Integrating Justice and Inclusion into Food Systems Transformations: A Case Study with Smallholder Farmers

Genia M. Hill



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Jesus College
School of Geography and the Environment
University of Oxford

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Abstract

Justice is increasingly recognised as central to the transformation of food systems, which link human health, environmental health, livelihoods, and wellbeing for a broad range of actors. Yet despite widespread consensus that food systems must be transformed in the face of climate change, biodiversity loss, food insecurity, obesity, and poverty, transformational processes to date have been largely top-down. This thesis flips this approach, aiming to contribute to food systems transformations (FSTs) becoming more just and inclusive. It achieves this by examining FSTs from "bottom-up" (community-led) perspectives from communities across Papua New Guinea (PNG) that practice a mix of cocoa cash cropping and subsistence farming. The research uses a mixed methods approach, including fieldwork insights from 160 semi-structured interviews across four communities and 20 half-day workshops with 127 attendees, using justice-oriented participatory systems methods. Across three thesis papers, this work offers novel perspectives on the role of low-influence actors in achieving more just FSTs.

The first thesis paper contributes a framework to examine cross-scale and cross-level dynamics of food systems, demonstrating the key role of individual actors in systems change. Using a case study with PNG cocoa farmers and data from interviews, this paper provides empirical evidence showing how these cross-scale and cross-level dynamics present, for example, between education policy and local to regional land use change. By explicitly embedding scale, level, and actor inclusion in its analysis, the framework proposed in this paper advances conceptual clarity, diagnostic precision, and coordination across research, policy, and governance domains needed for more just, effective, and inclusive FSTs.

The second paper investigates how low-influence actors can be engaged in systems transformations. It reflexively compares justice-oriented participatory systems methods and interviews, evaluating them for their effectiveness and transformative potential. The paper builds a case for inclusion, showing that for FSTs to be more just, they must also be inclusive of actors across all FST processes, particularly low-influence actors that may be otherwise left behind in efficient change processes. The paper uses empirical evidence from interviews and workshops with PNG smallholder farmers, finding that methods which relied less on research facilitators were the most useful in problem framing by shedding light on trade-offs, blind spots, or assumptions that were unclear from top-down perspectives which were only informed by interviews and/or literature.

The third paper shifts the focus from the current transformation paradigm that centres outcomes and instead looks to drivers and feedbacks for system actors, investigating *why* food systems have a given structure or function. This leads to a new analytical lens, the "Food Systems Context" (FSC). The FSC *is the result of the complex set of drivers influencing any food system actor, and forms the environment in which actors choose to undertake activities which later result in food system outcomes*. Using interview data and workshop outputs, and analysing drivers and feedbacks through Participatory Systems Maps (PSM) and Principal Component Analysis, this paper shows how the FSC can enable researchers and practitioners to identify change pathways for more just and inclusive transformations that typology-based and outcomes-focused approaches may overlook. It then connects this to pathways for enabling FST processes to be more just and inclusive.

Taken together, this thesis argues that there is a gap in understanding of how change is produced; outcomes emerge through contextual decisions, shaped by drivers and cross-scale, cross-level feedbacks, and enacted by actors whose knowledge and perspectives are often overlooked. Across the three papers, this thesis shows that justice is not an optional normative add-on to transformation, but a property of transformation itself and a process which can be built, or eroded, through how problems are bounded, how systems are understood, whose perspectives and knowledges are recognised or prioritised, and how interventions engage with the feedbacks and drivers that generate outcomes. A just FST is not only assessed by its system outcomes, but by the underlying processes within transformations.

Visual Abstract: Overview of this thesis including research aim, questions, methods, and findings.

Aim: Using a case study with cocoa smallholder farmers in PNG, this research aims to investigate how justice[1] considerations can be integrated into processes directed at transforming food systems.

To achieve this, an actor-centric approach to systems analysis is used to answer the following research questions using the below methods:

Paper 1: From Local to Global: A Cross-Scale and Cross-Level Framework Toward a more Just FST.

Research Question (RQ) 1: How do actors and systems transformations processes interact in food systems? 1a. How can interactions across scale and level be conceptualised? 1b. How can this understanding inform more just FSTs?	**Methods:** • 160 interviews across four communities in PNG recruited through snowball and spatial sampling techniques. • Interviews used a flexible, participant-led approach and were organised by themes of food system outcomes: Food security/health, environmental outcomes, economic outcomes, social outcomes. • Qualitative analysis of interview data, coding for emergent themes (two-step process described by Saldana). • Creation of a cross-scale and cross level conceptual framework for food systems based on literature review. • Outputs of qualitative analysis used to demonstrate/operationalise the conceptual framework with empirical evidence from coded interviews from PNG smallholder farmers.	**Findings:** Using the food systems framings of drivers, outcomes, feedbacks, and system actors, this paper uses an entry point of scale and level to consider the interaction between system actors and transformation. In this conceptual frame, outcomes from the individual level become drivers at the community level, outcomes from the community level become drivers at the landscape or country level, outcomes from the landscape level become drivers at the community level, and outcomes from the community level become drivers at the landscape level. This is applied to the spatial, jurisdictional, and network scales for food systems and can be extrapolated across different levels. The research posits there is a need for further linkages between qualitative and quantitative food systems science.

Paper 2: Exploring Participatory Methods for Achieving More Just Processes in FSTs.

RQ 2: How do different methods of engagement with low-influence actors lead to different system understandings and just transformation options? 2a. How can low influence food system actors be engaged in processes aiming to transform systems? 2b. How can engagement with these low-influence actors contribute to achieving more just FSTs?	**Methods:** • Half-day workshops with smallholder farmers interviewed for **RQ1**. Farmers were placed in workshop groups based on how commercially oriented their cash cropping practices were. Workshops used co-creation of knowledge and systems methods such as Rich Picturing and creation of Inter-Relationship Digraphs (IRDs) to systematically identify causal relationships between factors of the local food system from the perspectives of smallholder farmers. • IRDs were digitised and converted into PSMs in Python. Subsequent analysis determined out degree centrality across PSM nodes to identify system drivers as perceived across cocoa smallholder farmer groups. • These methods were reflexively compared for their transformative potential by systematically evaluating their process effectiveness, output effectiveness, and epistemic effectiveness, benefits, and challenges.	**Findings:** Actor inclusion and justice must be prioritised in the FST to achieve outcomes for all food system actors. Empirical evidence from interviews and workshops with PNG smallholder farmers found that participatory methods which relied less on research facilitators were the most useful in problem framing by shedding light on trade-offs, blind spots, or assumptions from top-down perspectives which were only informed by interviews and/or literature. Methods are a political choice which lead to systems understandings and the knowledge with which decisions are made to manage and govern these systems.

Paper 3: Beyond Typologies: Introducing the 'Food System Context' for More Just Transformations.

RQ 3: What can we learn about systems change by adding a drivers-focused approach to FSTs? 3a. What does it look like for systems change if we co-create knowledge that focuses on the perspectives on one low influence group of actors? 3b. What does this tell us for achieving more just FSTs?	**Methods:** • Data generated for **RQ1** and **RQ2** were used for this paper, with analysis that focused particularly on system drivers and feedbacks. • Further, the coded interview data from **RQ1** were also used in a 13-variable Principal Component Analysis (Factor Analysis of Mixed Data) to identify which factors were the most important in revealing patterns of association with the other assessed factors.	**Findings:** Rather than focusing primarily on outcomes, research and practice should adopt a holistic systems approach that includes "Food System Context" which brings drivers and feedbacks to the fore of system understanding and analysis. A case study with PNG cocoa smallholders highlights the benefits of this approach by demonstrating how involving low-influence actors fosters improved problem understanding and helps address both inclusion and data gaps in under-researched settings.

[1]Justice is conceptualised in this work to integrate inclusion, participation, influence, and power over system structure and function, and is based on broad framings of what "justice" means for FSTs. This work considers justice in terms of processes aiming to transform the food system, including research and discourse, as well as initiatives, policy change, and other efforts to change the food system so that system outcomes are achieved *for all* actors (human and non-human).

