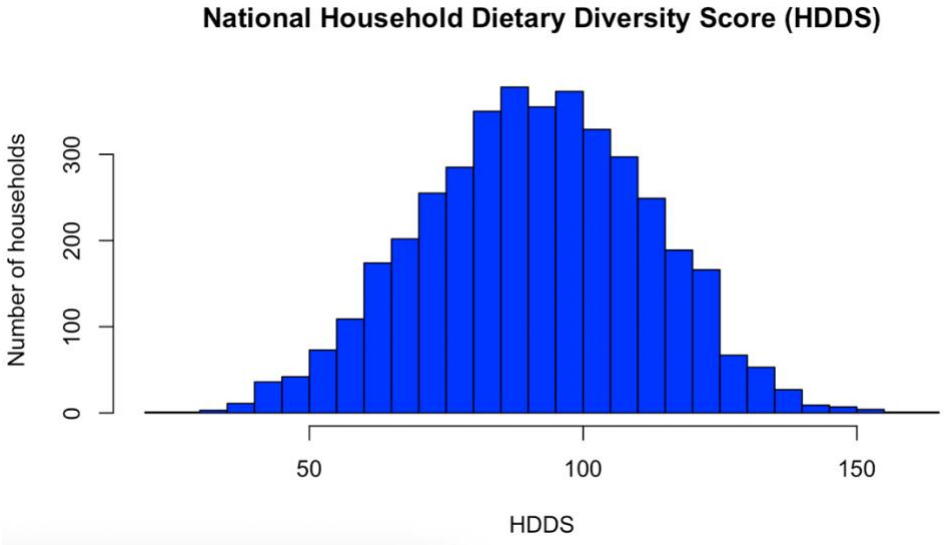


Figure 3. National Household Dietary Diversity Score (HDDS).

Macro-zone level

The HDDS data provides a comprehensive overview of dietary diversity among Chile's macro-zones. The mean HDDS indicate moderately diverse diets in Norte Grande (96.07 ± 19.23) and Zona Central (94.15 ± 19.81), while Norte Chico (93.35 ± 19.03) and Zona Austral (91.26 ± 20.56)

also exhibit reasonable diversity. Zona Sur shows a somewhat lower mean HDDS at 88.1 ± 21.28, suggesting a somewhat less diverse diet. The standard deviations reflect the variability within these regions. Median values closely align with the means, indicating relatively balanced distributions. Zona Central stands out with a mode of 110, suggesting a substantially greater HDDS. The interquartile range (IQR) demonstrates the spread of data, with Zona Central having the widest range (20.00 to 163.25), while Zona Sur exhibits the narrowest range (30.50 to 158.25). Details for all macro-zones can be found in table 8.

Table 8. Household Dietary Diversity Score (HDDS) across Chilean macro-zones.

Macro-Zone	Mean ± SD	Median	Mode	Q25	Q75	Min	Max
Norte Grande	96.07 ± 19.23	98.50	90.0	82.75	110	25.50	151.50
Norte Chico	93.35 ± 19.03	95.50	97.0	81.75	105.5000	38.75	135.50
Zona Central	94.15 ± 19.81	94.50	110.0	80.50	109.0000	20.00	163.25
Zona Sur	88.1 ± 21.28	88.00	95.0	73.00	103	30.50	158.25
Zona Austral	91.26 ± 20.56	90.75	76.5	75.75	104.6875	52.00	140.75

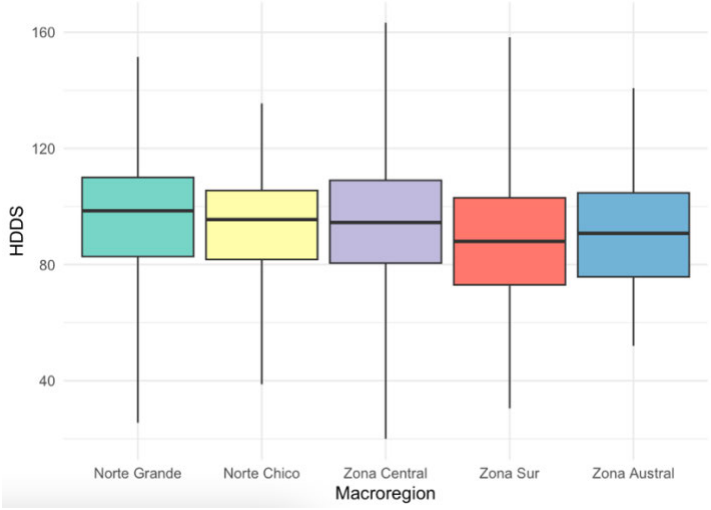


Figure 4. Distribution of HDDS across Chilean macro-zones.

4.3.2. HDDS association with household socio-demographic characteristics, food security determinants, and geographical determinants

The multiple linear regression analysis conducted to evaluate the relationship between the HDDS and socio-demographic characteristics, food security and geographical determinants showed significance in the overall model (R^2 adjusted = 0.0284, $F_{10,4036} = 12.84$, $p < 0.001$). HDDS was

positively correlated with number of minors in the household (β = 0.969, p = 0.005) and water access (β = 1.410, p = 0.050). In contrast, having food access issues (β = -2.267, p = 0.002) and residing in the ZS macro-zone, compared to NC as reference, (β = -4.976, p < 0.001) were negatively associated with HDDS. Other variables, namely age, gender, and food availability issues, did not show significant associations (Table 9).

Table 9. HDDS association with household socio-demographic characteristics, food security determinants, and geographical determinants.

				HDDS			
	Variables		*n*	%	*β*	*t*-Value	*p*-Value
Socio-demographic	Head of household age		-	-	0.011	41.582	0.672
	Gender of family head						
		M	542	13.4%	0.896	0.423	0.362
		F	3505	86.6%	-	-	-
	Underaged family members		-	-	0.969	2.791	0.005 *
Food security determinants	Access issues						
		Yes	1943	48.0%	−2.26	−3.080	0.002 *
		No	2104	52.0%	-	-	-
	Availability issues						
		Yes	1805	44.6%	−1.28	−1.714	0.087
		No	2242	55.4%	-	-	-
	Water access						
		Yes	2786	68.8%	1.4	−1.962	0.05 *
		No	1261	31.2%	-	-	-
Geographical determinants	Macro-zone						
		Norte Grande	178	4.4%	3.082	1.592	0.111
		Norte Chico	298	7.4%	-	-	-
		Zona Central	1668	41.2%	0.872	0.682	0.495
		Zona Sur	1805	44.6%	−4.98	−3.874	0.0001 *
		Zona Austral	98	2.4%	−1.90	−0.798	0.425

Note: *n*: number of households; %: percentage of households of the total; *β*: regression coefficient.

The calculated GVIF values, as shown in the table 10, confirm that no variable exhibits significant collinearity, supporting the robustness of the regression model.

Table 10. Variance Inflation Factor (VIF) Analysis for Predictor Variables.

Variable	VIF
Head of household age	1.804657
Head of household gender	1.098242
Underaged family members	1.750329
Food access issues	1.323603
Food availability issues	1.352717
Water access	1.083933
Macro-zone	1.111615

4.4. Development of a Spatial Warning System

4.4.1. Food groups intake in vulnerable households according to geographical macro-zones including “Norte Grande”, “Norte Chico”, “Zona Central”, “Zona Sur”, “Zona Austral”.

Fruits

The highest fruit average consumption were found in the Zona Central (19.8 ± 10.1) and Norte Chico (18.0 ± 9.7), whereas the lowest were found in the Zona Sur (16.3 ± 10.2) and the Zona Austral (15.9 ± 9.4). Although there was a difference of almost four days per month between the macro-zone with the highest and lowest intake, it was found that all macro-zones had on average an intake of one day every two days. All macro-zones showed a daily intake of fruits in at least one of their communes. However, n=8 communes in the Zona Central (0.48%), n=4 (0.2%) communes in the Zona Sur, and n=5 (5.1%) communes in the Zona Austral showed no intake of fruit during the month. Finally, whereas a daily intake of fruits was found as the more frequent value in the Norte Grande and Zona Central, in the Zona Austral the most repeated value, representing the 28% of the households was an intake of 6.4 days/month. Regarding the number of households below the recommended fruit intake, the southern macro-zones showed the highest values, with the Zona Austral (n=81) reaching a 82.6% of households under that condition, and Zona Sur (n=1,290) a 78.1% of households under the same classification. Details about the values of these indicators for each region and the spatial representation of these differences can be found in Table 11 and Figure 5, respectively.

Table 11. Fruits intake across Chilean geographical macro-zones.

	Norte Grande	**Norte Chico**	**Zona Central**	**Zona Sur**	**Zona Austral**
Monthly intake average (days)	17.5 ± 10.7	18 ± 9.7	19.8 ± 10.2	16.3 ± 10.2	15.9 ± 11
Highest (days)	30	30	30	30	30
n (%) [Households]	64 (36)	98 (32.9)	746 (44.7)	562 (31.1)	31 (31.6)
Lowest (days)	2.1	2.1	0	0	0
n (%) [Households]	25 (14)	16 (5.4)	8 (0.48)	4 (0.2)	5 (5.1)
Mode (days)	30	17.1	30	17.1	6.4
n (%) [Households]	64 (36)	110 (37)	739 (44)	596 (33)	27 (28)
No of households below recommended * (%)	113 (63.4)	199 (66.8)	938 (55.2)	1290 (78.1)	81 (82.6)

*Details of communes with more than 50% of households below recommended can be found in Supplementary Material, N6.

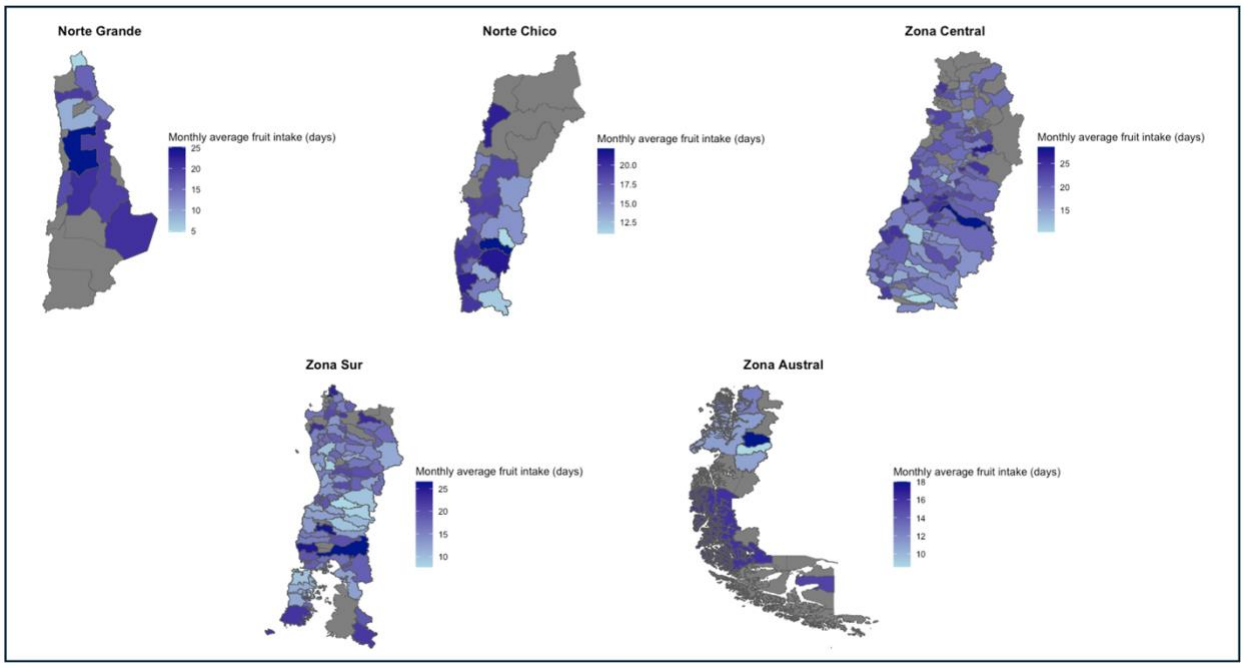


Figure 5. Monthly average fruit intake in days per macro-zone.

Vegetables

The Zona Central (23.81 ± 8.8), Norte Grande (21.2 ± 9.5) were the macro-zones with the highest vegetables monthly average intake per household, whereas the Zona Austral (18.1 ± 8.9) and the Norte Chico (19.9 ± 9.8) were the macro-zones with the lowest monthly average intake. All macro-zones had at least one household with an average intake of vegetables of 30 days/month, being the Zona Central (n=1,058; 63.4%) the macro-zone with the highest number, and the Zona Austral (n=29; 29.6%), the macro-zone with the lowest. However, it was only in the Zona Sur where we found households (n=2; 0.1%) with no consumption of vegetables. Finally, except for the Zona Austral, whose most frequent vegetable intake average was 17.1 days/month in n=38 (39%) of their households, all other macro-zones had a daily intake of vegetables as their most frequent value, compared to the other intake frequencies. As with fruit intake, the southern macro-zones were those with the greatest proportion of households in the "below recommended" category (Zona Sur: n=1,128 (63.5%); Zona Austral n=69 (70.4%). Details about the values of these indicators for

each region and the spatial representation of these differences can be found in Table 12 and Figure 6, respectively.

Table 12. Vegetables intake across Chilean geographical macro-zones.

	Norte Grande	Norte Chico	Zona Central	Zona Sur	Zona Austral
Monthly intake average (days)	21.2 ± 9.5	19.8 ± 9.8	23.8 ± 8.8	20.2 ± 9.6	18.1 ± 8.9
Highest (days)	30	30	30	30	30
n (%) [Households]	86 (48.3)	128 (43)	1058 (63.4)	784 (43.4)	29 (29.6)
Lowest (days)	2.1	2.1	2.1	0	6.4
n (%) [Households]	9 (5)	12 (4)	29 (1.7)	2 (0.1)	26 (6.4)
Mode (days)	30	30	30	30	17.1
n (%) [Households]	86 (48)	127 (43)	1053 (63)	767 (42)	38 (39)
No of households below recommended (%) *	93 (52.2)	175 (58.7)	646 (38)	1128 (63.5)	69 (70.4)

*Details of communes with more than 50% of households below recommended can be found in Supplementary Material, N6.

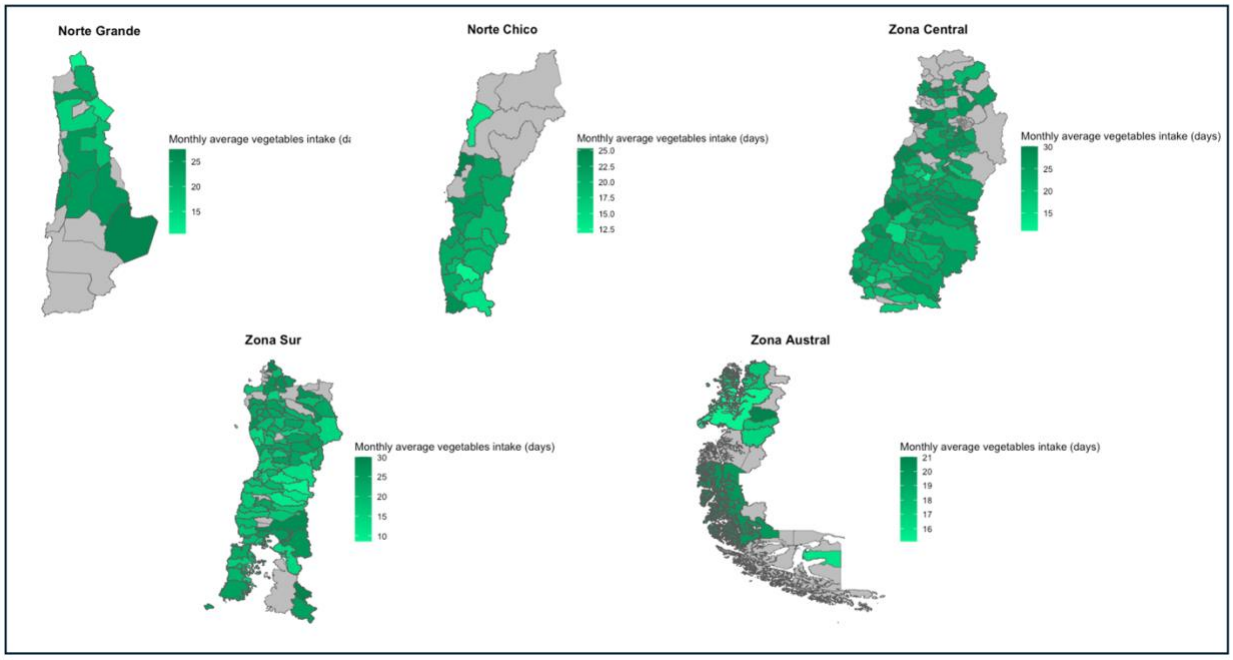


Figure 6. Monthly average vegetables intake in days per macro-zone.

Dairy

The highest dairy average intake per household was found in the Norte Grande (19.2 ± 10.8) and the Zona Central (18.5 ± 10.9), whereas the lowest average intake at the Zona Austral (15.9 ± 11)

and the Zona Sur. All macro-zones had at least one household that showed a daily intake of dairy products, being the Norte Grande (44%) and the Zona Central (41.8%) those with a major proportion. However, all macro regions had a daily intake of dairy products as their most frequent value. In addition, at least one household in all macro-zones showed a zero-intake of dairy products within the month period, most commonly in the Zona Central (n=51; 3.05%) and the Zona Austral (n=5; 5.1%). For this food group, 72.3% (n=1,284), of Zona Sur households were below the recommended intake of dairy products whereas 69.4% (n=68) of households in the Zona Austral fell into this classification. Details about the values of these indicators for each region and the spatial representation of these differences can be found in Table 13 and Figure 7, respectively.

Table 13. Dairy intake across Chilean geographical macro-zone.

	Norte Grande	**Norte Chico**	**Zona Central**	**Zona Sur**	**Zona Austral**
Monthly intake average (days)	19.2 ± 10.8	17.4 ± 10.4	18.5 ± 10.9	15.6 ±11	15.9 ± 11
Highest (days)	30	30	30	30	30
n (%) [Households]	79 (44.4)	101 (33.9)	697 (41.8)	524 (29)	31 (31.6)
Lowest (days)	0	0	0	0	0
n (%) [Households]	3 (1.7)	2 (0.7)	51 (3.05)	40 (2.2)	5 (5.1)
Mode (days)	30	30	30	30	30
n (%) [Households]	79 (44)	103 (35)	694 (42)	542 (30)	39 (40)
No of households below recommended (%) *	101 (56.7)	198 (66.4)	988 (58.1)	1284 (72.3)	68 (69.4)

*Details of communes with more than 50% of households below recommended can be found in Supplementary Material, N6.

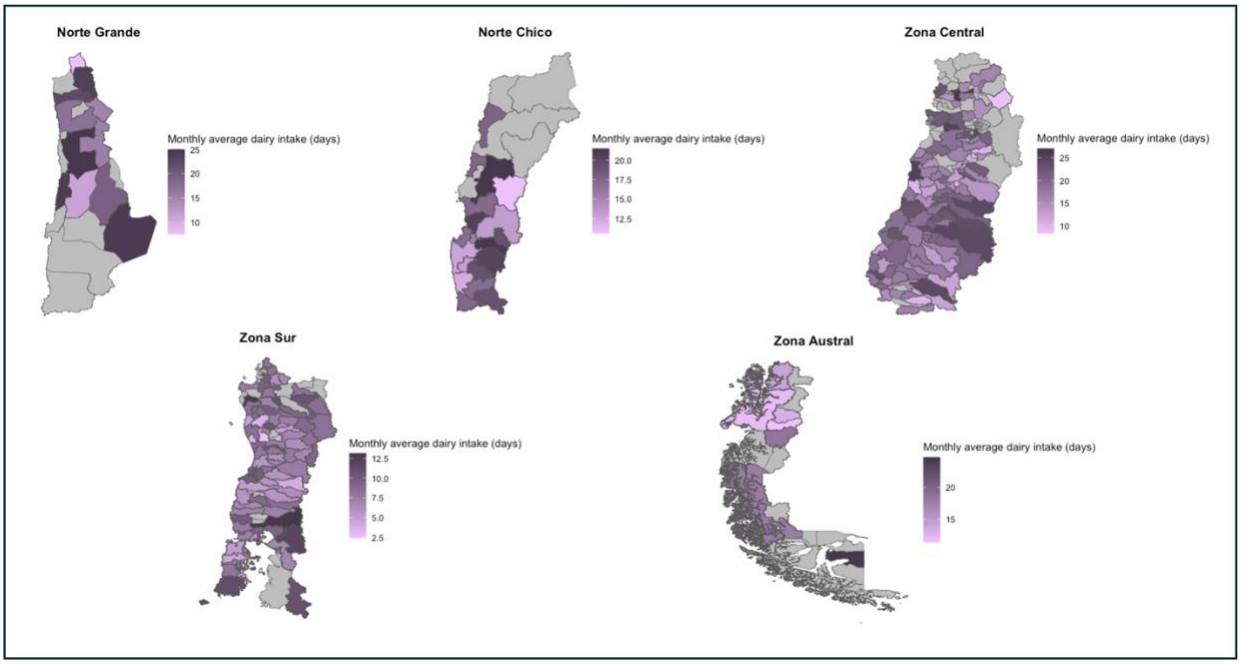


Figure 7. Monthly average dairy intake in days per macro-zone.

Fat

The Norte Grande (9.8 ± 10.7) and the Norte Chico (10.5 ± 10.2) were the macro-zones with the highest average intake of fat. All macro-zones had at least one household with a daily intake of fats: the Norte Grande (n=31; 17.4%) and the Norte Chico (n=46; 15.4%) had the highest values. Similarly, all macro-zones showed at least one household with no intake of fats at all. Of these, the Norte Grande (n=21; 11.8%) and the Zona Austral (n=10; 10.2%) were the macro-zones with major representation. Finally, the most frequent value for household fat intake across all macro-zones was 2.1 days/month. The northern macro-zone had the highest values regarding the overconsumption of fat. Thus, the Norte Chico presented a 56% (n=167) of households under this classification, whereas the Norte Grande had a rate of 50.6% (n=90). Details about the values of these indicators for each region and the spatial representation of these differences can be found in Table 14 and Figure 8, respectively.

Table 14. Fat intake across Chilean geographical macro-zone.

	Norte Grande	Norte Chico	Zona Central	Zona Sur	Zona Austral
Monthly intake average (days)	9.8 ± 10.7	10.5 ± 10.2	7.9 ± 9.4	6.1 ± 7.6	6.7 ± 8
Highest (days)	30	30	30	30	30
n (%) [Households]	31 (17.4)	46 (15.4)	197 (11.8)	118 (6.5)	7 (7.1)
Lowest (days)	0	0	0	0	0
n (%) [Households]	21 (11.8)	15 (5)	166 (10)	137 (7.6)	10 (10.2)
Mode (days)	2.1	2.1	2.1	2.1	2.1
n (%) [Households]	63 (35)	109 (37)	767 (46)	940 (52)	48 (49)
No of households above recommended (%) *	90 (50.6)	167 (56)	741 (43.6)	603 (34)	46 (46.9)

*Details of communes with more than 50% of households above recommended can be found in Supplementary Material, N6.

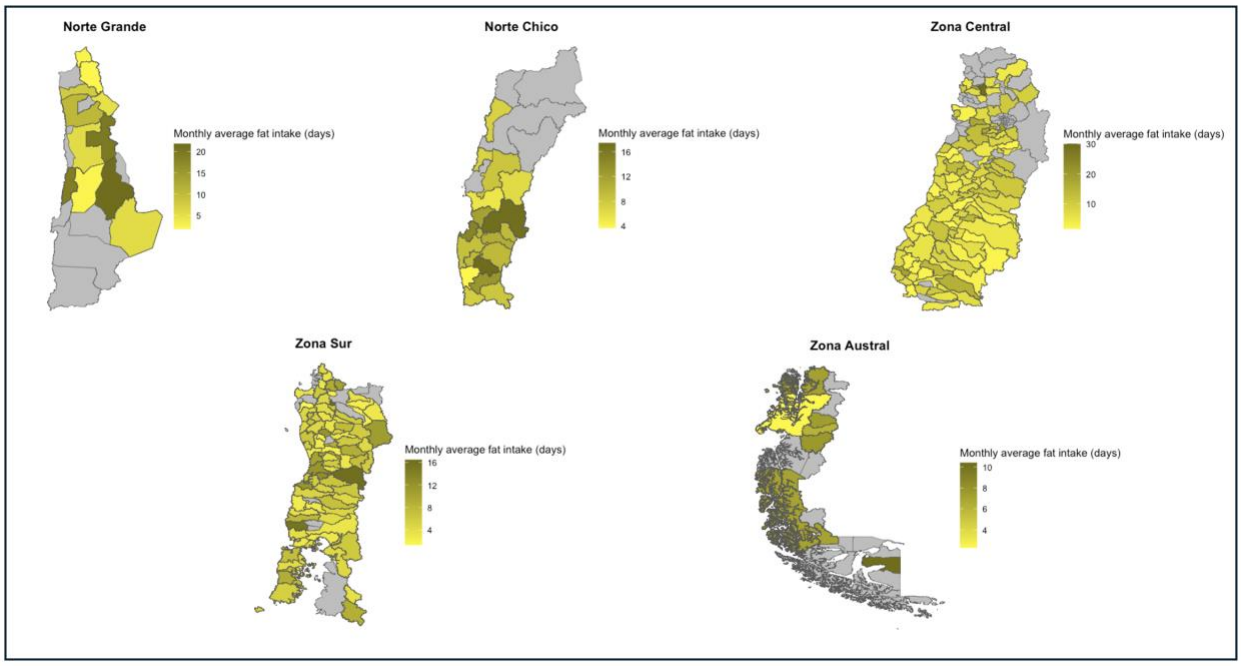


Figure 8. Monthly average fat intake in days per macro-zone.

Sugar

The macro-zones with the highest average sugar intake were the Norte Grande (10.5 ± 11.1) and the Zona Central (10.5 ± 11.3). All macro-zones had at least one household with a daily intake of sugar, being the Zona Central (n=363; 21.8%) and the Norte Grande (n=36; 20.2%) those with the highest values. Similarly, all macro-zones included some households with no intake of sugar. In this case, the Zona Austral (n=11; 11.2%) and the Zona Sur (n=192; 10.1) had the highest values.

For all macro-zones, the most frequent household sugar intake was 2.1 days/month. The Norte Grande (n=88; 49.4%), Norte Chico (n=149; 50%), and Zona Central (n=840; 49.5%) presented the highest rates of households with an overconsumption of sugar. Details about the values of these indicators for each region and the spatial representation of these differences can be found in Table 15 and Figure 9, respectively.

Table 15. Sugar intake across Chilean geographical macro-zone.

	Norte Grande	Norte Chico	Zona Central	Zona Sur	Zona Austral
Monthly intake average (days)	10.5 ± 11.1	9.4 ± 10	10.5 ± 11.3	6.8 ± 8.7	6.3 ± 8.1
Highest (days)	30	30	30	30	30
n (%) [Households]	36 (20.2)	43 (14.4)	363 (21.8)	169 (9.4)	7 (7.1)
Lowest (days)	0	0	0	0	0
n (%) [Households]	15 (8.4)	18 (6)	160 (9.6)	192 (10.1)	11 (11.2)
Mode (days)	2.1	2.1	2.1	2.1	2.1
n (%) [Households]	71 (40)	123 (41)	664 (40)	900 (50)	54 (55)
No of households above recommended (%) *	88 (49.4)	149 (50)	840 (49.5)	593 (33.4)	38 (38.8)

*Details of communes with more than 50% of households above recommended can be found in Supplementary Material, N6.

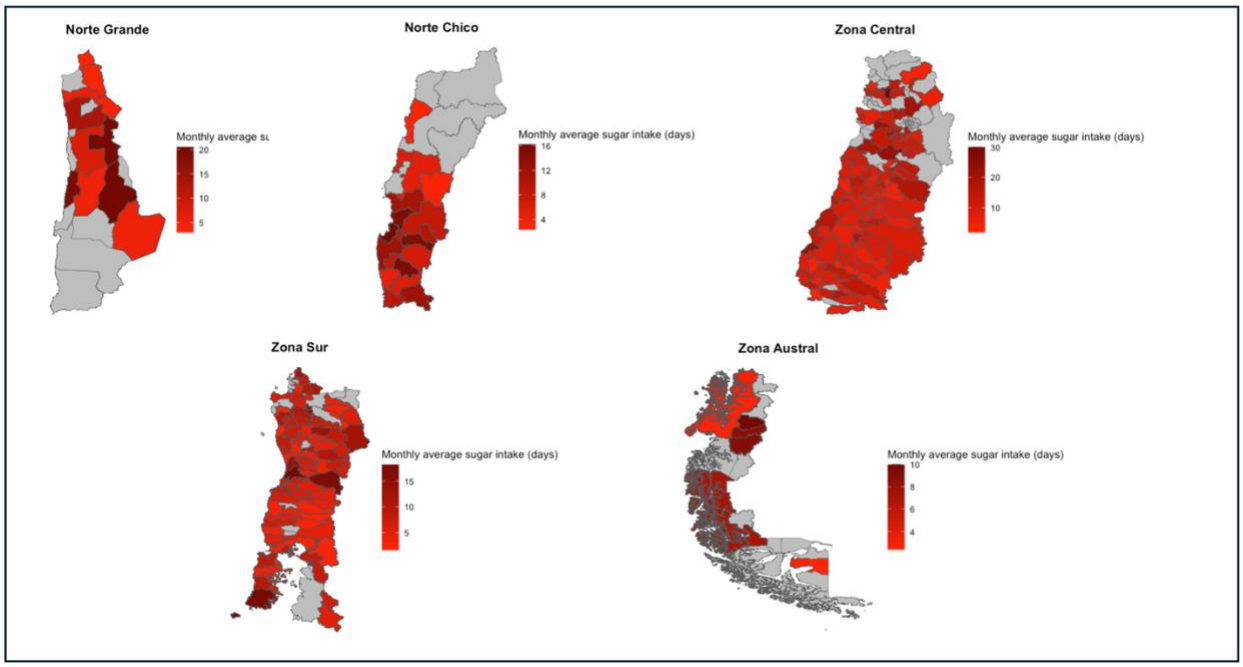


Figure 9. Monthly average sugar intake in days per macro-zone.

5. Discussion

The results of this research indicate significant differences HDDS based on the number of underage family members, access to water, food access issues and residing in the Zona Sur macro-region. Additionally, although the multivariate regression analysis showed that the gender of the head of household was not significantly related to the HDDS, the reality is that 86.6% of the households in the analyzed sample are led by women. Therefore, there is a need for special attention to how gender-focused food policies are addressed. This relationship between socio-demographic factors and dietary diversity in Chile reflects global trends. This is further contextualized by research from Honduras (Larson et al., 2019), suggesting the unique challenges of female-headed households, a demographic that is prevalent in Chile and that requires targeted interventions. In this sense, these findings could mean a first step to deepen into women's diet quality and micronutrient status in development countries to better inform interventions and policies, as suggested by (Ruel et al., 2010). Similarly, in South Africa (Megbowon & Mushunje, 2018), the link between education level and dietary diversity, as the approach followed by the FSPFS, emphasizes the potential for educational initiatives to enhance food security in Chile. These global insights highlight the importance of contextualized, gender-sensitive, and education-focused strategies to address the dietary diversity and food security nexus within Chilean households.

While the HDDS is a valuable tool for identifying food security and nutritional needs, it is important to note that the model explained approximately 2.84% of the variability in HDDS. This indicates that other factors not included in the analysis might be influencing household dietary diversity. For example, Kundu et al. (2020) note that HDDS fails to capture actual food consumption amounts, could be subject to reporting bias, and might not be representative due to its cross-sectional nature. Bezner Kerr et al. (2019) also point to the potential for measurement error given its reliance on self-reported data and its lack of granularity regarding the quantity of food within groups. Larson et al. (2019) echo this, emphasizing the score's inability to account for the specific nutritional content of foods. Pritchard et al. (2019) add concerns about potential biases and the lack of empirical evidence linking dietary diversity with energy intake. Lastly, Megbowon and Mushunje (2018) criticize the HDDS for not considering intra-household food distribution inequalities and the difficulty in comparing HDDS across different studies due to variations in

food groupings. Furthermore, the HDDS is a number that can be reached through different combinations of food group consumption, so it must also be viewed with caution.

The prevalent consumption patterns, particularly the under-consumption of fruits, vegetables, and dairy, and the over-consumption of fats and sugars, have direct implications for the nutritional health of vulnerable populations. The dietary patterns observed in Chile, characterized by the under-consumption and over-consumption of certain food groups, mirror global concerns highlighted in international research. In South Africa, Megbowon and Mushunje (2018) note that despite high dietary diversity, there is a lack of micronutrient-rich foods, a pattern that might be reflected in Chile's vulnerable populations, who also demonstrate gaps in essential nutrient intake. This is compounded by the findings from Honduras which indicate that despite adequate caloric intake, nutrient-rich dietary diversity is lacking (Larson et al., 2019), a concern that is likely paralleled in Chile. Similarly, Pritchard et al. (2019) in Myanmar report low dietary diversity with negative health implications, echoing the potential nutrient deficiencies among the Chilean populace. In Malawi, Bezner Kerr et al. (2019) suggest that increased dietary diversity correlates with better food security, a strategy that could be beneficial for Chile. Lastly, the socioeconomic factors affecting dietary habits in Bangladesh, as noted by Kundu et al. (2020), resonate with the Chilean context, where economic stresses, particularly due to the COVID-19 pandemic, may exacerbate dietary limitations, affecting health outcomes.

The results also show a centralization of healthy eating in Chile, highlighting regional disparities in the consumption of healthy foods in vulnerable population. In the Zona Central, there is a higher frequency of fruit and vegetable consumption, with a monthly average of 19.8 ± 10.1 days and 23.8 ± 8.8 days, respectively. In contrast, the extreme regions, such as the Norte Grande and the Zona Austral, face significantly different realities. The Norte Grande, with a monthly average consumption of fats and sugar of 9.8 ± 10.7 days and 10.5 ± 11.1 days, respectively, shows an unhealthy consumption profile. The Zona Austral, on the other hand, has the lowest consumption of fruits (15.9 ± 9.4 days), vegetables (18.1 ± 8.9 days), and dairy (15.9 ± 11 days). These disparities are partly due to the geographical and climatic conditions of the different macro-zones (Sarricolea et al., 2017). The Zona Central, being the main area for fruit and vegetable production (Meza et al., 2021), facilitates access to fresh produce. In contrast, the Norte Grande, an arid

region, and the Zona Austral, with conditions that do not favor mass production of fruits and vegetables (Sarricolea et al., 2017; Meza et al., 2021), face significant challenges in accessing a balanced diet. This situation underscores the need to improve food governance and ensure equitable physical access to healthy foods across the country.

The results also reflect the potential of the geospatial warning system proposed in pinpointing areas of food insecurity, representing a good tool for the FSPFS to know where the most critical areas are to better localize the resources needed. From this perspective, the literature widely recognizes the potential of these systems. For example, Hossain et al. (2020) validate its precision in identifying vulnerable districts, aiding in resource allocation and planning towards Sustainable Development Goals. Swati and Kavita (2021) emphasize its role in revealing spatial distribution and trends in Rajasthan, directing targeted interventions. Leroy et al. (2015) highlight mapping's capacity to elucidate spatial patterns, although they caution that its success hinges on data quality and stakeholders' interpretative skills. Similarly, Wauchope and Ward (2012) demonstrate how mapping informs on unmet needs, optimizing efforts to combat food insecurity in New Hampshire. However, some important limitations in this study are necessary to acknowledge. First, the use of a single-time data collection point during the diagnostic survey phase presents a “picture”, limiting the ability to observe changes over time or to continuously integrate new data. This is compounded by the reliance on the HDDS, which, although useful, cannot encapsulate the nuances of nutritional status or food consumption patterns over time. Additionally, the program's focus on new families each year complicates the ability to track longitudinal progress, with the only measure of continuity being the communal, regional, or macro-zone data trends.

While the spatial analysis focuses on individual food groups, which provides valuable information, it would be beneficial to understand how these food groups interact within vulnerable contexts. Specifically, analyzing "meals" rather than just ingredients could offer a more comprehensive view of dietary practices. This approach would allow for a better understanding of the nutritional balance and cultural relevance of food consumption patterns in these populations. Considering meals as holistic units rather than isolated components could reveal insights into dietary habits, food security, and nutritional outcomes that are otherwise obscured by looking at ingredients alone.

By shifting the focus to meals, interventions could be more effectively tailored to meet the actual dietary needs and preferences of vulnerable groups.

6. Conclusions

This study highlights that food insecurity remains a critical issue in Chile, particularly affecting vulnerable households as these exhibit limited dietary diversity, with insufficient intake of essential food groups like fruits, vegetables, and dairy, while consuming excessive fats and sugars. The analysis of intake frequency and HDDS revealed that sociodemographic factors, food access issues, and water availability significantly influence dietary patterns. A notable sociodemographic finding is the gender disparity, with 86.6% of households led by women, indicating a need for gender-sensitive policies related to food. The study also observed that average age differences between male and female household heads suggest potential age-related vulnerabilities. Additionally, small households in extreme regions highlight specific resource needs, while employment patterns reveal that housework, pensions, and family farming are the predominant work activities, providing insight into livelihood sources.

The practical recommendations based on the results and analysis of this study are as follows: (1) When selecting households that could participate in the program, it is essential to analyze their demographic characteristics to ensure that the inclusion of these households is based on identifying social conditions that make them more vulnerable to having lower food diversity. (2) Understanding the distribution of consumption of critical food groups across Chilean territory can also aid in the prior planning of the logistics required to improve access to these foods in the participating households.

While this study provides a comprehensive view of dietary diversity in vulnerable Chilean households, it is important to acknowledge its limitations. The single-time data collection limits the ability to observe changes over time. Furthermore, reliance on the HDDS, though useful, does not fully capture the complexities of nutritional status and food consumption patterns. The prevalence of concerning consumption patterns, such as the under-consumption of fruits,

vegetables, and dairy, and the over-consumption of fats and sugars, has direct implications for the nutritional health of vulnerable populations.

Recommendations for future studies include longitudinal tracking of households to assess changes in dietary diversity and nutritional status, as well as analyzing the interactions between different food groups within vulnerable contexts. Additionally, further investigation into how specific sociodemographic characteristics, such as the gender of the household head and family composition, influence food security and dietary diversity is suggested. Understanding these regional variations is vital for tailoring targeted interventions to address the specific dietary needs of each macro-zone.

7. Author Contributions

MdV, KS and SB: conceptualization and methodology; MdV: investigation and writing; KS, SB: supervision, review and editing.

8. References

Arimond, M., Wiesmann, D., Becquey, E., Carriquiry, A., Daniels, M. C., Deitchler, M., ... & Torheim, L. E. (2010). Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. The Journal of nutrition, 140(11), 2059S-2069S.

Becquey, E., & Martin-Prevel, Y. (2010). Micronutrient adequacy of women's diet in urban Burkina Faso is low. The Journal of nutrition, 140(11), 2079S-2085S.

Davis, J., Magadzire, N., Hemerijckx, L. M., Maes, T., Durno, D., Kenyana, N., ... & May, J. (2022). Precision approaches to food insecurity: A spatial analysis of urban hunger and its contextual correlates in an African city. World Development, 149, 105694.

EVS (Elige Vivir Sano) (2021). Estudio: Radiografía de la Alimentación en Chile. Resumen de primeros resultados. http://eligevivirsano.gob.cl/wp-content/uploads/2021/04/20210405-Radiografi%CC%81a-de-Alimentacio%CC%81n-en-Chile.pdf (Accessed on May 03 2021).

Hossain, M. J., Das, S., Chandra, H., & Islam, M. A. (2020). Disaggregate level estimates and spatial mapping of food insecurity in Bangladesh by linking survey and census data. PloS one, 15(4), e0230906.

Hwang, M., & Smith, M. (2012). Integrating publicly available web mapping tools for cartographic visualization of community food insecurity: A prototype. GeoJournal, 77(1), 47-62.

Kennedy, G., Ballard, T., & Dop, M. (2011). Guidelines for measuring household and individual dietary diversity.

Kerr, R. B., Kangmennaang, J., Dakishoni, L., Nyantakyi-Frimpong, H., Lupafya, E., Shumba, L., ... & Luginaah, I. (2019). Participatory agroecological research on climate change adaptation improves smallholder farmer household food security and dietary diversity in Malawi. Agriculture, Ecosystems & Environment, 279, 109-121.

Kundu, S., Al Banna, M. H., Sayeed, A., Sultana, M. S., Brazendale, K., Harris, J., ... & Khan, M. S. I. (2021). Determinants of household food security and dietary diversity during the COVID-19 pandemic in Bangladesh. Public Health Nutrition, 24(5), 1079-1087.

Larson, J. B., Castellanos, P., & Jensen, L. (2019). Gender, household food security, and dietary diversity in western Honduras. Global Food Security 20, 170–179.

Leisher, C. (2014). A comparison of tablet-based and paper-based survey data collection in conservation projects. Social Sciences, 3(2), 264-271.

Leroy, J. L., Ruel, M., Frongillo, E. A., Harris, J., & Ballard, T. J. (2015). Measuring the food access dimension of food security: a critical review and mapping of indicators. Food and nutrition bulletin, 36(2), 167-195.

Martin-Prevel, Y., Becquey, E., & Arimond, M. (2010). Food group diversity indicators derived from qualitative list-based questionnaire misreported some foods compared to same indicators derived from quantitative 24-hour recall in urban Burkina Faso. The journal of nutrition, 140(11), 2086S-2093S.

Mathenge, M., Sonneveld, B. G., & Broerse, J. E. (2023). Mapping the spatial dimension of food insecurity using GIS-based indicators: A case of Western Kenya. Food Security, 15(1), 243-260.

Megbowon, E. T., & Mushunje, A. (2018). Assessment of food security among households in Eastern Cape Province, South Africa: evidence from general household survey, 2014. International Journal of Social Economics, 45(1), 2-17.

Meza, F., Gil, P., & Melo, O. (2021). Agricultural uses. Water resources of Chile, 243-258.

Moursi, M. M., Arimond, M., Dewey, K. G., Treche, S., Ruel, M. T., & Delpeuch, F. (2008). Dietary diversity is a good predictor of the micronutrient density of the diet of 6-to 23-month-old children in Madagascar3. The Journal of nutrition, 138(12), 2448-2453.

Muthini, D., Nzuma, J., & Nyikal, R. (2020). Farm production diversity and its association with dietary diversity in Kenya. Food Security, 12, 1107-1120.

National Socioeconomic Characterization Survey. Ministry of Social Development and Family, Government of Chile. Food Insecurity Outcomes. (2022) https://datasocial.ministeriodesarrollosocial.gob.cl/fichaIndicador/814/1 (accessed on 03 May 2024).

Nica-Avram, G., Harvey, J., Goulding, J., Lucas, B., Smith, A., Smith, G., & Perrat, B. (2020, April). Fims: Identifying, predicting and visualising food insecurity. In Companion Proceedings of the Web Conference 2020 (pp. 190-193).