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List of Abbreviations

ACIAR	Australian Centre for International Agricultural Research
CFS	Committee on World Food Security
COP	Conference of Parties
CPB	Cocoa Pod Borer
CUREC	Central University Research Ethics Committee
DPhil	Doctor of Philosophy
FAMD	Factor Analysis of Mixed Data
FAO	Food and Agriculture Organization of the United Nations
FG	Focus Group
FSC	Food Systems Context
FST	Food Systems Transformation
HLPE	High Level Panel of Experts
IRD	Inter-Relationship Digraph
MLP	Multi-Level Perspective
NFE	Non-farm Enterprise
NGO	Non-governmental Organisation
PAR	Participatory Action Research
PGK	Papua New Guinea Kina
PNG	Papua New Guinea
PSM	Participatory Systems Mapping
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
RP	Rich Picture

RQ	Research Question
SDG	Sustainable Development Goal
SES	Social-ecological Systems
SoGE	School of Geography and the Environment
SSM	Soft Systems Methodology
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

1.1 Motivation and Justification of Research Focus

Food systems "comprise all the people, institutions, places, and activities that play a part in growing, processing, transporting, selling, marketing, and, ultimately, eating food" (Global Alliance for Improved Nutrition, 2025). They are a key unifier of both human and environmental health and wellbeing, as well as sitting at the nexus of all the Sustainable Development Goals (SDGs), the Paris Agreement, and the Kunming–Montreal Global Biodiversity Framework (Rockström et al., 2025). Cumulatively, food system activities result in the most significant global drivers of climate change, land use change, fresh water use, and biodiversity loss (Schneider et al., 2023, Ambikapathi et al., 2022). Simultaneously, rates of overweight and obesity are growing, while nearly a billion people remain undernourished (Moramarco et al., 2025). Although less prominent in research and policy agendas for transforming food systems, livelihoods and employment are also globally significant food system outcomes. Food systems activities employ 1.23 billion people and, including household members, support more than 3.83 billion livelihoods across every stage of the value chain in both rural and urban areas (Davis et al., 2023); often income from food system activities is insufficient, perpetuating cycles of poverty and reinforcing highly unequal power dynamics (De Schutter, 2017). Further compounding these challenges, the modern, globally dominant industrialised food system, which has gradually been liberalised since the end of the Second World War, (Friedmann, 1993, Chenery et al., 1988), has seen power increasingly concentrated among actors at high levels, such as large multi-national seed and agrochemical corporations (Clapp, 2021). As a result, ongoing changes within the system tend to direct

benefits upward, reinforcing existing power structures (Clapp, 2021, Clapp et al., 2025, Van Den Akker et al., 2024). In the context of contemporary global challenges, these factors continue to intensify across social, economic, and environmental domains, and hence, there is an urgent need to transform food systems for human health, for the benefit of diverse actors, and to improve environmental outcomes (Webb et al., 2020).

There is an abundance of literature urging for expedient food systems transformations (FSTs) to improve the health and wellbeing of people and the planet (El Bilali et al., 2019, Gerten et al., 2020, Wezel et al., 2020, Willett et al., 2019). Due to the scope of these challenges, FST research has focused primarily on improving human health and environmental outcomes through efficiency-oriented interventions, by coordination of system actors, and resilience building, with an emphasis on measurable indicators, technical levers for change, and top-down, system-wide changes (denoted here as the contemporary and predominant *food systems transformational paradigm*). While this approach has been vital for progressing sweeping improvements, there is a risk that this efficiency-first approach, which is driven by actors with disproportionate economic and political power, may reinforce existing power structures (Dahlberg, 2001, Leeuwis et al., 2021). Such concentration of power in global food agendas influences which problems are defined and which solutions are legitimised (Clapp, 2021, Clapp et al., 2025, Van Den Akker et al., 2024).

This thesis is motivated by the need to support systemic transformation that goes beyond improving dietary and planetary outcomes using an efficiency-oriented paradigm, and instead, shifts the focus of FST research to bringing in food system actors that may otherwise be left behind by efficient and sweeping change. At the same time, it seeks to

broaden the focus of transformational agendas to include and improve integration of social and economic outcome areas oriented towards justice. With this motivation, the necessity of an actor-centric approach led to the creation of research questions (RQs), which will be answered through the chapters in this thesis, as detailed in **Table 1.1**. Challenging the prevailing efficiency-first and outcomes-focused paradigm which characterises contemporary FST research and practice, this thesis argues that low-influence actors are essential decision-makers whose participation in transformational processes is critical to more just FSTs. This paradigm risks undergoing transformational activities that further sideline food system actors that have historically experienced (and presently experience) marginalisation within the system. Accordingly, the thesis reframes FSTs as a political and participatory process rather than a purely technical exercise. At the same time, the research seeks to shed light on why low-influence actors are vital decision makers, and must be brought into transformational processes including research, discourse, and policy building.

Table 1.1 RQs and the papers that address them in this thesis.

RQs	**Paper**
RQ1. How do actors and systems transformations processes interact in food systems? 1a. How can interactions across scale and level be conceptualised? 1b. How can this understanding inform more just FSTs?	Chapter 4: From Local to Global: A Cross-Scale and Cross-Level Framework Toward a More Just Food Systems Transformation
RQ2. How do different methods of engagement with low-influence actors lead to different system understandings and just transformation options? 2a. How can low influence food system actors be engaged in processes aiming to transform systems? 2b. How can engagement with these low-influence actors contribute to achieving more just FSTs?	Chapter 5: Exploring Participatory Methods for Achieving More Just Processes in Food Systems Transformations
RQ3. What can we learn about systems change by adding a drivers-focused approach to FSTs? 3a. What does it look like for systems change if we co-create knowledge that focuses on the perspectives on one low influence group of actors? 3b. What does this tell us for achieving more just FSTs?	Chapter 6: Beyond Typologies: Introducing the 'Food System Context' for More Just Transformations

There is a need to advance knowledge, not just on how food systems can be transformed, but how transformations can be more just. The challenge of transforming food systems is highly involved given their nature as complex adaptive systems with intricate cross-scale and cross-level dynamics, actors with competing objectives, and multiple system goals that are sometimes conflicting, particularly in the context of intensifying global change. This challenge requires both interdisciplinary and innovative solutions (Herrero et al., 2020). This thesis draws on perspectives from food systems science (and more broadly systems science), as well as participatory research, justice and inclusion in sustainability transitions, and work that has been done in the context of remote communities and developing economies in addition to engaging with creative and systems-focused participatory methods.

The focal point in this thesis is on inclusion of "low influence system actors"[1] as a key element of justice in FSTs. These actor groups (henceforth "low-influence actors") can vary widely both within their group and among different groups throughout the food system, but they share a common challenge in that their agendas may not be aligned with those driving FSTs at the sub-national, national, and global levels. Thus, they have a low level of influence on the food system as a whole, despite being important decision makers at the scale and level where they engage with the system. Inclusion of low-influence actors was selected as the focal point because it provides a theoretical lens as well as a practical approach to integrate the elements of justice that are relevant to FSTs and have been established in FST literature (these are historical, epistemological, social,

[1] The selection of this term is discussed in detail in the Literature Review of this thesis.

procedural, distributive, and recognition justices, which are further discussed in the Literature Review).

This thesis acknowledges its limitation in that achieving just FSTs requires more than inclusion of particular actor groups alone. Rather, for just FSTs, the numerous dimensions of justice (ex. procedural and distributive justices), must all be addressed and enacted in various ways. The work uses a case study to exemplify engagement of one low-influence actor group, cocoa smallholders in Papua New Guinea (PNG), although there is a diversity of low-influence actors across the entirety of the food system, such as farm and food service workers and those employed in food processing or for the gig economy.

Within these boundaries, this thesis explores RQs that address the gaps from the outcomes-focused and efficiency-oriented FST literature. These pertain to actor-system relations and scale-level interactions, methods for engaging low-influence actors towards systems transformation, and identifying the role of context in shaping the decision-making space for all food system actors. In addressing these questions, the work contributes to theoretical, methodological, empirical, and policy domains relevant for FSTs.

The theoretical contribution advances understanding of how justice (particularly in terms of actor inclusion, contributing to epistemic, recognition, distributional, and procedural dimensions of justice) can be meaningfully integrated into FSTs. By focusing on inclusion of low-influence actors, this work demonstrates that there are key voices missing from transformation agendas and systems knowledge, further showing why

inclusion of these excluded actors is essential for robust 'systems approaches', legitimacy of interventions, and their sustainability.

Methodologically, it demonstrates the need for bridges between qualitative and quantitative systems science. It shows the value of systems-oriented participatory approaches for eliciting the priorities and knowledge of actors who are often overlooked in systems change processes, contributing both epistemologically and morally to systems knowledge and transformation processes. This approach can provide a practical tool for researchers, practitioners, and policymakers seeking to operationalise inclusion to achieve more just FSTs.

Empirically, the thesis contributes context rich insights from PNG, illustrating how actor-system relations and governance structures shape system outcomes across scale, level, and context, and how this can be used to inform potential transformation pathways. These empirical findings are shared in detail in **Chapters 4**, **5**, and **6**. Collectively, these contributions provide a foundation as well as actionable recommendations for designing more just and context-appropriate food system policies and initiatives.

The work aims to benefit a range of groups, including low-influence actors, local and provincial governments, non-governmental organisations (NGOs), and development partners. By highlighting how inclusion strengthens the relevance, feasibility, and legitimacy of transformation efforts, the thesis offers pathways for translating evidence into practice. For example, this thesis provided a basis for how low-influence actors may be included into an example project results framework (see **Appendix B** for an approach to how this could be done in a hypothetical project results framework). Efforts in the food

systems domain have so far attempted to address these issues by mainstreaming certification schemes (ex. in the cocoa sector, FairTrade certification). While certifications and initiatives such as these have had varying success, this work offers an avenue to advance inclusion of low-influence actors throughout the food system. These pathways emphasise engaging marginalised actors early in decision processes[2], tailoring interventions to local contexts, and strengthening cross-scale and cross-level governance. In doing so, the thesis provides a foundation for more equitable and durable food systems change. Further, this work examines how we can make FSTs more just and include greater diversity in the knowledge that underlies food systems understandings to contribute to more thorough systems approaches. These aim to establish a more complete understanding of systems through diverse knowledges and assessment of system dynamics inclusive of drivers and feedbacks (rather than emphasising primarily outcomes). This will improve problem diagnosis and the identification of levers for change.

1.2 Why Papua New Guinea?

The geographical focal area of this doctoral project was across four cocoa-growing communities in PNG. The work in this thesis was conducted with communities that practice subsistence farming and cocoa production as a way to ground the approach across different community contexts. More detail of the PNG context is provided in the Literature Review and Methods sections. Food systems research in PNG is vital for improving food security and strengthening environmental and economic outcomes; in these areas, current trends are broadly not on improving trajectories. For example, more

[2] So early, in fact, that they are also integral in the knowledge creation process that underlies decision making.

than 56% of the population is multidimensionally poor (2016 – 2018 data)(UNDP, 2023) and over 57% experienced moderate or severe food insecurity from 2018 to 2020 (FAO, 2025). Despite this, the obesity rate in the adult population grew from 13.9% in 2000 to 20.5% in 2022 (FAO, 2025). Environmental outcomes are facing equally acute challenges. PNG has 41 million hectares of natural forest; and primary forest has significant ecological, economic, and cultural value (World Resources Institute, 2025); the country hosts nearly 7% of the world's biodiversity (including a high degree of endemism) in just 1% of the world's land area (UNEP, 2021). Despite the significance of these ecosystems, there are high rates of deforestation and land use change or degradation, in large part due to expansion of the agricultural frontier as well as illegal logging and mining. Between 2002 and 2021, PNG lost 820,000 ha of its humid primary forest (World Resources Institute, 2025). At the same time, more than 80% of Papua New Guineans depend on the natural resource base[3] for both their livelihoods and their dietary consumption. Further, in the PNG context, the vast majority (estimates range from 82% – 97%) of land is under customary land tenure arrangements, meaning that the smallholder farmers that rely on the natural resource base make key decisions about its' use (Filer, 2014, Kwapena, 2021, Chand and Yala, 2009). This high reliance on natural resources as well as the country's limited financial and institutional capacity makes PNG one of the most vulnerable countries to climate change impacts in the world (Notre Dame Global Adaptation Initiative, 2025). Food systems are a vital connector between environmental change and challenges of economics, livelihoods, and health. Further, these factors are drastically under-researched in the region, with a history of poor outcomes and responses to investment (Feeny, 2003, Hughes, 2003, Smith and Wesley-

[3] The natural resource base here refers to land surface uses, such as forestry, conservation, gardening (subsistence food, and farming cash crops); it does not refer to mining, which is out of the scope of this work.

Smith, 2021). Thus, this is a critical context in which to explore food systems and improve understanding of their underlying dynamics.

Cocoa is an important crop in PNG, and a significant driver of land use change as well as an important way for people in communities to access income across the country (Bourke, 2018). Around 150,000 out of 8,000,000 Papua New Guineans grow cocoa, mostly on blocks less than one hectare in size, predominantly using a low-input model, where cocoa is a low-labour crop and produces low yields, but it is still vital for accessing cash (Lescuyer et al., 2018, Pham et al., 2021). This model of production means that when smallholder farmers want to increase yields, they often expand their cocoa block into primary or secondary forest rather than increasing labour inputs to their existing block (Nelson et al., 2011, Scudder et al., 2022); further, if their cocoa block becomes run down, there is a tendency to leave it and plant anew, rather than rehabilitating their existing block (Curry et al., 2015). There are numerous and varied challenges throughout the cocoa supply chain that are largely described from a top-down perspective and with limited consultation from smallholders (described later in the Literature Review). These factors, along with the challenge that PNG and Melanesia more broadly is under-researched, mean that investigation of both this topic and this region are an important context to conduct actor-focused work that result in important outcomes for both people and planet. A brief vignette follows introducing context for the lived reality of remote smallholders in PNG.

1.2.1 A Brief Introduction to Papua New Guinean Food Systems

"*In Papua New Guinea, we call sago 'fast food'. [This is because] in the morning, we can cut the tree at 8:00 am, and by 6:00 pm, you can be eating dinner!*"

– Research Assistant, Rempi Community



1. Early morning: Cut down sago palm.
2. Morning until afternoon: Cut up the trunk of the sago palm into small wood chips and haul bags of wood chips to the river.



3. Mid-morning until mid-afternoon: Massage sago pulp over a screen. The sago 'silt' settles into the bottom of a dried piece of banana tree trunk while excess water flows back into the river.



4. Afternoon: Strain the sago into a ball of banana or palm leaves.



5. Prepare the sago: transfer to a bowl and start hydrating it.



6. Continue to hydrate and stir the sago, then prepare it in a variety of ways.



7. Evening: Once hydrated, the sago can be cooked in several different ways (after collecting firewood for the cookfire and building the fire).

1.3 Organisation of the Thesis

This thesis uses the article-based approach, presenting three independent pieces of research that each contribute conceptually, methodologically, and empirically to food systems science. The articles have been prepared for submission to peer reviewed academic journals. The framing around the articles provides context to inform the research, the methodological approach to the overall thesis, and the cumulative conclusions of this research. Due to the article-based structure of the thesis, and that the research has a tightly cohesive theme throughout the articles, some information may be necessarily repeated.

After this Introduction, **Chapter 2** subsequently provides a Literature Review which outlines the high-level theoretical approach of this work and identifies the gaps that this thesis addresses. This section non-exhaustively reviews the relevant literature and situates the thesis in the current research context, specifically regarding FSTs, important elements of scale and level in systems transformations, and in justice for FSTs. A targeted review of the relevant literature is also included in each article-based chapter. **Chapter 3** goes on to outline the methodological principles and approaches the overall thesis takes, as well as detailing the Selection of Case. **Chapters 4, 5,** and **6** all use data that were co-created with communities in PNG. They are stand-alone pieces of research which address the RQs proposed in this thesis with the overall view of contributing to the literature on justice within FSTs. Taking an entry point of scale and level in FSTs, **Chapter 4** investigates the relationship between individual food system actors and systems change, with a particular focus on including low-influence actors as an avenue for improving justice in processes aiming at transforming food systems. **Chapter 5** goes on to explore how low-influence actors can be included in systems science and FST processes, with a

reflexive comparison of data elicitation and assessment of how these strategies for data collection and evaluation contribute to transformative potential. **Chapter 6** then shifts the focal point to drivers and feedbacks, challenging the previously used outcomes focused approaches that centre typologies to inform FSTs. This new focal point gives rise to the "Food Systems Context" (FSC) as an analytical lens for supporting FSTs. The empirical evidence in this chapter shows the importance of FSC for low-influence actors and how this leads to system outcomes. **Chapter 7** concludes this thesis, considering the primary findings from answering the RQs, sharing cumulative insights from the synthesis of the work. It also discusses the implications of this work for integrating justice into processes aimed at transforming food systems. It goes on to acknowledge the caveats and limitations of this work, as well as gaps and open questions, proposing avenues for future research.

Taken together, the thesis seeks to contribute to the literature that sheds light on improving not only outcomes from food systems, but the manner in which system outcomes are transformed. It contributes to impact work by exploring how insights from both theoretical and empirical findings can help inform policy to improve processes aimed at transforming food systems. Overall, it makes four interlinked contributions to FST scholarship and practice. First, it develops and empirically grounds a cross-scale, cross-level framework that centres low-influence actors as analytically and normatively critical to transformation processes, rather than peripherally relevant and viewed only as "target beneficiaries". Second, it demonstrates that methods which are power-sensitive and participatory while also systems-oriented influence what (and whose) knowledge underlie agendas, which drivers are prioritised, and how transformational pathways are visible and actionable. Third, it introduces the concept of the "Food Systems Context" (FSC) as a dynamic, driver- and feedback-oriented lens that moves beyond static

typologies (which explain the “what” of systems rather than “why”). This improves how transformations are informed by actor decision making. Finally, by synthesising empirical findings from co-creative work, the thesis advances the argument that justice is not an elective “nice to have” for FSTs but a property of how transformation processes are structured, mediated, and enacted across levels. Together, these contributions position justice as fundamental in food systems and their transformations.

2 Literature Review

2.1 Section Overview

This literature review provides essential context for the research explored across the three papers in this thesis. It addresses key themes connecting the papers and provides framing for the work; each of the research papers included as thesis chapters also has a stand-alone literature review tailored to that paper. This review will first set the scene, examining systems thinking and the conceptual framings around food systems and their transformation. It will go on to address the urgency and operationalisation of the FST, actor inclusion, and related factors that aim to support more just FSTs (such as the role of influence, power, and knowledge creation in FSTs). For the key literatures highlighted here, I demonstrate the relevant research gap for this thesis and connect the foundational literature to the RQs in this work. Lastly, this section will review the development and environment context of the case used for this work, detailing why PNG is an important place to conduct actor-focused FST research. The literatures reviewed here are not exhaustive, but rather drawn upon to provide an overview relevant to the scope of this thesis and to provide important context needed in order to answer the RQs.