Pritchard, B., Rammohan, A., & Vicol, M. (2019). The importance of non-farm livelihoods for household food security and dietary diversity in rural Myanmar. Journal of Rural Studies, 67, 89-100.

Ruel, M. T., Deitchler, M., & Arimond, M. (2010). Developing Simple Measures of Women's Diet Quality in Developing Countries: Overview1, 2. The Journal of nutrition, 140(11), 2048S-2050S.

Sarricolea, P., Herrera-Ossandon, M., & Meseguer-Ruiz, Ó. (2017). Climatic regionalisation of continental Chile. Journal of Maps, 13(2), 66-73.

Swati, R., & Kavita, A. (2021). Measuring and mapping the state of food insecurity in Rajasthan, India. Geography, Environment, Sustainability, 14(1), 33-40.

Wauchope, B., & Ward, S. (2012). Mapping food insecurity and food sources in New Hampshire cities and towns.

Verger, E. O., Ballard, T. J., Dop, M. C., & Martin-Prevel, Y. (2019). Systematic review of use and interpretation of dietary diversity indicators in nutrition-sensitive agriculture literature. Global Food Security, 20, 156-169.

World Food Programme. (2009). Manual for food security assessment in emergencies: Second edition [Spanish version]. Rome, Italy.

1. Chapter's conclusions

Using a completely quantitative approach, this chapter attempts to answer the sub-research question *"how can data analysis support evidence-based decisions to reduce inequalities in food access in Chile?*". It demonstrates the value of data for identifying regional disparities in food access and enhancing the data-driven decision-making process. The study reveals several key findings regarding dietary habits among vulnerable Chilean households, including low dietary diversity marked by insufficient intake of fruits, vegetables, and dairy, alongside excessive consumption of fats and sugars. It also highlights the significant influence of socio-demographic factors, notable regional differences, with the Central Zone showing higher fruit and vegetable consumption compared to the more isolated Norte Grande and Zona Austral, and a pressing need for gender-sensitive food policies to strengthen FNS and promote healthier eating habits.

As noted in the chapter's introduction, this research also aligns with the emerging debate on coordination and collaboration in data sharing among different institutions discussed in Chapter 3. The chapter demonstrates how such collaboration can effectively occur across government and academic bodies. Additionally, while not its primary focus, the chapter set the stage for future discussion on ethical issues related to managing sensitive data, particularly concerning access to information about socially vulnerable families, and considers what happens when this sensitive data remains unused due to budgetary constraints.

The following and final chapter of this thesis adopts a different approach. Rather than being a conventional methodological chapter, it offers a reflective perspective that connects my journey from a researcher trained in conventional agronomy and strictly quantitative/positivist methods to an agroecology practitioner who has embraced mixed qualitative and participatory approaches to address FNS challenges and discuss how we create and share knowledge.

CHAPTER 5: Reflections on multi-methods and comprehensive knowledge for Food and Nutrition Security

Abstract

This chapter is a reflection on my experiences during my PhD research, which focused on understanding and suggesting solutions to the multifaceted challenges of FNS in Chile through the lenses of data governance. Initially, my training in agronomy was centered around using exclusively numerical data to evaluate agricultural success. However, my interactions over the past 10 years with small farmers and other relevant actors of the food system, particularly in Chile and Mozambique, revealed the limitations of relying solely on quantitative data. This realization inspired a shift in my approach, leading me to integrate these traditional quantitative methods with qualitative research, which involves more direct conversations and engagement with the people who are directly affected by FNS issues. Throughout the chapter, I discuss how combining knowledge from various sources can lead to more effective strategies for addressing FNS. One case study in southern Chile is explored, showcasing how this multifaceted approach has been applied in real settings. This example, as well as other mentioned in the chapter, demonstrate that incorporating different types of knowledge helps us understand the complex nature of food systems better and suggest solutions that are more practical and grounded in the actual needs of communities. By sharing these experiences, the chapter argues for a more inclusive research approach that uses multiple methods to knowledge creation and capture the full spectrum of FNS challenges. This approach not only broadens our understanding but also emphasizes the importance of adaptability and collaboration across different disciplines in research.

1. Introduction

Chile's agricultural landscape, shaped by conventional agronomy, has historically emphasized quantitative research with a framework that circles around production metrics, yield optimization, extensive monoculture farming, and a focus on large-scale operations equipped with advanced machinery. Such an approach often sidelined the complexities of rural livelihoods, food insecurity, sovereignty, and the broader implications of climate change, governance, and public health. This was the national context I experienced as an agronomy student from 2008 to 2013, where I learned to analyze these systems exclusively through quantitative data detached from context of the realities they represent.

This perspective began to shift during the final stages of my undergraduate degree. A curriculum adjustment opened my eyes to the challenges faced by Chile's agricultural sector, particularly in subsistence livestock farming. My BSc thesis work took me into the field, where I engaged directly with small farmers in central Chile, listening to their stories, and learning how their daily rhythms shaped their learning process and knowledge around food production. Suddenly, the numbers I had calculated took on a new meaning. For instance, I found myself questioning what "X liters of milk per season" represented for a family in the Quilapilún sector, how "X grams of daily weight gain" affected a six-goat flock in Chacabuco, or even how goat prolificacy influenced households in a northern region affected by desertification.

This curiosity about how lived experiences shaped knowledge creation deepened when I moved to northern Mozambique for my MSc fieldwork between 2016 and 2018. Immersed in a context influenced by the aftermath of the civil war and sporadic conflict, I reflected on the local food systems and traditions. Why did families sell their goats rather than consume them, despite protein intake deficiencies among the population? Why had the knowledge of meat preservation shrunk among younger generations? Daily conversations over meals became my doorway to understanding these realities, listening to stories and practices that government reports and statistical models could hardly capture.

Back in Chile, between 2018 and 2020, I started to embrace an agroecological perspective, contributing to a public program aimed at sustainable food production in vulnerable households. Traveling to isolated sectors, I encountered a different side of food systems, not only from the producer's perspective, but through the lens of consumers and cooks. In this context, agroecology appeared both as a toolkit for sustainable farming and as a framework for reimagining the connections between environment, health, justice, and policy.

Beginning my doctoral journey at the University of Edinburgh brought another shift. The COVID-19 pandemic limited my mobility, but it also introduced me to an intellectually diverse environment where FNS was approached from countless angles. The notion that agronomists and their quantitative methods held the sole key to solving global food insecurity challenges, as I constantly heard in my early years of agronomy studies, seemed increasingly inadequate. Conversations with peers, staff, and other food practitioners revealed alternative research methodologies and perspectives, challenging my own biases and assumptions.

But did this mean to abandon quantitative research in favor of other approaches? Are these paradigms mutually exclusive? Through slow and deliberate learning, I began to integrate these methodologies, recognizing their complementarity. Conversations that once took place in Spanish and Portuguese across Chile and Mozambique were now conducted in English, often in virtual spaces, as I navigated the linguistic and cultural traces of academic discourse. While I found large student/staff meetings intimidating, smaller discussion groups reminded me of those intimate conversations with farmers and families, where genuine exchange thrived.

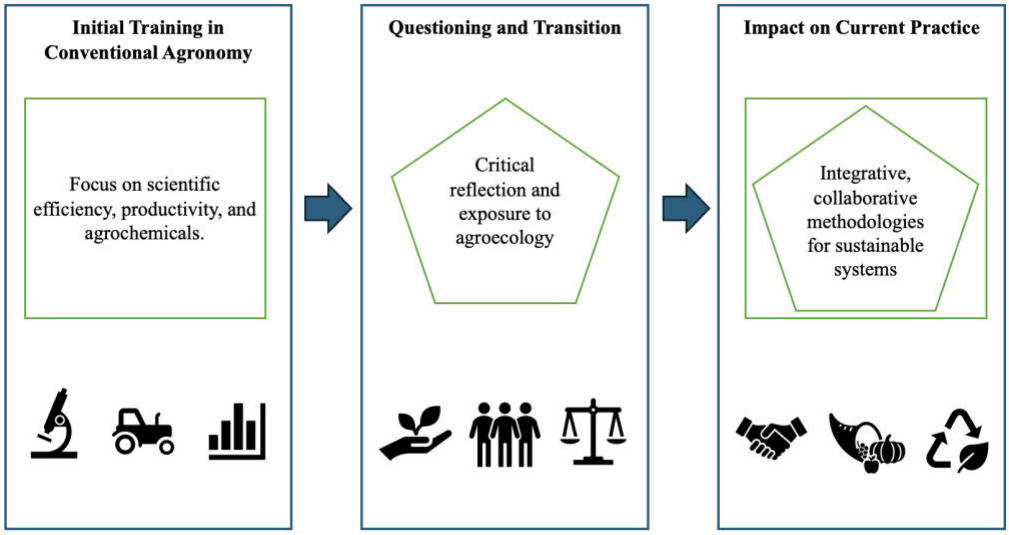
This last chapter reflects on how my intellectual, methodological, and disciplinary transition over the past years shaped the way I developed this PhD thesis. While the empirical chapters presented previously focus on the quantitative and qualitative analyses needed to address the double burden of FNS in Chile, this section tackles a critical dimension underlying the entire work: *how does my position as a researcher and my transition from conventional agronomy to a participatory, multi-method approach shape the knowledge produced about food and nutrition security in Chile?* To achieve this, the chapter is organized as follows:

Firstly, I share my journey from a traditional agronomic viewpoint to a more holistic and integrative approach to knowledge production. Secondly, I explore my transition from purely quantitative methods to embracing qualitative and collaborative approaches, eventually working to blend the two. Thirdly, a study case in collaboration with a local agroecological association in Mashue, Chile, where I reflect on how these alternative ways of knowing, along with qualitative and collaborative methods, were applied and integrated into this specific study. Finally, I discuss key lessons and considerations when combining multiple methodologies and knowledge origins in research.

2. Transition in agricultural knowledge production

During my undergraduate education, I focused on understanding traditional agronomic practices and their direct impact on productivity. The teaching framework largely emphasized yield optimization, mechanization, and productivity metrics as the primary markers of 'valid' agronomic knowledge, often sidelining local wisdom and small-scale family farming practices. This approach shaped my early perception of what 'counts' as legitimate knowledge, leading me to rely heavily on lab results, standardized protocols, and established input-output models. However, as I moved towards the end of my BSc and to the multifaceted challenges of the MSc and the PhD, my perspective began to expand beyond the field to a richer understanding of how agricultural systems interact with and are influenced by broader economic, social, and ecological systems. The process of this transition is schematized in Figure 1, which illustrates how my approach to agricultural knowledge production evolved over time.

Figure 1. My transition in agricultural knowledge production.



2.1. Initial training in conventional agronomy

My academic background in traditional agronomy led me to adopt a technical and scientific approach where knowledge was primarily measured in terms of productivity and efficiency. Within this context, solutions to agricultural challenges focused on the use of agrochemicals and mechanized techniques, while socio-environmental perspectives were often secondary. The prevailing view of knowledge was essentially objective.

2.2. Questioning and transition to agroecology

As my career progressed, I encountered limitations in this approach and began questioning its applicability in addressing real-world environmental and social challenges. Immediately, Chappell's (2018) words in Beginning to End Hunger resonate with me when I remember those times. He emphasizes that his reflections are not about gradually discontinuing food production, since a stable food supply is essential, but rather about questioning why and for whom we are producing it. Thus, exposure to agroecological practices in different contexts and collaborative research became pivotal in my transition. By the end of my undergraduate studies, I worked on a project with small goat holders in central Chile, which highlighted the disconnect between conventional agronomy taught in classrooms and the realities of small-scale farmers. This was

further deepened by voluntary work with Mapuche communities and peasants in southern Chile, where I witnessed how local knowledge and cultural practices were often undervalued in conventional agricultural frameworks.

These experiences laid the groundwork for my transition toward more holistic approaches that integrate both local and scientific knowledge. My internship at the FAO office for Latin America and the Caribbean in 2012/2013 introduced me to the broader frameworks of food security and sustainability, where interdisciplinary collaboration was essential. Later, during my MSc studies, I engaged in a collaborative project that covered rural Mozambique and urban Kenya, which underscored the importance of participatory methodologies in understanding diverse agricultural systems.

Finally, as a consultant in agroecology for a Chilean public program, I was able to implement and refine these approaches, focusing on promoting sustainability and ecosystem regeneration. These cumulative experiences have shaped my research philosophy, emphasizing the integration of diverse knowledge systems and the co-creation of solutions tailored to local contexts.

2.3.Impact on current practice

This shift in my methodological approach has deeply influenced my fieldwork. My current research combines quantitative and qualitative methods, emphasizing collaboration with local communities to develop more sustainable agri-food systems. During my PhD, I adopted a multimethod approach to analyze the intersection of household-level data, public program evaluations, and family farming perspectives in Chile. This allowed me to bridge empirical data with community realities and uncover actionable insights for food governance.

In addition, as an Earth Fellow at the University of Edinburgh, I collaborated with the UNHCR Jordan team to assess their vulnerability assessment framework and adapt it to incorporate climate change resilience. This work reinforced the importance of integrating local knowledge into global frameworks, ensuring that policies are both contextually relevant and inclusive. Also, being part of the One Health Field Network provided an invaluable opportunity to work with Syrian and Turkish colleagues on interdisciplinary approaches to address complex food security and health

challenges. These collaborations have not only enriched my understanding of participatory methodologies but also emphasized the critical role of diverse perspectives in shaping more inclusive and effective food policies.

This evolution naturally led me to question the methods I was using and opened the door to exploring new approaches to the research I wanted to conduct in my PhD. In the next section, I deepen into this methodological shift, where I moved away from purely quantitative methods to incorporate qualitative and collaborative approaches, ultimately working to blend them.

3. Back and forth: from quantitative to qualitative and collaborative methods

My transition from a positivist approach focused on quantitative data to qualitative and collaborative methods began during my undergraduate thesis work. I applied a survey to small-scale goat farmers in Colina, a rural area north of Santiago in central Chile. While conducting the surveys, often numerical data, I noticed that open-ended responses provided an unexpected layer of depth. The farmers' shared stories—about their daily lives, worries, and aspirations—gave context to the numbers. Those narratives became the "voice" behind the data, transforming the study from a mere analysis of trends into a reflection on the perceptions and lived realities of those families. The impact of this realization extended beyond the survey itself. With the findings, I helped secure funding to organize workshops with farming families, where they decided on the topics to address. These informal focus groups revealed dynamics that individual interviews did not capture, such as how some farmers felt more comfortable in small group settings where their voices felt stronger.

A few years later, when I moved to rural northwest Mozambique, I encountered a vastly different context that further deepened my reflection on knowledge construction. Although I initially intended to replicate some of the methodologies I had learned and developed in Chile, I quickly realized the need for adaptation. Learning Portuguese to communicate was my first challenge as it enabled me to interact with most people but not everyone. The limitations of working in a non-native language raised critical questions: Did this affect the richness of my qualitative data? What role did my outsider status play in shaping the interactions? How did this compare to the perceived

objectivity of quantitative methods in such settings? These reflections prompted me to invite an anthropologist trained in ethnographic methods to join my fieldwork team, allowing me to train in these techniques and understand their constraints.

Two years in Mozambique provided further insights, contextualizing production statistics, livestock data, and local decision-making processes. Returning to Chile, I carried those lessons into a public program supporting food-insecure households through agroecology. While the program's political and public nature required measurable outcomes, such as the number of families reached, budgets spent, and equipment distributed, I saw opportunities to incorporate qualitative insights. Traveling across Chile, I encountered not just unique landscapes but also the families who inhabited them, each with their own stories. These visits, although focused on quantitative monitoring, always included, around amazing meals. moments to ask and listen actively. By including these contextual details in my reports, I advocated for tailored solutions that addressed logistical and geographic challenges creatively.

These experiences taught me the value of combining methods and perspectives. I feel the grounding of fieldwork and the act of listening position us within the context, making us more creative in crafting joint solutions that respect lived experiences. Moving between rural areas of Chile and Mozambique reinforced my interest in interdisciplinary approaches, as I saw firsthand the creativity required to navigate the complex, multidimensional challenges of daily life.

These lessons guided me when I began my doctoral research. Addressing something than complex as the double burden of food insecurity in Chile required a multiple methods approach. The quantitative skills I had learned as an agronomy student complemented the qualitative practices of observing and listening that I had embraced during my earlier fieldwork. Together, they offered a richer understanding of the realities I wanted to study. Now, when I look back to this thesis chapters I can see how that was applied. Regardless of the methodology used for a specific research objective, or where the data came from, the majority of the progress achieved came from collaborations. Collaboration with librarians to learn how to conduct a literature review. Collaboration with writing fellows to help me with my English academic writing. Collaboration with government institutions to have access to sensitive data, with a consultancy to develop

workshops and conduct interviews. This is what I'm taking home, and what I would like to remember every time I start with a new project.

This blending of methods and the realization about the importance of collaboration in research prepared me to apply these concepts in a real-world context, such as a study case conducted in Mashue, Chile. The following section presents this case study, highlighting how these alternative approaches were integrated and applied in a practical setting.

4. Collaborative workshops in Mashue, Los Ríos, Chile: a reflexive case study

The study case described below emerged from established relationships between the local partner, Albatros Consultancy, and Mashue's Agroecological Association (MAA). These collaborations were built on trust cultivated over years of engagement, including previous surveys and field visits. I first connected with this consultancy in mid-2022, as some of its members were former colleagues from my agronomy days in Chile, and we were exploring potential collaborations. Our initial online meeting took place in October 2022, where I introduced my ongoing PhD thesis and its objectives. The following month, we held an extended meeting with my main supervisor. The groundwork laid by Albatros Consultancy enabled me, as a researcher, to engage with communities in a way that respected their agency and knowledge systems. The collaborative workshops were spaces for the co-creation of agroecological knowledge, serving as a methodological and practical foundation for engaging with small-scale farmers in Chile. This section analyzes the design, execution, and outcomes of the workshops, reflecting on their role as spaces for knowledge production through alternative approaches and their impact on my broader research journey. More information and details regarding this experience can be found in the Appendix Chapter 1.

4.1. Workshop design and methodological choices

The workshops were structured as participatory spaces where agroecological knowledge was co-created between researchers, consultancy members, and a farming community. Their design followed key principles of collaboration, aiming to integrate lived experiences with scientific and technical insights.

4.1.1. Methodological Framework:

- Participatory approach: The workshops employed a participatory methodology to ensure that farmers were active contributors rather than passive recipients of knowledge. Group discussions, role-playing exercises, and practical activities were used to capture diverse perspectives.
- Agroecological themes: Each workshop focused on specific themes, all of them directly informed by the participants' needs and local challenges. Details of the workshop's agenda can be found in Table 1.

Table 1. Workshops agenda.

Workshop	Title	Objective	Date
1	An Introduction to Agroecology and Agricultural Soils	To familiarize farmers with the basic principles of agroecology and sustainable agricultural soil management.	December 15th, 2022
2	Soil Fertility: Fertilizers, Rotations, and Associations	To discuss with farmers how to improve soil fertility through the appropriate use of fertilizers, crop rotations, and plant associations.	January 12th, 2023
3	Nutrition and Agroecology in Family Farming	To promote agroecological practices in family farming that improve nutrition and food security at the household level.	February 9th, 2023

Workshops were iterative, with outcomes from one session feeding into the design of subsequent ones, allowing the process to adapt to emerging insights.

4.1. Ethical and reflexive dimensions

Ethical considerations were at the center of the workshop process, ensuring that participants were safeguarded and their contributions valued. The most important considerations I, as the responsible researcher, considered were:

- Informed consent and transparency: Participants were fully informed about the objectives, potential outcomes, and voluntary nature of their involvement, either in the workshops or interviews.
- No risks for participants: The workshops were designed as safe, inclusive spaces, with no physical, emotional, or social risks to people involved. We did this by taking a collaborative approach to workshops design, where we not only agreed on the topics to be covered, but also in how to deliver each activity in a safe way.
- Positionality and reflexivity: Drawing on the principles outlined by Dr. Nicole Brown (2023), I maintained a reflexive attitude throughout the process. My role as a researcher required constant awareness of how my positionality, first as an agronomist trained in quantitative methods, born and raised in a big city, and later as an advocate for agroecology, shaped the dynamics of the workshops. Being both an insider, familiar with Chilean agricultural contexts, the language, and an outsider, with a formal academic background, required a careful balance between guiding discussions and stepping back to let participants and consultants take the lead.

Reflexivity also extended to recognizing power dynamics within the workshops, ensuring that all voices, particularly those of farmers, were amplified. This process highlighted the importance of humility in collaborative research and the need to continuously question one's assumptions and biases. It was very common that questions related to food production and pest/diseases management would come to me because I had studied its fundamentals during my undergrad studies. However, having studied it for five years seemed more important than having practiced on a daily basis for more than fifty years in some cases. That constantly made me think on what

the type of knowledge is we value more and give more power to. But if this was the case, then there was an opportunity for different types of knowledge could sat at the same table and interact one to each other and possibly generate something new.

4.2. Workshops as spaces for knowledge production

The workshops were transformative not only for the participants in the way they incorporated new knowledge but also for me as a researcher, as I found myself engaging as both a facilitator and a participant. The process of knowledge co-creation was central, with farmers contributing valuable traditional practices that grounded the discussions in real-world applications. While myself and the consultants introduced theoretical ideas and methodologies, their practical implementation heavily relied on farmers' expertise related to territorial factors such as water access, sunlight exposure, the operation of ox-drawn plows, or the type of local and seasonal ingredients we were going to eat in our closure meal. These knowledge exchanges resonate directly with this chapter's reflective question on transitioning from conventional agronomy to participatory approaches, highlighting the richness of local knowledge systems and their potential to inform sustainable practices, as illustrated in Figure 2. Looking back, the biggest takeaway was the realization that co-creation is an evolving process, requiring humility, open-ended dialogue, and iterative adaptation of methods to ensure that both academic frameworks and local realities shape the final outcomes.

Figure 2. Different moments of knowledge exchange and co-creation, and collaborative learning during workshops. *(1: use of an ox-drawn plow for water infiltration trenches; 2: site selection with constant sunlight for compost bin; 3: vermicomposting system in a cool, shaded area; 4: community lunch with local, seasonal ingredients).*

The whole process described above reinforced my commitment to participatory and interdisciplinary approaches in FNS research. They highlighted the importance of valuing local knowledge and co-creating solutions that align with the socio-ecological realities of farming communities. This experience shaped my understanding of agroecology as more than a set of techniques and reaffirmed that transforming food systems require not just technical interventions but also ethical and reflexive practices that prioritize inclusivity and power balances. This case study offered valuable insights that helped shape my broader understanding of multi-methodology in research. The final section builds on these reflections, discussing the key lessons and considerations for effectively combining multiple methodologies and knowledge production in food systems research.

5. Discussion: reflections on multi-methodology and knowledge production in food systems research

My path as a researcher, from a conventional agronomist to a doctoral candidate in Agriculture and Food Security, has been a profound journey into how diverse methodological approaches facilitate the creation of knowledge across different domains, including the academic, local, and practical. This exploration emphasizes the importance of research choices, for instance what data

and voices are highlighted at different moments of that journey and how these choices shape the understanding and outcomes of research, resonating with Becker's (1967) perspective on the inherent subjectivity of research. During my PhD research, subjectivity influenced my work at various points. For example, in Chapter 3 I chose to focus on the Social Determinants of Health (SDH) rather than on environmental or economic factors, among others. This decision reflects how deeply affected I was by the events in Chile during the 2019 demonstrations and the COVID-19 pandemic in 2020, both of which exposed significant disparities in access to healthcare, including access to food. In Chapter 4, there were certain demographic variables in the database that I decided not to include in order to make room for or "give voice" to the purely food-related variables. Similarly, the fact that I differentiated by administrative macro-regions rather than, for example, by types of ecosystems (desert, central valley, coastal zone, pre-cordillera) also reflects my primarily political/administrative approach to FNS, rather than one associated with physical geography. The fieldwork conducted in Mashue also reflects subjectivity. For example, I chose to work with small-scale agriculture rather than with large-scale farmers in the area. There was a particular voice I wanted to hear in relation to others. It is not that one perspective has greater validity than another as both play a role in the country's food system, but my interests ultimately guided the direction I took. Also, as detailed in Appendix Chapter 2, the interviews were conducted according to the elements I wanted to explore and considered important.

Related to the above, the facet methodology described by Mason (2011) supports viewing research subjects from multiple angles without prioritizing one over another, enriching the process of knowledge creation. I think this was visible in different moments of the research. For example, in my first doctoral paper "Food governance for better access to sustainable diets: a review" (del Valle et al., 2022; Appendix Chapter 1), I argued that integrating diverse policy perspectives, without prioritization, at various administrative levels could facilitate a comprehensive understanding of equitable access to sustainable diets. This was empirically applied in "Integration and coherence in food governance—a comprehensive analysis of food security public programs in Chile", or Chapter 3 for the purpose of this thesis, (del Valle et al., 2024b), where I examined the coherence of public policies, framed as public programs, affecting food security in Chile. This last analysis underlined the need for collaborative and cross-sectoral approaches, where Mason's facets were the different Chilean ministries, highlighting how policy coherence through public programs can

facilitate the adoption of knowledge that is both scientifically comprehensive and socially equitable. These facets were also evident in Chapter 4 when variables from various disciplines were integrated to develop the HDDS. It was not just a matter of examining the intake of specific food groups, but also of investigating whether demographic or territorial factors could influence the score. Nevertheless, as noted in the previous paragraph, there was a deliberate choice to emphasize some aspects over others. I think, however, that when Mason's approach was better put in practice was during the fieldwork conducted in Mashue. Here, the main idea was around "co-creation" of knowledge and, as detailed in Appendix Chapter 2, voices coming from the participants, consultants, and me as a researcher were equally considered from the moment we started to design the workshops and during its development and evaluation. I wonder, however, if more could have been done to further develop and share the co-created knowledge with the outside world.

Also related to knowledge production, Lynch (2020) promotes a symmetrical approach to studying scientific controversies, suggesting the equal valuation of quantitative data and qualitative community narratives. As a whole, this thesis reflects that approach by drawing on both quantitative and qualitative data from a wide range of sources—open-source, confidential, and experiential—to explore a broader research problem. If I look back to the early stages of my career as a researcher I can note that this is a concept that aligns with the approach I took during my MSc, particularly in "Local Knowledge for Addressing Food Insecurity: The Use of a Goat Meat Drying Technique in a Rural Famine Context in Southern Africa" (del Valle et al., 2019), where the exploration of local goat meat preservation techniques illuminated their substantial contributions to food security in rural poverty contexts. This study examined the integration of traditional knowledge with scientific research, highlighting the complexities of knowledge creation within communities. It aligns with Figuereido et al. (2020)'s work with Mapuche communities in Chile, emphasizing the importance of adapting research methods to respect local contexts. Their approach to integrating local knowledge into research designs mirrors my own experiences, where recognizing the unique environmental and cultural contexts has been key to shaping my studies along my academic career. This similarity underlines the need for a sensitive approach that respects and includes local community input, ensuring that the research is not only relevant but also truly helpful to those involved.

One of the most ambitious aspects of this thesis was applying a multimethod approach to address the research problem. This required learning new methodologies, engaging with unfamiliar literature, and often navigating through frustration. However, I believe that complex global challenges, such as those related to FNS in Chile, calls for an awareness of alternative methods for understanding these issues. Without that awareness, my focus might have remained solely on food production, which is not inherently negative, but it would have limited my perspective. Emphasizing multiple methodological approaches aligns with the work of Béné (2022) and Carlile and Garnett (2021), highlighting the necessity of considering various analytical scales, community, national, and global, all of them needing a different methodological approach to be properly studied and their outcomes integrated. Looking back once again, I note how the experience I gained in the field during my MSc gave me some of the tools to embrace this approach throughout my PhD. In one of my MSc thesis chapters called "Redefining Food Sources: Exploring the Disconnect between Goat Farming and Its Perceived Sustainability—A Case Study in Chitima, Mozambique" (del Valle et al., 2023), I examined the perceived versus actual sustainability of goat farming, employing both quantitative surveys and in-depth interviews to deepen into the local dynamics and the process of knowledge creation concerning economic and nutritional values within a specific regional context.

Reflecting on one's positionality in research, as suggested by Brown (2023), involves recognizing how our backgrounds and choices influence our work. This understanding is crucial not only during fieldwork but also in the academic decisions we make, such as which papers to read and which themes to present at seminars, resonating what was discussed at the beginning of this section. My academic journey, which began as a 100% city boy agronomist working with small goat farmers in central Chile (del Valle and Riveros, 2016), continued during my master's in northwest Mozambique (del Valle et al., 2019; del Valle et al., 2023), and has since been consolidated through my PhD research back in Chile (del Valle et al., 2022; del Valle et al., 2024a; del Valle et al., 2024b, del Valle et al., 2025), reflects a slow engagement with positionality. Each stage of this journey has been influenced by the unique contexts and challenges of the locations where I have worked, informing my choice of study areas, my interactions with local communities, and the issues I chose to focus on. Positionality, I think, also extends to the "indoor" aspects of research. The literature I engage with and the theoretical frameworks I adopt are profoundly shaped

by my field experiences and personal belief in the effectiveness of community-based approaches. These choices significantly impact the research narrative and outcomes, emphasizing the importance of localized, participatory solutions to food security. Acknowledging positionality, as stated by Brown (2023) means understanding that our research is shaped by our experiences and the decisions we make at every step of the process. Being aware of these influences ensures that our research is thorough and ethically rigorous, respecting the communities and environments we study.

6. Conclusions: Towards a transformation of food systems through knowledge production and methodological approaches

In chapter, I have reflected on the question "*how does my position as a researcher—and my transition from conventional agronomy to a participatory, multi-method approach—shape the knowledge produced about food and nutrition security in Chile?* Echoing on my doctoral journey, I recognize how much my experiences and choices of research methods have influenced my understanding of food systems. Starting my career focused on conventional agronomy in Chile and moving through different settings, from rural communities in my home country to challenging environments in Mozambique, and currently in a multi-disciplinary academic environment in the UK, has profoundly influenced my perspective. These experiences have taught me the importance of integrating diverse types of knowledge, from academic theories to the practical insights of small-scale farmers and the strategic viewpoints of policymakers.

As we face global challenges like climate change, economic instability, and social inequalities, the need for adaptable and inclusive research methods becomes more critical. Our approach to FNS must evolve to include a wide range of knowledge sources, ensuring that our strategies are robust and flexible. I see a future where interdisciplinary methods become the norm in food systems research, combining quantitative data with qualitative insights and local knowledge to create well-rounded solutions.

This four and a half years journey has not only been about learning different research techniques but also about understanding the importance of every voice in the conversation about FNS. As researchers, we need to remain open to learning from these interactions and continue to adapt our

methods to better serve the communities involved. This approach will continue guiding my future work, finding more inclusive and participatory solutions to the challenges in the field FNS.

7. References

Becker, H. S. (1967). Whose side are we on? Social Problems, 14(3), 239–247. https://doi.org/10.2307/799147

Béné, C. (2022). Why the Great Food Transformation may not happen–A deep-dive into our food systems' political economy, controversies and politics of evidence. World Development, 154, 105881.

Brown. (2023). Reflexivity and positionality in research. National Centre for Research Methods online learning resource. Available at https://www.ncrm.ac.uk/resources/online/all/?id=20808 [accessed: 6 January 2025].

Carlile, R., Garnett, T. (2021). What scale for the food system? Moving beyond polarised debates. TABLE Reports. TABLE, University of Oxford, Swedish University of Agricultural Sciences and Wageningen University & Research.

Chappell, M. J. (2018). Beginning to end hunger. In Beginning to End Hunger. University of California Press.

Del Valle M, M., Riveros, J.L. (2016). Goat farming trends and socio-cultural environment in central Chile. Saarbrücken, Germany. Editorial Académica Española. ISBN: 978-3-8417-6106-4.

Del Valle M, M., Ibarra, JT., Aguirre Hörmann, P., Hernández, R., Riveros, JL. (2019). Local Knowledge for Addressing Food Insecurity: The Use of a Goat Meat Drying Technique in a Rural Famine Context in Southern Africa. Animals. 9. 808. Doi: 10.3390/ani9100808.

Del Valle M, M., Shields K., Alvarado Vásquez-Mellado, S., Boza, S. (2022) Food governance for better access to sustainable diets – a review. Frontiers in Sustainable Food Systems. Sec. Nutrition and Sustainable Diets. doi.org/10.3389/fsufs.2022.784264

Del Valle M, M., Hernández, R., Boden, L., & Riveros, J. L. (2023). Redefining Food Sources: Exploring the Disconnect between Goat Farming and Its Perceived Sustainability—A Case Study in Chitima, Mozambique. Sustainability, 15(14), 11071. doi.org/10.3390/su151411071

Del Valle M, M., Shields, K., Boza, S. (2024a). Using Household Dietary Diversity Score and Spatial Analysis to Inform Food Governance in Chile. Nutrients,16,2937. https:// doi.org/10.3390/nu16172937

Del Valle M, M., Shields, K., Boza, S. (2024b). Integration and coherence in food governance—a comprehensive analysis of food security public programs in Chile. Frontiers in Sustainable Food Systems, 8:1431969. Doi: 10.3389/fsufs.2024.1431969

Figueiredo, A., Rocha, C., & Montagna, P. (2020). Data collection with indigenous people: Fieldwork experiences from Chile. In Researching peace, conflict, and power in the field: Methodological challenges and opportunities (pp. 105-127). Cham: Springer International Publishing.

Lynch, M. (2020). We Have Never Been Anti-Science: Reflections on Science Wars and Post-Truth. Engaging Science, Technology, and Society, 6, 49-57. https://doi.org/10.17351/ests2020.309

Mason, J. (2011). Facet methodology: The case for an inventive research orientation. Methodological Innovations Online, 6(3), 75-92.

CHAPTER 6: Conclusions

This PhD thesis focuses on exploring how integrated and diversified data governance approaches for FNS can effectively address Chile's double burden of malnutrition. This complex issue requires a multifaceted strategy that not only examines how data governance can enhance food policy integration and coherence but also supports evidence-based decisions to reduce inequalities in food access. While numerous studies have highlighted the potential of data to improve food and nutritional security, few investigations have provided practical guidelines for implementing these ideas in a fair, ethical, and inclusive manner. This research addresses that gap by using Chile as a case study, and it aims to investigate data management strategies that can achieve equitable and sustainable outcomes, in a context marked both by the increasing prevalence of overnutrition and its health impacts, and by the persistence of food insecurity.

This research not only seeks to address its aim but also establishes several specific objectives that deepen its analytical scope. Firstly, it aims to conduct a literature review addressing emerging debates on data governance approaches for FNS. Secondly, it attempts to analyze the coherence and integration of food governance policies in Chile through examining open-source data from public programs. Thirdly, it focuses on identifying vulnerable areas affected by food insecurity and enhancing data-driven decision-making through geospatial tools and data analysis from confidential sources. Finally, it reflects on my evolution as a researcher, from a conventional agronomist trained in quantitative and positivist methods to one embracing mixed-methods and participatory approaches, to better understand the complexity of food and nutrition insecurity and itr knowledge creation process. These objectives are further framed by key research questions: How do emerging debates and literature on data for FNS inform the types of data governance necessary for transforming food systems? How does data analysis contribute to the integration and coherence of food policies in Chile? How can data analysis support evidence-based decisions to reduce inequalities in food access in Chile? And how does my positional shift as a researcher shape the knowledge produced about FNS in Chile?

In order to address the research problem presented in the introduction and research gap stated in in the literature review, this thesis employed multiple methodologies derived from diverse

theoretical frameworks. First (i), a literature review analyzed emerging debates in the field of data governance in FNS to identify the research gap, design the thesis research questions, and set the stage for the following empirical chapters. A strict protocol containing inclusion and exclusion criteria, as well as the use of Boolean operators, specific search terms and a data extraction strategy was applied. Secondly (ii), to investigate FNS integration within Chilean public programs, the RPPO and APPO framework developed by the Budget Directorate of Chile categorized programs by their direct and indirect impacts on food security and its relationship with the NFNP. Program objectives content and budgets were retrieved from the BIPS and analyzed by using the software for qualitative analysis ATLAS.ti, in order to assess inter-ministerial integration and alignment with the NFNP. Thirdly (iii), socio-demographic characteristics, dietary intake, and FNS determinants among vulnerable Chilean households were explored using a framework that integrated socio-demographic analysis, dietary intake assessment, dietary diversity score calculation, and the design of a spatial warning system. Data from the FSPFS from the Ministry of Social Development and Family in Chile were analyzed using descriptive statistics, multivariate regression, spatial visualization tools using Rstudio. Finally, the reflective section was organized to integrate my reflections on my research journey with relevant literature on reflexivity and positionality in research, thereby providing a clearer understanding of how these factors shape the knowledge produced about FNS in Chile.

This final chapter is organized in order to present the thesis conclusions, including, the key findings from each chapter, the way in which this research expands on the existing knowledge, its practical applications, its limitations, directions where I think future research could go, and finally a personal reflection as a way to give this process an appropriate closure.

1. Thesis key findings

Different key findings were obtained as a result of this research, directly related to the objectives presented in the introduction. Chapter 2 findings revealed that multiple authors described data governance as a structured exercise of authority and control over data management, aiming to maximize value while minimizing associated risks. Some studies also emphasized power and control mechanisms, whereas others highlight the importance of assigning decision-related rights to treat data as an essential organizational asset. However, significant challenges remain, including

integrating big data with traditional systems, ensuring data quality, and addressing issues of privacy and non-equitable access. Emerging debates suggest the need for global coordination, standardized metrics, and ethical frameworks that balance open data principles with the protection of vulnerable groups. Furthermore, there is an increasing call to incorporate participatory and mixed method approaches to capture the social, cultural, and institutional dimensions of FNS. These findings underscore that robust, ethical, and inclusive data governance is crucial for transforming food systems and enabling evidence-based policy actions that can effectively address Chile's double burden of malnutrition.

After analyzing open-sourced qualitative and quantitative data, Chapter 3 findings show significant imbalances in funding allocation for FNS public programs among Chilean ministries and identifies limited inter-ministerial coordination in addressing FNS policies, particularly relate to NFNP. It highlights a disconnect between health and nutrition policy priorities, noting that a mere 0.042% of the national budget is directed toward FNS programs. This chapter's findings call for a multisectoral strategy to more effectively tackle food security issues and suggest the improvement of inter-ministerial cooperation to ensure a more harmonious and comprehensive policy framework.

Key findings from Chapter 4 demonstrates the value of quantitative data analysis for identifying territorial disparities in different food groups access and enhancing data-driven decision-making processes. The most important findings include a low dietary diversity in Chilean vulnerable households marked by insufficient intake of fruits, vegetables, and dairy, alongside with excessive consumption of fats and sugars. It also highlights Chile's Central Zone showing higher fruit and vegetable consumption compared to the more isolated regions such as Norte Grande (Atacama Desert) and Zona Austral (Patagonia), and a need for gender-sensitive approaches to strengthen FNS. Finally, the way the research for this chapter was carried out is an example of successful collaboration agreements between academia and public institutions, reflecting on what was discussed in the literature review related to coordination and collaboration in data sharing.

Although there are not measurable findings, the reflective chapter has shown me how my doctoral journey has reshaped my perspective on FNS in Chile by transitioning from conventional agronomy to a participatory, multi-method approach. My professional experiences—from

engagement with rural communities in Chile and challenging environments in Mozambique to working in a multidisciplinary academic setting in the UK—underscore the value of integrating academic theories with practical insights from local farmers and policymakers. This diverse exposure has revealed that combining quantitative data with qualitative, context-specific knowledge enriches our understanding of complex food systems. As challenges like climate change, economic instability, and social inequalities intensify, embracing inclusive and adaptable research methods becomes more essential.

2. How does this thesis expand on existing knowledge?

This research also expand on the existent knowledge in different ways, particularly in the case of Chile. Chapter 2 emphasizes that data should be regarded as a valuable asset, necessitating careful oversight. It also stresses the importance of incorporating ethical standards at every stage of data handling and fostering collaborative partnerships to expand effective practices. Additionally, it highlights that in the field of data governance in FNS, literature relies heavily in quantitative approaches, leaving less space -and opportunities- for more mixed or strictly qualitative methods. But also, it mentions the need of including participatory approaches, calling for major agency when it comes to data and information access. By using the case of FNS public programs in Chile, Chapter 3 reinforces the gap between food security public investments and health related outcomes, highlighting the need for increased funding and integrated and coherent approaches. It underscores the importance of coordinated policies across sectors and formal mechanisms for policy integration to address the multi-dimensional challenges of food security. It also expands in methodological knowledge in showing how the use of mixed methods can serve to conduct and publish relevant FNS research. Chapter 4 contributes to knowledge on household dietary diversity, a topic widely explored in different settings, by linking socio-demographic factors, gender, and regional disparities to food security outcomes. It adds to the current knowledge of food insecurity in Chilean vulnerable households, emphasizing the impact of different socio-demographic factors on dietary diversity and demonstrates the practical use of spatial analysis in identifying food insecurity hotspots. This chapter also contributes to the field of collaboration between academic and public institutions, demonstrating that complex problems, in particular those related to FNS, can and must be addressed aligning knowledge and efforts. Finally, from a personal perspective, I

believe that having included a reflective chapter as part of this thesis main body adds to the existing knowledge in a more symbolic way, calling for researchers at any stage of their careers to make a pause, step out for a bit and look back to reflect on our positionality, the biases we carry with us and to question the way we conduct research and approach to knowledge creation, just as we do on a daily basis with our colleagues.

3. Practical applications derived from this research

In terms of practical applications for enhancing FNS in Chile, this thesis advocates for expanding on research that incorporates heterogeneous, collaborative, and mixed approaches to data governance, as highlighted in Chapter 2. In this aspect, I consider it is critical that the way FNS related research is designed, either in Chile or in any other context, consider this call to incorporate these approaches. For example, if I want to expand on the key findings from Chapter 4, I could start by comparing the national data base with information coming from other ministries, public programs, or international databases, embracing then a heterogeneous approach to that particular data. Or I could call researchers from other disciplines to see the data and identify other research questions, or even to question if the way I am approaching to the information available meets the ethical standards established. Also, this approach can have a practical application for students starting their PhDs as it could be useful to look beyond their field of expertise and see how relevant data for their research is obtained, managed and shared.

Chapter 3 findings call for an increased investment in food security programs, improved interministerial coordination, and a holistic approach to policy-making that integrates all aspects of FNS. In this case, some practical applications of this chapter's key findings could be to serve as a starting point for an open-sourced national data base of FNS public programs. An open platform that aggregates information on all public programs related to food security and nutrition in Chile can significantly benefit both civil society and the public sector. It can enhance transparency and accountability, allowing citizens to understand the implementation and financing of these programs while encouraging greater civic engagement. Additionally, centralizing data fosters improved inter-institutional coordination and resource optimization by identifying overlaps and synergies, ultimately informing evidence-based policymaking. Researchers and analysts could

also leverage the available information to assess trends and impacts, further promoting innovative solutions and strategic public management in the field of FNS.

Chapter 4 highlights the potential use of socio-demographic data to tailor policies, and targeted nutrition programs based on regional dietary needs. Since the data used in this chapter was obtained through a collaboration agreement with the Chilean Ministry of Social Development and Family, there is an opportunity to apply those findings in the way the Family Support Program of Food Self-Sufficiency (FSPFS) makes their operational decisions. In fact, after this chapter was peer-reviewed and published in August of 2024, I had a meeting with this public program National Director to discuss how the program beneficiaries and professionals across Chile can benefit from the evidence provided by this research. Some ideas discussed were related to making the spatial visualization tools available and easily accessible for the professionals based in the different regions, in order to easily see how's the access to different food groups in a more interactive way than solely databases. Also, it was discussed that the methodology employed could also be applied to the data from previous years in order to see trends that allow to better understand the historical situation of vulnerable families as well as having enough evidence-based information for public resources allocation.

4. Limitations

As every research, this one also presents limitations that affect the results and their interpretations. In Chapter 2, the selection of studies was carried out by a single researcher, which can introduce significant bias, as the subjectivity and potential personal preferences in the selection process could lead to the omission of relevant research or the overrepresentation of certain approaches. This method increases the risk of confirmation bias by unintentionally favoring studies that support preexisting hypotheses or ideas and difficult the reproducibility of the study due to the lack of independent verification. Chapter 3's exclusive reliance on open-access data and the focus on a limited subset of ministries can lead to an incomplete understanding of food security efforts. By analyzing only those programs aligned with the social determinants of health, public interventions from other ministries that, although they do not directly fit within that framework, address important aspects of food and nutritional security are omitted. Additionally, the database

considered does not include programs developed in collaboration between public and private entities, further limiting the overall landscape of initiatives implemented in the country. This restricted approach not only discards potentially valuable sources of information but also neglects the contributions of key stakeholders in the implementation of these programs. The professionals who bring program objectives to the field and the beneficiaries themselves can provide practical insights and knowledge that enrich the analysis, allowing for the identification of critical gaps and opportunities for improvement. Including the perspectives and experiences of these groups could result in a more accurate and robust representation of the situation, offering a comprehensive view that reflects both the challenges and achievements in food and nutritional security. In Chapter 4, data were collected at a single point in time, which significantly limits the ability to identify and analyze changes over time regarding household food practices and dietary patterns. This cross-sectional methodology prevents the detection of seasonal trends or evolutions brought about by policy shifts, interventions, or socioeconomic fluctuations—elements that are essential for understanding food security dynamics in households. This situation is largely due to the availability and nature of the information. Since the data are derived from a public program, political interests often influence the approach, with an emphasis on reaching as many people as possible by the end of a specific government's mandate. Consequently, tracking the same families year after year would require additional resources without yielding a corresponding political benefit. Additionally, the use of the HDDS as the main indicator of nutritional quality, although practical for assessing overall dietary diversity, comes with inherent limitations. The HDDS does not capture detailed aspects of nutritional patterns, such as micronutrient intake or the frequency and distribution of meals, which restricts a deep understanding of both the quality and adequacy of the diet. Furthermore, evaluating results in aggregate may hide potential biases and intra-household variations: the distribution of food within a household can differ significantly based on gender, age, and socioeconomic factors, thereby affecting individual nutrition even if the overall HDDS remains unchanged.

5. Directions for future research

To expand upon the current research, different ways for future investigation can be pursued based on the findings and limitations of this thesis. Chapter 2 limitations suggest that involving additional

researchers in the literature review could enhance its scope and reduce potential biases. By adopting a more systematic approach—such as involving at least two researchers—this process can become more balanced and objective, thereby minimizing individual subjectivity. Moreover, utilizing specialized tools or methodological frameworks, like checklists designed for systematic reviews, can help to detect and quantifying bias, enhancing the transparency and rigor of the research process. Beyond these methodological improvements, this chapter lays the groundwork for assessing regional differences in data governance for FNS. It raises pertinent questions that could be addressed in future research such as: Which regions are the focal points of the data governance in FNS research? Which regions have more successful case studies than others? How do different governmental systems either facilitate or difficult access to FNS-related data? Additionally, the chapter opens up the possibility of creating a data governance assessment framework that could be applied to future research in the field of FNS, especially for those engaging with different data sets for the first time.

Related to Chapter 3 results, including qualitative methods to capture the perceptions and experiences of both program implementers and beneficiaries would enrich the understanding of the operational strengths and weaknesses in FNS public programs. Furthermore, extending the methodology to include an analysis of environmental, macroeconomic, cultural, and political determinants—not just the social ones—would provide a comprehensive perspective on the multiple factors influencing health and FNS in programs beneficiaries. Chapter 4's key findings emphasize the need for longitudinal tracking to monitor changes in dietary diversity and nutritional status over time, alongside comprehensive analyses of food group interactions. Building on this, it would be highly beneficial to conduct a regional analysis of seasonal variations in the consumption and access to different food groups using historical programmatic data. Additionally, developing a dynamic early warning system that periodically notifies authorities of potential food crises—especially pertinent in Chile, a country frequently affected by earthquakes and volcanic eruptions—could capitalize on the lessons learned during the COVID-19 pandemic, where greater accessibility to information led to more informed emergency decisions. A future research direction might also adopt a territorial approach by utilizing spatial visualization maps and engaging directly with families participating in the program. This would facilitate a deeper understanding of how these families perceive their territory and identify specific elements of local knowledge that can

contribute to improving the design and implementation of public programs aimed at enhancing FNS.

6. What comes next?

When I started writing the conclusions of this thesis, I planned to simply summarize the most important points. I intended to restate the research objectives, the questions, and the gaps that this study aimed to fill. I also wanted to show how the findings aligned with these objectives, acknowledge the limitations, suggest directions for future research, and then finish.

However, writing these conclusions turned out to be more than just a summary, as it became a way to reconnect with my research journey over the last four years. Each chapter, whether part of the main body or kept in the appendix, was written at a different stage of my doctoral studies. When I revisited what I wrote in Appendix Chapter 1 and Chapter 3, I remembered the early years of this process: where I lived, the people I met, the knowledge I had, and even my approach to research at that time. Reviewing Chapter 4 reminded me of those frustrating days when I decided to teach myself RStudio. I was making only 0.001% progress each day and felt completely overwhelmed. Looking back, I see how impatient I was, always wanting quick results. This and other experiences taught me the value of patience and the importance of letting knowledge build up slowly. When I looked over the work described in Appendix Chapter 2, I reconnected with the researcher I feel most comfortable with: the one who packs a bag and goes out to explore the field but also takes time to reflect and integrate what is learned from interacting with others.

Every stage of my doctoral journey brought different feelings. It has been satisfying to see how I have grown and allowed myself to change. I am not the same Martín who arrived in Edinburgh in late 2020 amid the uncertainty of a global pandemic, and I'm glad about that. Writing these conclusions not only makes me look back, but it also invites me to look forward. Now I ask myself: What do I do with these tools and this experience? What should I do with the ideas that took time to develop or that did not work out over these years? It will take time to settle everything and draw final conclusions, but one thing is clear to me: I want to continue with collaborative research, where people from different areas of FNS work together. In this chapter, I shared several research

ideas that could be developed from the results of this thesis. Perhaps that is a good starting point. Who knows?

As I finish these lines, I look out the window and see a rainy Edinburgh in late February. Immediately, I remember what I wrote in the introduction about my personal reasons for starting a PhD, recalling that rainy evening in Chile that sparked something in me. Rain, water, these elements, so present in this country with its rivers, lochs, and seas, now accompany me as I write the final lines of this work. May this serve as a gentle reminder of the motivations that give our lives meaning, the end of exciting cycles, and the beginning of new ones filled with a positive uncertainty.

APPENDIX CHAPTER 1: Food governance for better access to sustainable diets – a review

*This chapter is based on:

Del Valle, M., Shields K., Alvarado Vásquez-Mellado, S., Boza, S. (2022). *Food governance for better access to sustainable diets – a review*. Frontiers in Sustainable Food Systems. Sec. Nutrition and Sustainable Diets. doi.org/10.3389/fsufs.2022.784264

Supplementary information is publicly available online, accesable via the doi.

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Abstract

'Governance', understood as organizational governance, is essential to more sustainable food provisioning systems ensuring sustainable health, heritage, and natural environments. Governance enables regional and local perspectives to be aligned with commitments from national and international organizations. Within the wealth of scholarship on food systems governance, agricultural governance and agency is a rarely interrogated dimension, despite the clear impacts of agricultural decisions on health and environmental outcomes. In this paper we discuss the findings of a scoping review that focuses on the question "*How can food governance transform food systems to ensure better access to sustainable diets?*", meaning diet that protect health, cultures, and the natural environment. Our results show that it is first needed to determine the governance level and the expected outcomes. From a national perspective, policy coherence is described as a way in which different public institutions can add to the sustainable diets access goal. From a local perspective, community supported activities and the incorporation of local knowledge are also described as ways that can help achieving an improvement on sustainable diets access. Either from a regional or local perspective, commitment from organizations must be ensured for common objectives being aligned. Also, it is necessary to request more from the agricultural sector role in delivering nutritionally and environmentally appropriate food. Thus, the idea of governing agriculture as a health and environmental activity is an approach that should be considered when designing, implementing, and assessing food systems.

Key words: Agriculture, Culture, Food Governance, Food Systems, Scoping Review, Sustainable diets.

1. Introduction

Global food production represents an important pressure over the Earth's natural systems and is related to problems associated to food and nutrition insecurity (Willet et al., 2019). It is estimated that between 720 and 811 million people faced hunger in 2020, 118 million more than in 2019, while one in three people did not have access to adequate food during the same period (FAO, 2021). On the other hand, in 2016, 1.9 billion adults were overweight, and 650 millions of these were obese, while in 2020 and 39 million children under the age of 5 were overweight or obese (WHO, 2021). In addition, the number of people suffering from "hidden hunger" (insufficient intake of essential minerals and vitamins required in small amounts by the body for proper growth and development) was likely to be between 1 and 2 billion in 2021 (WHO, 2021). When these three conditions coexist in the same individual and/or community, we speak of the "triple burden of malnutrition", which nowadays represents the most worrying issue related to food and nutrition security (Ingram, 2020).

Food security definitions have evolved over time. In 1996 the international community defined that "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their daily energy needs and food preferences for an active and healthy life". Nowadays, however, we see how increasingly the environmental -e.g. "planetary health" and "one health" approaches- socio-cultural, acceptability and agency -or the power of citizens to the define and secure their rights, in particular to food security- dimensions have become more relevant (Calistri et al., 2013; Lerner and Berg, 2015; Chapell, 2018). For example, approaches such as the "agency" dimension proposed by Rocha and the concept of "food sovereignty" have been proposed, among other things, to enhance social inclusion and participation on food systems design and management (Chapell, 2018), considering cultural and acceptance values around food production and consumption.

Related to the above, the "sustainable diets" approach arises as a holistic paradigm that considers context specific ecological concerns together with health and nutrient adequacy, as well as the affordability and socio-cultural acceptability of diets at the global, regional, local, and individual level (Garnett, 2014; Johnston et al., 2014). To provide sustainable diets that help reducing both

food insecurity and the incidence of non-communicable diseases while strengthening the sustainable management of natural resources, is necessary to transform food systems (van Bers et al., 2019; Dupuoy and Gurinovic, 2020). To achieve the aforementioned, WHO (2020) and Swinburn et al. (2019) propose a focus on three complementary areas: (1) strengthening local levers and engaging civil society into food systems transformations (2) acknowledging the diversity and complexity of food systems, with a particular scope in a nutrition-sensitive agricultural production; and (3) the inclusion of local -indigenous/traditional- approaches to health and wellbeing. Actions in these areas require a multilevel coordination and a multi-sectorial approach that can only occur if proper conditions exist (Delabre et al., 2021; Lee et al., 2020). In this sense, the concept of governance appears both as a process and a value that allows the socio-cultural environment for a proper functioning of food systems (Berry, 2019).

Based on the presumed relationship of both concepts (food governance and sustainable diets) to socio-cultural dimensions of food and agriculture, most of the literature is extensive in exploring each of these concepts separately, paying less attention to elucidating whether and how they are related. Herein we review and discuss the evidence regarding what is known about the implications of food governance, its relation to sustainable diets, and recommendations for future research.

2. Methods

A scoping review was conducted from April 2021 to May 2021 to find evidence on our research question: "*How can food governance transform food systems to ensure better access to sustainable diets?"*. The search included peer-review papers of both qualitative and quantitative research, thought pieces, and book chapters from any country between 1990 and 2021. We chose the timeframe 1990 - 2021 for this review was to find out whether the theoretical link between the two concepts (food governance and sustainable diets) corresponded to something widely studied or was relatively new.

The search strategy covered three databases: Ovid, ProQuest, and Web of Knowledge. Three groups of research terms were applied: governance, diets, and food systems. Key words relating to governance (e.g., governance, food governance, public policy, food policy, etc.), diets (e.g.,

local, healthy, indigenous, etc.), were combined with terms indicating transformation of the food system (food system transformations, inclusive food systems, resilient food systems, etc.). Terms were combined using Boolean AND/OR strategies (e.g., food policy OR food governance AND food system transformation OR resilient food system, etc.).

Initial search conducted by a single reviewer (MdV) using the aforementioned databases. Title and abstract screening were conducted independently by two reviewers (MdV) and (ASAVM) using the web-based software platform Covidence, an online review and data-extraction tool. Disagreements were resolved through further discussion between both researchers, analyzing case by case the reasons that led them to choose if each article would fit in the review according to the inclusion criteria. The final list of papers was discussed with a third reviewer (KS). In this case, and due to the expertise of KS in food governance, the set of studies selected was assessed according to its explicit focus on governance structures examples regardless its level (global, regional, local), and explicit mention of different sustainable diets dimensions, such as ecological concerns, health and nutrient adequacy, affordability, and cultural acceptability, among others.

Data extraction was conducted using an Excel matrix spreadsheet in which findings were organized according to the following categories discussed previously between MdV and KS, based on the type of information we wanted to obtain from the review. Finally, information of each category was compared to find commonalities and differences between the different selected paper.

3. Results

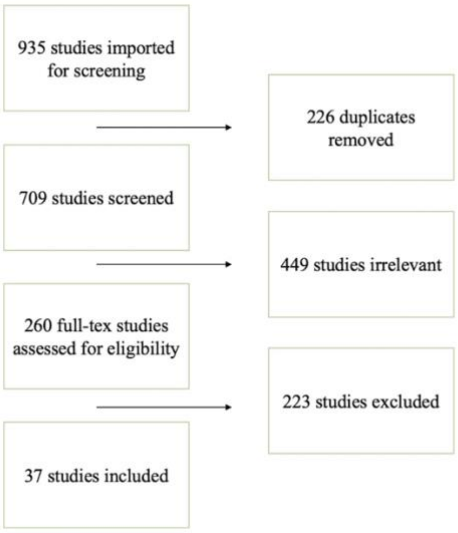
1.1.Selection process, research period and location.

Thirty-seven studies were found that fulfilled all inclusion criteria. Full reference details for these studies are presented in Table 1. Figure 1 explains the entire review process, from the database import phase to the final inclusion assessment. First, 226 duplicates found by Covidence were eliminated, leaving 709 studies for screening titles and abstracts. Of these, 449 studies were considered irrelevant because they did not match the objective of the review. Subsequently, 223 studies out of the 260 remaining for "full-text assessment for eligibility" were excluded for different reasons, such as "wrong focus" (190), "not available" (19), "wrong type of document" (13) and "duplicate" (1). Covidence did not initially find the last duplicate. The list of excluded studies categorized according to exclusion criteria available in the supplementary material, N1. The selected papers cover the period 2013-2021, concentrated especially between 2018 and 2020 (n=25; 68%), so studies linking the two concepts are relatively new. However, it should be noted that as the review was carried out between May and April 2021, studies published after the latter date were not considered for the selection process. Most selected papers belong to studies developed in Europe (33%) and to reviews and/or studies with no specific settings (32%), while in contexts commonly described as “low- and middle-income countries”, only a 11% of studies were found. All the studies were papers from scientific journals.

Table 1. Sustainability dimensions of diets from selected studies.

Group	Category	Studies
1	Sustainability focused on the environmental dimension	Balázs et al, 2021; Blay-Palmer et al, 2018; De Schutter et al., 2020; Détang-Dessendre et al., 2020; Dupouy and Gurinovic, 2020; Galli et al., 2020b; Graça et al., 2020; Hawkes and Popkin, 2015; Hunter et al., 2016; Kennedy et al., 2017; Lawrence et al., 2019; Lee et al., 2020; Leip et al., 2021; Parker et al., 2020; Pott et al., 2016; Swinburn et al., 2019; Vermeulen et al., 2020; Zurek et al., 2018;
2	Environmental and sociocultural aspects	Allen and Prosperi, 2016; Allen et al., 2019; Béné et al., 2019; Berry, 2019; Delabre et al., 2021; Downs et al., 2017; Gillespie et al., 2019; Kennedy et al., 2021; Lang, 2014; Mattioni and Caraher, 2018, Melesse et al., 2020; Galli et al., 2020a; Hawkes, 2007; Calistri et al., 2013
3	FAO definition	Boylan et al., 2020; Boylan et al., 2019; Lang and Barling, 2013; Lang and Mason, 2018; Lundqvist and Unver, 2018

Figure 1. Prisma diagram flowchart of studies selection process.



1.2.Processes of food governance

Food governance can be understood as the "architecture of food systems" (Berry, 2019) that allows formal and informal interactions between institutions and people to enable the environment in which food systems perform (Kennedy et al., 2017; Candel, 2015; Bené et al., 2019). These interactions can be vertical when different levels interact (global, regional, national, local, etc) and horizontal, where diverse stakeholders per level are involved (Allen and Prosperi, 2016; Hunter et al., 2016). Different levels and stakeholders involved implies interests and a strong presence of power and decision-making rules, availability and use of data, and economic incentives and disincentives, among others (Lang and Barling, 2013, Voβ and Kemp, 2006; Swinburn et al., 2019; Zurek et al., 2018). Some authors also understand governance as a social value of sustainability, by making clear that the balance of power, decision-making, and access to information among the different actors in food systems is what allows people to govern their food according to their own values and principles (Lang, 2014; Bené et al., 2019).

Together with balancing power over food systems, the selected studies also describe that strong governance is needed for other purposes. For example, it helps to build a common vision, to support evidence-based policies, and to promote effective coordination and

collaboration (Dupouy and Gurinovic, 2020). Other authors highlight how governance has ensured the right to food (Pott et al., 2016), strengthening local food systems and leading their transformations towards sustainability (Delabre et al., 2021; Hawkes and Popkin, 2015; Galli et al., 2020; Kennedy et al., 2017; Blay-Palmer et al., 2018). At the same time, when governance is deficient, for example when existing policies are inconsistent or fragmented (Balázs et al., 2021), crises are more likely to occur and progress in achieving sustainable diets can be threatened, as well as the efforts to address climate change, stop biodiversity loss, and achieve better incomes for farmers and food system workers (De Schutter et al., 2020).

1.3.Food governance levels and focuses

From a global, regional, and national perspective, food governance is a requirement for food policies performance (Boylan et al., 2019) as they operate across many levels shaped by international, national, and regional agreements (Balázs et al., 2021). Food policy integration and coherence are commonly described as a way in which actions from different sectors converge to meet public health and sustainability objectives, and a proper environment as a product of governance is key to achieve that (Graça et al., 2018; Farmery et al., 2020; De Schutter et al., 2020).

From a local perspective, community organization, food policy councils, learning garden programs and the incorporation of local knowledge are commonly described as another way of the interactions that occur as part of food governance actions (Sonnino, 2013; Wilkins et al., 2015; del Valle et al., 2019). In these cases, farmers' decisions about which animal breeds and vegetables varieties to produce are more influenced by community interests, natural resources, and agronomic skills than by market forces (see Wilkins et al., 2015 an example of sustainable diets through seasonally intake). It is also described that city-region is a key-level of governance to unlock food systems transformation and where collaboration between civil society and municipal government are effectively observed (Vermeulen et al., 2020). For example, food policy councils aim to forge new alliances between producers and consumers and between urban centers and their natural hinterlands (Sonnino, 2013).

Most of the papers selected for the review were strictly focused on food systems governance (n=20; 54.1%), while a smaller portion (n=9; 24.3%) although focused on food systems governance, had some other considerations, such as mentioning agriculture (Allen and Prosperi, 2016; Swimburn 2019; Vermeulen et al., 2020), ecosystems relevance (Galli et al., 2020; Lang 2014; Lang and Barling, 2013; Lang and Mason, 2018; Downs et al., 2017) and earth systems (Lawrence et al., 2019). In addition, there was a last portion of papers focused strictly on agriculture governance from different approaches. For example, some papers discussed the relevance of agricultural systems governance (Hunter et al., 2016; Pott et al., 2016; Déttang-Dessendre et al., 2020) and there was also one focused and governance over agriculture and environment (Dupouy and Gurinovic, 2020).

1.4.Sustainability approaches in sustainable diets.

Finally, and related to the definition and scope of sustainable diets, it was possible to find different approaches to and definitions of "sustainability". Three approaches were grouped together: Group 1 (n=18; 48.6%) were those papers mentioning health and sustainability as two complementary dimensions of diets, being the last only referred to environmental concerns, such as carbon and water footprint and/or GHG emissions; Group 2 (n=14; 37.8%) was composed by all the papers that explored other dimensions of sustainable diets beyond the "health and environment duality"; Group 3 (n=5; 13.6%) were all those papers which used the FAO (2010) definition[2] as a theoretical framework for their discussion, meaning another approach to go beyond the health and environment duality. Table 1 shows which papers are in each group.

[2] [*Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources*.

4. Discussion

In order to answer the research question "*How can food governance transform food systems to ensure better access to sustainable diets?",* the result of this review allows us to focus our attention on the way food governance allows an appropriate environment with context-specific characteristics for food systems to perform.

Regarding sustainable diets, most authors from group 2 agreed that a multi-criteria approach should be adopted when defining them, giving equal importance to health and environment, but also to sociocultural issues, preferences and values, socioeconomic wellbeing, diet quality and equitable access (Bené et al., 2019; Delabre et al., 2021; Kennedy et al., 2021; Mattioni and Caraher, 2018; Melesse et al., 2020; Downs et al., 2017). Is it necessary then to focus on other aspects besides health and the environmental impact? We believe so, especially because the interrelationships that characterize food systems should no longer be seen as something purely economic focused strictly on food production, but also agronomic, political, institutional, and social, grounded in knowledge, culture, consumer preferences and ways of life, among others (Sonnino, 2013; Eakin et al., 2017; Kennedy et al., 2017). However, this reality arises two related challenges. In the first place the nature of the dimensions involved could represent a special difficulty giving the different approaches and methodologies for addressing the same problem, most of the time not used to work together. And secondly, the fact that these actions are performed by the institutions that compose food systems imply that power, philosophies, values, and interests are involved. The above might imply the arise of tensions, making it difficult to act coordinated to address a major problem. This can be seen, for example, when asking if our contemporary food problems are strictly due to insufficient production and/or to the results of power differentials that results into a "structural violence" (Chappell, 2018). According to the values and interests involved, the answer will vary, meaning that the way of facing this problematic and the actions taken to address it will be different. In this sense, food systems governance can be considered as a value itself for sustainable diets, as implies a way of designing the "architecture" needed to achieve its goals (Berry, 2019). This means that food governance allows, among other things, an appropriate environment for food systems to transform in order to perform in a sustainable way. However, what makes "an appropriate environment" will depend on the context-specific

characteristics around it. Thus, as sustainable diets need a context specific approach in terms of the socio-cultural characteristics at different levels, food governance represents a value that can help achieving its objectives.

However, the results of this review are also focused on a national/regional scale, meaning that less attention has been paid to the effects local structures of food governance might have on improving the access to sustainable diets. This is especially important as one of the sustainability dimensions has to do with cultural preferences, knowledge, and ways of life, considered by some authors as "political dimensions" of food security. As mentioned in the introduction to this review, "agency" is an approach to food security that fits and rightly emphasizes the sustainability of food systems based on the power of people to govern them according to their own values and beliefs and to determine their own agricultural and food policy, organize their production and consumption to meet local needs and secure access to land, water and seed. (Chapell, 2018). However, only two papers (Galli et al., 2020; Mattioni and Caraher, 2018) mentioned "agency" as a relevant concept in food and nutrition security discussion when analyzing sustainable diets.

In the third place, and although agriculture production is one component of food systems, according to this review, food governance still does not adequately encompass governing agriculture, considering its relevance for leading food systems transformations (Hawkes and Popkin, 2015). The agricultural sector should be understood, not only as food provider, but also as a relevant stakeholder in public health planning in respect of nutrition and diets. Thus, the way in which the agricultural sector is governed might be crucial to improve the access to sustainable diets all year round, offering a route to provision of universal healthy diets within the planet's environmental capacity (Vermeulen et al, 2020). Agriculture governance could also support the environmental health of ecosystems, especially regarding biodiversity, and to reduce the risk to global health shocks (Hawkes, 2007; Détang-Dessendre et al., 2020). This review is focused on some examples of vertical governance, but less information was found in relation to how horizontal governance can be achieved. This is especially important, as is it at the same level where other dimensions of sustainable diets interact. In this sense, the coherence of agricultural and food policies as the result of robust governance is described

as a way to ensure that nations comply with the obligation to ensure the right to food for their inhabitants. But, again, to focus on governing agriculture should also imply the local levels, as many dimensions of socio-cultural sustainability are based there.

Finally, is important to note that this study has an important limitation that should be considered, as only a 11% of the selected studies belonged to low- and middle-income countries, which are those whose population suffer stronger effects from crises related to food and nutrition security. In this sense, successful governance examples in wealthier countries must be analyzed carefully when trying to replicate them in different contexts, especially given the importance of socio-cultural values and power management. In addition, the frequency with certain terms that appear in the selected studies must be carefully analyzed. As mentioned in the results section, this review considered studies published between 2013 and 2021. This does not mean that there was no related research in previous years, but rather that it was probably due to other terms and search criteria around food policy.

5. Conclusions

The results of this study allows to conclude important considerations of food governance and sustainable diets as independent, but also interrelated, concepts. From the food governance perspective, the 37 studies reviewed in this paper indicate that regardless of if we talk about vertical or horizontal governance, it is key to both ensure the sustainability of food systems performance and to avoid crises that could lead into threatening progress related to food and nutrition security. Also, due to the diversity of stakeholders involved, food governance is crucial to balancing power, decision-making and access to information across the food system, which is particularly important when diverse interests are present. We also found that, although being a key component of food systems, agriculture governance is under-developed as a field of study and more research in this area is essential to achieve food systems transformations that could led into improve the access to sustainable diets. Related to the above, agricultural governance must be developed to determine which diets changes can simultaneously benefit public health and the environment, and which policy instruments may promote their adoption by the different food systems relevant actors.

Regarding the sustainability of diets standpoint, most of the studies selected in this review understood sustainability strictly from the known “health-environment” duality. However, less attention has been paid to discuss other dimensions of sustainability, especially those related to socio-cultural aspects of diets. In this sense, “agency” appears a as a political dimension that goes on that direction and emphasizes the sustainability of food systems based on the power of people to govern them according to their own values, beliefs and needs.

However, the major contribution of this review has to do with reflecting on how food governance and sustainable diets are related, especially since food governance plays a role in supporting the socio-cultural dimension of sustainable diets. This highlights the question regarding how power is managed by different institutions immersed in food systems and the importance of focusing our attention not only in national/regional levels of governance, but also in how local levels organize their knowledge management and decision-making processes to improve the access to sustainable diets. Considering the above, we believe that future research should be focused on continue exploring the value food governance represents for sustainable diets and how the process of governing agriculture can contribute to understand that sector beyond food production for commercialization and visualize new opportunities as a relevant actor both in health and environmental sectors.

6. Author Contributions

MdV, KS and ASVM: conceptualization and methodology; MdV: investigation and writing; KS, SB: supervision, review and editing; ASVM: review and editing.

7. References

Allen, T., Prosperi, P., Cogill, B., Padilla, M., Peri, I. (2019). A Delphi approach to develop sustainable food system metrics. Social Indicators Research, 141(3), 1307-1339. https://doi.org/10.1007/s11205-018-1865-8

Balázs, B., Kelemen, E., Centofanti, T., Vasconcelos, M. W., & Iannetta, P. P. (2021). Integrated policy analysis to identify transformation paths to more sustainable legume-based food and feed value-chains in Europe. Agroecology and Sustainable Food Systems, 45(6), 931-953. https://doi.org/10.1080/21683565.2021.1884165

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I., de Haan, S., Prager, S., Khoury, C. (2019). When food systems meet sustainability–Current narratives and implications for actions. World Development, 113, 116-130. https://doi.org/10.1016/j.worlddev.2018.08.011

Berry, E. (2019). Sustainable food systems and the mediterranean diet. Nutrients, 11(9). https://doi.org/10.3390/nu11092229

Blay-Palmer, A., Santini, G., Dubbeling, M., Renting, H., Taguchi, M., & Giordano, T. (2018). Validating the city region food system approach: Enacting inclusive, transformational city region food systems. Sustainability, 10(5) https://doi.org/10.3390/su10051680

Boylan, S., Sainsbury, E., Thow, A. M., Degeling, C., Craven, L., Stellmach, D., ... & Zhang, Y. (2019). A healthy, sustainable and safe food system: examining the perceptions and role of the Australian policy actor using a Delphi survey. Public health nutrition, 22(16), 2921-2930. https://doi.org/10.1017/S136898001900185X

Boylan, S. M., Thow, A. M., Tyedmers, E. K., Malik, A., Salem, J., Alders, R., ... & Lenzen, M. (2020). Using input-output analysis to measure healthy, sustainable food systems. Frontiers in Sustainable Food Systems, 4, 93. https://doi.org/10.3389/fsufs.2020.00093

Calistri, P., Iannetti, S., L. Danzetta, M., Narcisi, V., Cito, F., Di Sabatino, D., Bruno, R., Sauro, F., Atzeni, M., Carvelli, A. and Giovannini, A. (2013). The Components of 'One World – One Health' Approach. Transbound Emerg Dis, 60: 4-13. https://doi.org/10.1111/tbed.12145.

Candel, J. (2014) Food security governance: A systematic literature review. Food Security, 6 (4); 585-601. https://doi.org/10.1007/s12571-014-0364-2

Chappell, M. J. (2018). Beginning to end hunger. University of California Press.

De Schutter, O., Jacobs, N., & Clément, C. (2020). A 'Common Food Policy'for Europe: How governance reforms can spark a shift to healthy diets and sustainable food systems. Food Policy, 96. https://doi.org/10.1016/j.foodpol.2020.101849

Del Valle M, M., Ibarra, J. T., Hörmann, P. A., Hernández, R., & Riveros F, J. L. (2019). Local Knowledge for Addressing Food Insecurity: The Use of a Goat Meat Drying Technique in a Rural Famine Context in Southern Africa. Animals, 9(10), 808. https://doi.org/10.3390/ani9100808

Delabre, I., Rodriguez, L. O., Smallwood, J. M., Scharlemann, J. P., Alcamo, J., Antonarakis, A. S., ... & Stenseth, N. C. (2021). Actions on sustainable food production and consumption for the post-2020 global biodiversity framework. Science Advances, 7(12). DOI: 10.1126/sciadv.abc8259

Détang-Dessendre, C., Guyomard, H., Réquillart, V., Soler, L. (2020). Changing agricultural systems and food diets to prevent and mitigate global health shocks. Sustainability, 12(16), 6462. https://doi.org/10.3390/su12166462

Downs, S. M., Payne, A., & Fanzo, J. (2017). The development and application of a sustainable diets framework for policy analysis: A case study of Nepal. Food Policy, 70, 40-49. https://doi.org/10.1016/j.foodpol.2017.05.005

Dupouy, E., Gurinovic, M. (2020). Sustainable food systems for healthy diets in Europe and Central Asia: Introduction to the special issue. Food Policy, 96. https://doi.org/10.1016/j.foodpol.2020.101952

Eakin, H., Rueda, X., & Mahanti, A. (2017). Transforming governance in telecoupled food systems. Ecology and Society, 22(4). https://doi.org/10.5751/es-09831-220432

FAO. (2021). The State of Food and Nutrition Security in the World 2021. http://www.fao.org/state-of-food-security-nutrition/en/ [Accessed August 17, 2021].

Farmery, A. K., Kajlich, L., Voyer, M., Bogard, J. R., & Duarte, A. (2020). Integrating fisheries, food and nutrition – Insights from people and policies in Timor-Leste. Food Policy, 91. https://doi.org/10.1016/j.foodpol.2020.101826

Galli, F., Prosperi, P., Favilli, E., D'Amico, S., Bartolini, F., & Brunori, G. (2020). How can policy processes remove barriers to sustainable food systems in Europe? Contributing to a policy framework for agri-food transitions. Food Policy, 96, 101871. https://doi.org/10.1016/j.foodpol.2020.101871

Galli, A., Pires, S. M., Iha, K., Alves, A. A., Lin, D., Mancini, M. S., & Teles, F. (2020b). Sustainable food transition in Portugal: Assessing the Footprint of dietary choices and gaps in national and local food policies. Science of the Total Environment, 749. https://doi.org/10.1016/j.scitotenv.2020.141307

Garnett, T., Appleby, M. C., Balmford, A., Bateman, I. J., Benton, T. G., Bloomer, P., Godfray, H. C. J. (2014). What is a sustainable healthy diet? A discussion paper. https://hdl.handle.net/10568/35584

Graça, P., Gregório, M.J., de Sousa, S.M. et al. A new interministerial strategy for the promotion of healthy eating in Portugal: implementation and initial results. Health Res Policy Sys 16, 102 (2018). https://doi.org/10.1186/s12961-018-0380-3

Hawkes, C. (2007). Promoting healthy diets and tackling obesity and diet-related chronic diseases: what are the agricultural policy levers?. Food and nutrition bulletin, 28; 312-322. https://doi.org/10.1177/15648265070282S210

Hawkes, C., Popkin, B.M. (2015). Can the sustainable development goals reduce the burden of nutrition-related non-communicable diseases without truly addressing major food system reforms?. 13 (1): 1-3. https://doi.org/10.1186/s12916-015-0383-7

Hunter, D., Özkan, I., Moura de Oliveira Beltrame, D., Samarasinghe, W., Wasike, V., Charrondière, U., Sokolow, J. (2016). enabled or Disabled: is the environment right for Using Biodiversity to improve Nutrition?. Frontiers in nutrition, 3, 14. https://doi.org/10.3389/fnut.2016.00014

Ingram, J. Nutrition security is more than food security. Nat Food 1, 2 (2020). https://doi.org/10.1038/s43016-019-0002-4

Johnston, J., Fanzo J., Cogill, B. (2014). Understanding sustainable diets: a descriptive analysis of the determinants and processes that influence diets and their impact on health, food security, and environmental sustainability Adv. Nutr. Int. Rev. J., 5, 418-429. https://doi.org/10.3945/an.113.005553

Kennedy, G., Hunter, D., Garrett, J, Padulosi, S. (2017). Leveraging agrobiodiversity to create sustainable food systems for healthier diets. UNSCN News. https://hdl.handle.net/10568/89400

Kennedy, E., Webb, P., Block, S., Griffin, T., Mozaffarian, D., & Kyte, R. (2021). Transforming Food Systems: The Missing Pieces Needed to Make Them Work. Current Developments in Nutrition, 5(1). https://doi.org/10.1093/cdn/nzaa177

Lang, T., & Barling, D. (2013). Nutrition and sustainability: an emerging food policy discourse. Proceedings of the Nutrition Society, 72(1), 1-12. https://doi.org/10.1017/S002966511200290X

Lang, T. I. M. (2014). Sustainable Diets: Hairshirts or a better food future?. Development, 57(2), 240-256. https://doi.org/10.1057/dev.2014.73

Lang, T., & Mason, P. (2018). Sustainable diet policy development: Implications of multi-criteria and other approaches, 2008–2017. Proceedings of the Nutrition Society, 77(3), 331-346. doi:10.1017/S0029665117004074

Lawrence, M. A., Baker, P. I., Pulker, C. E., & Pollard, C. M. (2019). Sustainable, resilient food systems for healthy diets: the transformation agenda. Public health nutrition, 22(16), 2916-2920. https://doi.org/10.1017/S1368980019003112

Lee, A. J., Cullerton, K., & Herron, L. M. (2020). Achieving food system transformation: insights from a retrospective review of nutrition policy (in) action in high-income countries. International Journal of Health Policy and Management. 10.34172/IJHPM.2020.188

Leip, A., Bodirsky, B. L., & Kugelberg, S. (2021). The role of nitrogen in achieving sustainable food systems for healthy diets. Global Food Security, 28, 100408. https://doi.org/10.1016/j.gfs.2020.100408

Lerner, H., & Berg, C. (2015). The concept of health in One Health and some practical implications for research and education: what is One Health? Infection ecology & epidemiology, 5(1) https://doi.org/10.3402/iee.v5.25300

Lundqvist, J., & Unver, O. (2018). Alternative pathways to food security and nutrition–water predicaments and human behavior. Water Policy, 20(5), 871-884. https://doi.org/10.2166/wp.2018.171

Mattioni, D., Caraher, M. (2018). Moving towards ecologically sustainable diets: Lessons from an Italian box delivery scheme. International Journal of Consumer Studies, 42(4), 430-438. https://doi.org/10.1111/ijcs.12437

Melesse, M. B., van den Berg, M., Béné, C., de Brauw, A., Brouwer, I. D. (2020). Metrics to analyze and improve diets through food Systems in low and Middle Income Countries. Food Security, 12(5), 1085-1105. https://doi.org/10.1007/s12571-020-01091-2

Parker, C., Carey, R., Haines, F., & Johnson, H. (2021). Can labelling create transformative food system change for human and planetary health? A case study of meat. International Journal of Health Policy and Management, 10(12), 923-933. 10.34172/IJHPM.2020.239

Pott, T., Claasen, N., & Lemke, S. (2016). Governance of agricultural programmes in South Africa-potentials and constraints for local food systems adopting a right to food lens. In 12th European International Farming Systems Association (IFSA) Symposium, Social and technological transformation of farming systems: Diverging and converging pathways (1-13).

Sonnino, R. (2013). Local foodscapes: place and power in the agri-food system. Acta Agriculturae Scandinavica, Section B–Soil & Plant Science, 63: 2-7. https://doi.org/10.1080/09064710.2013.800130

Swinburn BA, Kraak VI, Allender S, Atkins VJ, Baker PI, Bogard JR, Brinsden H, Calvillo A, De Schutter O, Devarajan R, Ezzati M, Friel S, Goenka S, Hammond RA, Hastings G, Hawkes C, Herrero M, Hovmand PS, Howden M, Jaacks LM, Kapetanaki AB, Kasman M, Kuhnlein HV, Kumanyika SK, Larijani B, Lobstein T, Long MW, Matsudo VKR, Mills SDH, Morgan G, Morshed A, Nece PM, Pan A, Patterson DW, Sacks G, Shekar M, Simmons GL, Smit W, Tootee A, Vandevijvere S, Waterlander WE, Wolfenden L, Dietz WH. (2019) The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report. Lancet; 393: 791-846. doi: 10.1016/S0140-6736(18)32822-8.

van Bers, C., Delaney, A., Eakin, H., Cramer, L., Purdon, M., Oberlack, C., Vasileiou, I. (2019). Advancing the research agenda on food systems governance and transformation. Current Opinion in Environmental Sustainability, 39, 94-102. https://doi.org/10.1016/j.cosust.2019.08.003

Vermeulen, S. J., Park, T., Khoury, C. K., & Béné, C. (2020). Changing diets and the transformation of the global food system. Annals of the New York Academy of Sciences, 1478(1), 3–17. https://doi.org/10.1111/nyas.14446

Voß, J., Kemp, R. (2006) Sustainability and reflexive governance: Introduction Reflexive Gov. Sustain. Dev., 3–28 10.4337/9781847200266.00009

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Murray, C. J. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet, 393, 447-492. https://doi.org/10.1016/S0140-6736(18)31788-4

Wilkins JL, Farrell TJ, Rangarajan A. (2015). Linking vegetable preferences, health and local food systems through community-supported agriculture. 13 :2392-401. doi: 10.1017/S1368980015000713.

WHO. (2020). The state of food security and nutrition in the world 2020: transforming food systems for affordable healthy diets (Vol. 2020).

WHO. (2021). Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight [Accessed September 13, 2021].

Zurek, M., Hebinck, A., Leip, A., Vervoort, J., Kuiper, M., Garrone, M., Achterbosch, T. (2018). Assessing sustainable food and nutrition security of the EU food system—an integrated approach. Sustainability, 10(11), 4271. https://doi.org/10.3390/su10114271

APPENDIX CHAPTER 2: Co-creating a common language for an agroecological transition through local food governance: lessons learned from discussion and practice in Mashue, Los Ríos, Chile

* This chapter is based on:

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1. Chapter's introduction

After navigating open-source and confidential data and exploring both mixed and purely quantitative approaches, it became time to step into the field, grab a cup of tea, and simply listen and observe. What happens when the insights from literature, academic conferences, and lectures mirror the everyday practices surrounding food security? This final section of the empirical work reflects on the sub-research question *"how can participatory data governance foster the co-creation of agroecological knowledge in southern Chile?*" It builds on the emerging debate about "inclusive governance and data as a public good", as presented in the literature review, to explore the integration of diverse knowledge sources and collaborative strategies aimed at addressing socio-ecological challenges in food systems governance.

This appendix chapter serves as a supplementary material to inform Chapter 5 and it employs qualitative and participatory methods to advance the co-creation of agroecological knowledge essential for initiating an agroecological transition within the Mashue sector of the Región de Los Ríos, Chile. Over a three-month period, focus groups, hands-on

workshops, and interviews brought together farmers, consultants, and researchers to define the fundamentals of agroecology in a manner that aligns with the unique needs of the territory. They also addressed challenges related to food and nutrition security and strategies to better preserve water from natural springs.

This experience is presented as a case study in which knowledge and community data are treated as public goods, allowing communities to exercise greater agency in their food security decisions.