2.2 Theoretical Foundations: Systems Thinking and the Food Systems Conceptual Approach

2.2.1 What is Systems Thinking? Why Use it for Food Systems?

Systems thinking as used in this thesis emerged in the context of Soft Systems Methodologies (SSM) with the "scope of 'managing' anything" (Checkland and Scholes,

1990, p. 1). While hard systems address problems as easily defined and fixed by technical solutions or engineering, soft systems are more complex and difficult to define, for instance, featuring competing perspectives about the nature of a given problem. Broadly, the motivation for systems thinking approaches was to work beyond siloed scientific disciplines to "promote the unity of science" and to explore increasingly messy human problems (Checkland, 2000, p. S11). The notion of systems thinking "encompasses any use of the core idea of an adaptive whole to understand or intervene in the complexities of human affairs" and in "tackling complex real-world problems" (Checkland and Haynes, 1994, p. 189). Rather than explaining phenomena by reducing them into constituent parts or siloed disciplines, systems thinking emphasises relationships, interactions, feedbacks, and emergent properties that arise from the behaviour of a whole system. Using systems thinking approaches acknowledges the complex "messiness" of reality, as well as important dynamics of these systems (such as feedbacks, non-linear relationships, multiple perspectives, and trade-offs).

Development of the food systems field of study followed, which applies whole systems thinking to food. It has become increasingly widely used since the early 2000s (Ingram, 2011); more recently, this approach has gained increasing prominence within food policy domains (ex. one of the top priorities of the United Nations Framework Convention on Climate Change (UNFCCC) COP30 was "Transforming Agriculture and Food Systems")(UNFCCC, 2025).

The food systems approach addresses food, not just in terms of its constituent (albeit important) components, such as agriculture or food security. Instead, the food systems approach addresses the complexities and dynamics of all food system activities, the

outcomes those activities give rise to, and the drivers and feedbacks that impact the system and its actors, activities, and processes. These terms are key to the food systems theoretical framing, and are defined as used in this thesis in **Table 2.1**. Food systems sit within human and natural systems and are subject to their dynamics, such as climate change and political shifts (Ericksen et al., 2012, Ingram, 2011); activities capture production, processing, retailing, consuming, storing, and disposing food (Ericksen et al., 2012, Ingram, 2011). Analysis of the dynamics of these systems occurs through their drivers, outcomes, and feedbacks (Ericksen et al., 2012, Ingram, 2011, Hasnain and Hill, 2025).

Table 2.1 Key terms for a food systems approach.

Term	**Food Systems Theory Description**
Food System	The food system itself sits within natural and human systems. These systems can be thought of as social-ecological systems (SES), complex networks of actors and activities, and/or as complex value chains and their interactions (Hebinck et al., 2021b). Within the food system, there are several key activities: production, processing, retailing, consuming, and disposing, all which have flows between them (connections and processes)(Ericksen, 2008). The food system is subject to drivers (which are shaped by feedbacks) and gives rise to food system outcomes. Drivers lead to outcomes as facilitated by food system actors and activities, then outcomes can become drivers, mediated by feedbacks (Hasnain and Hill, 2025).
Drivers	Food system drivers "represent forces that exert influence on the sustained structure, function, and trajectory of a food system" (Hasnain and Hill, 2025). They can be internal to the system, such as technological innovation, or external to the system, such as climate change, and can operate and interact across various scales and levels (Hasnain and Hill, 2025).
Outcomes	Food system outcomes capture 'what we get' from 'what we do' (Ingram, 2011). They arise as "the 'impacts' of food system activities or the performance characteristics of the system itself, spanning scales and levels from the individual to the global" (Hasnain and Hill, 2025). Food system outcomes fall within four main categories: health/food security outcomes, environmental outcomes, economic outcomes, and social outcomes (Ericksen, 2008).
Feedbacks	Feedbacks connect outcomes to drivers and shape drivers. They occur "when a process interacts with a system component and the response then produces

	another reaction"; they “can reinforce or counterbalance the original process" (Ericksen, 2008).
Actors and Activities	Food system actors undertake system activities. “Actors can be human, non-human, or institutional” and “the activities they undertake are subject to drivers. Actors exist across levels and undertake activities across scales. These activities result in outcomes across scales” (Hasnain and Hill, 2025).

The food systems approach is useful in that it helps to identify multiplicity of viewpoints and important trade-off areas and to illustrate key linkages, such as between ecosystem services and one of the most fundamental necessities of human survival: food availability, access, utilisation, and stability (the key elements of food security)(Ericksen et al., 2012, p. 40). The systems approach helps to deliver an understanding of the complex interactions and multiple processes that will help to solve increasingly complex problems of the food system, such as prolific food insecurity and environmental damage including ecological degradation, biodiversity loss, and greenhouse gas emissions driven by food system activities. These factors are increasingly challenging, which demonstrates the necessity of taking a systems approach. Shocks (fast acting) and stresses (slow acting) to the food system range from global pandemics and fuel crises to climate change and inflation. These impact actors throughout the system in a range of ways through complex systems dynamics and feedbacks, giving rise to impacts such as livelihood access, social necessities, and food security. As this thesis shows, the food system connects factors such as these in a complex manner, which would be concealed without a “whole-of-system” approach. Further, within the exploration of soft systems, these are not understood as existing within an objective truth, but as socially constructed representations of reality. Consequently, whose perspectives (and interests) are included in defining system boundaries, identifying drivers, and interpreting feedbacks becomes an important methodological and normative question.

2.2.2 Why Use a Food Systems Conceptual Approach?

Food systems framing is distinct from others which could also be applicable to the food systems domain, such as SES, agroecology, food sovereignty movements, and so on. While broadly these approaches all aim to understand and improve social, environmental, and economic factors related to food system activities, the food systems approach is distinct in that it is specific to food-related factors with the focus on the dynamics of systems, such as the feedbacks between drivers and outcomes and trade-offs between system outcomes (Ericksen et al., 2012). It takes a food-specific approach more focused than a broader SES approach, which is useful for targeting the unique and specific sets of challenges and contextual factors faced by food systems.

Additionally food systems can be classified as complex adaptive systems or networks of actors (Ericksen et al., 2012, Hebinck et al., 2021b, Ingram, 2011, Woodhill, 2019). These classifications take a systems science approach, which attempts a more realist ontology that aims to be neutral (albeit laden with values that are entrenched in the scientific method and perspectives arising from scientific or "Western knowledge"). This is distinct from more ideological or values-based approaches such as agroecology and food sovereignty movements. These inherently have an aim beyond understanding reality through a specific lens (in this case, the "systems science lens") and instead focus on ideological shifts that usually prioritise environmental outcomes and food security. For instance, the agroecology approach specifically aims to enable "change that brings sustainability to all parts of the food system: ecological, economic, and social…" further, it "confronts the economic and political power structures of the current industrial food system with alternative social structures and policy action" (Gliessman, 2018 pp. 599).

While the ultimate goals of agroecology and many taking the food systems approach may be aligned, the food systems approach itself acknowledges winners and losers, for instance but does not necessarily prioritise a specific systemic outcome or manner in which outcomes can be reached (Bell and Bellon, 2018, Gliessman, 2018, Wezel et al., 2009, Davis et al., 2022, de Wit et al., 2021, Leeuwis et al., 2021). Instead, the food systems approach focuses on system dynamics and interactions. This focus is central to the RQs posed in this thesis, as it aimed to explore the complex dynamics and interactions through the perspective of PNG cocoa smallholders, who make decisions that directly result in outcomes across system dimensions (food security/health, environmental, and socio-economic outcomes).

Food systems scientists broadly acknowledge that the system must be transformed; this is where dynamics and interactions become a useful entry point, and where the direction of change becomes relevant; however, the exact direction or nature of transformation is not a necessity for the food system approach, and it does not inherently have a specifically intended direction (Edwards et al., 2024). When systems undergo transformational processes, however, the direction of transformation is values-laden, political, and subjective, which is why a participatory systems approach is used in this work to unpack the dynamics as perceived by target participants. This is discussed further in the Literature Review section on Justice in FSTs.

While this systems approach is beneficial for shedding light on the dynamics of the system and delineating a conceptual boundary, it can also be highly complex. This complexity has sometimes led to a lack of clarity or disparate understandings of food systems, and precisely how and what about food systems should change (Anggraeni et

al., 2022, Edwards et al., 2024, Leeuwis et al., 2021). Further, the term "food systems" has also gained substantial attention, with systems approaches sometimes being claimed but not actually used, further encumbering congruency in food systems boundaries and terms.

While the overall utility and necessity of the food systems approach has been firmly established in the literature, subsequent work has established a need for transformation of the system and for improved resilience. Again, concepts of transformation and resilience in food systems have long been the subject of debate. For example, what should be transformed: the system outcomes? The system structure? Something else? And: what should be more resilient: The system itself? The system outcomes? The system structure? Actors within the system? Something else? Ingram and Thornton clarified this: specifically, food system *outcomes* are what must be transformed (Ingram and Thornton, 2022). This will occur by reassessing policies that drive actors to adapt their activities (Ingram and Thornton, 2022). Further, they note that resilience should be directed at both outcomes and actors.