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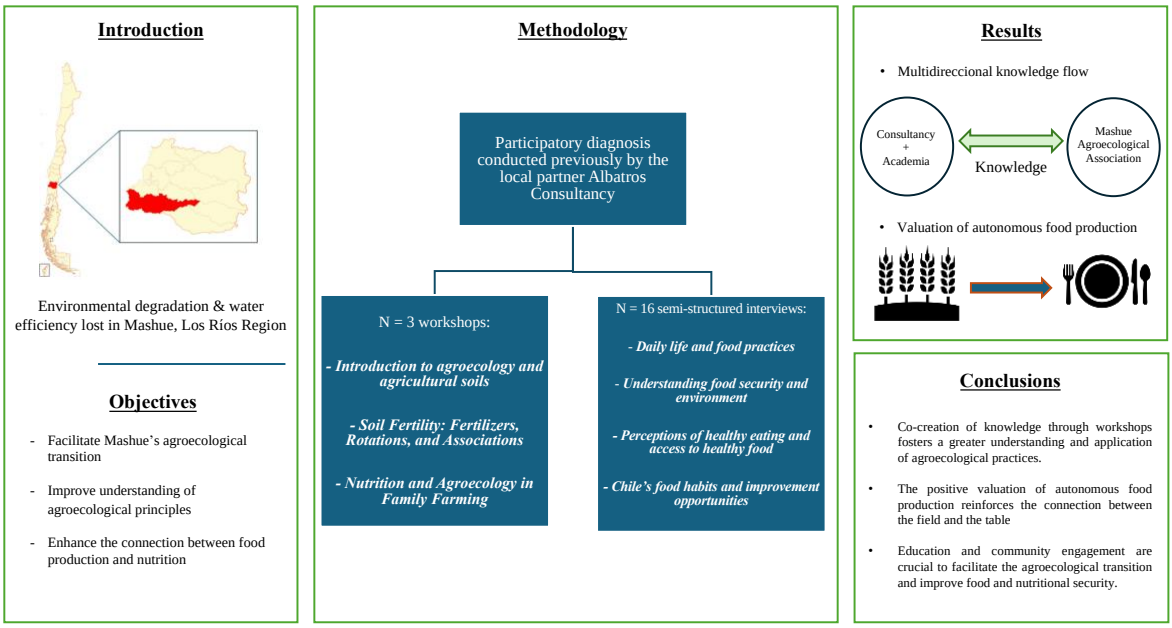
Abstract

In Mashue, Los Ríos Region, Chile, agroecology emerges as a response to environmental degradation and loss of water efficiency, underscoring the need for an agroecological transition to recover the vitality of agricultural soils and promote sustainable intensification. However, the gap in familiarity and understanding of agroecological principles hinders this transition and effective public funding allocation. This study addresses the lack of a common language around agroecology by co-creating and implementing educational workshops in collaboration with the Mashue Agroecological Association, Albatros consultancy, and the University of Edinburgh. Through a qualitative methodological approach, including n=3 participatory workshops and n=16 semi-structured interviews, it examined how agroecological principles can inform local governance practices and the transition towards sustainable food systems. Results indicate that co-creation of knowledge through workshops fostered greater understanding and application of agroecological practices, while interviews revealed a positive valuation of autonomous food production and a direct connection between the field and the table. Results confirm that community engagement is crucial in facilitating agroecological transitions and improving food and nutritional security. However, future research should address the long-term impact of these interventions on local agricultural and economic practices, as well as the need of expanding its geographical scope to broader Chilean reality.

Key words: Agroecology, Chile, Climate action, Food Security, Local Governance, Responsible consumption and production, Sustainable cities and communities, Zero Hunger.

Graphic abstract



2. Background

2.1.Introduction to Agroecology: definition, evolution, and core principles

Agroecology has evolved from its initial conception focused on applying ecological principles to enhance agroecosystem's sustainability into a comprehensive framework that integrates ecological, social, and economic sustainability in food systems (Gliessman, 2018). This transformation began in the early 20th century, responding to industrial agriculture's drawbacks and has evolved to bridge gaps between traditional and scientific knowledge systems (Utter et al., 2021). Chappell and LaValle (2009), Wezel et al. (2009), and Gliessman (2018) expand this definition to include agroecology's role as a scientific discipline, a practical approach and a socio-political movement, rooted in traditional practices and aimed

at sustainable food systems. Dalgaard et al. (2003) and Bezner Kerr et al. (2021) further highlight its holistic nature, considering ecological, health, social, and economic dimensions at various scales and its evolution into a recognized approach for food system transformation by international bodies.

This evolution in definition is matched by the evolution of agroecological principles, both biophysical and socio-relational, to guide sustainable agricultural practices. Agroecology is proposed as a transformative approach to tackle climatic, food, and ecosystemic crises, applying ecological and humanistic principles to support long-term productivity and resilience of food systems (Bezner Kerr et al., 2023). Practices include landscape and farm diversification, intercropping, crop and pasture rotation, adding organic amendments, cover crops, and minimizing or avoiding synthetic inputs. Amoak et al. (2022) outline these principles, emphasizing biomass recycling, functional biodiversity, species diversification for ecological health, and addressing power imbalances to promote farmer independence and diverse knowledge systems. Chappell and LaValle (2009) highlight the importance of diversity, resilience, and the co-creation of knowledge, underlining the significance of incorporating local and traditional wisdom. In addition, Bezner Kerr et al. (2021) point out the context-dependency of agroecological principles, which include optimizing ecological processes, ensuring environmental and public health, and encouraging economic diversification. Wezel et al. (2009) further detail the principles of agroecology to include sustainability, biodiversity, and socio-economic equity, leading to practices like crop rotation and agroforestry that mimic natural ecosystems. For a better understanding, Table 1 summarizes these principles according to different categories, including biophysical, socio-relational and context-dependecy.

Table 1. Agroecological categories and principles according to different authors.

Category	Agroecological principle	Reference
Biophysical	Recycling of biomass	Amoak et al. (2022)
	Functional biodiversity	Amoak et al. (2022)
	Species diversification	Amoak et al. (2022)
	Optimization of ecological processes	Bezner Kerr et al. (2021)

	Sustainability	Wezel et al. (2009)
	Biodiversity	Wezel et al. (2009)
Socio-relational	Addressing power imbalances	Amoak et al. (2022)
	Diversity	Chappell and LaValle (2009)
	Resilience	Chappell and LaValle (2009)
	Co-creation of knowledge	Chappell and LaValle (2009)
	Socio-economic equity	Wezel et al. (2009)
Context-dependency	Environmental and public health	Bezner Kerr et al. (2021)
	Economic diversification	Bezner Kerr et al. (2021)

2.2.Agroecological Transition in Agricultural Communities: examples, challenges and benefits

Agroecological transitions (AETs) include different examples and approaches that range from conventional and industrial practices towards more holistic sustainable systems. For example, Ollivier et al. (2015) refers to AET as a paradigm shift that redefines technology, practices, and farmer identities, advocating for the incorporation of ecological processes into both food production and distribution. Similarly, Teixeira et al. (2018) describe AETs as a participatory process that emphasizes crop diversity, ecological practices, and the reduction of external inputs, aiming to enhance local socio-economic conditions. Meek (2015) takes a complementary approach, viewing AETs as influenced by cultural politics, where social actors with differing cultural meanings and practices engage in conflicts. Duru et al. (2015) focus on the integration of ecological principles to enhance biodiversity and ecosystem services, aiming for a reduction in chemical inputs. Lastly, Vizuete et al. (2024) identify AETs as a multifaceted process driven by neo-rural movements, highlighting the importance of social engagement and the pursuit of greater autonomy and sustainability.

The success of AETs can be observed in various case studies across different regions, showcasing the adaptability of agroecological principles in diverse contexts. Ollivier et al. (2015) cite examples such as the Gascony hillside forest management and the Pays de Caux soil run-off study, demonstrating successful applications of AETs in varied environmental settings. In Brazil, Teixeira et al. (2018) describe how farmers' organizations, in collaboration with stakeholders, have driven transitions leading to a resilient agricultural system in Zona

da Mata. Moreover, Meek (2015) analyzes the Movement of Landless Rural Workers' settlements in Brazil, where a shift towards agroecological practices has been influenced by historical land use patterns. Beyond these, studies like those by Lojka et al. (2021) examine the resurgence of traditional agroforestry practices in the Czech Republic, highlighting the sustainability potential in modern agriculture. Also, Losardo (2016) discusses the Italian Ecovillage Network, illustrating how Italian communities are applying agroecological principles to foster resilient and eco-friendly living environments. Finally, Mailfert (2007) work on new farmers in France emphasizes the role of social networks in agroecological initiative successes, while Márquez-Barrenechea et al. (2020) provide insights into the policy perceptions and challenges of agroecology in the Madrid region in Spain.

AETs bring both challenges and benefits, impacting communities diversely yet universally striving towards sustainability and resilience. A common challenge identified by Ollivier et al. (2015) and Duru et al. (2015) is the resistance to change, necessitating the balancing of ecological, socioeconomic, and technological dimensions, alongside the integration of diverse forms of knowledge and managing complexities at various scales. This is echoed by Teixeira et al. (2018), who add the adaptation to diverse social and bio-physical conditions and the integration of varied agricultural practices as hurdles. Meek (2015) points out the difficulties in overcoming entrenched agricultural practices and the cultural politics surrounding knowledge transfer. Vizuete et al. (2024) highlight the challenges of adapting to new practices and overcoming institutional barriers. On the other hand, the benefits can be multifaceted. Ollivier et al. (2015) and Teixeira et al. (2018) observe benefits such as the sustainability of agricultural systems, resilience of rural communities, fostering of new social relationships, and the creation of sustainable, equitable food systems. Meek (2015) emphasizes the potential for increased sustainability and political participation, while Duru et al. (2015) note the ecological benefits of increased biodiversity, improved soil health, and enhanced resilience against climate change. Vizuete et al. (2024) conclude with the revitalization of rural areas, promotion of sustainable practices, and fostering of social innovation.

2.3.Local Governance and Food Security

Through the implementation of tailored policies, regulations, and initiatives, local governance plays a critical role in ensuring food security in rural communities and in advancing sustainable agricultural practices. Food security is defined by the FAO (1996) as a state in which all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life. This concept is central to understanding the role of local governance in fostering equitable and sustainable food systems. Candel (2014) notes the importance of coherent multi-level governance structures that incorporate democratic values and resource allocation to support sustainable agriculture. Related to this, De Araújo Palmeira et al. (2020), highlighting the benefits of decentralization, community-level funding, and policymaking, illustrate how Brazilian rural areas benefit from governmental initiatives that enhance local capacities and community engagement. In this context, the concept of food environment becomes critical as it encompasses the physical, economic, political and sociocultural context in which each consumer engages with the food system (Schönfeldt and Pretorius, 2018). Slade and Carter (2017) recognize the challenges of embedding food security principles within local strategies under constrained resources, focusing on strategic equity-oriented policy development Sidibé et al. (2018) discuss the varied outcomes of applying national laws at the local level, affecting both service access and social cohesion. Lastly, Jirén et al. (2020) identify local governance's pivotal role in addressing social sustainability and equitable access to food-related services.

Local governance also faces some significant challenges in fostering sustainable food security and agricultural practices. For example, the need to establish effective bridges between different levels of government and sectors, as highlighted by Candel (2014), as well as the complexity of coordinating objectives among governance systems, particularly in ensuring healthy eating patterns, which depend not only on food availability but also on accessibility, affordability, and education surrounding nutritious diets. Additionally, decentralization and community-level funding, as suggested by these authors, may encounter obstacles when attempting to align policies and resources. Slade and Carter (2017) emphasize

the importance of developing equity-oriented strategic policies, which may require additional effort in local contexts. On the other hand, crafting local conventions for resource management, as discussed by Sidibé et al. (2018), may conflict with established national policies. Finally, Jirén et al. (2020) highlight the need to promote initiatives that harness local farmer knowledge and integrate innovative productive systems but also point out a gap in market pathway improvements, highlighting a key area for addressing in local governance.

2.4.Theoretical Frameworks and Conceptual Model for understanding the relationship between agroecology and food security in rural contexts?

The conceptualization of the interplay between agroecology and food security in rural contexts varies across studies, illustrating a rich diversity of approaches and views. Pant (2016) frames this interplay as a complex dynamic of cooperative and competitive interactions within agricultural systems, leading to either incremental or transformational adaptations. This perspective underscores the nuanced balance between sustaining traditional practices and adapting to emerging challenges. In contrast, Rosset and Martínez-Torres (2012) view the interplay through the lens of re-peasantization, emphasizing the re-invention of peasant practices and territories in response to external pressures such as corporate landownership and market challenges. This approach situates agroecology within socio-political struggles for autonomy and sustainability. Putnam et al. (2014) highlight the role of participatory action research and agroecology, focusing on community involvement and traditional knowledge as central to enhancing food sovereignty and security, thus prioritizing local agency and cultural identity. Bailey and Buck (2016) approach the interplay by advocating for diversity and learning within adaptive management systems, suggesting that resilience and adaptive capacities are key to navigating the challenges posed by climate change. Finally, Amekawa (2011), through a sustainable livelihood approach within agroecology, emphasizes the importance of integrated rural development approaches that account for smallholder farming practices, vulnerability, and multifunctionality, advocating for a holistic view of agroecology's role in securing food and water resources.

2.5.Research objectives and rationale

The literature presented so far allows us to understand the relationship between agroecology, agroecological transitions, and local governance to strengthen food security and sustainable practices in rural communities. However, the reviewed literature mainly focuses on productive practices and to a lesser extent on the food dimension. Considering this, the following study aims to answer: *"How can the implementation of agroecological principles through collaborative governance and educational workshops in the Mashue community influence the transition towards sustainable and health-oriented agricultural practices, particularly considering the role of food and nutrition?"*.

In order to deepen the analysis, the following objectives have been proposed:

1. To co-develop and implement a series of workshops between the Mashue Agroecological Association (MAA), Albatros consultancy, and the University of Edinburgh, and evaluate their effectiveness in sharing essential knowledge and skills for agroecological practices.

2. To identify and analyze the role that food and nutrition plays within the Mashue community during their AETs.

The co-creation and implementation of workshops with the Mashue Agroecological Association represents a commitment to local governance through education and community engagement. The first objective underscores the importance of collaboration and local knowledge in developing food production systems that are resilient and tailored to the specific needs and conditions of the community. Prior to the agroecological transition workshops, agricultural practices in Mashue predominantly relied on conventional methods that lacked sustainable soil management and that were part of a conventional technical assistance provided by the Chilean state. This included limited crop rotation, over-reliance on chemical fertilizers and biocides, and inadequate water conservation techniques. These practices contributed to soil degradation and declining productivity, underscoring the urgency

for a transition towards more sustainable approaches focused on soil health and ecological balance. The urgency of transitioning to agroecological practices stemmed not only from the need to reverse these environmental impacts but also to build resilient food systems aligned with the socio-economic realities of the community. Given Mashue's dependence on agriculture as a primary economic activity and its vulnerability to climatic and market pressures, fostering sustainable practices became a key priority for improving soil health, ensuring long-term productivity, and enhancing community well-being.

The second objective, which focuses on the analysis of the role that food and nutrition play within the Mashue community, addresses local governance from the perspective of consumption. It is not enough to promote sustainable agricultural practices; it is crucial to understand how these practices influence the community's nutrition and health. This objective considers how decisions about agroecology affect food quality, accessibility, and dietary preferences of the population, and how, in turn, these nutritional factors can influence the long-term acceptance and success of agroecological practices.

By researching how agroecology can serve as an example of local governance while also understanding the impact of the agroecological transition on food and nutrition, the research offers an integral view of how local food systems can be transformed in ways that benefit both the environment and human health. However, while this research aims to explore the implementation of agroecological principles within the Mashue community, it is important to recognize its limitations. The effectiveness of the workshops and the accurate assessment of food and nutrition's role may be influenced by factors such as participant engagement, local economic conditions, and seasonal variations that are not fully controlled within the study. Additionally, the findings may not be universally applicable to other communities due to unique cultural, ecological, and economic contexts that differ from those of the Mashue community. Therefore, results should be interpreted with caution and considered as a case-specific study rather than a universal solution.

3. Methods

The current research received ethical approval from the Human Ethical Review Committee (HERC) of the Royal (Dick) School of Veterinary Studies at the University of Edinburgh, with approval number HERC_2022_148 on November 30, 2022. The approval letter is available in Supplementary Material, N7, and it was granted on the condition that the research is conducted according to the description provided in the application and the assurances made.

This study took place in Mashue, located in the commune of La Unión in the Los Ríos Region of Chile, an area encompassing 2,137.0 km^2 (Figure 1). As per the 2017 census, La Unión accounted for 9.8% of the region's inhabitants (Censos de Población y Vivienda, Proyecciones de Población, INE). The locality deals with notable socioeconomic challenges, including above-average rates of income (13.35%) and multidimensional poverty (24.47%), a significant percentage of the population without basic amenities (30.2%), and considerable household overcrowding (12.3%) (CASEN 2017, MDS). In terms of the relevant economic activities, the period from 2016 to 2018 saw an 84.63% surge in employment within agricultural and fisheries sectors, underscoring their vital role in the local economy (Biblioteca Nacional del Congreso, 2024).

Figure 1. Commune of "La Unión", Los Ríos Region, Chile.

Source: Adapted from Wikipedia images.

To address the objective of co-developing and assessing the impact of agroecological workshops, we engaged in a collaborative process with the MAA, Albatros consultancy, and the Global Academy of Agriculture and Food Systems at the University of Edinburgh. The most pertinent topics for the workshops were established through discussions with MAA and included (1) An Introduction to Agroecology and Agricultural Soils, (2) Soil Fertility: Fertilizers, Rotations, and Associations, and (3) Nutrition and Agroecology in Family Farming. Each workshop began with an open discussion guided by specific questions related to the theme. Participants were then divided into groups to delve into more detailed questions that were consistent across all groups. These group activities were followed by a focus group session where discussions, perceptions, and ideas were pooled together to explore their application within MAA and the participants' homes. To reinforce the theoretical discussions, practical activities demonstrating examples and techniques related to the conversational topics were conducted after the focus groups, providing a hands-on approach to the application of agroecological practices. Throughout these sessions, a participatory observation method as "participant as observer" was employed to meticulously document the function and dynamics of the activities, forming the basis for evaluating their efficacy in imparting essential knowledge and skills.

The effectiveness of the workshops was evaluated through qualitative perceptions derived from participatory observations. These observations documented the engagement, understanding, and interactions of participants during the theoretical discussions and hands-on activities, offering insights into the learning process and knowledge exchange.

To address the objective of identifying and analyzing the current perceptions and practices related to food security, healthy eating, and agroecology among the MAA, 16 semi-structured interviews employing a set of 9 open-ended questions (found in Supplementary Material, N8) were implemented. Participant engagement was initiated with informed consent (available in Supplementary Material, N9), facilitated by the voluntary recruitment conducted by Albatros consultancy. All interviews took place in the farmers' households, except for two, which took place at their workplace. Interviews were recorded with a

recording device. Conducted in Spanish between December 2022 and February 2023, the interviews captured the nuanced views of the community members. Upon returning to Edinburgh, the data was transcribed and rigorously analyzed using Atlas.Ti software, enabling the extraction of thematic patterns.

4. Results

4.1. Workshops

Three workshops were implemented from December 15th, 2022, to February 9th, 2023, addressing various aspects of agroecology in family farming. The agenda, titles, and objectives of these workshops are detailed in Table 2.

Table 2. Workshops agenda

Workshop	Title	Objective	Date
1	An Introduction to Agroecology and Agricultural Soils	To familiarize farmers with the basic principles of agroecology and sustainable agricultural soil management.	December 15th, 2022
2	Soil Fertility: Fertilizers, Rotations, and Associations	To discuss with farmers how to improve soil fertility through the appropriate use of fertilizers, crop rotations, and plant associations.	January 12th, 2023
3	Nutrition and Agroecology in Family Farming	To promote agroecological practices in family	February 9th, 2023

		farming that improve nutrition and food security at the household level.	

4.1.1 Workshop 1: An Introduction to Agroecology and Agricultural Soils

On December 15th, 2022, we met at the Mashue Rural Drinkable Water Centre for the workshop titled "An Introduction to Agroecology and Agricultural Soils". The day started with an unplanned, but very welcome and welcoming shared breakfast which fostered community spirit as participants contributed homemade bread, eggs, and warm beverages. This set the stage for casual yet insightful discussions about health, agriculture, and market experiences. This spontaneous exchange continued until the final attendee arrived. Juan Pablo from Albatros consultancy inaugurated the session, highlighting the significance of active participation in this educational cycle. Following this, the first author of this article introduced himself, outlining his role and prompting a dialogue on nutrition and food origins, an issue accentuated by the presence of children due to school vacations, which, while causing interruptions, also brought to light the challenges of integrating family and farming life.

The workshop examined how agroecological principles were understood, sparking a participatory conversation on the living soil filled with microorganisms. The correlation between the health of the soil and the community's health became a focal point, as participants related their agricultural knowledge to broader environmental challenges, drawing parallels between the Covid-19 pandemic and the 'pandemic in the land' posed by pests. Participants drew from their own experiences to engage with unfamiliar concepts, such as that of organic matter, and this experiential response saw confidence and excitement as they related concepts to the health of their soils.

Breaking into groups, participants pondered over the role of soil in agricultural-livestock production and the unique conditions of soil in their farms. They discussed environmental changes, economic pressures, and the long-term consequences of certain agricultural

practices. These reflections were enriched by a subsequent focus group discussion (Figure 2), weaving together the threads of past, present, and future agricultural practices, community solidarity, and the symbiotic relationship between soil and water.

Figure 2. Introduction to the workshop series and group discussion on soil health and agroecological principles. Mashue, December 15th, 2022.

Lunch, a communal affair, became an extended time for shared food and conversation, reinforcing the social fabric of the group. In this sense, it was noted that together, cooking, eating and dishwashing had a strong community binding value, as it was an opportunity for new neighbors to meet and engage with other farmers. We had thought that lunch would take us 45-60 min, but it actually took around 2 hrs, which was essential for these new social relationships to settle. The practical session that followed aimed to illustrate soil conservation techniques through hands-on activities (Figure 3), such as comparing soil erosion in different land management scenarios and demonstrating water infiltration in bare versus covered soil. Participants engaged with ancestral knowledge by exploring contour lines and infiltration trenches, learning to use the tools provided and contributing their own expertise to the collective learning process. Throughout, we documented in video recording the dynamics and the efficacy of these soil protection methods in fostering agroecological understanding. This reinforced the bidirectional flow of knowledge between consultants, researchers and community participants. After lunch hands-on activities were developed more fluently as the participants all had had the opportunity to meet and interact to each other. This points to the power collaborative work can have in strengthening relationships within the same community.

Figure 3. Workshop 1 practical activities: lines and infiltration trenches; water infiltrarion in bare versus covered soil; and soil erosion comparison. Mashue, December 15th, 2022.

4.2.2. Workshop 2: Soil Fertility: Fertilizers, Rotations, and Associations

On January 12th, 2023, we reconvened for the second workshop, this time focusing on "Fertility, Crop Associations, and Crop Rotations". Embracing the “communal ethos” that marked our first meeting, we started with a breakfast during which we summarized our prior session, specifically reflecting on the novel concept of infiltration trenches and the recognition of soil as a precious, finite resource. The day's conversations commenced with a simple yet profound inquiry into the meaning of general soils’ fertility. The discourse naturally weaved through personal anecdotes, cultural wisdom on composting, and skepticism regarding chemical fertilizers, highlighting a common belief in the supremacy of 'homemade' over 'store-bought': “*we (mistakenly) believe that the more chemicals we apply, the better the results will be*”.

As we reinforced the essential knowledge of macronutrients—nitrogen (N), phosphorus (P), and potassium (K)—, we revisited their presence in plant and animal byproducts (Figure 4). The discussions were enriched by practical wisdom and collective experiences, emphasizing the long-term benefits of nurturing the soil over immediate plant yield.

Figure 4. Introduction to the workshop and conversation on the presence of different macronutrients in the plants. Mashue, January 12th, 2023.

Our first hands-on activity of this day centered on planning crop rotations, identifying nutrient-depleting crops versus those that enrich the soil, and recognizing the vital role of fallow periods with pasture or forage crops. This exercise sparked an exchange of knowledge among the farmers, including information related to what crops take nutrients in the soil, what crops leave nutrients in the soil, and what crops let the soil rest. The construction of a vermicompost bed served as our second hands-on activity, where participants read from a guide, delegated roles, and deliberated on the nuances of pre-decomposition and environmental conditions for optimal composting. The gender dynamics observed during this task provided a moment of light-heartedness and camaraderie.

In the third activity, building a fertilizer and compost bin, we discussed the importance of soil and microorganisms in the composting process. All three activities are shown in figure 5. The collaboration blurred traditional gender roles, with mixed-gender teams sharing various tasks, and some men participating in meal preparation. The compost bin's assembly involved a strategic layering logic, reinforcing the concept of nutrient recycling. This relates directly to the research question by showing how such collaborative and hands-on workshops can influence the adoption of agroecological principles. It aligns with the objectives by demonstrating the workshop's role in imparting skills (Objective 1) and involving the community in sustainable food practices (Objective 2).

Figure 5. Crop rotations activity; vermicompost bed construction; and fertilizer and compost bin construction. Mashue, January 12th, 2024.

The workshop transitioned into an informal space over lunch, where participants contemplated the sustainability of the practices introduced. The conversation revealed a shift in perception regarding market sales, which historically signified poverty but now represents a universal activity. As the day concluded, a relaxed atmosphere enveloped the group, encouraging the sharing of diverse experiences.

4.2.3. Workshop 3: Nutrition and Agroecology in Family Farming

On February 16th, 2023, we gathered for the third of our agroecological workshop series, this time with a lens on "Nutrition and Agroecology in Family Farming." Welcoming 16 participants, the session started with the familiar ritual of a communal breakfast. The dialogue began with reflections on soil health and interpersonal relationships, weaving the insights from our previous discussions into a narrative that framed food production as integral to soil restoration.

The discussion then turned to the quality of food contrasting the ephemerality of fast food with the value and lasting strength derived from wholesome, homegrown fare. The conversation saw a series of feelings on the changing food environment, with participants lamenting the societal rush, the misplaced valorization of wealth over wellbeing, and the ease of purchasing all types of food which has led to a disconnection from the very processes that

sustain life. Discussions emerged about the intrinsic value of land and water, the erosion of agrarian pride under urban scrutiny, and the challenges brought by globalization. The recognition that farmers are catalysts for change was very important, yet it was shadowed by an introspective question about the relevance and application of local knowledge in a rapidly evolving world that had been challenged by the COVID-19 pandemic. In our collaborative group work, informed by the guiding questions on flip charts, we explored the impacts of Covid-19 on dietary habits and agricultural production (Figure 6). The narrative that unfolded told of initial anxieties giving way to a resilient return to traditional food preservation methods, a testament to the enduring wisdom inherent in rural practices.

Figure 6. Collaborative group work exploring the impacts of Covid-19 on dietary habits and agricultural production. Mashue, February 9th, 2023.

Our shared cooking experience was a microcosm of the workshop's essence, with participants contributing ingredients and collectively preparing the traditional Chilean dish "porotos granados". The kitchen became a space of inclusion and learning, with gender roles subtly challenged as all, regardless of age, took part in the preparation, embodying the communal spirit we were looking for. The decision for our communal lunch was a deliberate one, meticulously planned to showcase seasonal produce and communal contribution. The logistics, communicated via a WhatsApp group, ensured everyone had a role, reinforcing the sense of unity and purpose. As we had lunch together, joined by the Commune Mayor and his team, the table became more than a place to eat; it was a forum for sharing, reflecting,

and envisioning (Figure 7). Conversations flowed about the past months, the evolution of our work, and the critical role of farmers in shaping the future. The meal we shared was as much about feeding our bodies as it was about nourishing the community. It prompted us to ponder the transformative power of such gatherings. We questioned whether the alchemy that changed ingredients into a meal could similarly catalyze a metamorphosis in us, turning inertia into action, and transforming individual efforts into collective triumphs. The above relates with this study's second objective by showing how the community's engagement in cooking and sharing a meal during the workshops helps to foster a deeper understanding and appreciation of sustainable, health-oriented agricultural practices.

Figure 7. Community cooking and lunch as workshop series final activities. Mashue, Februrary 9th, 2023.

As mentioned in the methods, the participants' learning was assessed based on their active engagement in the collaborative construction of agroecological tools and techniques during the practical sessions. These activities were directly informed by the theoretical discussions held in the mornings, showcasing how participants internalized and applied the concepts of soil conservation, crop rotation, and nutrient management. Furthermore, two months after the workshops, the community demonstrated their newly acquired knowledge by independently applying for and securing public funding for one year to continue their agroecological transition process to support their community initiatives, ensuring continuity of the practices discussed during the workshops.

Related to the knowledge exchange, the participants' contributions were fundamental in bridging the gap between theoretical knowledge and practical implementation during the workshops. For example, in Workshop 1, the creation of infiltration trenches required the use of oxen and a plow—a practice that none of the facilitation team members were familiar with but was common knowledge among the participants. In Workshop 2, the placement of the vermiculture unit and composting structures was guided by participants' expertise regarding the terrain, ensuring optimal sunlight exposure to accelerate decomposition and sufficient shade to protect the photosensitive worms. Similarly, in Workshop 3, the participants' understanding of seasonal agricultural production and ingredient availability shaped the preparation of meals that reflected both their culinary traditions and the integration of agroecological principles.

4.2. Interviews

The interviews aimed to surface current perceptions and practices related to food security, healthy eating, and agroecology among the Mashue community. After transcribing and analyzing the recordings, four areas related to the research question and objectives were identified: (1) "Daily life and food practices" which explored how agroecological principles alter daily routines and diets, directly reflecting the objective of implementing educational workshops that promote sustainable and health-oriented agricultural practices. (2) "Understanding food security and environment" which enabled a better understanding of the impact of these practices on food security and environmental management, which are key to sustainable development. (3) "Perceptions of healthy eating and access to healthy food" which analyzed changes in perception and access to nutritious food, indicating the potential of agroecological interventions in terms of nutrition. Finally, (4) "Chile's food habits and improvement opportunities" which provided insights into how local habits compared with national trends to identify areas for improvement, helping to adapt and expand agroecological principles in line with sustainability and health objectives.

4.2.1. Daily life and food practices

> *"Preparing food at home is fundamental, it allows us to control our diet and ensure it is healthy"* (Woman, 45).

The daily activities of farmers reflect an organized life around the management of their crops and animals. From sunrise to sunset, their days are filled with tasks ranging from animal care to crop supervision. "I get up at 5 in the morning to start working in the field" (Man, 60), exemplifies the early start of their days. Another farmer said, "after breakfast, I go straight to the field until noon" (Man, 58), highlighting the dedication to agricultural work. Evenings are often dedicated to additional farming tasks, as another respondent indicates, "In the afternoon, I check the agricultural machines and tools" (Man, 46).

Agricultural and livestock practices are described with a focus on sustainability and environmental care. Farmers talked about specific techniques and daily routines that help maintain the health of their crops and animals. "I use crop rotation to improve soil fertility" (Woman, 54), shows the application of sustainable agricultural practices. Another highlighted, "my animals are fed with natural forage" (Man, 64), indicating a commitment to responsible livestock practices. The importance of water management was also referenced, "I take great care in using water, implementing efficient irrigation systems" (Woman, 43).

Meal preparation is framed in a context of self-sufficiency, where fresh fruits and vegetables produce is the basis of the daily diet. Farmers share how the harvest directly influences their meals, "I prepare my food with what I pick from the garden" (Man, 70), evidencing the connection between the field and the table. Food preservation is also a common practice, "I make jams and preserves to take advantage of seasonal fruits" (Woman, 60), reflecting an interest in maximizing available resources. Another adds, "Preparing food at home is fundamental, it allows us to control our diet and ensure it is healthy" (Woman, 45).

4.2.2. Understanding food security and environment

> *"For me, (food security) is super relevant. We as a family have tried to make the production almost a complete circle" (Man, 46)*

The understanding of food security among the interviewees varied, the majority had prior knowledge (n= 13; 81.2%) while a few were hearing it for the first time (n=3; 18.8%). One respondent spoke of how food security was associated with being careful in food preparation, such as ensuring that vegetables grow properly without contamination, "being careful with what is going to be served. For example, with vegetables…" (Woman, 57). Another who hadn't heard the term before, interpreted it as ensuring one's own food supply and life, "for example, in the greenhouse, I have to know how the production is going so I don't run out of anything" (Man, 60). These responses indicate a mix of familiarity and new learning about the concept, reflecting both a practical understanding and the introduction to a more formal or technical notion of food security. Some perceived food security in terms of healthy and natural feeding, contrasting with current practices they considered less healthy, "of course, the food used to be the healthiest (thing) someone had because it was all natural" (Woman, 54).

The community primarily interpreted food security as the quality and naturalness of food. One participant emphasized the importance of nearly closed-loop food production within the family, highlighting the move towards more sustainable and natural practices, "for me, it is super relevant. We as a family have tried to make the production almost a complete circle" (Man, 46). Another farmer pointed out the need to maintain strict hygiene and cleanliness in food production and preparation, highlighting the importance of avoiding chemicals and artificial products to achieve safe food, "(it means) that we keep everything clean and work carefully with things, with hygiene and cleanliness" (Woman, 60), "I would relate it to the (absence of) chemicals that food brings these days" (Man, 36). These perspectives underscore a strong preference for traditional and natural food production methods, along with a growing awareness of the risks of chemicals and processed foods for health and overall well-being.

On the other side, the understanding of the concept of "food environment" significantly varied among the respondents. Again, some expressed familiarity or attempts to relate it to their daily experience, while others admitted to not having heard the term before or not being clear about its meaning. For instance, one respondent associated the food environment with practices of raising and feeding animals, highlighting the importance of avoiding contamination to ensure food safety "it has to do with animal husbandry practices" (Woman, 57). Another interpreted it as the impact of climate on agriculture, noting changes in crop ripening times due to climate variations "it is related to the impact of climate in agriculture" (Woman, 54). However, some respondents explicitly acknowledged their lack of knowledge about the term, indicating they had not heard it before or do not know exactly what it implies "never heard it before..." (Man, 64). These divergences highlight a mix of intuitive understandings based on personal experience and a notable lack of familiarity with the concept itself.

4.2.3. Perceptions of healthy eating and access to healthy food

> *"...the most beautiful (thing) is you feel happy when you're serving a cucumber salad that's produced right there from your land" (Woman, 60).*

Many farmers associated healthy eating with the consumption of " vegetables and cereals. Not so many fried foods and that sort of stuff" (Woman, 57), and they emphasize a diet low in fats, sugars, and processed foods. Some linked healthy eating to "what you grow is a healthy thing" (Man, 60), and the practices of traditional agriculture, suggesting that food from one's land, "without chemicals, strong and nutritious" (Man, 60), is healthier. The concept of 'natural' and free from industrial processing was highlighted by others: "To eat as natural as possible" (Man, 36), and "to eat healthy is (to eat) what we produce here" (Woman, 48), indicating a desire for food as close to its original state as possible. Additionally, there was an understanding of healthy eating as part of sustainable and environmentally friendly agriculture "to become sustainable farmers" (Man, 46). However, there were also some unique perspectives, such as disregarding dietary restrictions once health had improved, and emphasizing moderation, some commenting that "all food abuses are malicious" (Man, 33).

Farmers shared a variety of perspectives on what they considered a "healthy dish". The responses reveal a mix of intuitive knowledge, cultural practices, and a leaning towards organic and locally produced food as pillars of healthy eating. They agreed on the importance of naturalness and the local origin of food. For instance, one interviewee spoke of how a healthy dish could be "a porridge made of legumes with things that one produces in the field" and described how meat should be "natural produced by oneself and not artificial" (Woman, 54). Self-production was a recurring theme; another farmer expressed that a healthy dish is one that includes "products from here, "like fresh lettuce from the garden and eggs from one's chickens", showing a disconnection from processed foods and a preference for those "you take directly from there and eat" (Man, 64). Additionally, another highlighted how they preferred traditional preparation, like a "tasty field casserole cooked on a wood stove", valuing traditional cooking methods over modern ones (Woman, 60).

To access a healthy diet, farmers recognized that alongside self-production of fresh foods they needed to supplement these with market purchases, for example for certain products like "rice noodles oil", (Woman, 43). However, it was what was personally harvested that was seen as having value, with one farmer expressing this "the most beautiful (thing) is you feel happy when you're serving a cucumber salad that's produced right there from your land" (Woman, 60). Concerns about the quality of food were evident, with one remarking on doubts about organic certification, "unfortunately today there is nothing that assures us that what is done outside of our radius certifies 100% that it is organic" (Man, 46). They also reflect changes in agricultural practices. One farmer regreted the inability to reuse seeds due to transgenics: "before you used to sow and save your seeds, but today you can't do that" (Woman, 54). While some were less dependent on the market, we have "potatoes and what we buy, and the meat also comes from here" (Woman, 43), others acknowledged that they needed to engage with the commercial food system "we are trapped in the system" (Man, 64), indicating a resigned acceptance of the current reality.

4.2.4. Chile's food habits and improvement opportunities

"(we need to) go back and recover the historical memories of how (food) it was produced 100 years ago" (Man, 46).

The dietary habits in Chile, as perceived by the interviewed farmers, highlight a concern for the dominance of "junk food" and a preference for quick, non-nutritive eating, "Terrible. Terrible" said one woman farmer (Woman, 57), another spoke of "lots of junk food" (Man, 58). They noted how the speed of modern life led people to choose less healthy options, as "most people work, and they go for the fastest thing" (Woman, 54). This trend is exacerbated by economic factors, as "someone who does not earn a big salary, it is difficult" (Man, 70), emphasizing the important message that healthy eating is not always affordable for everyone. Some point out differences in eating practices between the countryside and the city, with some in rural areas "eating up to four times a day" (Man, 64). The lack of government policies and subsidies promoting healthy eating is also highlighted: "it is not a relevant issue for the governments in turn" (Man, 48). Nonetheless, the same farmer mentions an appreciation for nutritional education and agroecological practices as potential solutions to improve eating habits.

The perception of dietary changes over time, as described by respondents, highlights a shift from traditional, home-prepared meals towards a faster, more convenience-oriented food culture. Initially, meals consisted of natural, locally sourced ingredients, with less processed food, reflecting a time when "people used to grow their own food" (Man, 46). Meals were prepared and consumed with greater care and time investment. Today, influenced by the demands of modern life and greater availability of processed foods, there is a noticeable move towards quicker, ready-to-eat options. This transition reflects broader changes in lifestyle where both time constraints and different societal roles have reshaped eating habits. The modern diet is often critiqued for its health implications compared to the seemingly healthier, simpler diets of the past, where "before it was healthier, because here at home my grandmother would prepare the pasta from scratches" (Man, 64).

To improve eating habits in Chile, respondents emphasize the importance of education and leading by example at home. They highlight the role of mothers in teaching from childhood to "give them their food" and the responsibility that "as moms we are responsible" (Woman, 57). They point out the importance of returning to more traditional food and production practices, such as the use of "organic fertilizers and less processed foods" (Man, 60), and the need for experts to "change people's mindset back so that everything is natural" (Woman, 54). They also mention economic inequality that limits access to healthy food, suggesting that "the poor have more access to drugs and alcohol" due to poor diet (Man, 64). The recovery of sustainable agricultural techniques is seen as crucial, proposing to "go back and recover the historical memories of how it was produced 100 years ago" (Man, 46). Industrialization is viewed as a barrier, as "it favors mass-produced foods over natural ones" (Man, 36). Some proposed that "education in schools could be key in promoting healthy habits" (Woman, 60). Finally, suggestions emerged that there needed to be a "micro action from everyone" to reconnect with food could be essential (Man, 33).

5. Discussion

The three workshops' observation embodied the effective bidirectional knowledge exchange between the community, consultants, and researchers, emphasizing the understanding of agroecological principles, soil conservation and food discussion through active participation and hands-on activities. Available literature underscores the importance of such participatory workshops in enhancing local food security as conducted during this research. For example, Benyei et al. (2020) demonstrated the value of collective educational workshops by showing that a citizen science school program intervention had a positive effect on valuing and accessing traditional agroecological knowledge. Similarly, Coquil et al. (2018) provided evidence of the benefits of experiential learning, active participation in diverse networks, and knowledge transfer among farmers. Additionally, Bezner Kerr et al. (2022) showed that participatory workshops facilitate community resilience and empower farmers through knowledge exchange by actively engaging participants in creating dramas, fostering open dialogue, and promoting collaborative problem-solving. Francis et al. (2011) also highlighted

that participatory workshops offering hands-on learning experiences and collaborative problem-solving opportunities enable community members to share local knowledge, build social networks, and collectively develop sustainable solutions for agricultural challenges. These studies suggest that workshops not only improve technical skills but also strengthen community cohesion and collaboration, fundamental elements for the sustainability of food security. In addition, practical agroecological training, as the one developed in Mashue, can significantly increase food production, and promote sustainable practices, as it allows farmers to adopt efficient agroecological techniques, leading to greater productivity and sustainability (Benyei et al., 2020; Coquil et al., 2018; Francis et al. 2011) and have a vital role in creating resilience against climatic and economic challenges (Bezner Kerr et al., 2022).

All three workshop discussions also highlighted a common interest in both viewing produce sales as a positive economic activity and the relevance of sustainable practices and healthy eating, as the ones coming from agroecology, in family farming. Related to the economic implications of agroecological practices, Benyei et al., (2020), Coquil et al., (2018), and Francis et al., (2011) agree that adopting them has a positive economic impact, in terms of cost reduction from reducing the dependence on external inputs and increased income for farmers. Similarly, Bezner Kerr et al. (2022) add that, in addition to direct economic benefits, agroecological practices also have significant indirect economic effects, such as enhancing community well-being and reducing economic vulnerability. In this study, the workshops provided a platform for new residents to integrate into the community and begin building social networks. These networks potentially enhance daily well-being and foster the development of commercial agricultural connections and the exchange of agricultural technical expertise.

The interviews revealed that the farmers' daily lives are closely related to sustainable agricultural practices and efficient water management, highlighting autonomous food production and the direct connection between "field and table". This organization of daily life not only reflects a value system that appreciates the quality and naturalness of food but also highlights a preference for locally produced natural products. Such preference stands in

clear resistance to the impact of modern dietary habits and industrialization, which have altered traditional Chilean diets. Education emerges as a powerful tool, along with the implementation of sustainable agricultural practices, as potential solutions to reverse these effects.

One important aspect to consider is that the initial focus of this research was on the role of community governance in fostering local food security, reflecting a concern with ensuring consistent access to nutritious and safe food within the community. However, as the study progressed, it became evident through both the interviews and the workshops that the participants were engaging in practices more aligned with the concept of food sovereignty. This shift was particularly notable in their participatory reflection on agroecological knowledge, the perceived similitude of this knowledge to ancestral practices in disuse, as well as their collective decisions regarding the types of food to produce and the strategies needed to strengthen their agricultural practices. This exercise of sovereignty underscores the community's autonomy in defining their food systems, contrasting with the more outcome-oriented framing of food security. While food security emphasizes the availability, accessibility, and utilization of food, food sovereignty places greater emphasis on the rights of communities to control their food systems, including the processes of production and knowledge integration. In this context, the Mashue community's actions demonstrated an alignment with sovereignty, as their participatory approach allowed them to articulate and pursue a shared vision for their food and agricultural future. This distinction invites further exploration of how local governance can simultaneously address both food security and food sovereignty in similar contexts.It is imperative to explore in more depth how education impacts food security, as education alone may not be adequate to enhance habits and behaviors. Implementation requires opportunities such as access to food, availability, utilization knowledge, and other factors. It is also critical to recognize that there are gender disparities and gendered roles within food securitization. However, in this experience gender roles were notably subverted in several instances during the workshops, highlighting a shift from traditional norms in both male and female participants. For example, in the assembly of agroecological technologies and structures—a task culturally associated with masculine physical labor—both men and women actively collaborated and worked equally. Similarly, tasks like washing dishes and tidying up after theoretical discussions or lunch, traditionally

assigned to women, were evenly distributed among all participants, reflecting a shared responsibility. However, certain cultural patterns persisted in relation to food preparation. While cooking meat was exclusively undertaken by men, the preparation of vegetables, side dishes, and desserts was predominantly carried out by women. This dual dynamic illustrates how gendered practices were both challenged and reaffirmed in the context of agroecological knowledge exchange. Nevertheless, it is important to highlight that these challenges in gender dynamics may be specific to community events, and this research cannot determine whether such behaviors persist at the household level.

Imamura et al., (2015) point out how the sustainable practices are fundamental in fostering healthier dietary habits and improving global food security. McCullum et al., (2005) echo this point, highlighting the crucial role of sustainable agriculture in ensuring long-term access to nutritious foods and in positively transforming the dietary patterns of communities. However, Wezel et al. (2020) indicate that sustainable practices alone are insufficient, and advocate for addressing the broader power inequalities in food systems to achieve a significant impact on food security and nutrition. Moreover, the literature emphasizes the importance of local food systems in the preservation of cultural food practices and food quality. Kilelu et al., (2013) illustrate how these systems are essential in the development of smallholder dairy farmers and in maintaining cultural heritage and food quality. McKerchar et al., (2015) and Wezel et al., (2020) argue for the traditional food systems as pillars of cultural identity, community cohesion, and nutrition.

Also related to relevant literature, we found that the steps taken by the MAA in their transition process align with the first two phases of Gliessman's (2015) framework for transforming agri-food systems—increasing input efficiency and replacing conventional practices with agroecological alternatives. As noted by Gliessman, these initial phases lack transformative capacity. This limited scope may reflect the recent start of the process in 2021, in a region with little agroecological background. Moreover, advancing through the five phases requires addressing broader rural dynamics that extend beyond food production—dimensions not covered in this article. While Gliessman's principles provide a useful framework to assess agroecological transitions, their application should account for context-specific challenges and gradual implementation, which may reveal transformative potential over time.

Finally, transitioning to sustainable food systems poses distinct challenges and opportunities in rural contexts like Mashue, as as indicated by the literature. For example, Nederlof and Pyburn (2012) explore the complexity of such transitions and the potential of innovation platforms to bring about positive institutional changes. Similarly, Mendonça (2014) emphasizes the need for effective public policies and active citizenship to overcome resource and infrastructure constraints. But is the work done by Wezel et al. (2020) which echoes more closely with the work done with those in Mashue, as they advocate for participatory innovation governance, knowledge co-production, and transparent governance mechanisms as prerequisites for a successful transition. Finally, and related to the agroecological approach of this research, Madero Navajas (2020) highlights the importance of agroecology and food sovereignty movements in tackling land rights, food security, and environmental sustainability issues.

This research, while providing insightful findings on the Mashue community's transition to agroecology and its impact on food and nutrition, presents certain limitations that can lead the way for future research directions. The distinct cultural, geographic, and economic conditions of this group may not represent the broader population engaged in agroecological practices. Moreover, the study's assessment of the workshops' immediate effectiveness lacks a longitudinal perspective to evaluate the long-term impact of these educational interventions on local agricultural practices and economies. Implementing longitudinal studies to track participants over time would provide critical data on the long-term sustainability and economic and environmental impacts of agroecological changes. Such studies could significantly enhance our understanding of the lasting effects of educational interventions in agroecology. Additionally, while participatory observation was a primary method for evaluating the effectiveness of the workshops along with the semi-structured interviews to farmers, incorporating more quantitative or mixed-methods approaches could offer a more comprehensive understanding of their impact.

6. Conclusions

The workshops co-developed and implemented by the Mashue Agroecological Association, Albatros Consultancy, and the Global Academy of Agriculture and Food Systems, as well as interviews conducted with local farmers, were pivotal in addressing the research question: *How can the implementation of agroecological principles through collaborative governance and educational workshops influence sustainable and health-oriented agricultural practices in the Mashue community*? These activities demonstrated a successful bidirectional knowledge exchange, reinforcing the link between agricultural practices and community resilience. By actively engaging community members and researchers, the workshops highlighted the crucial role of soil health, which aligns with Objective 1 to evaluate the effectiveness of these educational sessions in fostering agroecological practices. This participatory approach not only deepened understanding of agroecological principles but also supported Objective 2 by showcasing the impact of these practices on food and nutrition within the community. The integration of hands-on activities ensured that agroecological principles were applied practically, enhancing both community strength and sustainable agriculture in southern Chile.

The discussion also brought into focus the long-term benefits of sustainable practices, like the reduction in dependency on external inputs, leading to cost savings and enhanced soil fertility. These practices, rooted in the principles of agroecology, not only contribute to direct economic benefits for farmers but also have substantial indirect impacts, such as improved community well-being and reduced economic vulnerability. The workshops underscored the role of agroecological practices in building resilience against various challenges, including climatic changes and economic fluctuations. The collaborative and inclusive nature of these workshops thus marks a significant step forward in the journey towards sustainable agriculture and food security.

The research within the Mashue community also illustrates the intrinsic link between sustainable agricultural practices, efficient water management, and autonomous food production, underscoring a profound connection between field and table. This daily lifestyle

not only mirrors a value system that values the quality and naturalness of food but also indicates a clear preference for locally produced and natural products, contrasting to the impact of modern dietary habits. The findings from the interviews and Workshop 3 highlight that adopting an agroecological approach encompasses more than just production methods; it also integrates aspects of food security such as food utilization and agency. This suggests that agroecology can be promoted and embraced not only in the production phase but also in the consumption stage of the food system, aligning with our research objective of examining the role of food and nutrition within the Mashue community's shift towards agroecology.

7. Author Contributions

MdV, KS, JPdV, RDF and JAL: conceptualization and methodology; MdV: investigation and writing; KS, SB, FB, and LG: supervision, review and editing.

8. References

Amekawa, Y. 2011. Agroecology and sustainable livelihoods: Towards an integrated approach to rural development. Journal of Sustainable Agriculture 35 (2):118–62. doi: 10.1080/10440046.2011.539124.

Amoak, D., I. Luginaah, & G. McBean. 2022. Climate change, food security, and health: Harnessing agroecology to build climate-resilient communities. Sustainability14 (21):13954. doi: 10.3390/su142113954.

Bailey, I., and L. E. Buck. 2016. Managing for resilience: A landscape framework for food and livelihood security and ecosystem services. Food Security 8 (3):477–90. doi: 10.1007/s12571-016-0575-9.

Benyei Peco, P., L. Aceituno-Mata, L. Calvet-Mir, J. Tardío, M. Pardo de Santayana, D. GarcíaDel Amo, & V. Reyes-García. 2020. Seeds of change: Reversing the erosion of traditional agroecological knowledge through a citizen science school program in Catalonia. Spain: Ecology and Society. doi: 10.5751/ES-11471-250219.26

Candel, J. J. 2014. Food security governance: A systematic literature review. Food Security6 (4):585–601. doi: 10.1007/s12571-014-0364-2.

Chappell, M. J., and L. A. LaValle. 2011. Food security and biodiversity: Can we have both? Anagroecological analysis. Agriculture and Human Values 28 (1):3–26. doi: 10.1007/s10460-009-9251-4.

Coquil, X., M. Cerf, C. Auricoste, A. Joannon, F. Barcellini, P. Cayre M. Chizallet, B. Dedieu, N. Hostiou, and F. Hellec. 2018. Questioning the work of farmers, advisors, teachers and researchers in agro-ecological transition. A review. Agronomy for Sustainable Development38 (5):1–12. doi: 10.1007/s13593-018-0524-4.

Dalgaard, T., N. J. Hutchings, and J. R. Porter. 2003. Agroecology, scaling and interdisciplinarity. Agriculture, Ecosystems & Environment 100 (1):39–51. doi: 10.1016/S0167-8809(03)00152-X.

de Araújo Palmeira, P., R. Araujo de Mattos, and R. Salles-Costa. 2020. Food security governance promoted by national government at the local level: A case study in Brazil. Food Security 12 (3):591–606. doi: 10.1007/s12571-019-01000-2.
Duru, M., O. Therond, and M. H. Fares. 2015. Designing agroecological transitions; a review. Agronomy for Sustainable Development 35 (4):1237–57. doi: 10.1007/s13593-015-0318-x.

Food and Agriculture Organization. 1996. Report of the world food summit.

Francis, C. A., N. Jordan, P. Porter, T. A. Breland, G. Lieblein, L. Salomonsson, and N. Sriskandarajah, M. Wiedenhoeft, R. DeHaan, and I. Braden. 2011. Innovative education in agroecology: Experiential learning for a sustainable agriculture. Critical Reviews in PlantSciences 30 (1–2):226–37. doi:10.1080/07352689.2011.554497.

Gliessman, S. 2015. Agroecology: The ecology of sustainable food systems, 3rd ed. Boca Raton, Florida, United States: CRC Press. Gliessman, S. 2018. Defining agroecology. Agroecology & Sustainable Food Systems42 (6):599–600. doi: 10.1080/21683565.2018.1432329.

Imamura, F., R. Micha, S. Khatibzadeh, S. Fahimi, P. Shi, J. Powles, and D. Mozaffarian. 2015.Dietary quality among men and women in 187 countries in 1990 and 2010: A systematic assessment. Lancet Global Health 3 (3): e132–42. doi: 10.1016/S2214-109X(14)70381-

X.Jiren, T. S., I. Dorresteijn, J. Hanspach, J. Schultner, A. Bergsten, A. Manlosa, A. Jager, F.Senbeta, and J. Fischer. 2020. Alternative discourses around the governance of food security: A case study from Ethiopia. Global Food Security 24:100338.

Kerr, R. B., S. Madsen, M. Stüber, J. Liebert, S. Enloe, N. Borghino, P. Parros, D. M. Mutyambai, M. Prudhon and A. Wezel. 2021. Can agroecology improve food security and nutrition? A review. Global Food Security 29:100540. doi: 10.1016/j.gfs.2021.100540.

Kerr, R. B., J. C. Postigo, P. Smith, A. Cowie, P. K. Singh, M. Rivera-Ferre M. C. Tirado-von der Pahlen, D. Campbell, and H. Neufeldt. 2023. Agroecology as a transformative approach to tackle climatic, food, and ecosystemic crises. Current Opinion in Environmental Sustainability 62:101275. doi: 10.1016/j.cosust.2023.101275.

Kerr, R. B., S. L. Young, C. Young, M. V. Santoso, M. Magalasi, M. Entz, and S. S. Snapp. 2022.Farming for change: Developing a participatory curriculum on agroecology, nutrition, climate change and social equity in Malawi and Tanzania. In Critical adult education infood movements, ed. C. R. Anderson, R. B. Adell, M. P. Pimbert and M. R. Ferre, 29–46. Cham: Springer Nature Switzerland.

Kilelu, C. W., L. Klerkx, and C. Leeuwis. 2013. Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. Agricultural Systems 118:65–77. doi: 10.1016/j.agsy.2013.03.003.

Lojka, B., N. Teutscherová, A. Chládová, L. Kala, P. Szabó, A. Martiník J. Weger, J. Houška,J. Červenka, and R. Kotrba. 2021. Agroforestry in the Czech Republic: What hampers comeback of a once traditional land use system? Agronomy 12 (1):69. doi: 10.3390/agronomy12010069.

Losardo, M. 2016. “New ways of living, as old as the world” best practices and sustainability inthe example of the Italian Ecovillage network. Studia ethnologica Croatica 28:47–70. doi: 10.17234/SEC.28.3.

Mailfert, K. 2007. New farmers and networks: How beginning farmers build social connectionsin France. Tijdschrift voor economische en sociale geografie 98 (1):21–31. doi: 10.1111/j.1467-9663.2007.00373.x.

Márquez-Barrenechea, A., M. García-Llorente, X. López-Medellín, F. Llobera, andM. Redondo. 2020. How do policy-influential stakeholders from the Madrid region (Spain) understand and perceive the relevance of

agroecology and the challenges for its regional implementation? Landbauforsch/Journal of Sustainable and Organic Agricultural Systems 70 (2):145–56.

McCullum, C., E. Desjardins, V. I. Kraak, P. Ladipo, and H. Costello. 2005. Evidence-based strategies to build community food security. Journal of the American Dietetic Association105 (2):278–83. doi: 10.1016/j.jada.2004.12.015.
McKerchar, C., S. Bowers, C. Heta, L. Signal, and L. Matoe. 2015. Enhancing Māori food security using traditional kai. Global Health Promotion 22 (3):15–24. doi: 10.1177/1757975914543573.

Meek, D. 2016. The cultural politics of the agroecological transition. Agriculture and Human Values 33 (2):275–90. doi: 10.1007/s10460-015-9605-z.

Mendonça Leao, M., and R. S. Maluf. 2014. Effective public policies and active citizenship: Brazil's experience of building a food and nutrition security system. Nairobi, Kenya: OxfamInternational.

Navajas, F. M. 2020. Movimientos sociales y derecho a la tierra:"agroecología y soberaníaalimentaria como alternativas". Quaderns d'animació i educació social 32:6.

Nederlof, S., and R. Pyburn. 2012. One finger cannot lift arock: Facilitating innovation platforms to trigger institutional change in West Africa. Amsterdam, The Netherlands: The Royal Tropical Institute.

Ollivier, G., D. Magda, A. Mazé, G. Plumecocq, and C. Lamine. 2018. Agroecological transitions: What can sustainability transition frameworks teach us? An ontological and empirical analysis. Ecology and Society 23 (2). doi: 10.5751/ES-09952-230205.

Pant, L. P. 2016. Paradox of mainstreaming agroecology for regional and rural food security in developing countries. Technological Forecasting & Social Change 111:305–16. doi: 10.1016/j.techfore.2016.03.001.

Putnam, H., W. Godek, S. Kissmann, J. L. Pierre, S. H. Alvarado Dzul, H. Calix de Dios, andS. R. Gliessman. 2014. Coupling agroecology and PAR to identify appropriate food security and sovereignty strategies in indigenous communities. Agroecology & Sustainable Food Systems 38 (2):165–98. doi:10.1080/21683565.2013.837422.

Rosset, P. M., and M. E. Martínez-Torres. 2012. Rural social movements and agroecology: Context, theory, and process. Ecology and Society 17 (3). doi: 10.5751/ES-05000-170317.

Schönfeldt, H. C., and B. Pretorius. 2018. Agriculture and food systems for improved nutrition. In Advances in food security and sustainability, ed. A. Sharma, M. Kumaar and P. Sharma,vol. 3, 53–68. Cambridge, Massachusetts, United States: Elsevier.

Sidibé, A., E. Totin, M. Thompson-Hall, O. T. Traoré, P. C. S. Traoré, and L. S. Olabisi. 2018.Multi-scale governance in agriculture systems: Interplay between national and local institutions around the production dimension of food security in Mali. NJAS-Wageningen Journal of Life Sciences 84 (1):94–102. doi: 10.1016/j.njas.2017.09.001.28

Slade, C., and J. Carter. 2017. Local governance for social sustainability: Equity as a strategic response to neoliberal constraints in food security initiatives. The Australian Geographer48 (3):385–99. doi: 10.1080/00049182.2016.1265882.

Teixeira, H. M., L. Van Den Berg, I. M. Cardoso, A. J. Vermue, F. J. Bianchi, M. Peña-Claros, and P. Tittonell. 2018. Understanding farm diversity to promote agroecological transitions. Sustainability 10 (12):4337. doi: 10.3390/su10124337.

Utter, A., A. White, V. E. Méndez, and K. Morris. 2021. Co-creation of knowledge in agroecology. Elementa: Science of the Anthropocene 9 (1):00026. doi: 10.1525/elementa.2021.00026.

Vizuete, B., E. Oteros-Rozas, and M. García-Llorente. 2024. Role of the neo-rural phenomenon and the new peasantry in agroecological transitions: A literature review. Agriculture and Human Values 41 (3):1–21. doi: 10.1007/s10460-023-10537-0.

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 Development29 (4):503–15. doi: 10.1051/agro/2009004.

Wezel, A., B. G. Herren, R. B. Kerr, E. Barrios, A. L. R. Gonçalves, and F. Sinclair. 2020.Agroecological principles and elements and their implications for transitioning to sustain-able food systems. A review. Agronomy for Sustainable Development 40 (6):1–13. doi: 10.1007/s13593-020-00646-z.

9. Chapter's conclusions

Reflecting on the thesis sub-research question, *"how can participatory data governance foster the co-creation of agroecological knowledge in southern Chile?"*, this chapter has examined how inclusive governance and the treatment of data as a public good can bring greater agency in community's food security decisions.

After extensive discussions, diverse viewpoints, numerous agreements, and several community meals, the participatory workshops facilitated a bidirectional exchange of knowledge among community members, consultants, and researchers. This exchange enhanced the understanding and application of agroecological principles specifically tailored to the local context in Mashue, a critical development given the community's historical reliance on conventional agricultural methods that contributed to soil degradation. In addition, interviews underscored the vital relationship between agroecological practices and nutrition, highlighting how these methods can improve food quality, accessibility, and overall community health.

In many ways, this chapter also touches on emerging debates from the literature review and other empirical chapters, such as data-driven decision-making and the integration of diverse data sources (e.g., Mashue's sector climate change indicators alongside the qualitative data resulting from this study). These overlapping debates need not be dissected separately; rather, they collectively illustrate how the issues raised in the literature are manifest in everyday realities. This chapter, therefore, serves as an example of how the debates introduced at the beginning of this thesis are reflected in the field, where all dimensions of food and nutrition security interact daily and shape lived experiences in food systems governance.

Supplementary material

N1 - Appendix Ch1 excluded studies.

Wrong focus

Title	Authors	Published Year	Study
Empowering the citizen-consumer: re-regulating consumer information to support the transition to sustainable and health promoting food systems in Canada.	MacRae, R.; Szabo, M.; Anderson, K.; Louden, F.; Trillo, S.	2012	MacRae 2012
The Case for Public Financing of Environmental Common Goods for Health	Lo, Selina; Gaudin, Sylvestre; Corvalan, Carlos; Earle, Alexandra J.; Pruss-Ustun, Annette; Neira, Maria; Soucat, Agnes; Hanssen, Odd	2019	Lo 2019
'Sustainability does not quite get the attention it deserves': synergies and tensions in the sustainability frames of Australian food policy actors	Trevena, Helen; Kaldor, Jenny C.laire; Downs, Shauna M.	2015	Trevena 2015
Reframing the debate on urbanisation, rural transformation and food security.	Tacoli, C.; Vorley, B.	2015	Tacoli 2015
Agri-food system transformations and diet-related chronic disease in Australia: a nutrition-oriented value chain approach	Hattersley, Libby	2013	Hattersley 2013
Research and innovation as a catalyst for food system transformation.	Boer, A. C. L. den; Kok, K. P. W.; Gill, M.; Breda, J.; Cahill, J.; Callenius, C.; Caron, P.; Damianova, Z.; Gurinovic, M.;	2021	Boer 2021

	Lahteenmaki, L.; Lang, T.; Sonnino, R.; Verburg, G.; Westhoek, H.; Cesuroglu, T.; Regeer, B. J.; Broerse, J. E. W.		
Governing urban food systems in the long run: comparing best practices in sustainable food procurement regulations.	Fesenfeld, L. P.	2016	Fesenfeld 2016
Four perspectives of sustainability applied to the local food strategy of Ghent (Belgium): need for a cycle of democratic participation?	Crivits, M.; Prove, C.; Block, T.; Dessein, J.	2016	Crivits 2016
Special Issue: Food systems and public health: linkages to achieve healthier diets and healthier communities.	Story, M., Hamm, M. W., & Wallinga, D. (2009). Food systems and public health: Linkages to achieve healthier diets and healthier communities. Journal of hunger & environmental nutrition, 4(3-4), 219-224.	2009	Story 2009
The paradox of productivity: agricultural productivity promotes food system inefficiency	Benton, Tim G; Bailey, Rob	2019	Benton 2019
From disaster management to adaptive governance? Governance challenges to achieving resilient food systems in Australia.	Smith, K.; Lawrence, G.	2018	Smith 2018
Aboriginal health learning in the forest and cultivated gardens: building a	Stroink, Mirella L; Nelson, Connie H	2009	Stroink 2009

nutritious and sustainable food system			
Climate change adaptation at the intersection of food and health	Edwards, Ferne; Dixon, Jane; Friel, Sharon; Hall, Gillian; Larsen, Kirsten; Lockie, Stewart; Wood, Beverley; Lawrence, Mark; Hanigan, Ivan; Hogan, Anthony; Hattersley, Libby	2011	Edwards 2011
Transition heuristic frameworks in research on agro-food sustainability transitions.	El-Bilali, H.	2020	El-Bilali 2020
A new understanding and evaluation of food sustainability in six different food systems in Kenya and Bolivia	Llanque, Aymara; Giger, Markus; Augstburger, Horacio; Buergi-Bonanomi, Elisabeth; Tribaldos, Theresa; Jacobi, Johanna; Ifejika Speranza, Chinwe; Mukhovi, Stellah; Mwangi, Veronica; Bessa, Adriana; Golay, Christophe; Haller, Tobias; Kiteme, Boniface P.; Delgado Burgoa, Jose M F; Rist, Stephan	2020	Llanque 2020
A food policy package for healthy diets and the prevention of obesity and diet-related non-communicable diseases: The NOURISHING framework	Hawkes, C.; Jewell, J.; Allen, K.	2013	Hawkes 2013
Governments, grassroots, and the struggle for local food systems: containing, coopting, contesting and collaborating.	Laforge, J. M. L.; Anderson, C. R.; McLachlan, S. M.	2017	Laforge 2017

Sustainable food systems, health and infectious diseases: Concerns and opportunities	Pradyumna, Adithya; Utzinger, Jurg; Egal, Florence	2019	Pradyumna 2019
Governance for urban food systems - recommendations from SUPURBFOOD project.	Schmid, O.; Moschitz, H.; Dubbeling, M.; Fritschi, R.; Jahrl, I.; Wiskerke, H.	2016	Schmid 2016
Trade, development, and regulatory issues in food	Ramaswamy, Sunder; Viswanathan, Brinda	2007	Ramaswamy 2007
Adaptation and development pathways for different types of farmers	Stringer, L.C.; Lyon, C.; Ward, C.F.M.; Fraser, E.D.G.; Harris, D.; Pereira, L.; Simelton, E.	2020	Stringer 2020
US-based food and agricultural value chains and their relevance to healthy diets	Gereffi, Gary; Lee, Joonkoo; Christian, Michelle	2009	Gereffi 2009
Food systems and public health: Linkages to achieve healthier diets and healthier communities	Story, Mary; Hamm, Michael W.; Wallinga, David	2009	Story 2009
How can health, agriculture and economic policy actors work together to enhance the external food environment for fruit and vegetables? A qualitative policy analysis in India	Thow, A. M.; Verma, G.; Soni, D.; Soni, D.; Beri, D. K.; Kumar, P.; Siegel, K. R.; Shaikh, N.; Khandelwal, S.	2018	Thow 2018
Transforming research and innovation for sustainable food systems-a coupled-systems perspective.	Kok, K. P. W.; Boer, A. C. L. den; Cesuroglu, T.; Meij, M. G. van der; Wildt-Liesveld, R. de; Regeer, B. J.; Broerse, J. E. W.	2019	Kok 2019
Empowering People—Democratising the Food System? Exploring the	Bornemann, Basil; Weiland, Sabine	2019	Bornemann 2019

Democratic Potential of Food-Related Empowerment Forms			
Leveraging Agriculture for Nutrition Impact through the Feed the Future Initiative	Du, Lidan; Pinga, Victor; Klein, Alyssa; Danton, Heather	2015	Du 2015
Getting civil about food: The interactions between civil society and the state to advance sustainable food systems in Canada	Koc, Mustafa; Macrae, Rod; Desjardins, Ellen; Roberts, Wayne	2008	Koc 2008
Addressing food poverty in systems: governance of food assistance in three European countries.	Galli, F.; Hebinck, A.; Carroll, B.	2018	Galli 2018
Paths of convergence for agriculture, health, and wealth	Dube, Laurette; Pingali, Prabhu; Webb, Patrick	2012	Dube 2012
Agricultural biodiversity as a link between traditional food systems and contemporary development, social integrity and ecological health	Johns, Timothy; Eyzaguirre, Pablo B; Powell, Bronwen; Maundu, Patrick	2013	Johns 2013
Nutrition-sensitive agriculture - a South African perspective.	McLachlan, M.; Landman, A. P.	2013	McLachlan 2013
Digital solutions for nutrition-sensitive SME transformation.	Trendov, N.; Liu Bin; Anta, M.; Zeng Meng	2020	Trendov 2020
From "Healthy Eating" to a Holistic Approach to Current Food Environments	Traverso-Yepez, M.; Hunter, K.	2016	Traverso-Yepez 2016
The potential of diversified agroecological systems to deliver healthy outcomes: making the link between agriculture, food systems & health.	Frison, E.; Clement, C.	2020	Frison 2020

First Nations Peoples' Participation in the Development of Population-Wide Food and Nutrition Policy in Australia: A Political Economy and Cultural Safety Analysis	Browne, Jennifer; Backholer, Kathryn; Gilmore, Michelle; Lock, Mark	2020	Browne 2020
Nutrition Transition and Climate Risks in Nigeria: Moving Towards Food Systems Policy Coherence	Morgan, Alexandra E.; Fanzo, Jessica	2020	Morgan 2020
Food systems for sustainable development: proposals for a profound four-part transformation.	Caron, P.; Ferrero y de Loma-Osorio, G.; Nabarro, D.; Hainzelin, E.; Guillou, M.; Andersen, I.; Arnold, T.; Astralaga, M.; Beukeboom, M.; Bickersteth, S.; Bwalya, M.; Caballero, P.; Campbell, B. M.; Divine, N.; Fan ShengGen; Frick, M.; Friis, A.; Gallagher, M.; Halkin, J. P.; Hanson, C.; Lasbennes, F.; Ribera, T.; Rockstrom, J.; Schuepbach, M.; Steer, A.; Tutwiler, A. [et al]	2018	Caron 2018
Agricultural biodiversity, social-ecological systems and sustainable diets.	Allen, T.; Prosperi, P.; Cogill, B.; Flichman, G.	2014	Allen 2014
Mainstreaming Underutilized Indigenous and Traditional Crops into Food Systems: A South African Perspective	Mabhaudhi, T.; Chibarabada, T. P.; Chimonyo, V. G. P.; Murugani, V. G.; Pereira, L. M.; Sobratee, N.; Govender, L.; Slotow, R.; Modi, A. T.	2019	Mabhaudhi 2019

Linking sustainable agriculture and public health: Opportunities for realizing multiple goals	Hamm, Michael W.	2008	Hamm 2008
Testing the price and affordability of healthy and current (unhealthy) diets and the potential impacts of policy change in Australia	Lee, Amanda J.; Kane, Sarah; Ramsey, Rebecca; Good, Elizabeth; Dick, Mathew	2016	Lee 2016
The importance of food systems and the environment for nutrition	Fanzo, Jessica; Bellows, Alexandra L.; Spiker, Marie L.; Thorne-Lyman, Andrew L.; Bloem, Martin W.	2021	Fanzo 2021
Why food in health security (FIHS)?	Wahlqvist, M. L.	2009	Wahlqvist 2009
Creating sustainable, resilient food systems for healthy diets.	Herforth, A.; Ahmed, S.; Declerck, F.; Fanzo, J.; Remans, R.	2017	Herforth 2017
The role of food policy councils in developing sustainable food systems	Schiff, Rebecca	2008	Schiff 2008
Linking biodiversity, diet and health in policy and practice	Johns, T.; Eyzaguirre, P. B.	2006	Johns 2006
Integrating fisheries, food and nutrition - Insights from people and policies in Timor-Leste.	Farmery, A. K.; Kajlich, L.; Voyer, M.; Bogard, J. R.; Duarte, A.	2020	Farmery 2020
Creating momentum for nutrition-sensitive agriculture: experiences and lessons from the Australian aid program.	Carter, L.; Peishi, Z.	2018	Carter 2018
Local solutions for sustainable food systems: the contribution of orphan crops and wild edible species.	Borelli, T.; Hunter, D.; Padulosi, S.; Amaya, N.; Meldrum, G.; Beltrame, D. M. de O.; Samarasinghe, G.; Wasike, V. W.;	2020	Borelli 2020

	Guner, B.; Tan, A.; Dembele, Y. K.; Lochetti, G.; Sidibe, A.; Tartanac, F.		
Food production and consumption in Bamyan Province, Afghanistan: the challenges of sustainability and seasonality for dietary diversity	Poole, N.; Amiri, H.; Amiri, S. M.; Farhank, I.; Zanelli, G.	2019	Poole 2019
Regional food culture and development	Lee, Meei-Shyuan; Wahlqvist, Mark L.	2007	Lee 2007
Linking vegetable preferences, health and local food systems through community-supported agriculture	Wilkins, Jennifer L.; Farrell, Tracy J.; Rangarajan, Anusuya	2015	Wilkins 2015
Food policies: A threat to health?	Lobstein, Tim	2002	Lobstein 2002
Local foodscapes: place and power in the agri-food system.	Sonnino, R.	2013	Sonnino 2013
Transforming governance in telecoupled food systems.	Eakin, H.; Rueda, X.; Mahanti, A.	2017	Eakin 2017
Sustainable diets within sustainable food systems.	Meybeck, A.; Gitz, V.	2017	Meybeck 2017
A 'common food policy' for Europe: how governance reforms can spark a shift to healthy diets and sustainable food systems.	Schutter, O. de; Jacobs, N.; Clement, C.	2020	Schutter 2020
The Role of Healthy Diets in Environmentally Sustainable Food Systems	Clark, Michael; Macdiarmid, Jennie; Jones, Andrew D.; Ranganathan, Janet; Herrero, Mario; Fanzo, Jessica	2020	Clark 2020
Agricultural biodiversity, nutrition, and health: Making a difference to hunger and	Frison, Emile A.; Smith, Ifeyironwa Francisca; Cherfas, Jeremy; Eyzaguirre,	2006	Frison 2006

nutrition in the developing world	Pablo B.; Johns, Timothy		
Hungry in the heartland: Using community food systems as a strategy to reduce rural food deserts	Mader, Erin; Busse, Heidi	2011	Mader 2011
Demand-Side Food Policies for Public and Planetary Health	Temme, E. H. M.; Vellinga, R. E.; de Ruiter, H.; Kugelberg, S.; van de Kamp, M.; Milford, A.; Alessandrini, R.; Bartolini, F.; Sanz-Cobena, A.; Leip, A.	2020	Temme 2020
Insights from agroecology and a critical next step: integrating human health.	O'Rourke, M. E.; DeLonge, M. S.; Salvador, R.	2017	O'Rourke 2017
National food policies in the islamic republic of iran aimed at control and prevention of noncommunicable diseases	Moslemi, Masoumeh; Jannat, Behrooz; Kheirandish, Mehrnaz; Mazaheri, Ramin Nezhad Fard; Hosseini, Hedayat; Mofid, Vahid; Moghadd-Am, Atefeh; Karimian, Nader	2020	Moslemi 2020
Obesity and the food system transformation in Latin America	Popkin, B.M.; Reardon, T.	2018	Popkin 2018
Food decision-making framework: Connecting sustainable food systems to health and well-being	Gillespie, Ardyth H.; Smith, Laura E.	2008	Gillespie 2008
Modelling the cost differential between healthy and current diets: The New Zealand case study	Vandevijvere, Stefanie; Mackay, Sally; Swinburn, Boyd; Young, Nick; Gahegan, Mark	2018	Vandevijvere 2018
Healthy and sustainable diets: The development and application of a	Downs, Shauna; Payne, Alex; Fanzo, Jessica	2016	Downs 2016

policy analysis framework			
Assessing gaps and opportunities for policy to promote healthy diets in the development of food sovereignty legislation in Ecuador	Garton, K.	2014	Garton 2014
Leveraging food and agriculture policy mapping and analysis for nutrition-sensitive planning	Meerman, Janice; Dode, Marie Caroline; Dufour, Charlotte	2016	Meerman 2016
A new paradigm for world agriculture: productive, sustainable and nutritious food systems to meet human needs.	Graham, R. D.; Welch, R. M.	1999	Graham 1999
The potential contribution of livestock to food nutrition security: the application of the One Health approach in livestock policy and practice.	Nabarro, D.; Wannous, C.	2014	Nabarro 2014
Sustaining healthy diets: The role of capture fisheries and aquaculture for improving nutrition in the post-2015 era	Thilsted, S. H.; Thorne-Lyman, A.; Webb, P.; Bogard, J. R.; Subasinghe, R.; Phillips, M. J.; Allison, E. H.	2016	Thilsted 2016
The role of metrics in food policy: lessons from a decade of experience in New York City.	Freudenberg, N.; Willingham, C.; Cohen, N.	2018	Freudenberg 2018
A new paradigm for world agriculture: meeting human needs productive, sustainable, nutritious.	Welch, R. M.; Graham, R. D.	1999	Welch 1999
Why Food System Transformation Is Essential and How Nutrition Scientists Can Contribute	Lartey, Anna; Meerman, Janice; Wijesinha-Bettoni, Ramani	2018	Lartey 2018

Food Systems and Public Health: The Community Perspective	Herrera, Henry; Khanna, Navina; Davis, Leon	2009	Herrera 2009
Systemic analysis of Food Supply and Distribution Systems in city-region systems - an examination of FAO's policy guidelines towards sustainable agri-food systems.	Armendariz, V.; Armenia, S.; Atzori, A. S.	2016	Armendariz 2016
Understanding the Impact of Historical Policy Legacies on Nutrition Policy Space: Economic Policy Agendas and Current Food Policy Paradigms in Ghana	Thow, Anne Marie; Mulcahy, Georgina; Apprey, Charles; Annan, Reginald; Winters, Janelle; Stellmach, Darryl; Alders, Robyn; Aduku, Linda Nana Esi	2020	Thow 2020
MINIMUM WAGES AND HEALTHY DIET	Clark, Kathryn L; Pohl, R Vincent; Thomas, Ryan C	2020	Clark 2020
Position of the American Dietetic Association: food and nutrition professionals can implement practices to conserve natural resources and support ecological sustainability	Harmon, Alison H; Gerald, Bonnie L	2007	Harmon 2007
Nutritious subsistence food systems.	Graham, R. D.; Welch, R. M.; Saunders, D. A.; Ortiz-Monasterio, I.; Bouis, H. E.; Bonierbale, M.; Haan, S. de; Burgos, G.; Thiele, G.; Liria, R.; Meisner, C. A.; Beebe, S. E.; Potts, M. J.; Kadian, M.; Hobbs, P. R.; Gupta, R. K.; Twomlow, S.	2007	Graham 2007
Exploring the dynamics of food-related policymaking	Gade Waqa; Moodie, Marj; Snowdon, Wendy; Latu,	2017	GadeWaqa 2017

processes and evidence use in Fiji using systems thinking	Catherine; Coriakula, Jeremaia; Allender, Steven; Bell, Colin		
Sustainable agriculture and food, Volume 3: agriculture and food systems.	Pretty, J.	2008	Pretty 2008
Westernization of Asian diets and the transformation of food systems: implications for research and policy.	Pingali, P.	2007	Pingali 2007
The potential for competitive and healthy food chains of benefit to the countryside	Traill, W. B.; Arnoult, M. H. P.; Chambers, S. A.; Deaville, E. R.; Gordon, M. H.; John, P.; Jones, P. J.; Kliem, K. E.; Mortimer, S. R.; Tiffin, J. R.	2008	Traill 2008
How important are supermarkets for the diets of the urban poor in Africa?	Wanyama, R.; Godecke, T.; Chege, C. G. K.; Qaim, M.	2019	Wanyama 2019
What does it cost to improve household diets in Nepal? Using the cost of the diet method to model lowest cost dietary changes.	Biehl, E.; Klemm, R. D. W.; Swetha Manohar; Webb, P.; Devendra Gauchan; West, K. P., Jr.	2016	Biehl 2016
Advancing healthy and sustainable food environments: the Flathead Reservation case study.	Ahmed, S.; Shanks, C. B.; Dupuis, V.; Pierre, M.	2019	Ahmed 2019
Promote healthy diets to reduce the double burden of malnutrition in India.	Silva, A. de	2018	Silva 2018
Agricultural biodiversity, social-ecological systems and sustainable diets	Allen, T., Prosperi, P., Cogill, B., & Flichman, G. (2014). Agricultural biodiversity, social–ecological systems and sustainable diets. Proceedings of	2014	Allen 2014

	the Nutrition Society, 73(4), 498-508.		
Beyond eating right: The emergence of civic dietetics to foster health and sustainability through food system change	Wilkins, Jennifer L.; Lapp, Julia; Tagtow, Angie; Roberts, Susan	2010	Wilkins 2010
Application of multidimensional poverty index methodology to sustainable diets' measurement: Dimensions and concept	Ezekannagha, O.; Akinyele, I.	2013	Ezekannagha 2013
A healthier US diet could reduce greenhouse gas emissions from both the food and health care systems	Hallstrom, E.; Gee, Q.; Scarborough, P.; Cleveland, D. A.	2017	Hallstrom 2017
Future Smart Food: Harnessing the potential of neglected and underutilized species for Zero Hunger	Li, Xuan; Siddique, Kadambot H.M.	2020	Li 2020
Intersection of Diet, Health, and Environment: Land Grant Universities' Role in Creating Platforms for Sustainable Food Systems	Ringling, K. M.; Marquart, L. F.	2020	Ringling 2020
Multi-indicator sustainability assessment of global food systems	Chaudhary, Abhishek; Mathys, Alexander; Gustafson, David	2018	Chaudhary 2018
Eating green: The policy challenge of sustainable diets	Lang, T.	2011	Lang 2011
Food for all in 2020: Can the world be fed without damaging the environment?	Pinstrup-Andersen, Per; Pandya-Lorch, Rajul	1996	Pinstrup-Andersen 1996

'Du bist was du isst': challenges in European nutrition policy	Lafranconi, Alessandra; Birt, Christopher A.	2017	Lafranconi 2017
Environmental impacts of food consumption and nutrition: where are we and what is next?	Nemecek, Thomas; Jungbluth, Niels; i Canals, Llorenc Mila; Schenck, Rita	2016	Nemecek 2016
Food security in complex emergencies: Enhancing food system resilience	Pingali, Prabhu; Alinovi, Luca; Sutton, Jacky	2005	Pingali 2005
An integrated approach to identifying and characterising resilient urban food systems to promote population health in a changing climate	James, Sarah W.; Friel, Sharon	2015	James 2015
Promoting sustainable local food systems in the United States.	Dahlberg, K. A.	1999	Dahlberg 1999
Biodiversity and sustainability of indigenous peoples' foods and diets.	Kuhnlein, H. V.	2012	Kuhnlein 2012
Using dietary quality scores to assess sustainability of food products and human diets: a systematic review.	Hallstrom, E.; Davis, J.; Woodhouse, A.; Sonesson, U.	2018	Hallstrom 2018
Addressing malnutrition through nutritionsensitive agri-food policies in europe and central asia region	Dupouy, Eleonora; Kerekes, Kata; Gurinovic, Mirjana	2015	Dupouy 2015
Agricultural Biodiversity and Diets Evidence, Indicators, and Next Steps	Jones, A. D.; Kennedy, G.; Raneri, J. E.; Borelli, T.; Hunter, D.; Creed-Kanashiro, H. M.; Zimmerer, K. S.; DeHaan, S.	2019	Jones 2019

Regional foods in Brazilian school meals.	Fabri, R. K.; Proenca, R. P. C. da; Martinelli, S. S.; Cavalli, S. B.	2015	Fabri 2015
Traditional diets; their value and preservation.	Wilson, C. S.	1994	Wilson 1994
Nutrition and food systems.	HLPE. (2017). Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition.	2017	HLPE 2017
A Community-Level Initiative to Prevent Obesity: Results From Kaiser Permanente's Healthy Eating Active Living Zones Initiative in California	Cheadle, Allen, PhD; Atiedu, Akpene, MPH, MA; Rauzon, Suzanne, MPH; Schwartz, Pamela M, MPH; Keene, Laura, MPH; Davoudi, Mehrnaz, MPH; Spring, Rebecca, MPH; Molina, Michelle, MA; Lee, Lynda, MA; Boyle, Kathryn, BA; Williamson, Dana, MPH; Steimberg, Clara, MHA; Tinajero, Roberta, BA; Ravel, Jodi, MPH; Nudelman, Jean, MPH; Azuma, Andrea Misako, MS; Kuo, Elena S, PhD, MPH; Solomon, Loel, PhD	2018	Cheadle 2018
Why sustainable and 'nutritionally correct' food is not on the agenda: Western Sydney, the moral arts of everyday life and public policy.	Dixon, J.; Isaacs, B.	2013	Dixon 2013
State Preemption of Food and Nutrition Policies and Litigation: Undermining	Pomeranz, Jennifer L, JD, MPH; Zellers, Leslie JD; Bare, Michael, MPH; Pertschuk, Mark, JD	2019	Pomeranz 2019

Government's Role in Public Health			
International moves to strengthen food policies	Lobstein, T.	2009	Lobstein 2009
The One Planet Sustainable Food Systems (SFS) Programme as a multistakeholder platform for a systemic approach.	Solon, M. M.; Mink, P.; Dernini, S.; Bortoletti, M.; Lomax, J.	2019	Solon 2019
Review of methodologies for assessing sustainable diets and potential for development of harmonised indicators	Eme, Paul Eze; Kim, Nicholas; Burlingame, Barbara; Douwes, Jeroen; Foliaki, Sunia	2019	Eme 2019
Application of the Nutrition Functional Diversity indicator to assess food system contributions to dietary diversity and sustainable diets of Malawian households	Luckett, Brian G.; DeClerck, Fabrice A. J; Fanzo, Jessica; Mundorf, Adrienne R.; Rose, Donald	2015	Luckett 2015
How ethnobiology can contribute to food security.	Kuhnlein, H. V.	2014	Kuhnlein 2014
Why food in health security (FIHS)?	Wahlqvist, M. L. (2009). Why food in health security (FIHS)?. Asia Pacific journal of clinical nutrition, 18(4), 480-485.	2009	Wahlqvist 2009
Obesity and the future of food policies that promote healthy diets	Peeters, Anna	2018	Peeters 2018
City region food systems and food waste management: linking urban and rural areas for sustainable and resilient development.	Dubbeling, M.; Bucatariu, C.; Santini, G.; Vogt, C.; Eisenbeiss, K.	2017	Dubbeling 2017