The emphasis on transformation towards more resilient outcomes has established a vital foundation for food systems research. To achieve this, the majority of food systems work to date has focused on outcomes, indicators, and the dynamics of systems, with the objective of transforming outcomes (particularly measurable outcomes) towards being more resilient. Transformation investigation has been directed at whole system shifts, coordination, and levers for change, often at the national or global level (El Bilali et al., 2019, Gerten et al., 2020, Wezel et al., 2020, Willett et al., 2019). While these have all been necessary to address the huge scope of food system challenges by responding

efficiently, there remain gaps in the food systems literature that have come at the cost of this efficiency; more work is needed around transformations, particularly thinking about beneficiaries, which system actors will be left out of transformation processes, and how the transformation can be more just. This thesis addresses a key element of this research gap, which unpacks how justice concerns can be integrated with the dynamics of food systems and inform transformational processes. This is implemented through inclusion of low-influence actors while maintaining a systems orientation. This drives the RQs in this thesis to focus on actor-centric perspectives of low-influence actors and how they can contribute to processes that support more just FSTs including the knowledge used to underpin transformations and their governance.

2.3 Key Literatures: Food Systems Science, Transformations, Scale and Level, and Justice

The focal point of this thesis is on integrating justice with the processes that will transform the food system. This is done by taking an actor-centric approach to FSTs with special consideration of low-influence actors. Low-influence actors are key to this work given their inclusion in FST processes is a vital step in enabling more just transformations. The conceptual framing will hence focus on frameworks that are directed at FSTs, systems science, and system actors. Based on that theoretical foundation, this work uses an entry point of scale and level, reviewing how actors interact with systems, which will help to answer **RQ1** and is later discussed in **Chapter 4**. Thereafter, the review investigates approaches to food systems justice, particularly through mechanisms for inclusion of diverse and low-influence actors (this helps answer **RQ2**, explored in **Chapter 5**) and their drivers (addressing **RQ3**, explored in **Chapter 6**).

2.3.1 Food Systems Transformation Conceptual Approaches, Their Use in This Thesis, and Policy Contexts

The agenda to transform food systems has been gradually refined over the last decade on the basis that sweeping changes are needed to find a better balance between food system outcomes that fall within three or four categories: Food/Nutrition Security, Environmental Outcomes, and Economic and Social Outcomes (which are sometimes framed as one combined Socioeconomic Outcome)(Ericksen, 2008). A useful way to trace how FST discourse has evolved since the field began expanding rapidly over a decade ago, and to situate the RQs raised in this thesis, is to examine shifts in globally significant food systems reports. These have been constructed on the updated food systems science of their time. In large part, they have been driven by the High Level Panel of Experts on Food Security and Nutrition (HLPE) of the Committee on World Food Security (CFS) and by the United Nations (UN) Food Systems Summits (formerly the UN Food Summits). The HLPE is the UN body for analysis and assessment of the science related to global food security and nutrition, drawing on the expertise of academics and practitioners, and regularly updating the state of food systems science; it thus is a useful reference point for the most current research in food systems science and the science-policy interface.

The trends of HLPE publications generally reflect the broader FST literature: early HLPE reports focused on singular or intersecting dimensions of food and nutrition with challenges such as food price volatility, land tenure, climate change, and social protection (HLPE, 2011b, HLPE, 2011a, HLPE, 2012a, HLPE, 2012b). Thereafter, the focus shifted from food security and nutrition to “sustainable food systems” and more intersectional

challenges throughout the food system (HLPE, 2014). The shift then transitioned towards focusing more on the role of people and institutions within food systems, such as through multi-stakeholder partnerships, youth engagement, and in reducing inequalities (HLPE, 2018, HLPE, 2021, HLPE, 2023). This period coincided with a broader shift in the UN toward systems based approaches; the World Food Summits started in 1996 and 2002 and transitioned to the World Summit on Food Security in 2009, then shifted towards the explicit adoption of a food systems approach through the UN Food Systems Summit in 2021 (followed by stocktakes in 2023 and 2025)(Canfield et al., 2025, Hoffmann et al., 2023). More recently, the importance of just food systems has begun to grow, such as with the HLPE's focus on rights-based approaches to food (HLPE, 2025). While this recent approach is a vital addition to the literature, it still engages with food primarily for its contribution to food security and nutrition outcomes and its sustainability, and engage with food systems less as an avenue for the right to a secure and dignified life or livelihood, which is vital in the context of this thesis and important for the numerous low-influence actors in the food system including (but not limited to) food producers, processors, non-human actors, and so on.

Beyond the trends illustrated by the evolution of UN-backed publications, Juri et al. (2024) conducted a semi-systematic overview and synthesis of the field of food systems and the approach to transitions and transformations from 1994 to 2022 (Juri et al., 2024). This work reinforces the trends described throughout UN publications, noting three main phases of food systems research: 1994 to 2004, characterised by early but sparse literature on food systems, 2005 to 2014, characterised by the increasing use of transition theories such as socio-technical transitions, and 2015 to 2022. This period was characterised by a great expansion in FST research which focus on a range of topics including system-wide

coordination through interdisciplinary work, increasing acknowledgement of system heterogeneity, and a more recent, growing focus on bottom-up processes such as through Alternative Food Networks, agroecology, participation, and the emergence of research addressing power and justice issues (Juri et al., 2024). This work also explores demographics of academic publishing on food systems. They delineate between "Global North" and "Global South" noting that the vast majority of corresponding authors publishing on FSTs are based in the Global North with low representation of articles authored from the Global South (Juri et al., 2024). Further, emerging initiatives such as FOSTER (Fostering food system transformation by integrating heterogeneous perspectives in knowledge and innovation within the European Research Area), which have a primary objective on getting food systems researchers across geographical contexts (in this case, in Europe) to create a unified concept of boundaries and what constitutes food systems research by bridging the gap between traditional scientific research, policy making, and citizen-led initiatives.

The FST literature has evolved in important ways, recently trending towards issues of power, justice and inclusion, providing useful context and highlighting the gap this thesis aims to address. Hence, this work draws directly on the framework from Foresight for Food with support from Béné et al. (2019) and Caron et al. (2018) to establish a theoretical basis underpinning the RQs. While not a chapter in this thesis, alongside discussion of these selected frameworks, Hasnain and Hill (2025) catalogues 14 of the most impactful policy-relevant food system frameworks, describing how each represents and describes system outcomes, drivers, and feedbacks; this provides explanation of additional relevant literature on food systems frameworks and how they represent and define important food

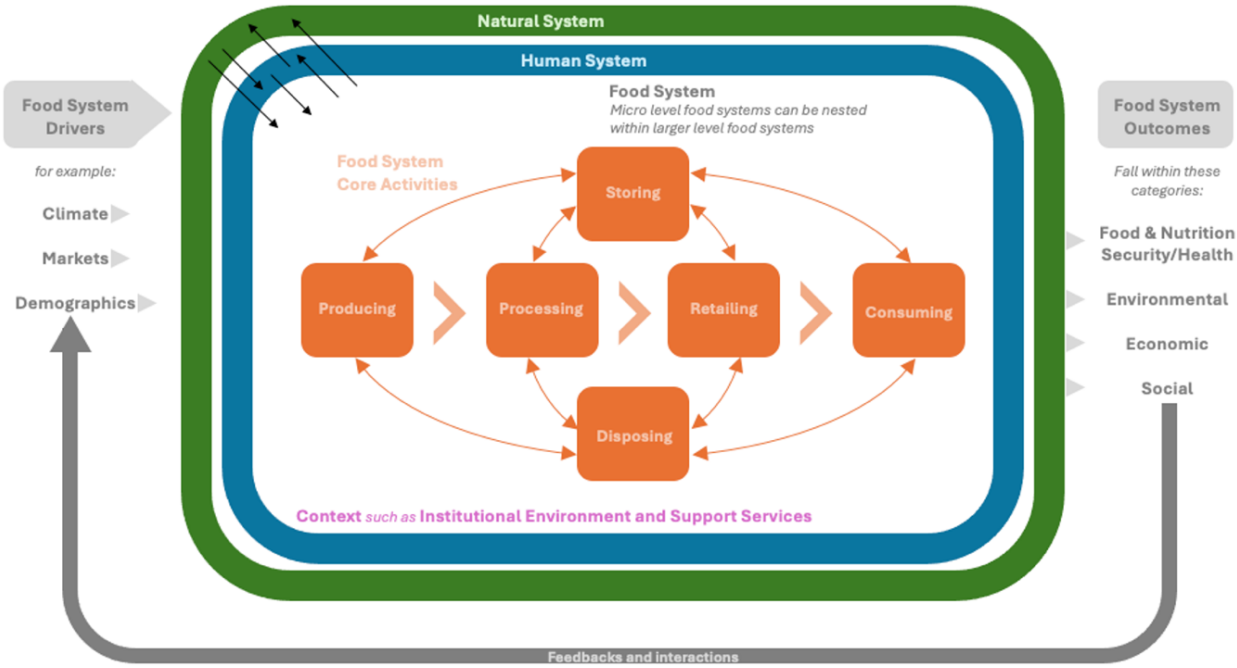
system dynamics (see **Appendix L** for the full table detailing drivers, outcomes, and feedbacks that I co-authored alongside this thesis).

The policy-relevant frameworks reviewed in **Appendix L** are an effective demonstration of how systems thinking has been used in food policy, linking systems thinking approaches to FSTs. Taken together, these show that food systems science has been used in policy contexts to integrate multiple outcome areas, to trace links between drivers, activities, outcomes and feedbacks, to expose trade-offs and synergies, to support scenario-building and foresight, to develop metrics and monitoring tools, and to reframe food policy as a cross-sectoral and multi-level, multi-scale governance challenge (Acharya et al., 2014, Béné et al., 2019b, Brunori et al., 2013, Ericksen, 2008, Fanzo et al., 2021, Global Panel on Agriculture Food Systems for Nutrition, 2014, HLPE, 2018, Nguyen, 2018, Parsons et al., 2018, Stefanovic et al., 2020, Webb et al., 2023, Woodhill, 2019, Zurek et al., 2018). Comparing them also shows that there remains inconsistency in how dynamics in food systems, such as drivers, outcomes, and feedbacks, are conceptualised and defined. This unevenness suggests that food systems science has become influential in food policy partly because it offers holistic but adaptable framing and breaks down siloed areas of governance. However, usefulness for policy depends on conceptual clarity about what is being transformed, which drivers are being acted upon, which outcomes are prioritised, and how feedbacks are understood and integrated with systems change processes.

The policy-facing food systems frameworks further show how applications of systems thinking have been used in food policy. They translate core systems thinking principles, such as relationships between components, feedbacks, non-linearity, multiple outcomes,

trade-offs, system boundaries, and cross-scale/ cross-level interactions into analytical frameworks for food systems governance. Rather than treating food policy with a siloed approach, such as by focusing on agricultural production, nutrition, environmental sustainability, or market governance, these frameworks conceptualise food systems as dynamic configurations of actors, activities, drivers, outcomes, and feedbacks (or as complex adaptive systems, or social-ecological systems). These frameworks enable an approach that surfaces how interventions in one part of the system may generate consequences elsewhere, how outcomes can become drivers, and how food systems are shaped by broader human and natural systems. Each varies in how fully they operationalise systems thinking; while some explicitly represent feedbacks, drivers, and cross-scale dynamics, others use systems language mainly to organise multiple sectors within a shared policy frame and reduce the siloed nature of constituent parts of the food system and its governance.

The Foresight for Food conceptual model was selected because it takes a systems thinking approach to food systems, it is directed towards systems transformation, and it is applicable across food system scales and levels. The frame centres system activities, fitting well with the approach in this thesis (in all **RQs 1**, **2**, and **3**) which focus on actors and what drives them to undertake key activities. Further, the Foresight for Food model separates outcomes by overall outcome category (ex. environmental and economic), which is useful in the context of this thesis in the identification of trade-offs as perceived (and acted upon) by key actors. Foresight for Food explicitly frames food systems as complex adaptive systems with external drivers (such as population, wealth, politics), and outcomes (economic and social, food and nutrition, and environmental sustainability), which are connected to drivers via feedbacks, with additional flows between food, human,



and natural systems. The adapted conceptual framework from Foresight for Food as used in this thesis is shown in **Figure 2.1**. This framing is directly important for answering **RQ1** and provides the foundation for the cross-scale and cross-level framework proposed in **Chapter 4**.

Figure 2.1 The primary conceptual framework this thesis draws upon.

The second key framing that is foundational for this work is from Béné et al. (2019a), which focuses on sustainability transitions with particular attention on system drivers and the links between those drivers and food system transitional change. This work discusses key lenses for looking at food systems, how each lens views 'sustainability', and identifies 'key elements' for policy moving forward. It also establishes a framework identifying how to transition to sustainable food systems. This framework is important to inform this thesis as it takes a drivers-focused approach (important for answering **RQ3**) and questions whose perspectives are embedded in FSTs (important for answering all RQs and embedded in the processes for answering **RQ2** in particular). The framework from Béné et al. (2019a) is useful for the overall justice lens that this work takes. It shows consumers nested within food environments, which is further nested within food system

supply actors and activities, meaning that while all actors are consumers, some system actors are both consumers and otherwise involved in the supply chain or system, which is true for the complex "multi-actors" working in the case study for this thesis. They have roles as consumers, producers of subsistence food, producers of cash crops, as well as processors and distributors, which is particularly important for answering **RQ3** that demonstrates how multi-actors respond to their decision-making context across multiple dimensions (ex. their behaviour as consumers and as producers, which is mismatched to typology models, as shown in **Chapter 6**).

The final key framing this work draws on is from Caron et al. (2018), which shows the interconnected nature of food systems and the UN SDGs. This is highly relevant for the current work in its consideration of the multiple important outcomes of food systems (economic, environmental, and relating to food security) and how they trade off with one another but also contribute to and interconnect with sustainable and inclusive development and impact. The framework outlined by Caron et al. (2018) is oriented to transformation that is simultaneous across outcome areas, stressing the importance of social justice in such transformations that include changes across levels, which they explain through the convergence of local and global priorities, and through local-level innovation that is consistent with global actions and national expectations. This is particularly useful for providing a frame to answer **RQ1** in the scale and level investigation. Further, it provides an important foundation for considering trade-offs as perceived by system actors, which is a repeating theme across **RQs 1**, **2**, and **3**.

2.3.1.1 Agrarian Transformations

While not directly within the food systems research domain, it is useful to provide context of the relevant paradigms from agricultural economics, particularly agrarian transformation and the role this plays in FST paradigms. This work later discusses food system typologies, for instance, which are built on (in part) by these underlying theories. Particularly relevant in this work are the foundations from Kuznet's description of income and inequality (and its application in agriculture and environmental change in developing economies (Cetin et al., 2022, Kuznets, 1955). Further, this work draws on Timmer (2009) for context on agricultural transformation. For the purposes of this work, these literatures provide key background information. They describe the phenomenon that as the market-based economies of countries change and they grow richer, agriculture usually follows a trajectory under which land and resource use intensify in order to feed a growing population. This often degrades environmental conditions, however, rising incomes, urbanisation, and structural transformation later reduce agriculture's economic importance and enable cleaner technologies and stronger environmental regulation (Cetin et al., 2022, Kuznets, 1955, Timmer, 2009). There is also a simultaneous demographic transition, with lower fertility rates, urban migration, and a shrinking farm labour force, as well as a shift from low productivity farming toward fewer, more productive farms and land ownership that is consolidated, as described by Timmer (2009) and the broader literature on economic development transformations. Lastly, as income per capita rises during this transition, income inequality is theorised to initially increase and then decline at higher levels of development (Kuznets, 1955).

2.3.1.2 Participatory Research in International Agricultural Development

Another fundamental field of enquiry for this thesis, which is out of the direct domain of food systems research, addresses participatory work in international development. While the Methodological Approach section of this thesis details the more directly related literature on participatory and co-creative methods oriented to systems science, this section explores more fundamental bodies of work in participatory international agricultural development.

Early approaches to international agricultural development tended to be top-down, with change processes focussed on sharing new technologies and knowledge with farmers, from institutions that promoted scientific advancement and extension expertise; this was closely tied with colonial knowledge hierarchies and severe disparities in power and perceived knowledge (Hodge, 2007). This was challenged by Chambers, whose farmer first work argued that researchers, scientists, administrators, and fieldworkers often failed to appreciate the richness and validity of the knowledge held by rural and often resource-poor peoples (Chambers, 2011). This questioned "whose knowledge counts", recognising that farmers know a great deal from practical management of their farming systems, and arguing that this knowledge had been previously discounted by earlier development strategies and practitioners. Chambers' farmer first school of thought meant transitioning from technology transfer objectives in agricultural development to empowering farmers (Chambers, 2011). This was fundamental in Chambers' proposed transition from Rapid Rural Appraisal (the previously dominant paradigm of agricultural research) to Participatory Rural Appraisal. This marked a shift from largely extractive models of Rapid Rural Appraisal, where outside professionals extracted information from rural peoples for external analysis, toward participatory approaches in

which rural people themselves helped generate, analyse, present, and own knowledge. In practice, this meant transitioning from "learning about" rural communities to "learning from and with" them, with greater emphasis on facilitation, reflexivity, shared analysis, and local priorities (Chambers, 1993, Chambers and Conway, 1992).