Using Input-Output Analysis to Measure Healthy, Sustainable Food Systems	Boylan, S. M.; Thow, A. M.; Tyedmers, E. K.; Malik, A.; Salem, J.; Alders, R.; Raubenheimer, D.; Lenzen, M.	2020	Boylan 2020
Sociocultural Influences on Food Choices and Implications for Sustainable Healthy Diets	Monterrosa, Eva C.; Frongillo, Edward A.; Drewnowski, Adam; de Pee, Saskia; Vandevijvere, Stefanie	2020	Monterrosa 2020
How to create a sustainable food system with affordable, accessible, and available health promoting food-a policy perspective	Schindler, K.	2018	Schindler 2018
Improving human nutrition from the ground up: Linking agriculture to human health	Welch, R.M.	2011	Welch 2011
Aligning food systems policies to advance public health	Muller, Mark; Tagtow, Angie; Roberts, Susan L.; Erin, MacDougall	2009	Muller 2009
Mapping disruption and resilience mechanisms in food systems.	Savary, S.; Akter, S.; Almekinders, C.; Harris, J.; Korsten, L.; Rotter, R.	2020	Savary 2020
Designing lifestyle-specific food policies based on nutritional requirements and ecological footprints	Mózner, Zsófia Vetöné; Csutora, Mária	2013	Mózner 2013
Indigenous and tribal foods for addressing food and nutrition security in two tribal communities of Jharkhand, India	Ghosh-Jerath, S.; Kamboj, P.; Singh, A.; Magsumbol, M.S.; Goldberg, G.	2013	Ghosh-Jerath 2013
The role of pulses in sustainable and healthy food systems	McDermott, John; Wyatt, Amanda J.	2017	McDermott 2017
Improving diets through food systems in low- and middle-	Melesse, M. B.; Berg, M. van den; Bene, C.;	2019	Melesse 2019

income countries metrics for analysis.	Brouwer, I. D.; Brauw, A. de		
Diet transformation in Africa: the case of Ethiopia.	Worku, I. H.; Dereje, M.; Bart Minten; Kalle Hirvonen	2017	Worku 2017
The role of agriculture in improving nutrition in the global context: Commitments guidelines and the rome-based agencies	Dufour, Charlotte; Garrett, James; Friedrich, Juliane; Kennedy, Gina; Aburto, Nancy; Marshall, Quinn	2017	Dufour 2017
Youth, urban governance, and sustainable food systems: the cases of Hamilton and Victoria, Canada.	Botelho, Z.	1999	Botelho 1999
Measuring food insecurity using the food abundance index: Implications for economic, health and social well-being	Murrell, Audrey; Jones, Ray	2020	Murrell 2020
Food systems and food security: A conceptual model for identifying food system deficiencies	Rutten, Lila Finney; Yaroch, Amy Lazarus; Story, Mary	2011	Rutten 2011
Monitoring the price and affordability of foods and diets globally	Lee, A.; Mhurchu, C.N.; Vandevijvere, S.; Sacks, G.; Swinburn, B.; Snowdon, W.; Hawkes, C.; L'Abbe, M.; Rayner, M.; Sanders, D.; Barquera, S.; Friel, S.; Kelly, B.; Kumanyika, S.; Lobstein, T.; Ma, J.; Macmullan, J.; Mohan, S.; Monteiro, C.; Neal, B.; Walker, C.	2013	Lee 2013
Climate change and sustainable and healthy diets.	Pahlen, C. T. von der	2019	Pahlen 2019
Evaluating the sustainability of diets-combining	Roos, Elin; Karlsson, Hanna; Sundberg,	2015	Roos 2015

environmental and nutritional aspects	Cecilia; Witthoft, Cornelia		
Putting all foods on the same table: Achieving sustainable food systems requires full accounting	Kuempel, Caitlin D.; Halpern, Benjamin S.; Cottrell, Richard S.; Blanchard, Julia L.; Nash, Kirsty L.; Bouwman, Lex; Froehlich, Halley E.; Gephart, Jessica A.; Jacobsen, Nis Sand; McIntyre, Peter B.; Metian, Marc; Moran, Daniel D.; Tobben, Johannes; Williams, David R.	2019	Kuempel 2019
Shaping Physical, Economic, and Policy Components of the Food Environment to Create Sustainable Healthy Diets	Drewnowski, Adam; Monterrosa, Eva C.; de Pee, Saskia; Frongillo, Edward A.; Vandevijvere, Stefanie	2020	Drewnowski 2020
A Food Systems Approach To Healthy Food And Agriculture Policy	Neff, Roni A; Merrigan, Kathleen; Wallinga, David	2015	Neff 2015
Enhancing Linkages Between Healthy Diets, Local Agriculture, and Sustainable Food Systems: The School Meals Planner Package in Ghana	Fernandes, Meenakshi; Galloway, Rae; Hamdani, Salha; Kiamba, Josephine; Aurino, Elisabetta; Peel, Francis; Drake, Lesley; Gelli, Aulo; Mumuni, Daniel; Quarshie, Kate; Bhatia, Rita	2016	Fernandes 2016
A new health care prevention agenda: sustainable food procurement and agricultural policy.	Harvie, J.; Mikkelsen, L.; Shak, L.	2009	Harvie 2009
Policy Action Within Urban African Food Systems to Promote Healthy Food Consumption: A Realist Synthesis in Ghana and Kenya	Booth, Andrew; Barnes, Amy; Akparibo, Robert; Bash, Kristin; Laar, Amos; Graham, Fiona; Asiki, Gershim; Holdsworth, Michelle	2021	Booth 2021

Food security, food safety & healthy nutrition: are they compatible?	Walls, H.; Baker, P.; Chirwa, E.; Hawkins, B.	2019	Walls 2019
Poverty does not modify the association between perceived diet healthiness and adherence to nutritional guidelines in the constances cohort (France).	Plessz, M.; Kesse-Guyot, E.; Zins, M.; Matta, J.; Czernichow, S.	2019	Plessz 2019
Healthy foods and healthy diets. How government policies can steer food reformulation	Frost, Gary; Gressier, Mathilde; Sassi, Franco	2020	Frost 2020
Consumers' sense of farmers' markets: tasting sustainability or just purchasing food?	Giampietri, E.; Koemle, D. B. A.; Yu XiaoHua; Finco, A.	2016	Giampietri 2016
Integrated mixed methods policy analysis for sustainable food systems: Trends, challenges and future research	Cuevas, Soledad	2016	Cuevas 2016
Using price policies to promote healthier diets.	World Health Organization. (2015). Using price policies to promote healthier diets. World Health Organization. Regional Office for Europe.	2015	WHO 2015
Articulated food systems and transverse to food security.	VertigO, 2014	2014	VertigO 2014
Promoting healthy diets and tackling obesity and diet-related chronic diseases: What are the agricultural policy levers?	Hawkes, Corinna	2007	Hawkes 2007

Adapting food systems of the Indo-Gangetic plains to global environmental change: Key information needs to improve policy formulation	Aggarwal, P.K.; Joshi, P.K.; Ingram, J.S.I.; Gupta, R.K.	2004	Aggarwal 2004
Importance of adequate policies for the implementation of sustainable food systems: the case of Mexico.	Cabada, X.; Calvillo, A.	2014	Cabada 2014
Moving local food through conventional food system infrastructure: value chain framework comparisons and insights.	Bloom, J. D.; Hinrichs, C. C.	2011	Bloom 2011
The politics of food in the Pacific: coherence and tension in regional policies on nutrition, the food environment and non-communicable diseases	Dodd, Rebecca; Sparks, Emalie; Webster, Jacqui; Reeve, Erica; George, Anita; Buresova, Dai; Vivili, Paula; Win Tin, Si Thu; Thow, Anne-Marie	2020	Dodd 2020
Food value chain transformations in developing countries: selected hypotheses on nutritional implications.	Gomez, M. I.; Ricketts, K. D.	2013	Gomez 2013
Sustainable diets: linking nutrition and food systems.	Burlingame, B.; Dernini, S.	2019	Burlingame 2019
A multi-country survey of public support for food policies to promote healthy diets: Findings from the International Food Policy Study	Kwon, Janelle; Cameron, Adrian J.; Sacks, Gary; Hammond, David; White, Christine M.; Vanderlee, Lana; Bhawra, Jasmin	2019	Kwon 2019
Nutrition-sensitive agriculture and food systems in practice:	Lartey, A.	2017	Lartey 2017

options for intervention.			
Local challenges and successes associated with transitioning to sustainable food system practices for a west Australian context: Multi-sector stakeholder perceptions	Sambell, Ros; Andrew, Lesley; Godrich, Stephanie; Devine, Amanda; Wolfgang, Justin; Vandenbroeck, Dieter; Stubley, Katie; Rose, Nick; Newman, Lenore; Horwitz, Pierre	2019	Sambell 2019
Environmental sustainability perspectives of the nordic diet	Meltzer, Helle Margrete; Brantsaeter, Anne Lise; Trolle, Ellen; Eneroth, Hanna; Fogelholm, Mikael; Ydersbond, Trond Arild; Birgisdottir, Bryndis Eva	2019	Meltzer 2019
The global face of nutrition: what can governments and industry do?	Kennedy, E. T.	2005	Kennedy 2005
Healthy diets ASAP - Australian Standardised Affordability and Pricing methods protocol	Lee, Amanda J; Lewis, Meron; Kane, Sarah; Good, Elizabeth; Dick, Mathew; Landrigan, Timothy J; Pollard, Christina M	2018	Lee 2018
Testing the price of healthy and current diets in remote aboriginal communities to improve food security: Development of the aboriginal and torres strait islander healthy diets ASAP (Australian standardised affordability and pricing) methods	Lewis, Meron; Lee, Amanda	2018	Lewis 2018
Sustainable and healthy diets: Synergies and trade-offs in Switzerland	Kopainsky, B.; Frehner, A.; Muller, A.	2020	Kopainsky 2020

Rural transformation and the double burden of malnutrition among rural youth in developing countries.	Suneetha Kadiyala; Aurino, E.; Cirillo, C.; Srinivasan, C.; Zanello, G.	2019	SuneethaKadiyala 2019
Streamlined data-gathering techniques to estimate the price and affordability of healthy and unhealthy diets under different pricing scenarios	Zorbas, Christina; Peeters, Anna; Backholer, Kathryn; Lee, Amanda; Lewis, Meron; Landrigan, Timothy	2021	Zorbas 2021
How the food industry can contribute to healthy and sustainable food systems	Spieldenner, Jorg	2015	Spieldenner 2015
Contribution to the development of a food guide in Benin: linear programming for the optimization of local diets	Levesque, Sarah; Delisle, Helene; Agueh, Victoire	2015	Levesque 2015
Building local food governance: the case of the food plan of the Pisa province.	Rossi, A.; Fastelli, L.; Innocenti, S.	2015	Rossi 2015
Highlighting interlinkages between sustainable diets and sustainable food systems.	Meybeck, A.; Gitz, V.	2019	Meybeck 2019
Climate smart food supply chains in developing countries in an era of rapid dual change in agrifood systems and the climate.	Reardon, T.; Zilberman, D.	2018	Reardon 2018
Comparing the Recommended Eating Patterns of the EAT-Lancet Commission and Dietary Guidelines for Americans: Implications for Sustainable Nutrition	Blackstone, Nicole Tichenor; Conrad, Zach	2020	Blackstone 2020

Sustainable food systems for optimal planetary health	Canavan, Chelsey R.; Noor, Ramadhani A.; Fawzi, Wafaie; Golden, Christopher D.; Juma, Calestous	2017	Canavan 2017
Climate smart nutrition: Co-benefits of nutrition-sensitive climate mitigation and adaptation	Amadeo, A.; Chen, K.; Tirado, M.C.; Mascarenas, A.	2015	Amadeo 2015
Estimates of the willingness to pay for locally grown tree fruits in Cusco, Peru	Blare, T.; Donovan, J.; del Pozo, C.	2019	Blare 2019
Today's food system: How healthy is it?	Wallinga, David	2009	Wallinga 2009
Improving policy evidence base for agricultural sustainability and food security: a content analysis of life cycle assessment research.	Gava, O.; Bartolini, F.; Venturi, F.; Brunori, G.; Pardossi, A.	2020	Gava 2020
A scoping review of policies promoting and supporting sustainable food systems in the university setting	Grech, Amanda; Howse, Eloise; Boylan, Sinead	2020	Grech 2020
Getting it done: Frameworks, approaches, and tools for national capacities in agriculture and nutrition	Aburto, Nancy	2017	Aburto 2017
Effects of food policy actions on Indigenous Peoples' nutrition-related outcomes: a systematic review	Browne, J.; Lock, M.; Walker, T.; Egan, M.; Backholer, K.	2020	Browne 2020
Towards a code of conduct for sustainable diets.	Burlingame, B.	2019	Burlingame 2019
Designing a tax to discourage unhealthy food and beverage purchases: The case of Chile	Caro, J. C.; Ng, S. W.; Taillie, L. S.; Popkin, B. M.	2017	Caro 2017

Disintegration of traditional food systems as a challenge to food security: a case study of Kollimalai Hills in South India.	Bohle, H. G.	1992	Bohle 1992
Transferability of private food marketing success factors to public food and health policy: an expert Delphi survey.	Aschemann-Witzel, J.; Perez-Cueto, F. J. A.; Niedzwiedzka, B.; Verbeke, W.; Bech-Larsen, T.	2012	Aschemann-Witzel 2012
Shifting the Balance: Getting the Private Sector to Favour Nutritious, Affordable and Accessible Diets	(World Food Regulation Review, 2018)	2018	World Food Regulation 2018
Writing a recipe for teaching sustainable food systems: lessons from three university courses.	Brekken, C. A.; Peterson, H. H.; King, R. P.; Conner, D.	2018	Brekken 2018

Wrong type of document

Title	Authors	Published Year	Study
The state of food and agriculture: food systems for better nutrition.	UN Food and Agriculture Organization. (2014). The State of Food and Agriculture. Food Systems for Better Nutrition.	2013	UN 2014
Intelligent agrifood chains and networks: current status, future trends and real-life cases from Japan.	Voros, M.; Gemma, M.	2011	Voros 2011
Integrating agriculture and food policy to achieve sustainable peri-urban fruit and vegetable production in Victoria, Australia.	Carey, R.; Krumholz, F.; Duignan, K.; McConell, K.; Browne, J. L.; Burns, C.; Lawrence, M.	2010	Carey 2010
Securing sustainable and nutritious food systems through mainstreaming	Tutwiler, Ann; Padulosi, Stefano; Hunter, Danny	2017	Tutwiler 2017

agricultural biodiversity: An interdisciplinary study			
Developing an integrated, sustainable urban food system: the case of New Jersey, United States.	Hamm, M. W.; Baron, M.	1999	Hamm 1999
Redirecting investment for a global food system that is sustainable and promotes healthy diets.	Morrison, J.; Bianchi, E.; Bowyer, C.; Vos, R.; Wellesley, L.	2018	Morrison 2018
Improving the school food environment through policy: a case study of challenges and recommendations from Mexico.	Macari, M.; Bahena, L.; Torres, F.; Berner, R.; Calvillo, A.	2019	Macari 2019
School lunches: getting healthy food on the menu in government-sponsored lunch programmes in the United States and Brazil	Feldman, Charles; Veiros, Marcela Boro; McGill, Tonya	2018	Feldman 2018
Biodiversity loss: we need to move from uniformity to diversity.	Frison, E. A.; Jacobs, N.	2019	Frison 2019
Identification of traditional food resources and their importance in a rural farming community in Southwestern Nigeria	Ejoh, S.I.; Akinyele, I.O.	2013	Ejoh 2013
Determining key research areas for healthier diets and sustainable food systems in Viet Nam.	Raneri, J. E.; Kennedy, G.; Trang Nguyen; Wertheim-Heck, S.; Haan, S. de; Ha Do; Nguyen Phuong; Le Thi Huong; Truong Tuyet Mai; Thanh Thi Duong; Nguyen Hung; Tuan Nguyen;	2019	Raneri 2019

	Tuyen Huynh; Nodari, G. R.; Spellman, O.; Talsma, E. F.; Stoian, D.; Minh Cam Duong; Lam Nguyen Tran; Bene, C.		
Current concepts and applied research in sustainable food processing.	Martindale, W.; Finnigan, T.; Needham, L.	2014	Martindale 2014
Food and nutrient gaps in rural Northern Ghana: Does production of smallholder farming households support adoption of food-based dietary guidelines?	de Jager, I.; Giller, K. E.; Brouwer, I. D.	2018	deJager 2018
The Role of Food Systems in Shaping Diets and Addressing Malnutrition: Delivering on the Sustainable Development Agenda	Hemrich, Gunter	2020	Hemrich 2020
Transforming food systems under climate change: local to global policy as a catalyst for change.	Rawe, T.; Antonelli, M.; Chatrchyan, A.; Clayton, T.; Fanzo, J.; Gonsalves, J.; Matthews, A.; Nierenberg, D.; Zurek, M.	2019	Rawe 2019
Unravelling the Food-Health Nexus to Build Healthier Food Systems	Yambi, Olivia; Jacobs, Nicholas; Rocha, Cecilia	2020	Yambi 2020
Moving obesity prevention to the non-health sector	Moodie, Marj; Carter, Rob; Swinburn, Boyd; Allender, Steve; Osborne, Richard; Lawrence, Mark	2013	Moodie 2013
Food systems for healthier diets in Ethiopia: toward a research agenda.	Mestawet Gebru; Remans, R.; Brouwer, I.; Kaleab Baye; Melesse, M. B.; Covic, N.; Fekadu Habtamu; Alem Hadera Abay;	2018	MestawetGebru 2018

	Tesfaye Hailu; Hirvonen, K.; Kassaye, T.; Kennedy, G.; Lachat, C.; Ferew Lemma; McDermott, J.; Minten, B.; Tibebu Moges; Fidaku Reta; Eneye Tadesse; Tamene Taye; Truebswasser, U.; Vandenberg, M.		
The Push, Pull, and Enabling Capacities Necessary for Legume Grain Inclusion into Sustainable Agri-Food Systems and Healthy Diets	Vasconcelos, Marta W.; Gomes, Ana M.; Pinto, Elisabete; Ferreira, Helena; Vieira, Evla D F; Martins, Ana P.; Santos, Carla S.; Balazs, Balint; Kelemen, Eszter; Hamann, Karen T.; Williams, Michael; Iannetta, Pietro P M	2020	Vasconcelos 2020

Not available

Title	Authors	Published Year	Study
Food policy, systems, and environment: strategies for making healthful food the easiest choice.	Tagtow, A.; Clancy, K.; Gussow, J.; Sanchez, E. J.; Story, M.; Wilkins, J. L.	2011	Tagtow 2011
Fruits and vegetables: a neglected wealth in developing countries.	Ganry, J.; Egal, F.; Taylor, M.	2011	Ganry 2011
Towards sustainable food systems: a holistic, interdisciplinary and systemic approach.	Moscatelli, S.; El-Bilali, H.; Gamboni, M.; Capone, R.	2016	Moscatelli 2016
Our quest for healthy diets: The role of nutrition scientists	Lartey, Anna	2017	Lartey 2017
Homeland security planning: what victory gardens and fidel castro can teach us in preparing for food crises in the United States.	Endres, A. B.; Endres, J. M.	2009	Endres 2009

How to do it better: Evidence and communications for healthy diets and sustainable agriculture and food systems	Kennedy, Gina	2017	Kennedy 2017
Are healthy diets really more expensive and How would potential policy changes impact affordability?	Lee, A.J.; Kane, S.	2016	Lee 2016
Econutrition within reach: A framework to assist decision-making in large-scale nutrition interventions	Fanzo, J.; Luckett, B.; Rose, D.; Clerck, F.D.	2013	Fanzo 2013
Local solutions for global target of sustainable food and nutrition.	Mohammadi-Nasrabadi, F.	2018	Mohammadi-Nasrabadi 2018
A keystone for sustainable development.	Defait, V.	2019	Defait 2019
The Development of a Provincial Food and Nutrition Strategy through Cross-Sector Collaboration	Roblin, Lynn; Truscott, Rebecca; Boddy, Meaghan R.	2018	Roblin 2018
New approaches in securing more sustainable urban food futures: case from Cologne-Bonn region.	Heuschkel, Z.; Hirsch, D.; Terlau, W.; Lorleberg, W.	2018	Heuschkel 2018
How Can Dietitians Leverage Change for Sustainable Food Systems in Canada?	Carlsson, Liesel; Broman, Goran; Callaghan, Edith	2019	Carlsson 2019

Duplicate

Title	Authors	Published Year	Study
Special Issue: Sustainable food systems for healthy diets in Europe and Central Asia.	Dupouy, E., & Gurinovic, M. (2020). Sustainable food systems for healthy diets in Europe and Central Asia: Introduction to	2020	Dupouy 2015

	the special issue. Food Policy, 96, 101952.		

N2 - Budget Allocation for RPPO Across Selected Chilean Ministries in 2021.

Ministry	**Program**	**Budget 2021 (kMM CLP)**
Social Development and Family (n=8)	Local Action (Ex - Comprehensive Intervention in Vulnerable Territories - More Territory)	$894.00
	Support for Families for Self-Consumption	$3.10
	Center for Children of Seasonal Primary Caregivers	$457.00
	Indigenous Development Fund - Support for Acquired and Transferred Lands	$2.76
	Indigenous Land and Water Fund - Subsidy for the Construction of Irrigation and Drainage Works for Indigenous People	$18.00
	Indigenous Land and Water Fund - Subsidy for the Acquisition of Water Rights by Indigenous People	$2.14
	ELEAM Subsidy Fund	$8.14
	Habitability	$15.04
Agriculture (n=12)	INDAP-PRODEMU Agreement (Rural Women's Program)	$3.14
	Supervision of regulations under the jurisdiction of SAG	$6.44
	Agricultural Program for the Integral Development of Small Farmers in the Dryland Region of Coquimbo (PADIS)	$3.43
	Productive Alliances Program	$4.23
	Support Program for Research for Agri-food and Forestry Competitiveness	$188.00
	Economic Associativity Program (PAE)	$1.81
	Local Action Development Program (PRODESAL) - Consulting and Investments	$38.86
	Indigenous Territorial Development Program INDAP-CONADI (PDTI)	$35.06
	Incentive Program for Private Investment in Irrigation and Drainage Works - Law No. 18.450 (Minor and medium-sized works)	$123.39
	Irrigation Program	$21.10

	Incentives System for Agro-environmental Sustainability of Agricultural Soils (SIRSD-S)	$8.16
	Agro-environmental Sustainability Incentives System for Agricultural Soils SIRSD-S Law 20.412	$21.35
Health (n=8)	Healthy Child Check-ups in Educational Establishments	$1.27
	Choose Healthy Living (Ex Healthy Life)	$11.27
	Complementary Feeding Program for the Elderly (PACAM)	$23.61
	Program for Environmental Surveillance and Inspection for Rural Population Protection	$373.00
	Food Environment Surveillance and Inspection Program	$589.00
	Healthy Eating and Physical Activity Program for Elige Vivir Sano - Health Families.	$499.00
	National Complementary Feeding Program (PNAC)	$37.75
	Protected Residences and Homes Program	$10.94
Education (n=7)	Higher Education Feeding Scholarship	$197.24
	Patagonia Aysén Scholarship	$6.06
	Student Homes and Residences	$6.60
	Classic Kindergarten Direct Administration	$132.76
	Classic Kindergarten VTF Administration	$310.96
	School Feeding Program	$728.80
	Obesity Pilot Program	$559.00

N3 - Budget Allocation for APPO Across Selected Chilean Ministries in 2021.

Ministry	Program	Budget 2021 (kMM CLP)
Social Development and Family (n=16)	Abriendo Caminos - SSyOO	$6.40
	Access to Microcredit	$1.00
	Support for People Living on the Street - SSyOO	$5.46
	Biopsychosocial Development Support - ChCC	$20.45
	Comprehensive Support for the Elderly Vínculos - SSyOO	$10.54
	Woman's Work Bonus	$44.92
	Chile Indígena (Phase II)	$7.24
	Condominium of Supervised Housing for the Elderly	$992.00
	Financial Education	$441.00
	Financial Education for Children	$441.00
	Indigenous Development Fund - Promotion of Indigenous Economy	$2.50
	Kume Mognen Pu Zomo - Quality of Life and Self-Care	$218.00
	Indigenous Micro-entrepreneurship (ex Urban Indigenous Micro-entrepreneurship Generation)	$511.00
	Family Program - SSyOO	$28.30
	I Undertake	$9.83
	I Undertake Seed	$20.19
Agriculture (n=3)	Financial Incentive - FIA	$6.82
	National Program for Technological Transfer and Extension (INIA)	$1.19
	Protected Wild Areas	$17.63
Health (n=1)	Home Care for People with Severe Dependence	$655.00
Women and Gender Equality (n=3)	Surveillance and Control Program for Population Exposed to Contaminants PECA	$45.00
	DIR APS Program Alcohol, Tobacco and Other Drugs (Ex Healthy Life - Alcohol)	$2.78
	Woman Entrepreneurs (Ex Women Associativity and Entrepreneurship)	$254.00
Education (n=12)	Aysen Scholarship	$2.27
	Support Scholarship for School Retention (Secondary Education Program)	$1.22
	Support Scholarship for Students of the University of the Sea	$100.00

	Vocational Teacher Support Scholarship	$577.00
	Maintenance Scholarship for Higher Education	$3.32
	Indigenous Scholarship	$32.43
	Territorial Integration Scholarship (Special Program Scholarship Art. 56 Law No. 18.681)	$3.88
	Magallanes Scholarship	$1.97
	Polymetals Arica Scholarship	$962.00
	President of the Republic Scholarship	$30.21
	Professional Practice Bonus, Technical Professional Secondary Education	$3.17
	Healthy Schools for Learning	$2.33

N4 – Ch4 HERC approval.

THE UNIVERSITY of EDINBURGH
The Royal (Dick) School of Veterinary Studies

Human Ethical Review Committee (HERC)

Royal (Dick) School of Veterinary Studies

The University of Edinburgh

Roslin

EH25 9RG

Email HERC.vets@ed.ac.uk

16 July 2024

Dear Martín

HERC Reference: HERC_2022_148

Full name of applicant: Martín del Valle Menéndez

Study title: Enhancing Food Security through Data Insights: Exploring how Household Dietary Diversity Score and Spatial Visualization in Chilean vulnerable population can inform food governance

Ethical Opinion

The Committee can give a favourable ethical opinion of the above research on the basis described in the application form and supporting documentation (reviewed 31 Oct 2022).

You may proceed with this research only on the basis that it conforms to the description you provided and the assurances you made in your application and the amendment of 11 and 15 July 2024. If you undertake research that deviates in any significant way from the application you submitted, that research needs to be reviewed/considered by HERC before proceeding. If, following the receipt of this letter, you find that you want or need to change your methods and/or materials in any significant way, or where there have been any serious incidents you must submit a revised application and/or notify HERC by email.

With HERC's best wishes for the success of this project.

Yours sincerely

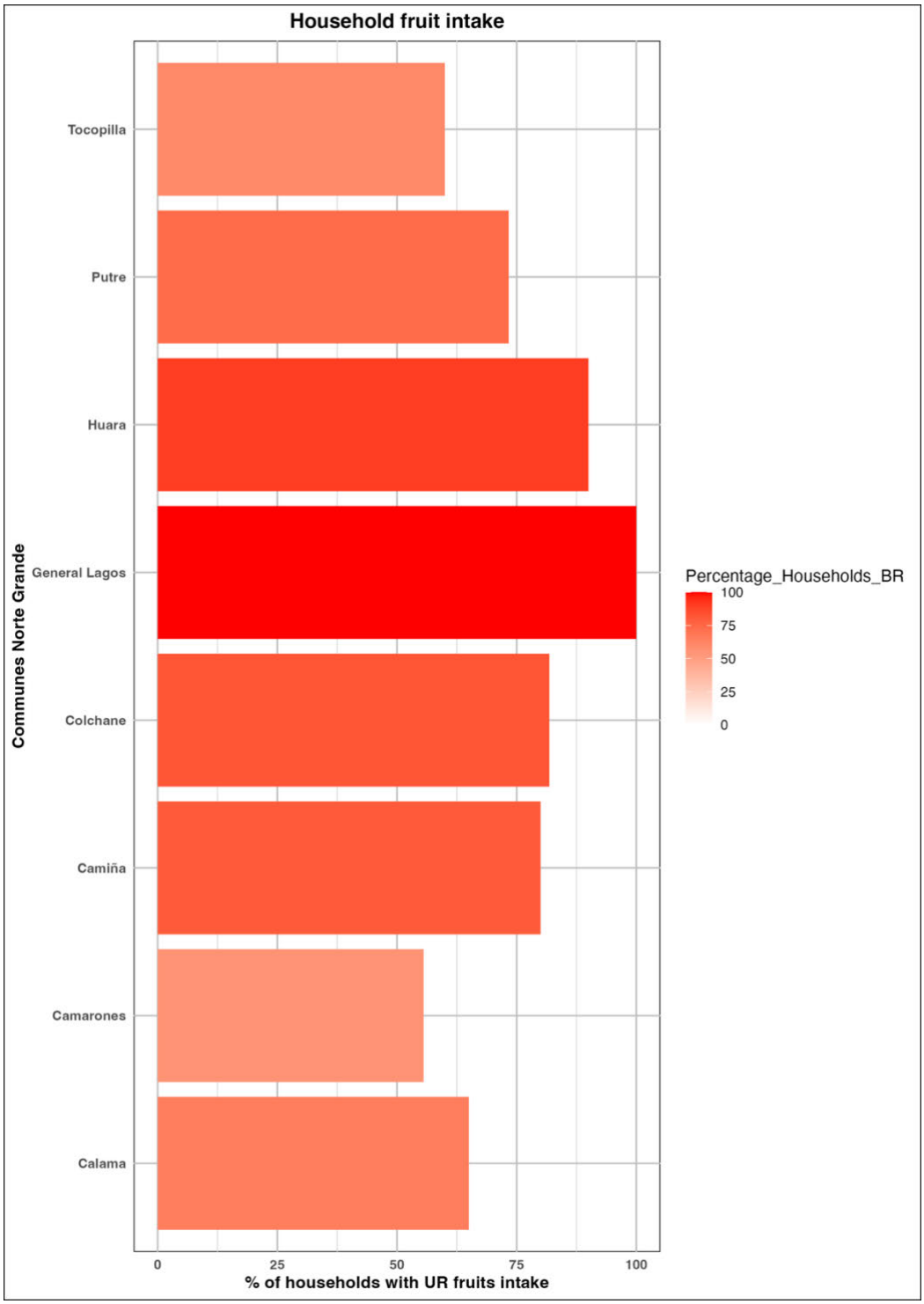
Human Ethical Review Committee (HERC)

N5 - Intake of different food groups in Chilean vulnerable households.

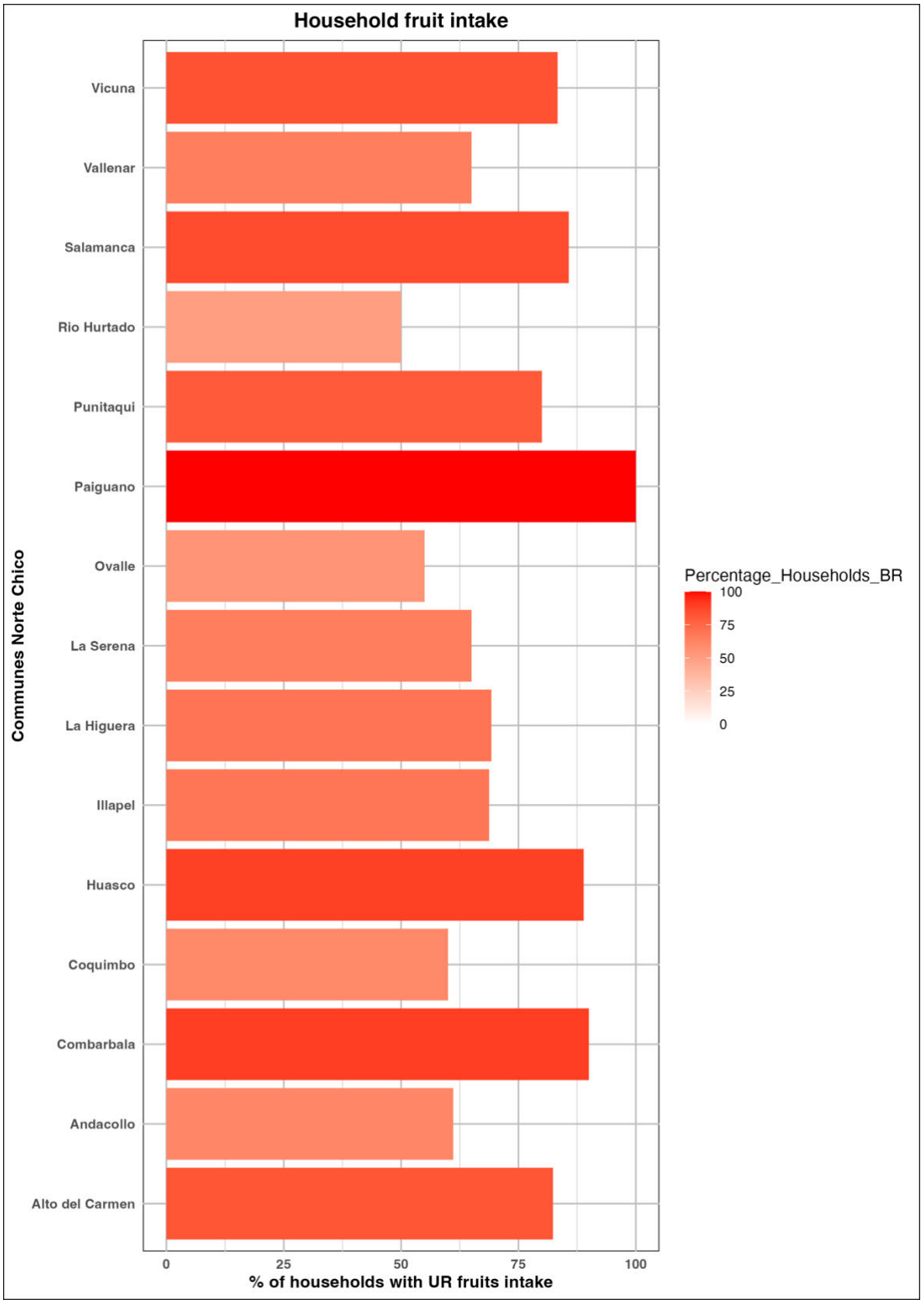
Number of households								
Food group	**Below recommended**	**Recommended**	**Above recommended**	**Weekly intake**				
				Never	**Sometimes**	**1-2/week**	**3-5/week**	**Everyday**
Vegetables	2,111	1,936	-	2	130	604	1,226	2,085
Fruit	2,658	1,389	-	14	354	941	1,289	1,449
Dairy	2,639	1,408	-	101	538	860	1,078	1,470
Legumes	764	3,282	1	57	398	2,879	663	50
White meat	683	3,302	62	20	623	2,050	1,291	63
Red meat	1,237	2,272	538	117	1,136	2,245	468	81
Eggs	456	3,038	553	42	406	1,292	1,727	580
Water	572	3,475	-	19	33	70	156	3,769
Cereals	350	3,690	7	3	61	685	1,103	2,195
Bread	321	3,724	2	4	21	51	111	3,860
Fat	253	2,147	1,647	349	1,928	926	445	399
Sugar	248	2,091	1,708	386	1,814	783	446	618

N6 - Communes with more than 50% of households below/above recommended for each food group across the different Chilean Macro-zone.

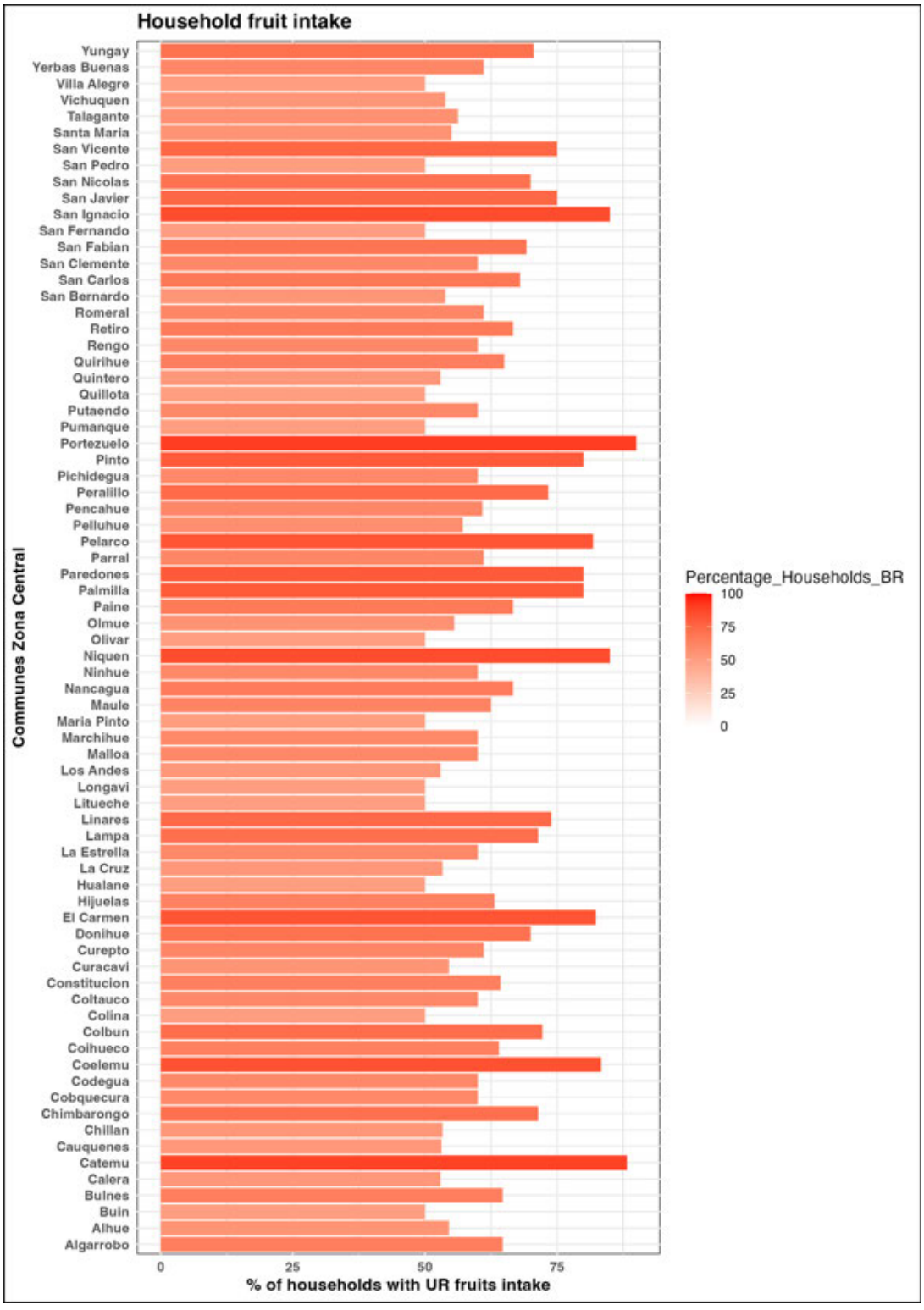
1. Fruits
    a. Norte Grande



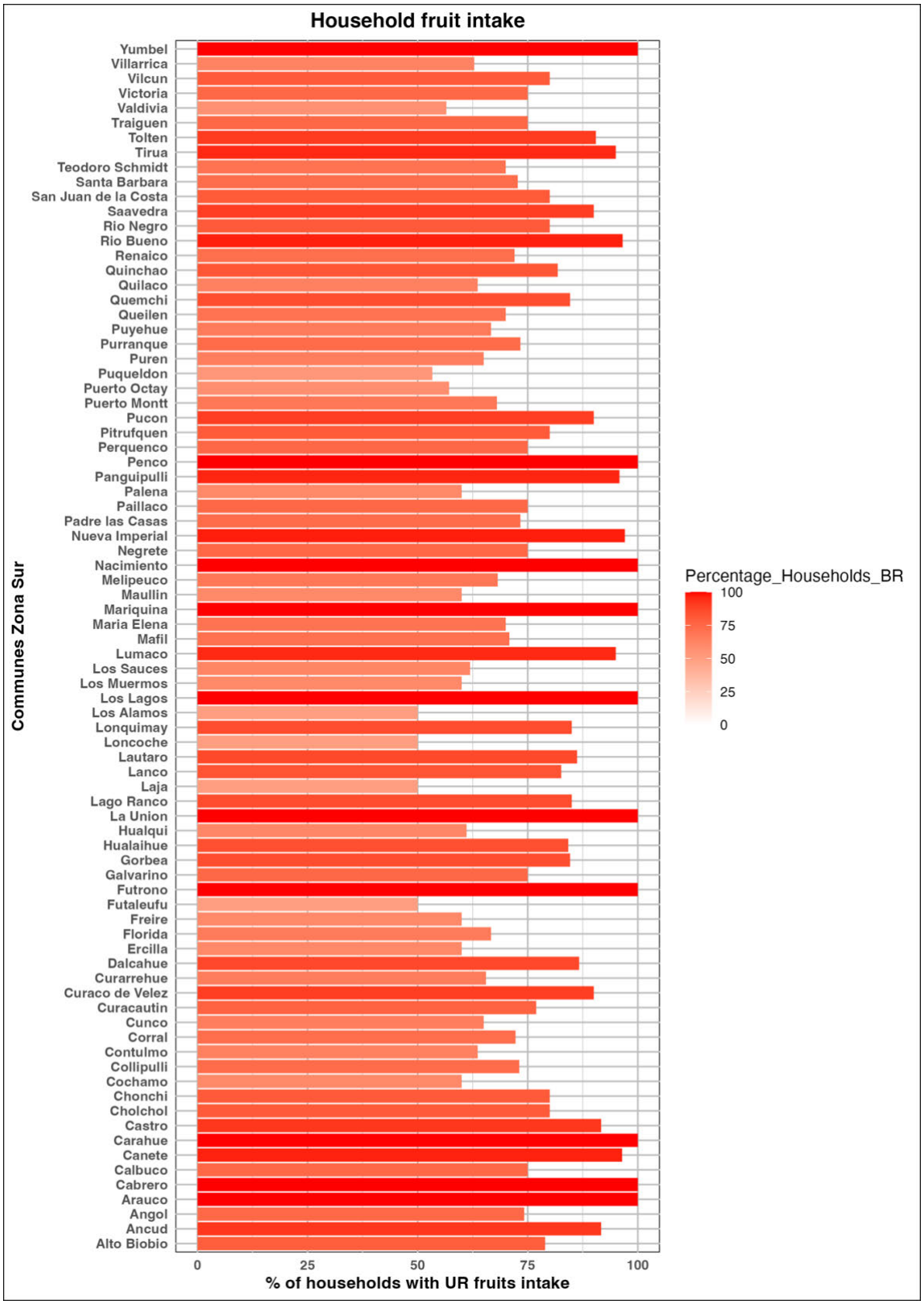
    b. Norte Chico



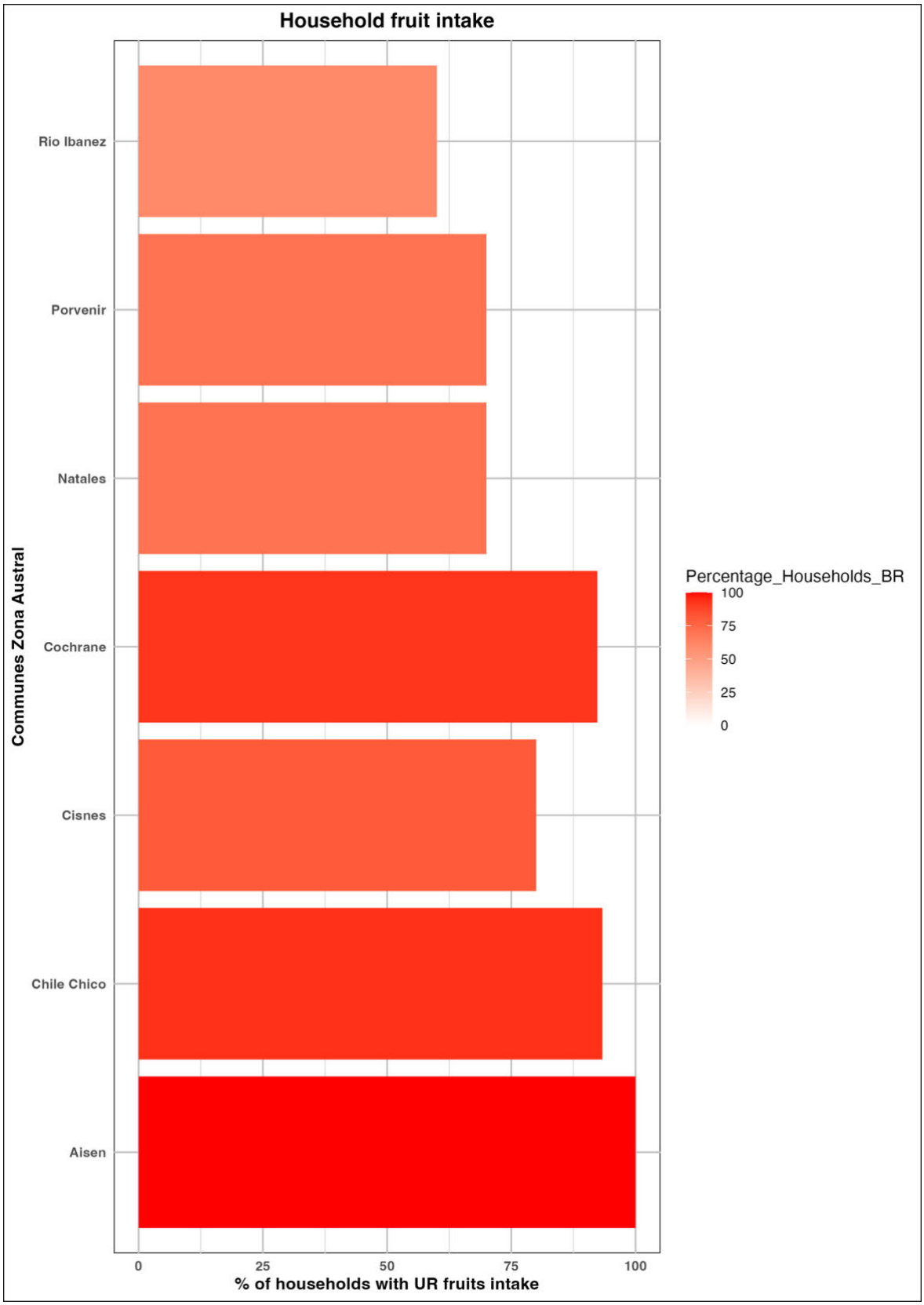
c. Zona Central


Household fruit intake
Communes Zona Central
Yungay
Yerbas Buenas
Villa Alegre
Vichuquen
Talagante
Santa Maria
San Vicente
San Pedro
San Nicolas
San Javier
San Ignacio
San Fernando
San Fabian
San Clemente
San Carlos
San Bernardo
Romeral
Retiro
Rengo
Quirihue
Quintero
Quillota
Putaendo
Pumanque
Portezuelo
Pinto
Pichidegua
Peralillo
Pencahue
Pelluhue
Pelarco
Parral
Paredones
Palmilla
Paine
Olmue
Olivar
Niquen
Ninhue
Nancagua
Maule
Maria Pinto
Marchihue
Malloa
Los Andes
Longavi
Litueche
Linares
Lampa
La Estrella
La Cruz
Hualane
Hijuelas
El Carmen
Donihue
Curepto
Curacavi
Constitucion
Coltauco
Colina
Colbun
Coihueco
Coelemu
Codegua
Cobquecura
Chimbarongo
Chillan
Cauquenes
Catemu
Calera
Bulnes
Buin
Alhue
Algarrobo
0
25
50
75
% of households with UR fruits intake
Percentage_Households_BR
100
75
50
25
0