As this new paradigm developed, so then did its critiques and support, which primarily argued that while participation is by-and-large beneficial, if not conducted carefully, it can cause further harms. Farrington and Martin's 1988 review assesses Chambers' proposed paradigm shift of farmer participatory research in response to conventional transfer-of-technology and top-down agricultural research models. This emphasises the value of involving farmers directly in identifying problems, testing technologies, and shaping research priorities. Their review situates farmer participation within farming systems research and Indigenous technical knowledge debates, showing how participatory approaches sought to make agricultural research more responsive to the conditions of resource-poor farmers (Farrington and Martin, 1988). Challenging and advancing the paradigm, Cooke and Kothari argue that participatory development can be problematic, reproducing domination rather than overcoming it, especially when participation becomes a fashionable requirement that obscures who controls agendas, knowledge, and decision making (Cooke and Kothari, 2001). They argue that the pro-participation rhetoric of empowerment can obscure unjust or illegitimate exercises of power in practice, causing more harm than benefit (Cooke and Kothari, 2001). Further, Hickey responds to the tyranny of participation critique by arguing that participation is not inherently depoliticising, but that under certain political and institutional conditions, participation can still be connected to genuinely transformative outcomes for marginalised or low-power groups as long as it is linked to power, rights, and wider

processes of social change (Hickey, 2004). In more contemporary responses to the paradigm shift of participatory international agricultural research, Dey de Pryck and Elias (2023) argue that participatory agricultural research often becomes technocratic when facilitators are not prepared to deal with unequal power relations, and so research and practice must go beyond participation to address power. They show that participation can create more inclusive spaces for identifying development challenges and solutions, but only when facilitation is skilled, self-reflective, and attentive to gender and social inclusion (Dey de Pryck and Elias, 2023).

2.3.2 Approaches to Cross-Scale Interactions

The literature on scale and level interactions to inform FSTs is burgeoning, building food-specific work on the foundation of more general systems research, such as Cash et al. (2006) and Geels (2002). The specific exploration of these works and their use in food systems is detailed below, and further detailed in **Chapter 4**.

Cash et al. (2006) describe cross-scale and cross-level interaction in complex systems in general (not specific to food systems), detailing how these dynamics and interactions operate, which directly helps to answer **RQ1** in unpacking how these dynamics play out in food systems. Cash's work has been used to inform significant research about FSTs: these acknowledge that cross-scale and cross-level interactions are important in food systems, however those interactions and dynamics are not further developed or applied using empirical evidence (see Ericksen, 2008, Zurek et al., 2022, Allen and Prosperi, 2016, Béné et al., 2019b, Tendall et al., 2015, Foran et al., 2014, Ingram, 2011).

In contrast, Geels' work on Multi-Level Perspectives (MLPs)(Geels, 2002, Geels, 2011, Geels et al., 2016) is applied more directly in food systems research. The MLP approach describes cross-level dynamics of a system, particularly for change processes across levels, through the interactions that occur between (1) niches, (2) regimes, and (3) landscape shifts. This MLP approach explains how socio-technical transitions occur: (1) niches are the protected spaces where radical innovations emerge and mature, (2) regimes are the stable status-quo state of systems (with dominant structures, rules, and practices), and (3) landscapes are the broad external forces (such as cultural trends and macroeconomics) that shape and stress regimes. Socio-technical transitions occur when landscape pressures destabilise the regime, changes at the niche level gain momentum, and innovations break through to transform or replace the incumbent system (Geels, 2002, Geels, 2011).

Bui et al. (2016), Conti et al. (2021), Gaitán-Cremaschi et al. (2019), and Leeuwis et al. (2021) apply Geels' work to food systems (or agri-food systems) change processes. Building on Geels' work, Bui et al. (2016) posit that new practices, rules, and interactions fostered by initiatives across the food system shape alternative visions of FST processes, gradually gaining wider acceptance and demonstrating the linkages between niche, regime, and landscape shift. They also argue that collaboration between niche actors and local level authorities facilitates the integration of changes into local systems and emphasises the key roles of local authorities in transforming established regimes (Bui et al., 2016).

In contrast, Conti et al. (2021) state that systems are resistant to change through six explanations: embedded nature of technologies, misaligned institutional settings,

individual attitudes, political economy factors, infrastructural rigidities, and research and innovation priorities; in order to address these resistance areas, they propose that agri-food must focus on the temporal scale and on interdependencies between temporal and physical scales to address food system problems, suggesting that further scale and level analysis is needed to enable transformation processes (Conti et al., 2021).

Assessing environmental and food security outcomes, Gaitán-Cremaschi et al. (2019) use MLP analysis, arguing that the food system regime (the dominant large scale food system in a given country) faces internal tensions and external pressures from the landscape level to the macro-level, creating opportunities for innovations in both dominant systems and niches. They argue that actors within a regime can also drive transitions, although change processes require niche-system interactions. Due to the interconnected nature of food systems, both regime and niche innovations can result in multiple co-existing, hybrid systems within a given country or context. These may include dominant systems supported by the regime, niche systems challenging the status quo, and hybrid systems combining elements of both. The boundaries between these systems are often blurred and permeable (Gaitán-Cremaschi et al., 2019).

Leeuwis et al. (2021) instead posit that supporting the FST requires more than science-based understanding and analysis of system interactions across scales and levels, but rather that a broader social and political challenge must be tackled that addresses the emergent properties of food systems (what they call ‘food system synthesis’). Although these pieces of research show how scale and level can support change processes, they do not explore how scale and level can contribute to those change processes while integrating justice or inclusion.

Beyond the acknowledgment of scale and level through addressing and applying the cross-scale and cross-level work of Cash and Geels to food systems research, Ewert et al. (2023) explore cross-scale and cross-level approaches for agroecology. They propose a fully integrated and multiscale systems approach from farm to region to globe, positing that it may be useful for solving food system problems by transitioning to large-scale agroecology (Ewert et al., 2023). The focal point of this integrated approach is on system drivers as well as important processes and relationships, sustainability indicators, and assessment methods across all scales, directed at transforming agriculture toward more sustainable and resilient food systems (Ewert et al., 2023). This is further supported in work from Caron et al. (2018)(one of the key frames for this thesis), which provides evidence supporting the need to synergise policies through convergence of local and global priorities and find pathways for local level innovation and global action towards sustainable development (Caron et al., 2018). Despite the broad acknowledgement that cross-scale and cross-level dynamics are important for food systems, a gap remains in addressing how these cross-scale and cross-level dynamics actually arise in terms of the dynamics of food systems. Further, there is a gap in empirical evidence addressing this with food system actors. The cross-scale and cross-level interactions are more thoroughly and directly explored in the targeted literature review in **Chapter 4** and in answering **RQ1** which addresses the theoretical and empirical gap raised here using a case study with low-influence actors to link this to the thesis aims and objectives of improving food system justice.

2.3.3 Justice in Food Systems Transformations

'Justice' as it relates to the food system is a fragmented and nebulous concept, with work in and around the food systems arena addressing issues from food sovereignty to alternative food networks, and defining these around terms such as democracy, power, justice, inclusion, influence, and so on. These concepts are "messy" and each has its own set of (often contested) definitions and relationships to the other concepts; for example, power itself can be defined as the capacity to *influence* the behaviour of others or the course of events (Zimmerling, 2005). The vast range of approaches result in an opacity in which conceptualisations or principles of justice have been used to inform FSTs. Further, an additional barrier to addressing theoretical approaches to integrating justice into FSTs is that justice itself can be considered an outcome of the system or a lens with which to look at the system (it can represent a result of the food system or an approach for looking at that system as a whole)(Stefanovic et al., 2020, Nordhagen et al., 2022). To ensure clarity in these concepts across the thesis, key terms relating to justice and how it is addressed in this thesis are shown in **Table 2.2**.

Table 2.2 Relevant terms used across this thesis relating to just FSTs.

Term/Phase	**Justice Oriented Focus Description**
Low-influence actors (from **Chapter 5**)	This work engages "low-influence actors in the food system" recognising that they are critical decision makers at local levels, but have little influence over the structure and function of regional and national food systems (or *the* global level food system which is often the focal point of FST research, and hence, the point of reference in this work). Their perspectives may not be considered (or are minimally considered) in the dominant policy agendas at sub-national, national, and global levels. In other research and theoretical approaches which are close to this work and research context, these actors may be framed as "marginalised" or "low power" actors, as well described by Indigeneity, smallholdings, or peasant farming in their own unique contexts. "Low-influence actor" is not an identity category, however it is a term to describe the systems oriented, relational position of actors that are the focal point of this work. These concepts will be integrated as appropriate for the PNG context in a manner that is both scale and level sensitive and oriented to systems science: smallholder farmers in PNG are largely from their local area – the majority of the population could be considered "Indigenous", both by ancestry and by their ongoing relationships to land, language, and custom (Government of Papua New Guinea, 1975, p. 158)[4], however, they do not have a high degree of influence over their food system structure and function, so the case study group will be described as smallholder farmers or low-influence actors in this work. Although this term is imperfect, it was selected as an alternative to "marginalised" given the association between marginalisation and systematic removal of agency from actors. "Low-influence actors" is approached here as a systems science term and used with regard to whole (and global level) systems transformation (originally it was "Low Influence System Actors", however, this was deemed impractical due to its length).
Justice	Justice is conceptualised in this work to integrate inclusion, participation, influence, and power over system structure and function, and is based on broad framings of what "justice" means for the FST (later reviewed in **Chapter 5**). This work considers justice in terms of processes aiming to transform the food system, including processes aimed at transformation (see below explanation), such that system outcomes are achieved for all actors (human and non-human). This integrates and addresses justice in historical, epistemological, social, procedural, distributive, and recognition dimensions.
Processes [Aimed at More Just and Inclusive FSTs]	This thesis refers to the "processes" aimed at transforming the food system in normative terms. FSTs are discussed later in the literature review, however, the term "processes" in this context refers to the broader context of change for a range of activities including but not limited to system actor engagement, discourse (academic, policy, and otherwise), epistemological processes, interventions/initiatives, policy and other processes that aim to contribute to the overall FST.

[4] PNG's Constitution and domestic laws do not contain a formal definition of "Indigenous" and rather consider "custom", which "means the customs and usages of indigenous inhabitants of the country existing in relation to the matter in question at the time when and the place in relation to which the matter arises, regardless of whether or not the custom or usage has existed from time immemorial" GOVERNMENT OF PAPUA NEW GUINEA 1975. Constitution of the Independent State of Papua New Guinea. Port Moresby: Government of Papua New Guinea..

The focal point of this thesis is on "low-influence actors". This term is imperfect but an analytically useful concept for identifying actors in a system whose knowledge, priorities, and decision-making contexts are often weakly represented in processes aimed at transforming food systems. The term applies to actors in the case study used here (PNG cocoa farmers) but could also be used for other food system actors, such as gig economy workers, casualised workers, or low-income consumers. The term is not used here as a fixed identity category, nor to imply that such actors lack agency, knowledge, or importance. Rather, influence is understood here as relational, contextual, and unevenly distributed across scales, levels, and decision contexts. An actor may have substantial influence over household food practices, local land-use decisions, or local production systems, but still have very little influence over factors such as market prices, infrastructure or service provision, research agendas, or transformation discourses (Jacobi et al., 2022, Brock et al., 2024, Hill et al., 2025). In this sense, low influence refers to a limited capacity to shape systems through the formalised and higher-level structures which determine priorities and processes through which FSTs are governed and produced. This concept is closely related to, but not interchangeable with, terms such as "marginalised", "vulnerable", or "Indigenous" actors. These terms carry different analytical and political implications, some of which may obscure the relational and systems focus of this work and the situated authority of the actors considered in this thesis. The choice of "low influence" was therefore selected to focus attention to asymmetries of power (and related concepts herein), while avoiding a framing that positions actors only through deprivation or marginality. The concept, however, raises broader questions about how influence is defined, measured, and recognised, who has authority to make such assessments, and how influence relates to power, discourse, resource distribution,

knowledge/ perceived knowledge legitimacy, and institutions. These questions have been widely debated in theories of power and participation and cannot be fully resolved within the scope of this thesis. Instead, this thesis uses "low influence" pragmatically and normatively to direct attention to a specific justice problem within FSTs around actors who are consequential for system outcomes but do not currently shape the agendas, policies, and interventions that seek to transform those systems.

The RQs in this thesis all bring in low-influence actors as a key component of contributing to more just FSTs. The primary underpinning logic being that understanding and achieving more just FSTs requires centring low-influence actors while maintaining a holistic systems view. Examining the concepts of justice in FSTs and linking inclusion to justice is vital for conducting actor-centric analysis. Actors in food systems range from large multinationals to communities and individuals, all of whom have greatly varying roles and access to justice (as well as power, influence, and inclusion, etc.) within the system. Food systems have stark structural inequalities in all outcome areas and engaging with and including diverse actors is vital in addressing these system-wide inequalities (Huttunen et al., 2022, Reece, 2018). There is further emphasis on addressing these inequalities in localised contexts, particularly for marginalised groups that are disproportionally affected by resource reliance and use (Allen, 2008, Allen, 2010, de Bruin et al., 2024, Gonzalez, 2015, Huttunen et al., 2022, Reece, 2018).

There are varying approaches to assessing concepts of justice in food systems and multiple dimensions of justice, described in **Table 2.3**. The broad approaches from social and food justices, food sovereignty to alternative food networks, etc., are detailed in **Table 2.4**, which covers these concepts and also links them to concepts around level and scale

in the food system, providing context for **RQ1**. The focus on inclusion of low-influence actors which is employed by the RQs in this thesis integrates multiple dimensions of justice by ensuring their meaningful participation in decision making (procedural justice), recognising their knowledge and central role in shaping food system outcomes (recognition justice), and addressing inequities in the distribution of resources, opportunities, and power (distributive justice). It also advances social justice by interrogating institutional power relations and resource allocation, while acknowledging historical injustices that have structured present-day exclusions which must be confronted to enable just transformation. A full analysis of theories and philosophies of justice, power, and influence, and beyond are outside the scope of this Literature Review, however, this is more deeply engaged with throughout the thesis.

Table 2.3 Justice dimensions explicitly explored throughout food systems literature.

Lens	Explanation
Procedural Justice*	The procedural justice lens allows researchers, practitioners and policy makers alike to consider the inclusion of diverse actor groups in the decision-making processes regarding the transformation. Inclusion in decision-making processes is vital for uptake of those decisions and for interventions across the system to be taken up (and maintained) by the subjects of those interventions (de Bruin et al., 2024).
Recognition Justice*	Recognition justice is important to ensure that the diverse range of actors are credited as both vital for the transformation process and as key decision makers in the food system, as they are often at the coalface of important food system decisions, undertaking activities that lead to important system outcomes across scales and levels (de Bruin et al., 2024).
Distributive Justice*	Distributive justice is important to assess the fairness and equity of interactions and transactions within the system, including for all system activities. Further, it is vital in assessing who holds resources and opportunities (including access to power as well as access to change the system (de Bruin et al., 2024).

Lens	Explanation
Social Justice	Social justice allows identification of resource allocation, particularly between institutional actors and individuals or groups of individuals. It also provides a lens through which institutions and power can be directly assessed, which is important in the relational approach of the theory of change in this work (Caron et al., 2018).
Historical Justice	Historical justice provides a lens through which system relationships can be better understood given the long history of inequity which has plagued the system, and which must be combatted to achieve holistic change and a FST that is sustained and consistently seeks to achieve more just processes over time (Whitfield et al., 2021).

*Whitfield et al. (2021) describe representational justice as acknowledging a wide range of people and knowledges, particularly those who are historically marginalised, requiring them to be involved in shaping food futures. This dimension of justice integrates procedural and recognition justices, and also advocates for inclusion, connecting it to the need for distributive justice.

To date, few works have focused specifically on integrating justice into FST processes. In food systems, distributive justice is frequently treated as an ideal rather than being firmly built into structures, while recognition and procedural justice are implemented inconsistently because of local power imbalances and institutional norms (Cifuentes et al., 2026).

In conceptual approaches to food systems justice, de Bruin et al. (2024) offer a framework to guide thinking to help consider how justice is addressed in FSTs, specifically those developing FST interventions. This framework offers a tool for reflection on how justice is conceptualised within those interventions. Taking a people-focused approach to food system actors, de Bruin et al. (2024) demonstrate overlapping conceptualisations of justice for food systems initiatives: procedural, distributional, and recognition justice, positing that the "subjects of justice" by their assessment were actors with a "particular role in the food system, people who are marginalised, Indigenous communities, those

with experiences of negative consequences of the food system, future generations, and non-humans" (de Bruin et al., 2024, p. 356).

In contrast, Whitfield et al. (2021) offer a framework for examining justice in FST research. This offers ways to think about justice when looking at FST initiatives but does not integrate justice directly into transformational systems dynamics. Here, Whitfield et al. (2021) argue that justice must be explicitly integrated into food system transformation agendas, proposing three lenses for doing so: historical, representational, and distributional. These lenses guide how justice is understood and addressed throughout transformational processes. The historical justice lens surfaces how past injustices and context drive contemporary food systems and can be reproduced or challenged as transformation takes place. The representational justice lens emphasises whose voices, perspectives, and knowledges are included in the visioning and governance of change (towards transformation). The distributional justice lens focuses on how the benefits and burdens of FSTs are shared among different actors. Together, these lenses integrate to offer a framework for examining justice across stages of FSTs.

The RQs in this thesis build on the work of de Bruin et al. (2024) and Whitfield et al. (2021) in integrating justice not only into food systems understandings and interventions, but explicitly integrating justice into the dynamics of food systems analysis as well as by providing pathways (primarily through participatory research and co-creation of knowledge) for FST processes to integrate justice considerations. This is further built upon by providing empirical evidence with low-influence actors to analyse the nature of engagement and how it can contribute to more just FSTs. The focal point of this thesis, low-influence actor inclusion in systems transformations processes, draws specifically on

elements of procedural, distributive, recognition, and epistemological justices, which will be more specifically explored throughout the chapters therein. Whilst epistemological justice is extremely important in this work, the literature on this dimension of justice has to date been focused more broadly on sustainability transitions than FSTs (Cummings et al., 2023, Temper and Del Bene, 2016, Walker and