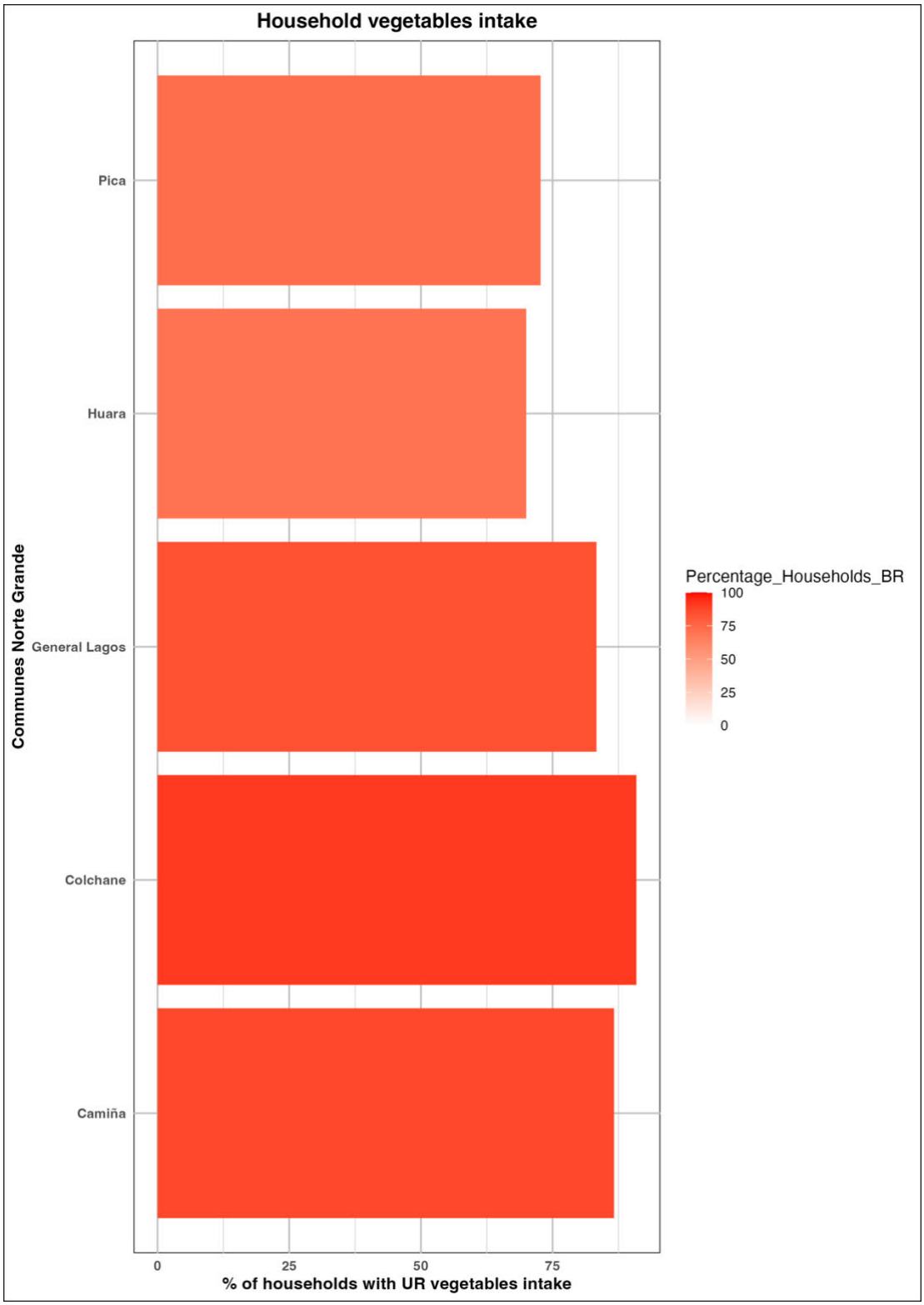
d. Zona Sur



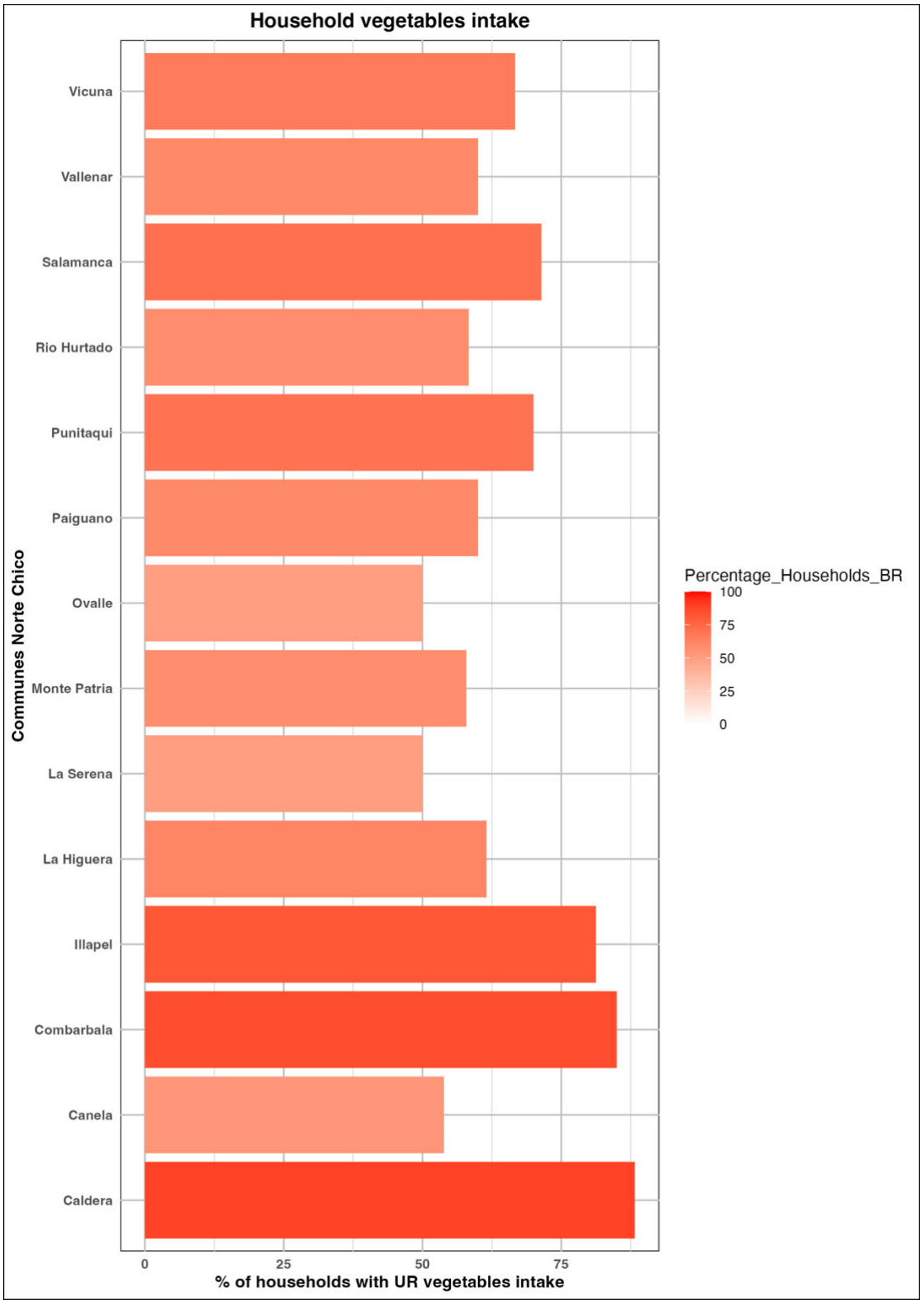
e. Zona Austral



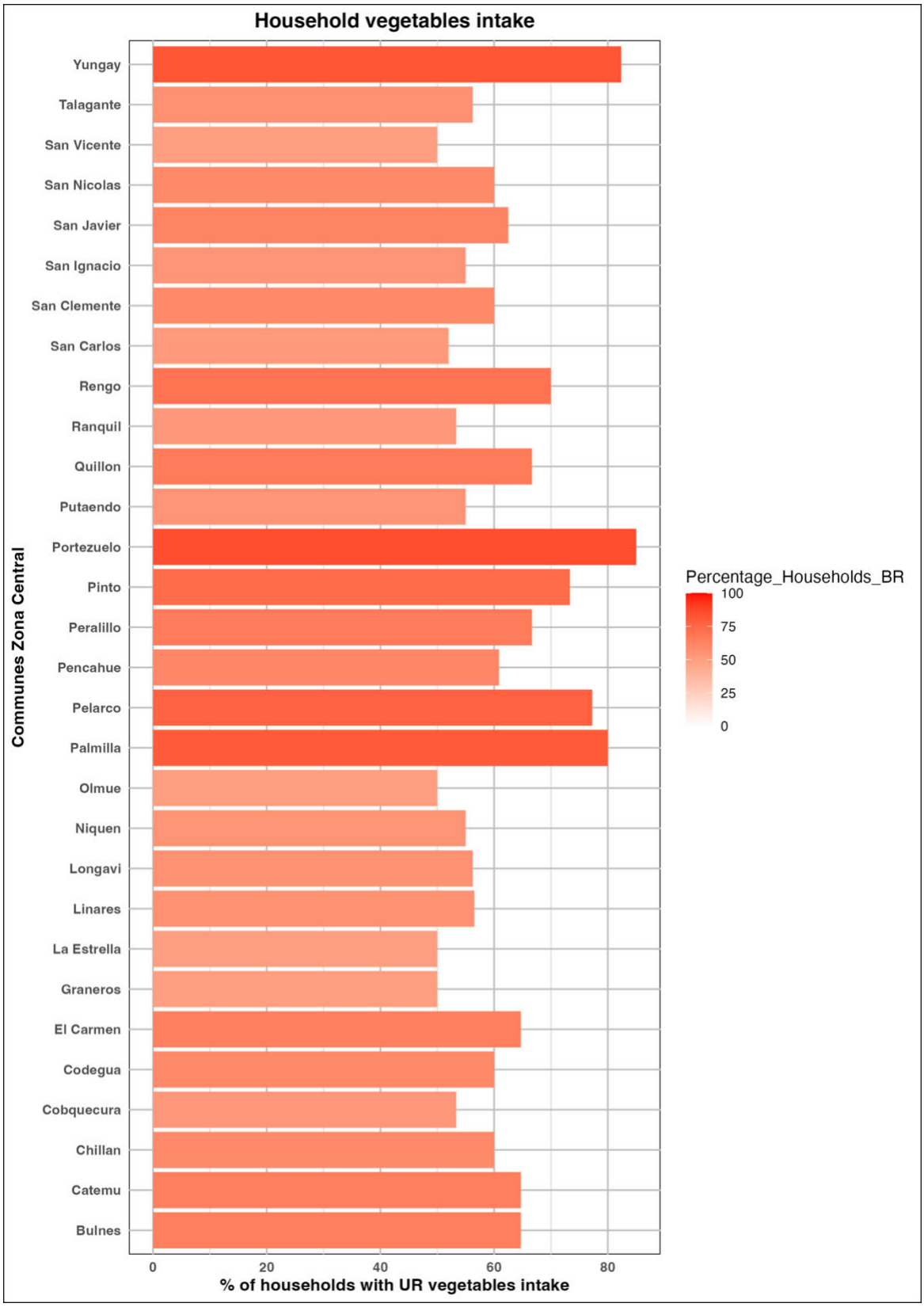
2. Vegetables
    a. Norte Grande



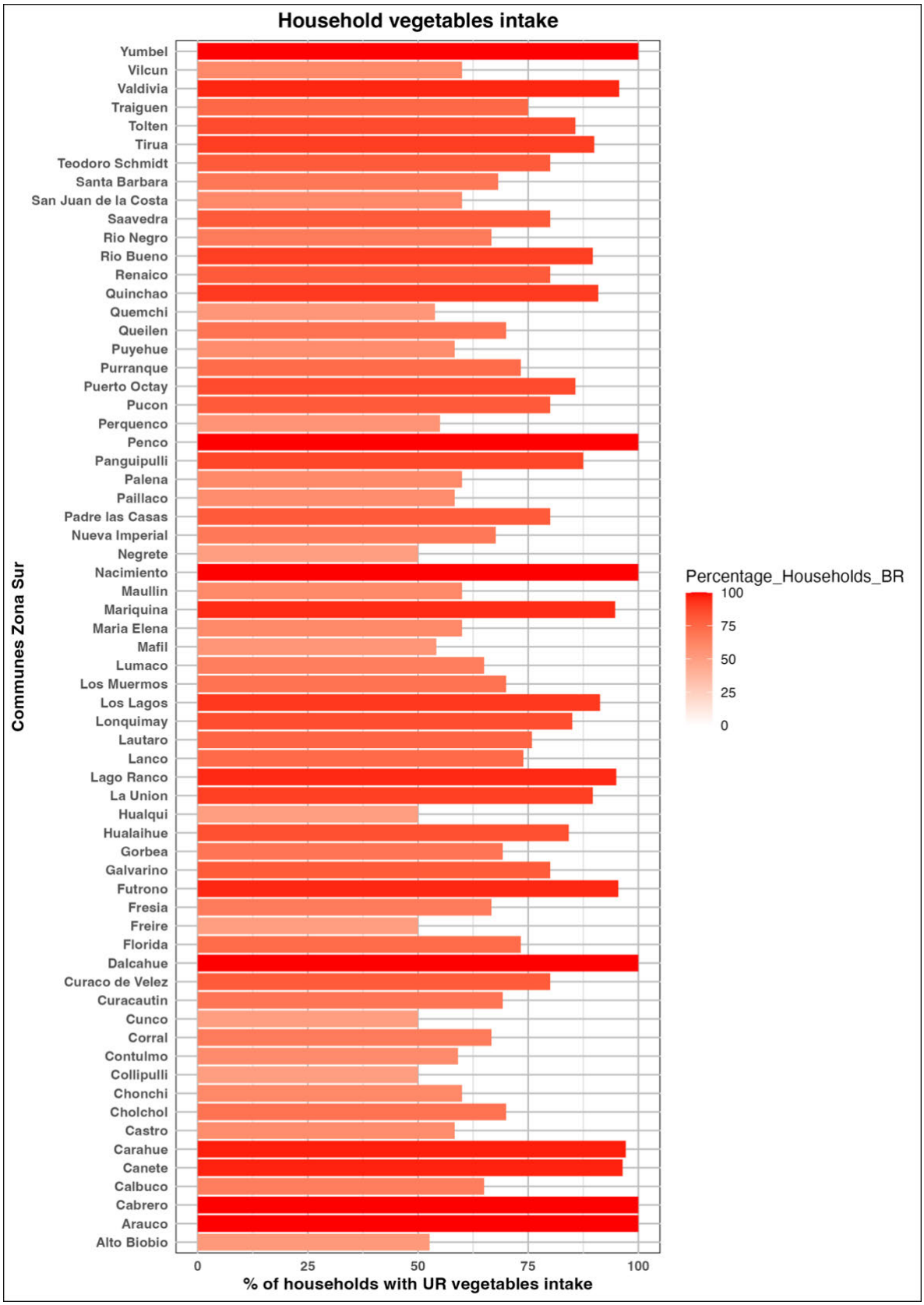
b. Norte Chico



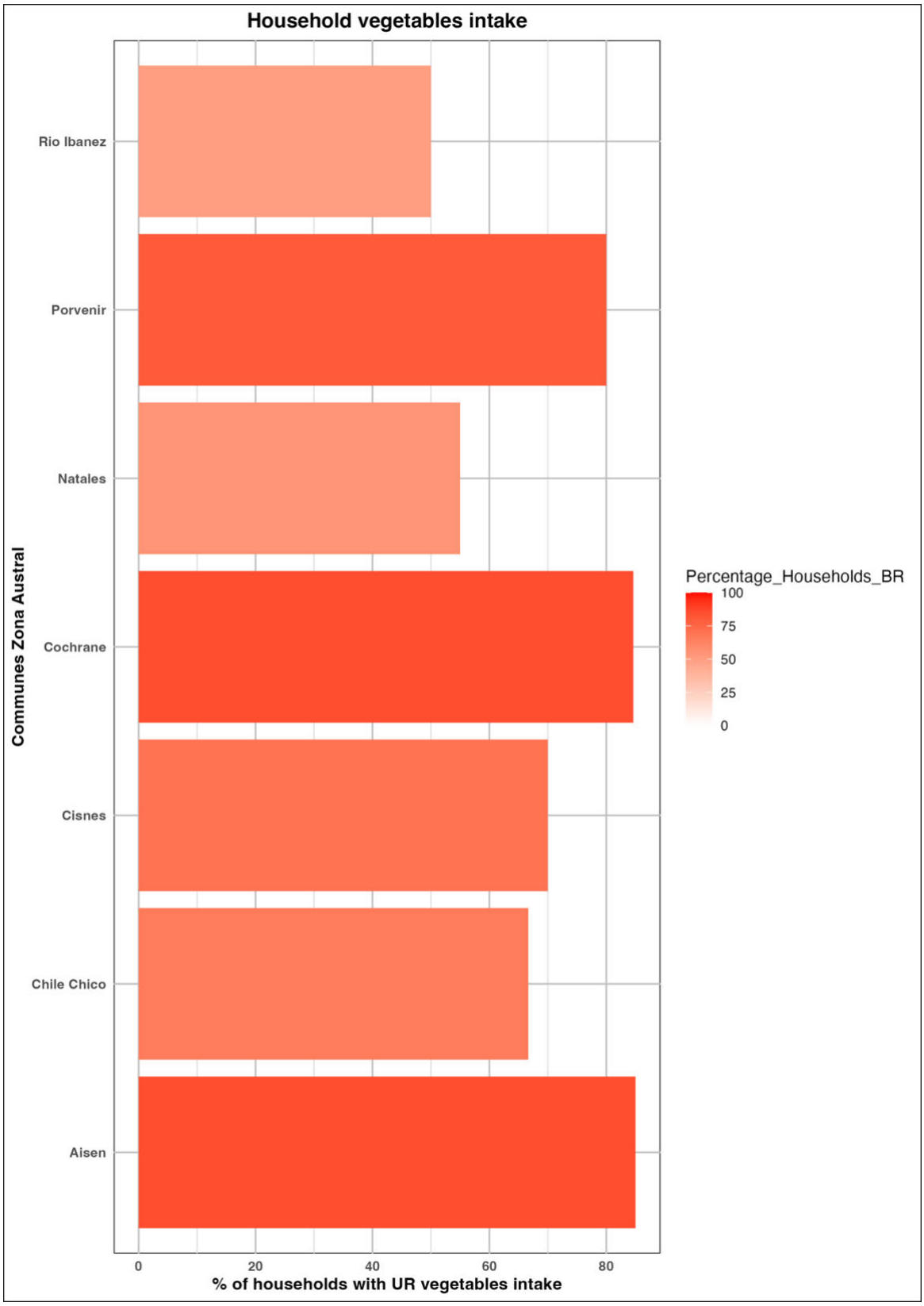
c. Zona Central


Household vegetables intake
Yungay
Talagante
San Vicente
San Nicolas
San Javier
San Ignacio
San Clemente
San Carlos
Rengo
Ranquil
Quillon
Putaendo
Portezuelo
Pinto
Peralillo
Pencahue
Pelarco
Palmilla
Olmue
Niquen
Longavi
Linares
La Estrella
Graneros
El Carmen
Codegua
Cobquecura
Chillan
Catemu
Bulnes
Communes Zona Central
0
20
40
60
80
% of households with UR vegetables intake
Percentage_Households_BR
100
75
50
25
0

d. Zona Sur

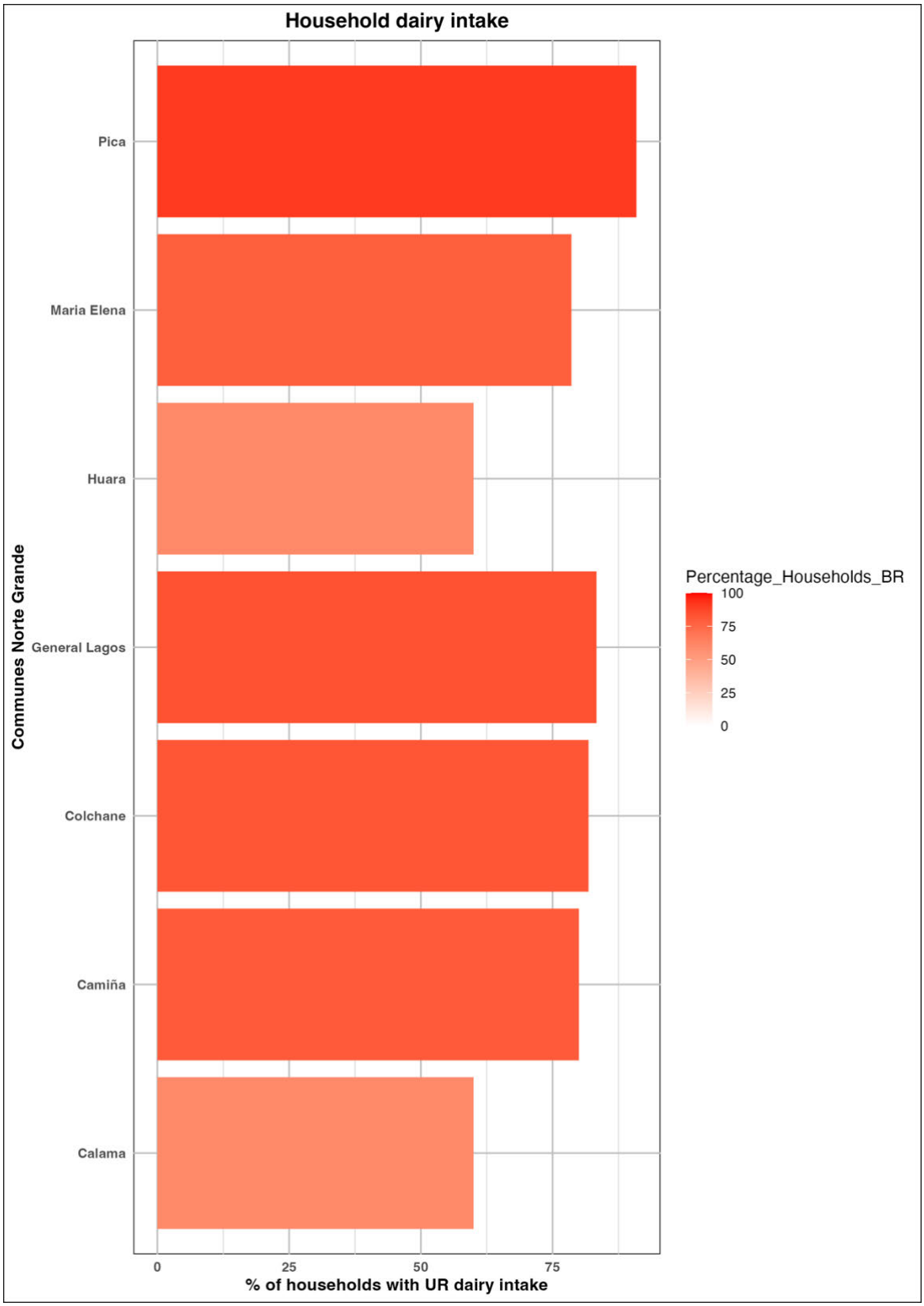


e. Zona Austral

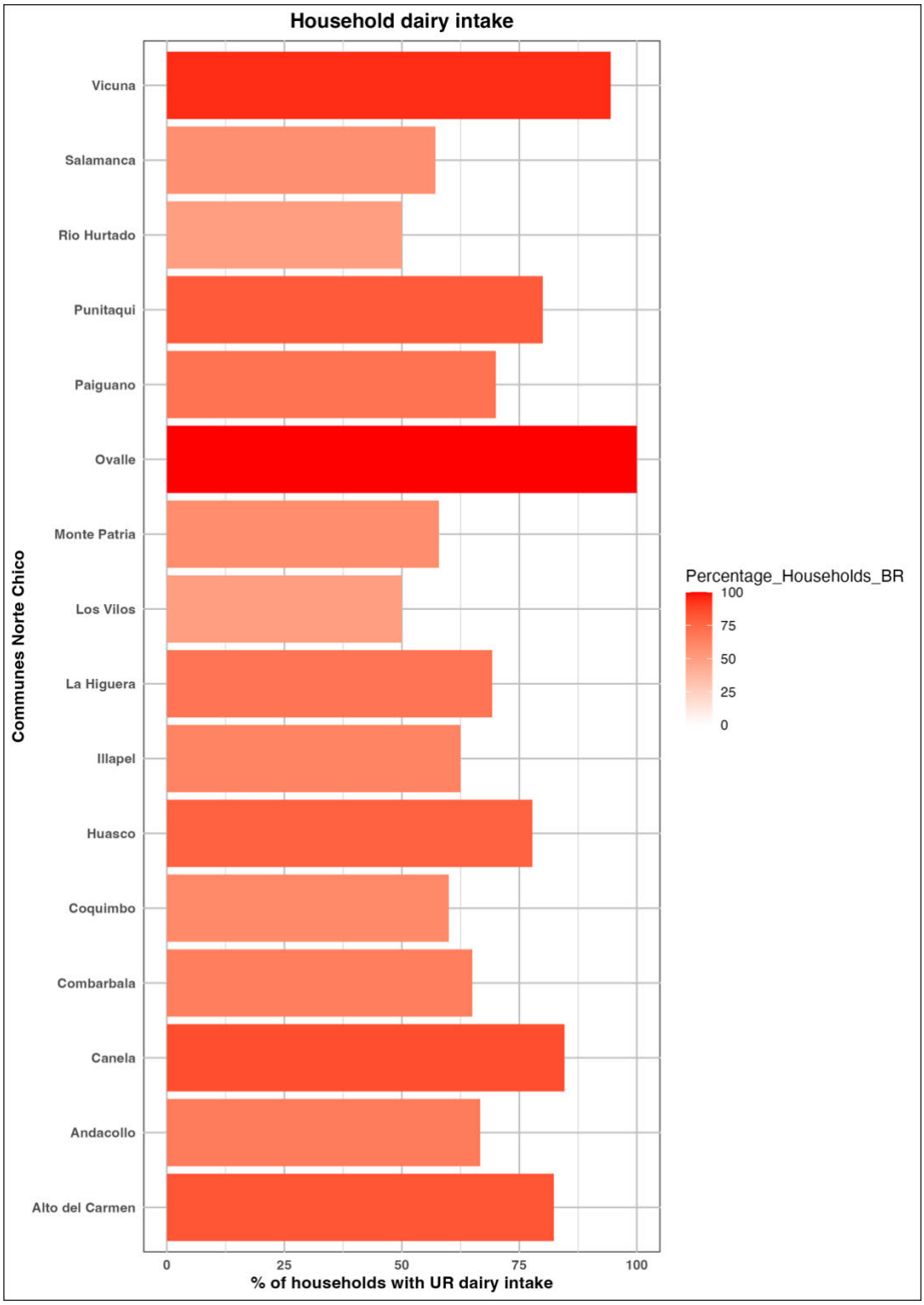

Household vegetables intake
Rio Ibanez
Porvenir
Natales
Cochrane
Cisnes
Chile Chico
Aisen
Communes Zona Austral
0
20
40
60
80
% of households with UR vegetables intake
Percentage_Households_BR
100
75
50
25
0

3. Dairy

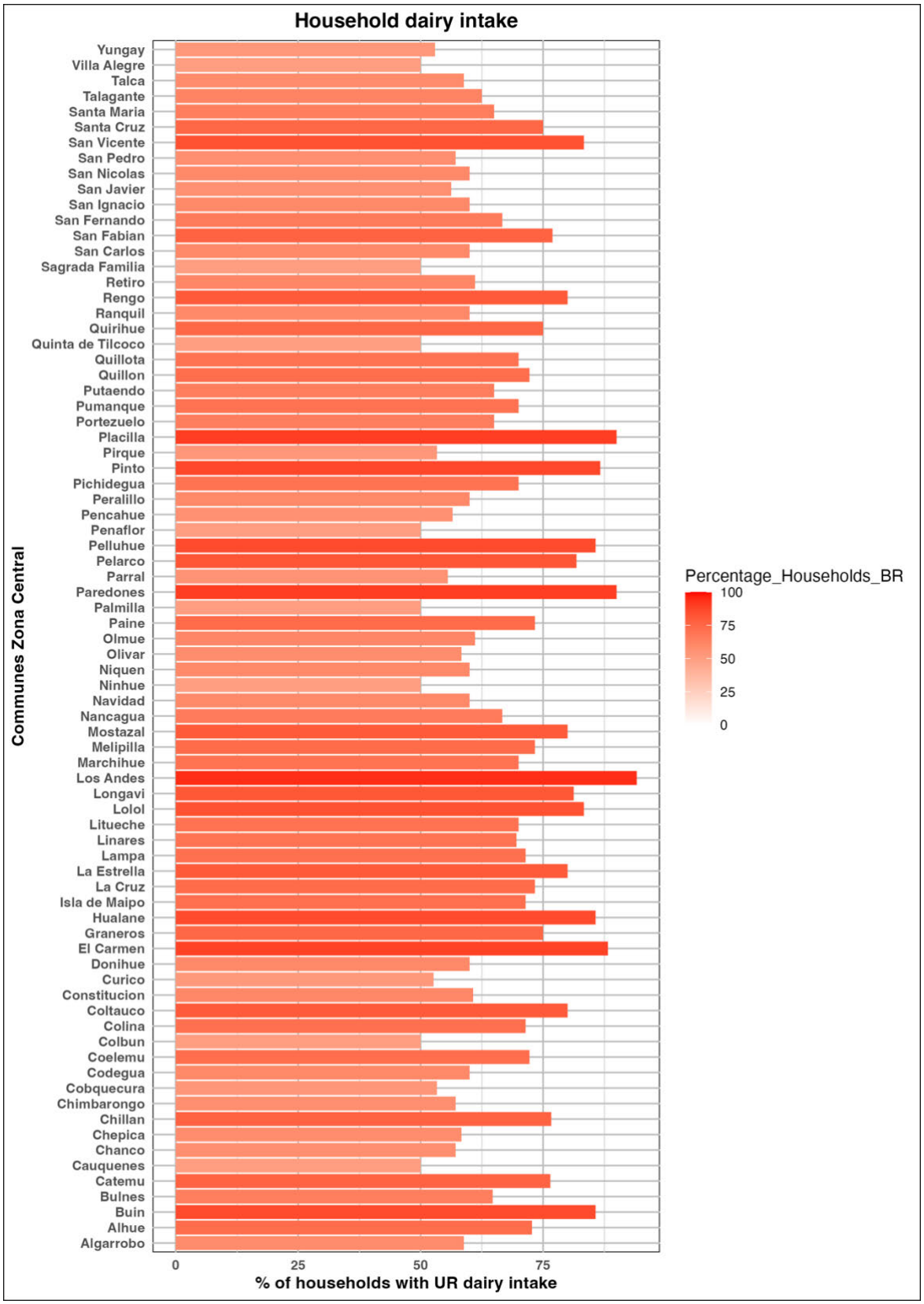
a. Norte Grande



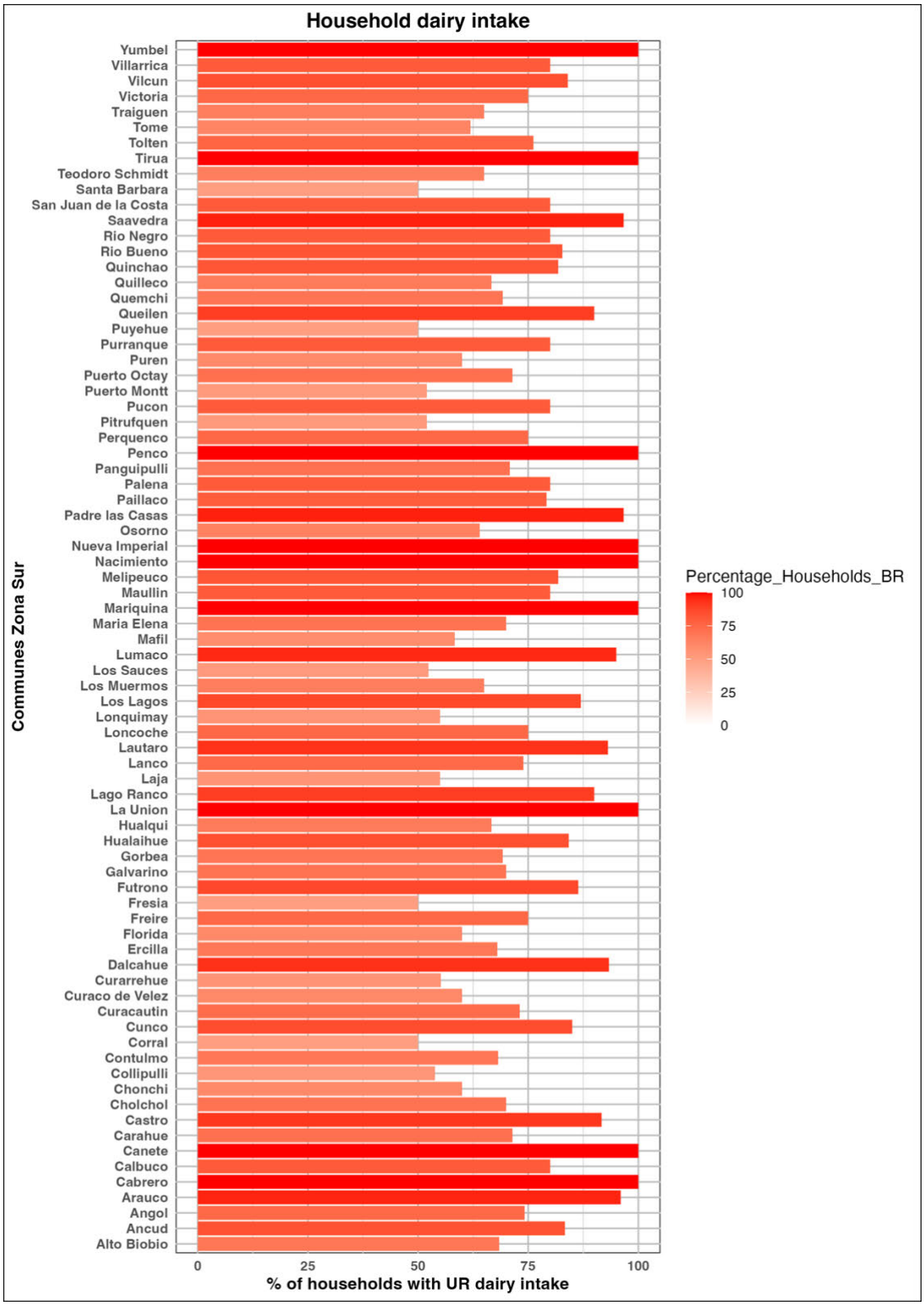
b. Norte Chico



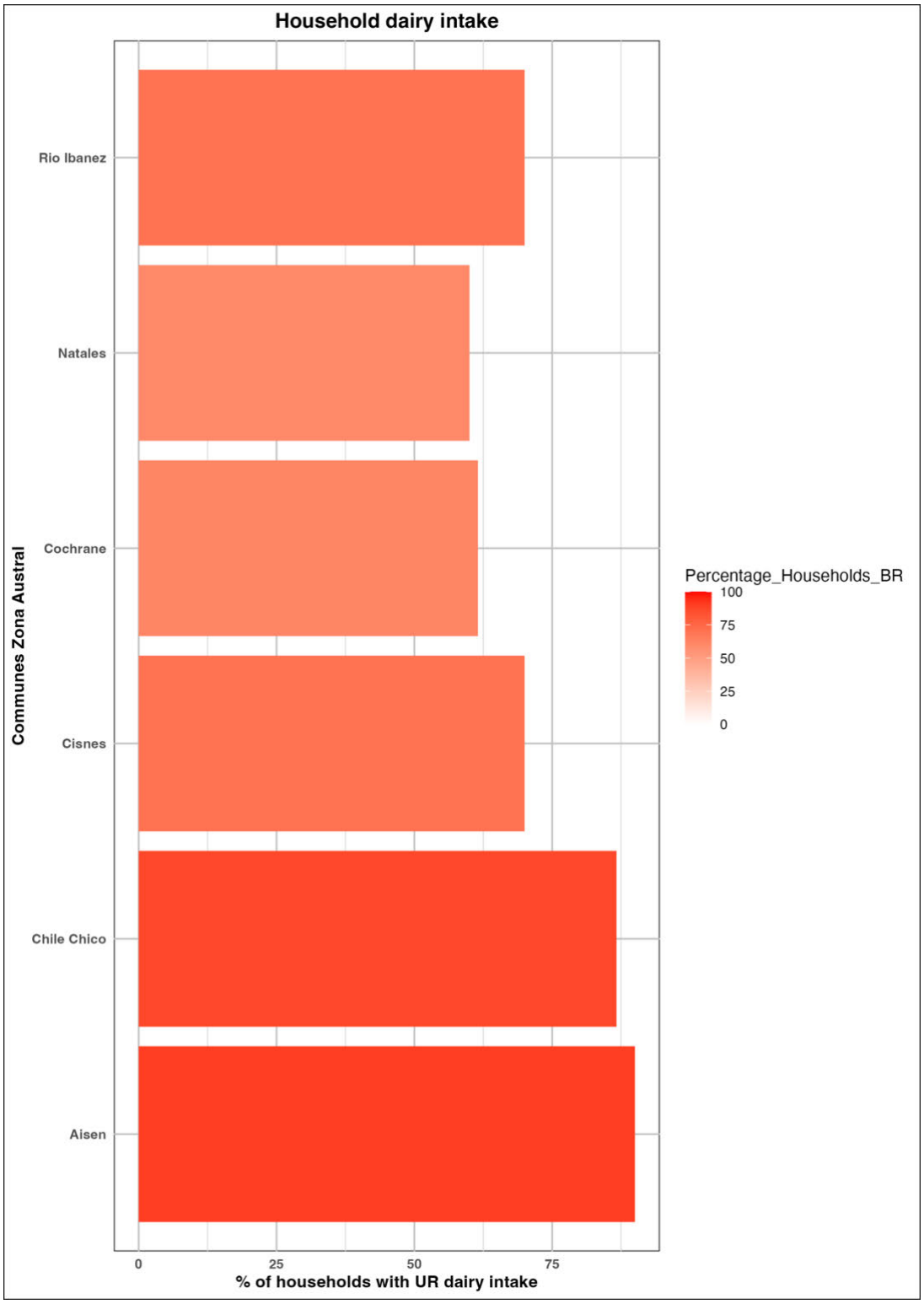
c. Zona Central


Household dairy intake
Communes Zona Central
Yungay
Villa Alegre
Talca
Talagante
Santa Maria
Santa Cruz
San Vicente
San Pedro
San Nicolas
San Javier
San Ignacio
San Fernando
San Fabian
San Carlos
Sagrada Familia
Retiro
Rengo
Ranquil
Quirihue
Quinta de Tilcoco
Quillota
Quillon
Putaendo
Pumanque
Portezuelo
Placilla
Pirque
Pinto
Pichidegua
Peralillo
Pencahue
Penaflor
Pelluhue
Pelarco
Parral
Paredones
Palmilla
Paine
Olmue
Olivar
Niquen
Ninhue
Navidad
Nancagua
Mostazal
Melipilla
Marchihue
Los Andes
Longavi
Lolol
Litueche
Linares
Lampa
La Estrella
La Cruz
Isla de Maipo
Hualane
Graneros
El Carmen
Donihue
Curico
Constitucion
Coltauco
Colina
Colbun
Coelemu
Codegua
Cobquecura
Chimbarongo
Chillan
Chepica
Chanco
Cauquenes
Catemu
Bulnes
Buin
Alhue
Algarrobo
0
25
50
75
% of households with UR dairy intake
Percentage_Households_BR
100
75
50
25
0

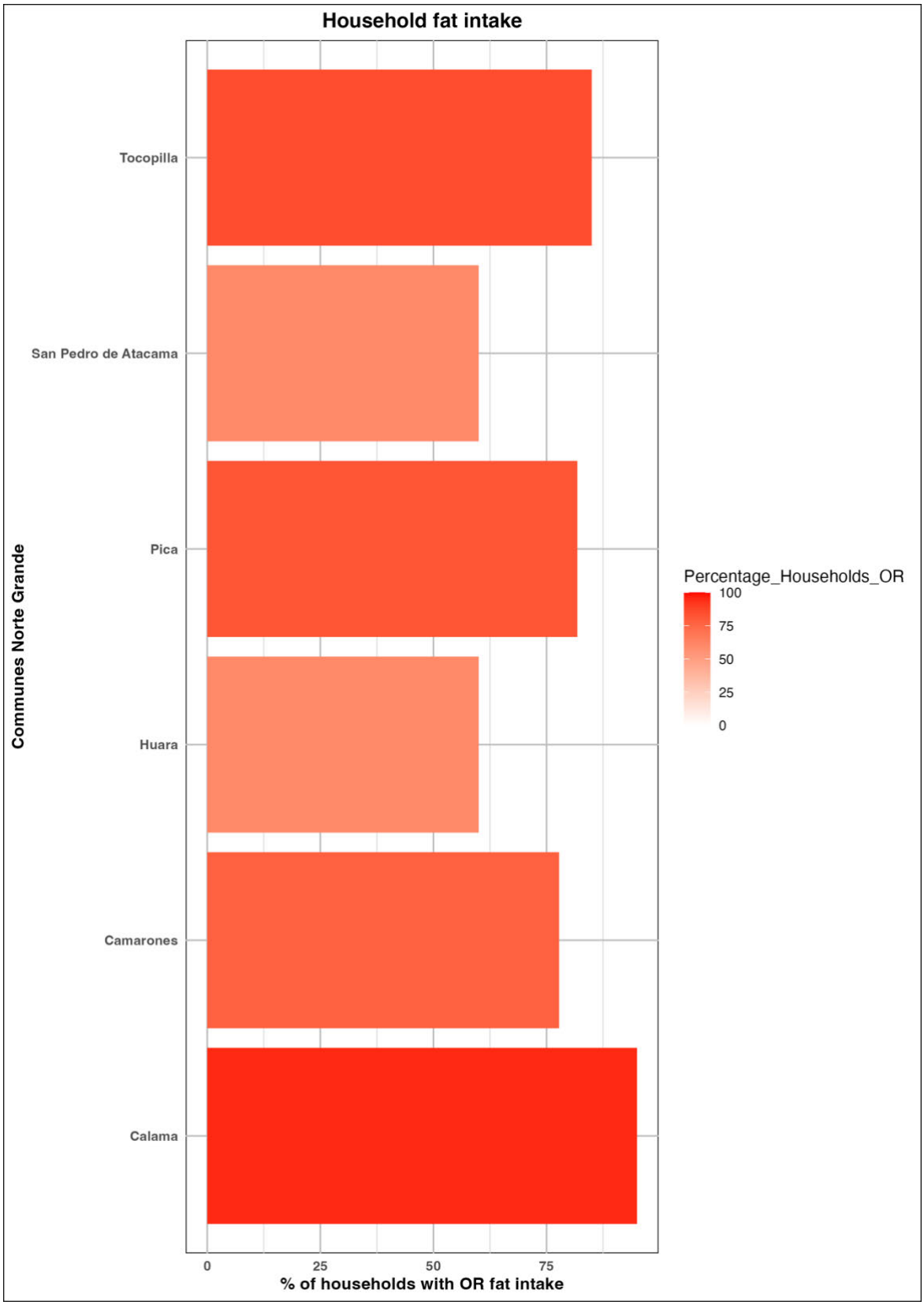
d. Zona Sur



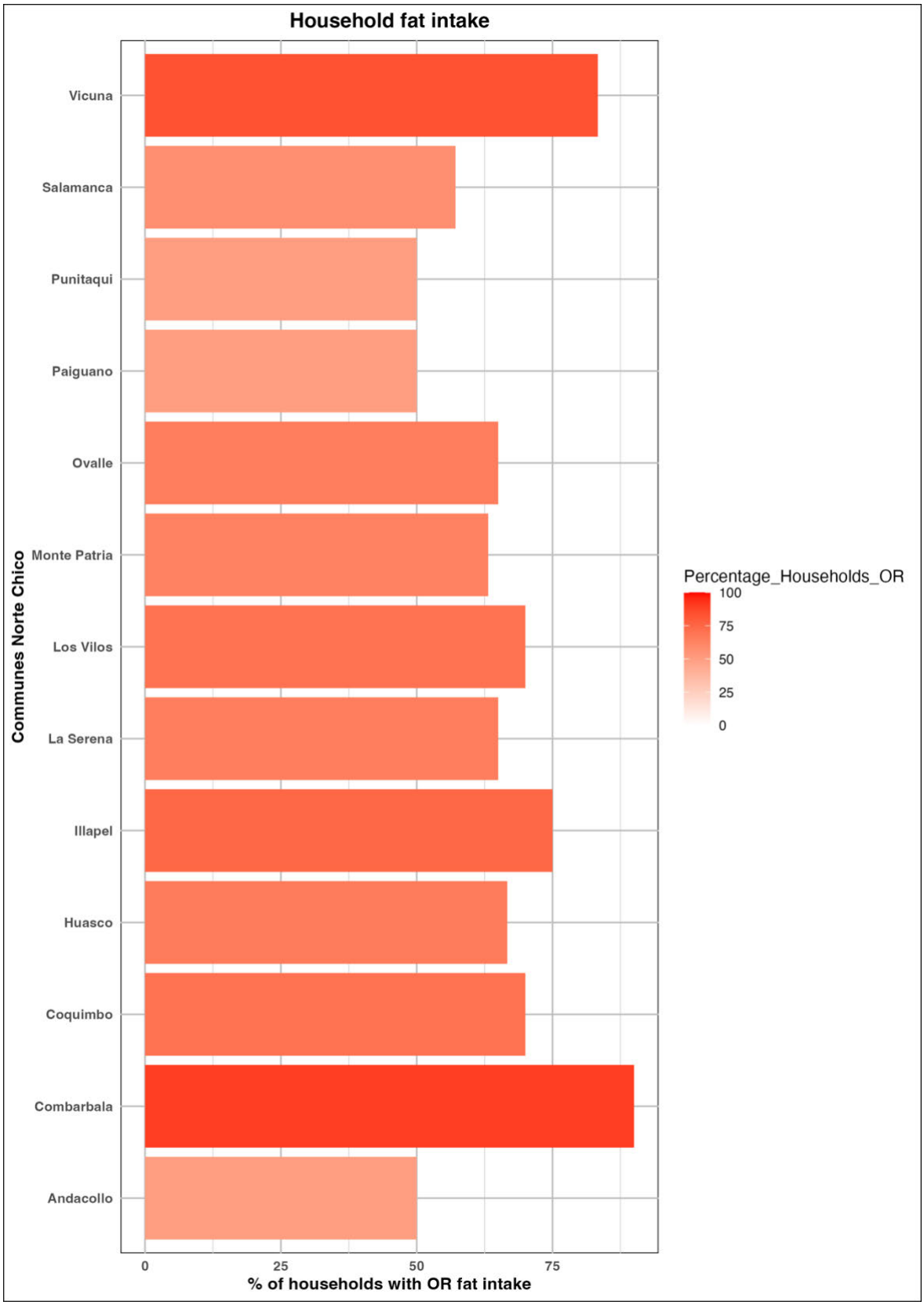
e. Zona Austral



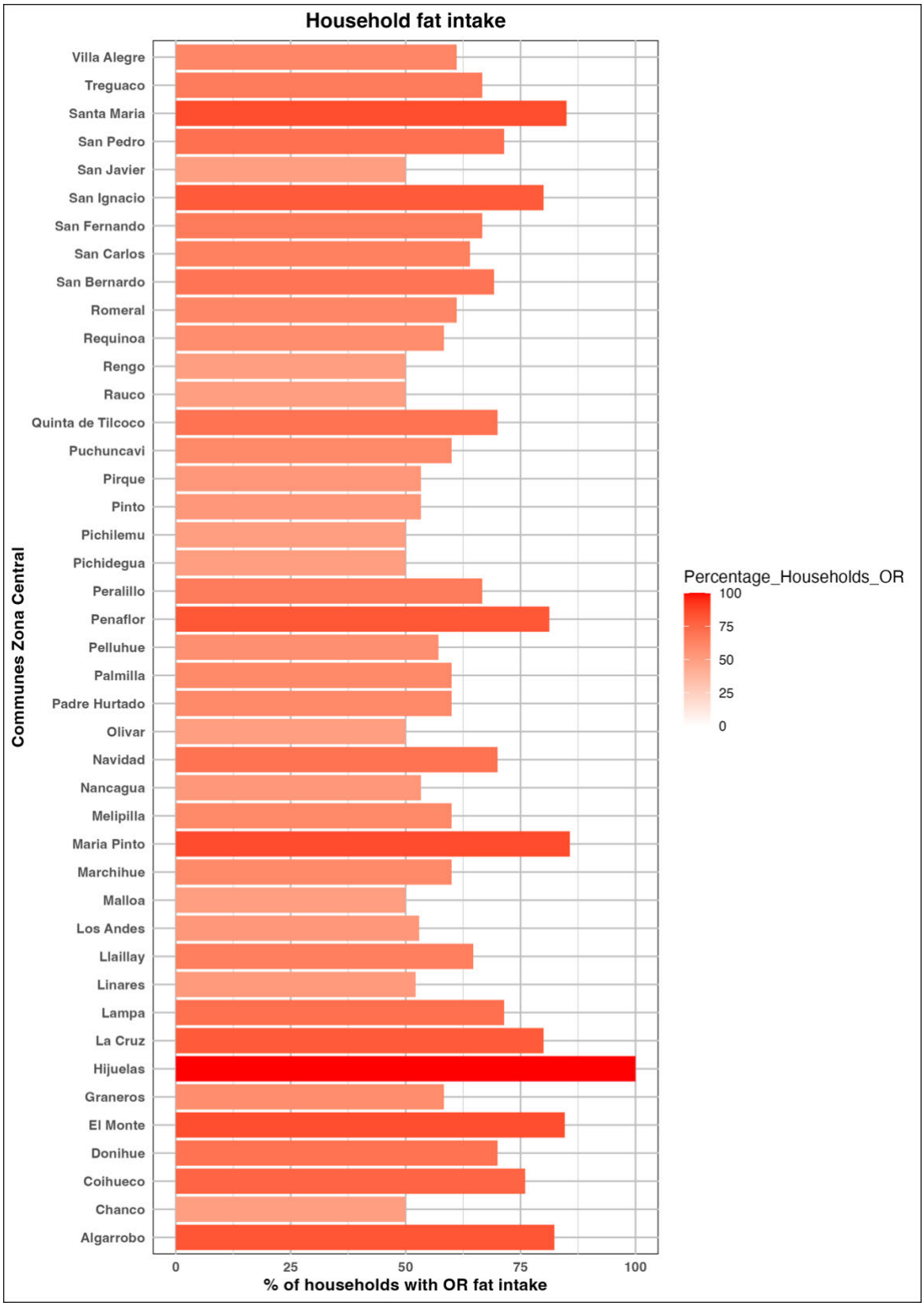
4. Fat
    a. Norte Grande



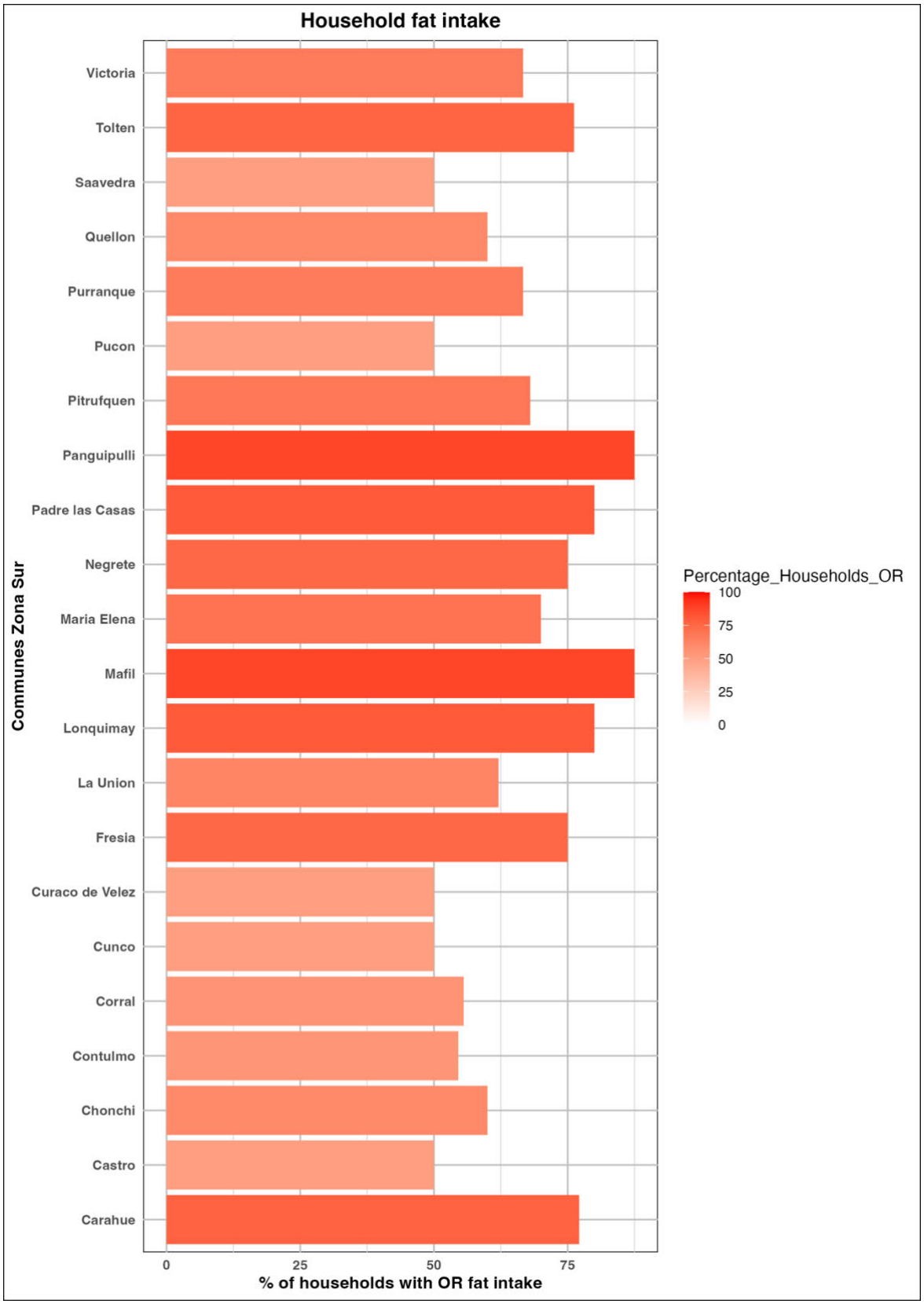
b. Norte Chico



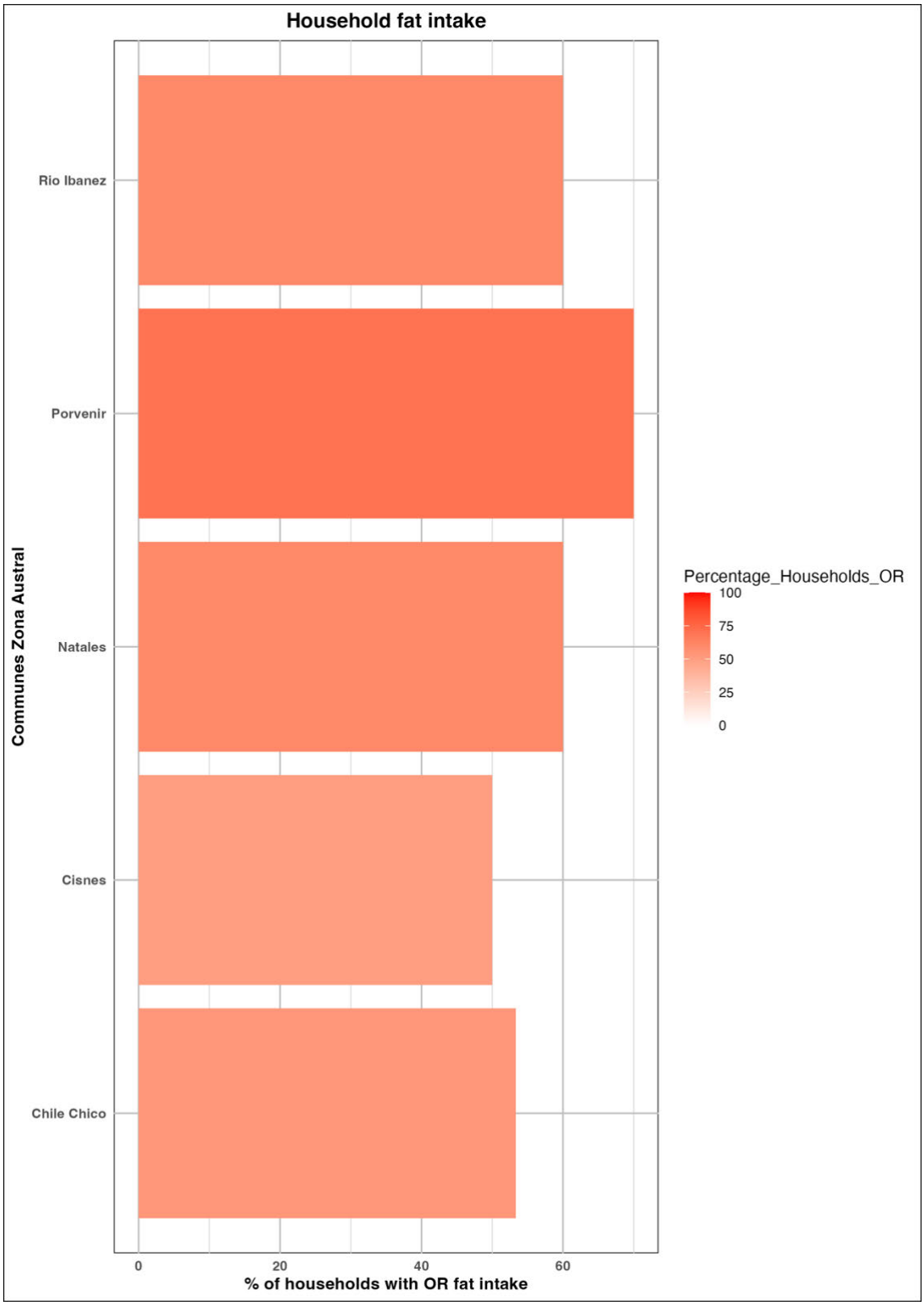
c. Zona Central


Household fat intake
Villa Alegre
Treguaco
Santa Maria
San Pedro
San Javier
San Ignacio
San Fernando
San Carlos
San Bernardo
Romeral
Requinoa
Rengo
Rauco
Quinta de Tilcoco
Puchuncavi
Pirque
Pinto
Pichilemu
Pichidegua
Peralillo
Penaflor
Pelluhue
Palmilla
Padre Hurtado
Olivar
Navidad
Nancagua
Melipilla
Maria Pinto
Marchihue
Malloa
Los Andes
Llaillay
Linares
Lampa
La Cruz
Hijuelas
Graneros
El Monte
Donihue
Coihueco
Chanco
Algarrobo
Communes Zona Central
0
25
50
75
100
% of households with OR fat intake
Percentage_Households_OR
100
75
50
25
0

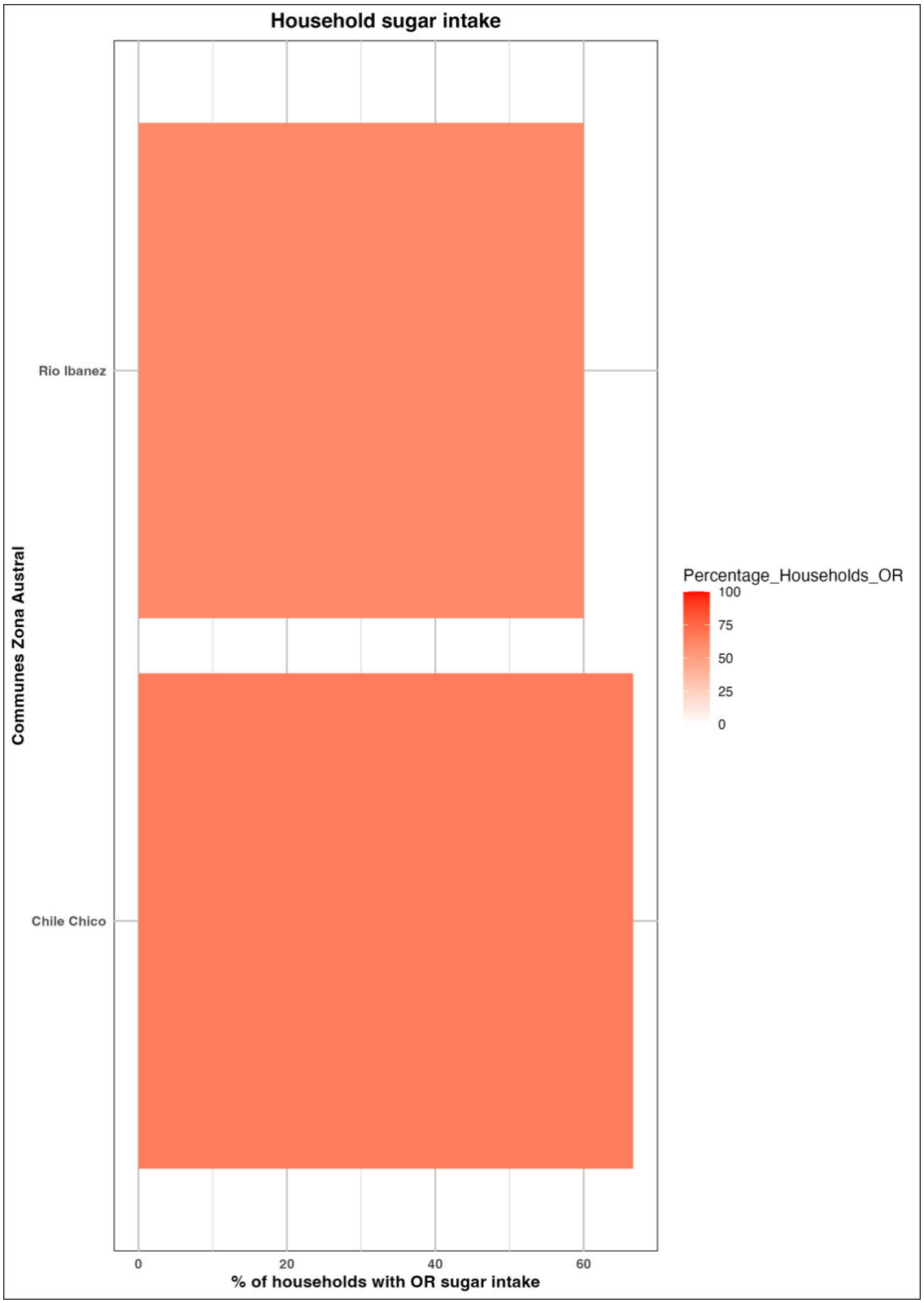
d. Zona Sur



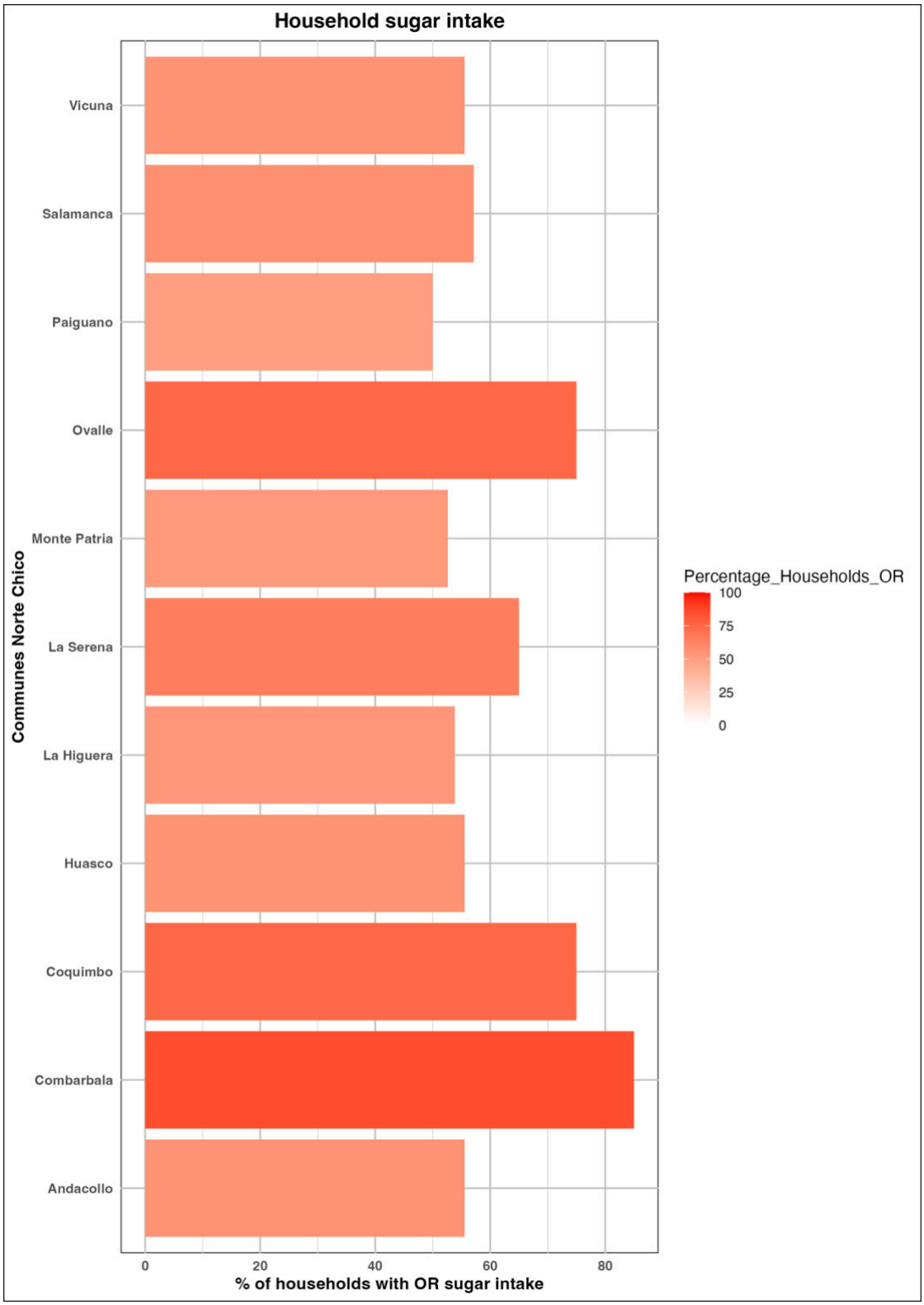
e. Zona Austral


Household fat intake
Rio Ibanez
Porvenir
Natales
Cisnes
Chile Chico
Communes Zona Austral
0
20
40
60
% of households with OR fat intake
Percentage_Households_OR
100
75
50
25
0

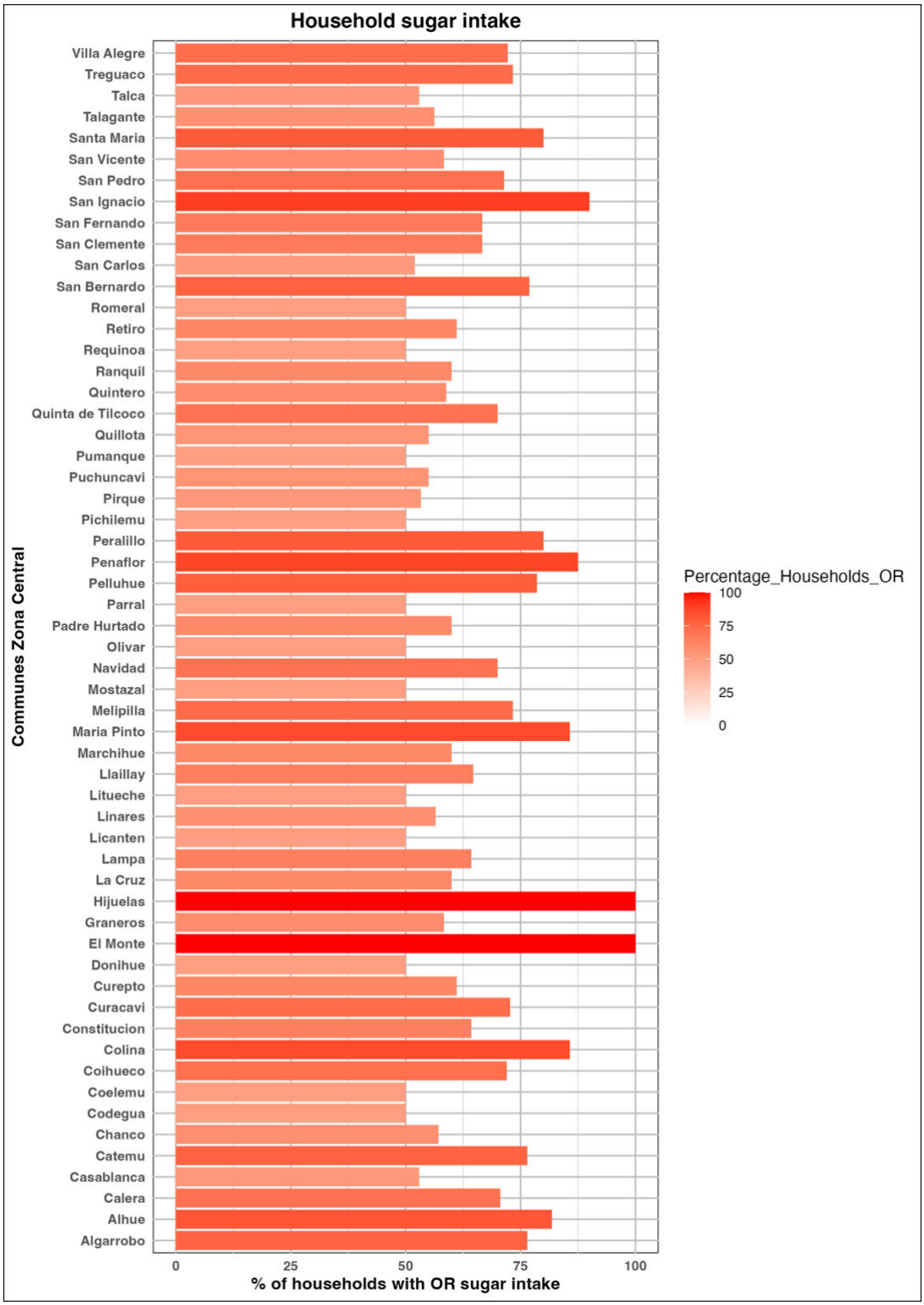
5. Sugar
   a. Norte Grande



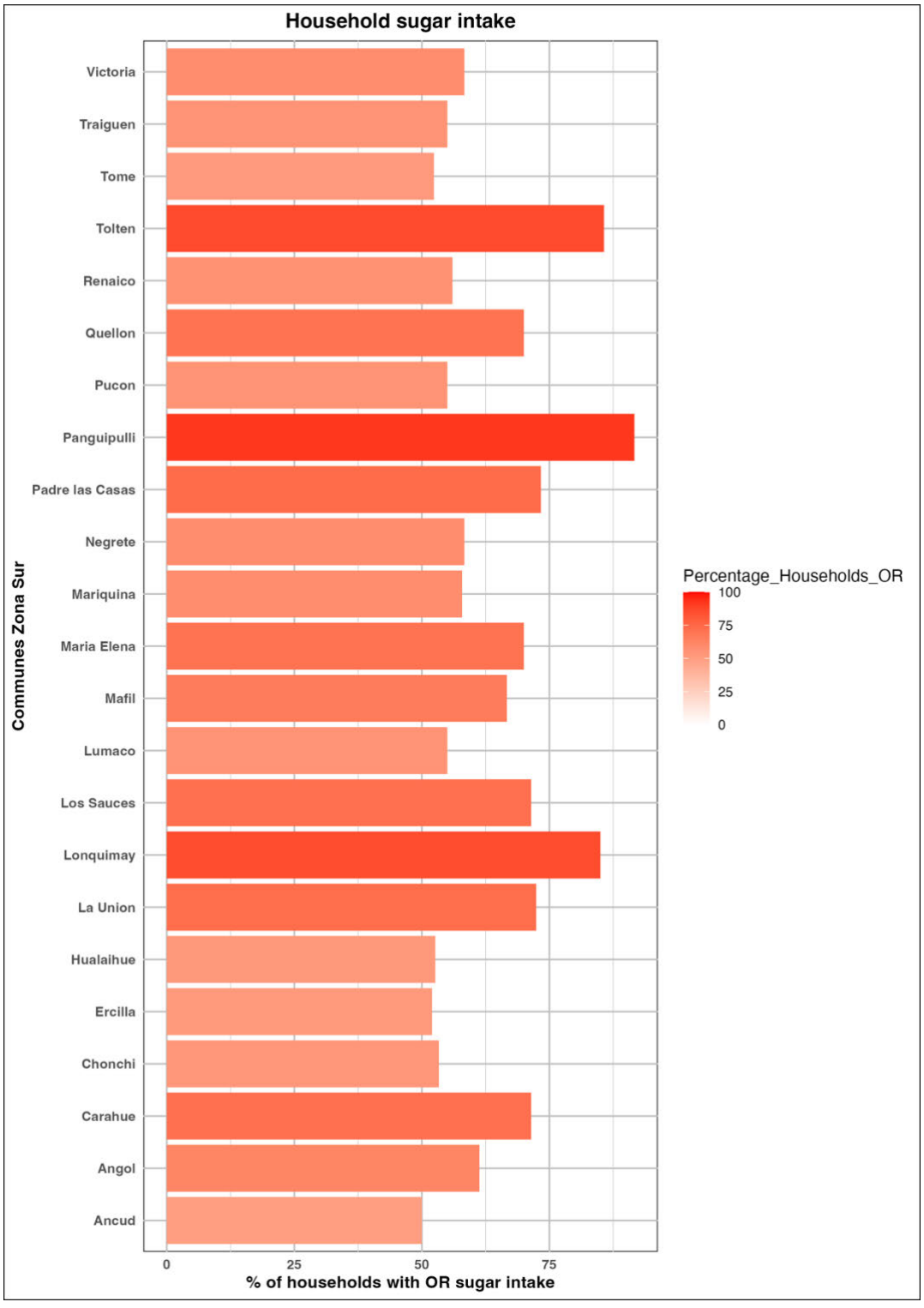
   b. Norte Chico



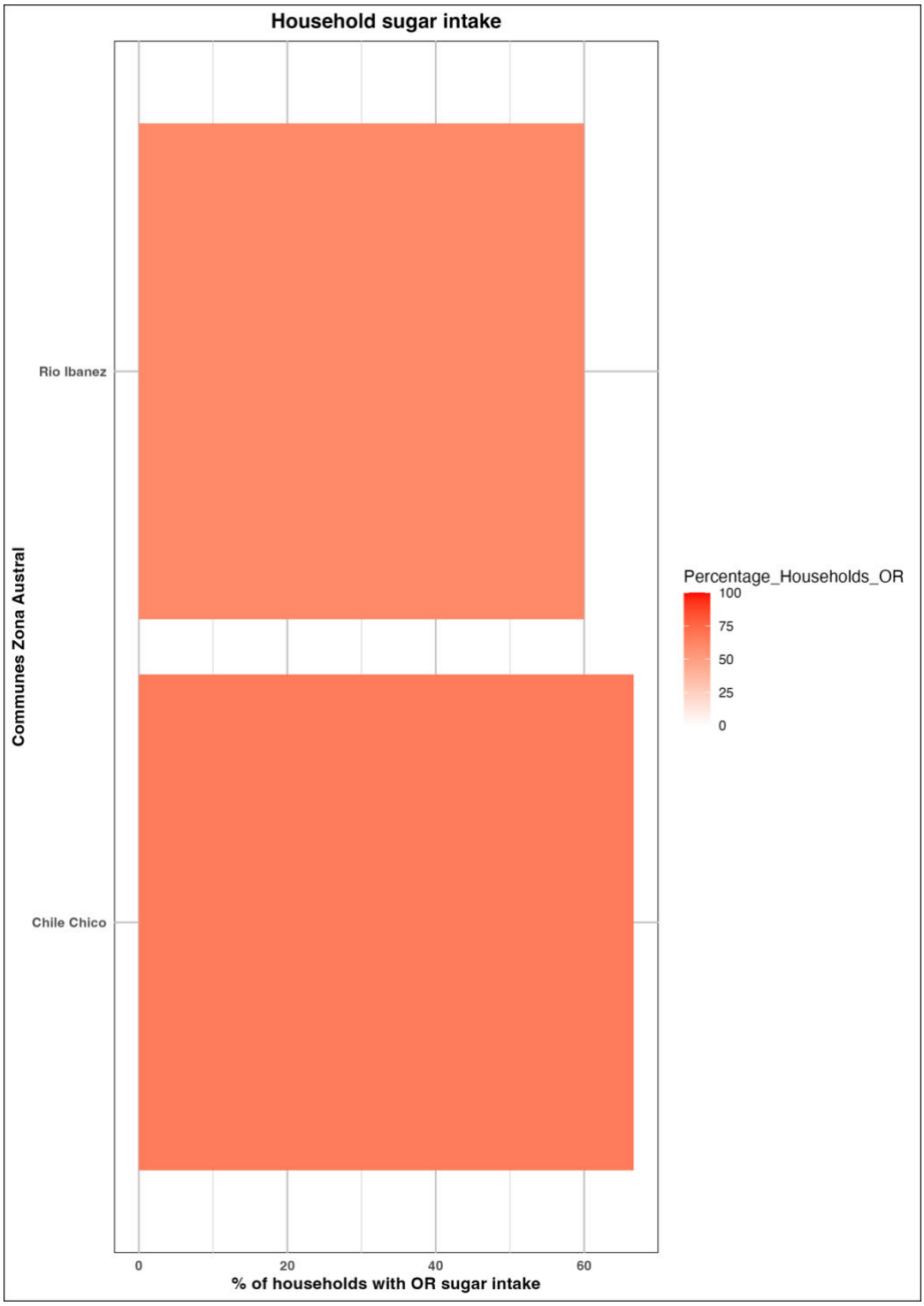
c. Zona Central


Household sugar intake
Villa Alegre
Treguaco
Talca
Talagante
Santa Maria
San Vicente
San Pedro
San Ignacio
San Fernando
San Clemente
San Carlos
San Bernardo
Romeral
Retiro
Requinoa
Ranquil
Quintero
Quinta de Tilcoco
Quillota
Pumanque
Puchuncavi
Pirque
Pichilemu
Peralillo
Penaflor
Pelluhue
Parral
Padre Hurtado
Olivar
Navidad
Mostazal
Melipilla
Maria Pinto
Marchihue
Llaillay
Litueche
Linares
Licanten
Lampa
La Cruz
Hijuelas
Graneros
El Monte
Donihue
Curepto
Curacavi
Constitucion
Colina
Coihueco
Coelemu
Codegua
Chanco
Catemu
Casablanca
Calera
Alhue
Algarrobo
Communes Zona Central
0
25
50
75
100
% of households with OR sugar intake
Percentage_Households_OR
100
75
50
25
0

d. Zona Sur



e. Zona Austral


Household sugar intake
Communes Zona Austral
Rio Ibanez
Chile Chico
0
20
40
60
% of households with OR sugar intake
Percentage_Households_OR
100
75
50
25
0

N7 – Appendix Ch2 HERC approval.

THE UNIVERSITY of EDINBURGH
The Royal (Dick) School of Veterinary Studies

Human Ethical Review Committee (HERC)

Royal (Dick) School of Veterinary Studies

The University of Edinburgh

Roslin

EH25 9RG

Email HERC.vets@ed.ac.uk

30/11/2022

Dear Martín,

The research described in your application HERC_2022_148 entitled ''Literacy for the agroecological transition of farms for peasant family farming in the town of Mashue, Región de Los Ríos, Chile'' now has HERC ethical approval.

You may proceed with this research only on the basis that it conforms to the description you provided and the assurances you made in your application. If you undertake research that deviates in any significant way from the application you submitted, that research does not have the HERC's approval. If, following the receipt of ethical approval, you find that you want or need to change your methods and/or materials in any significant way, you must submit a revised application.

N8 – Appendix Ch2 Interviews.

1. Introduction

- Anonymity
- Reason of interview
- Goal of interview
- Duration

2. Food security and food environments

- Could you describe a normal day in your life?
- What does the concept “food security” tell you?
- What does the concept “food environment” tell you?
- What is healthy eating for you?
- How would you define a healthy dish?
- What do you do to access healthy food?
- How do you consider the food habits in the country?

3. Future

- What has to happen for food habits to improve?

4. Closing questions

- Is there anything that you want to share or that you want to add that I haven’t asked you about?

N9 – Appendix Ch2 Consent Form/Statement.

1. Title of Project: Literacy for the agroecological transition of farms for peasant family farming in the town of Mashue, Región de Los Ríos, Chile

2. Description of project:

The research will be carried out by Martín del Valle Menéndez, postgraduate student in Agriculture and Food Systems at the University of Edinburgh.

The town of Mashue, located in the "Región de Los Ríos" in Chile, has experienced since the 1990s how its natural springs have been drying up, meaning, among other things, the loss of native vegetation and the degradation of agricultural soils. Based on this reality, the community of Mashue, together with the Consultancy Albatros, has carried out a series of activities that seek, among other objectives, to initiate an agroecological transition that allows the recovery of the productive potential of agricultural soils and increase efficiency in the use of water. The foregoing, in addition to the benefits related to the use of water, would allow the community to begin a sustainable intensification of its agricultural production, allowing, among other things, to improve its access to a diverse diet and acquire the required to access public funds to finance projects long-term projects. However, there is still a gap related to the familiarity and understanding of the agroecological principles necessary for the implementation of said transition and subsequent allocation of funds. This is how the following proposal of "literacy for the agroecological transition of farms for peasant family farming" is presented.

3. Eligibility: Participants must be:

- Over 18 years old.
- Head of households
- Members of the APR (rural drinking water) committee.
- Farmers.

4. Involvement:

- 60 min
- To answer an in-depth interview related to the knowledge of agroecology and sustainable intensification of farms.
- "Your participation is voluntary. You may choose not to participate and you may withdraw at any time. If you decide not to participate or to withdraw from the study, you will not be penalised in any way, and your responses will not be used."

- Your responses will be confidential. We do not collect identifying information such as name, your email, or your IP address.
- The recordings used for the interviews will be deleted after transcription.

5. Contact information: Martín del Valle Menéndez, +447845529407,

6. Consent statement:

- You understand the purpose of this study, and that your areable to ask questions about it at any time.
- You understand that you are free to withdraw my consent for involvement.
- You understand that your name will not appear in any published document relating to this study, as all information collected is completely anonymous.
- You understand that the data collected will - though fully anonymised - appear in publications and reports relevant to this area of research.

By continuing, you have read and understood the above.

Initials: Date: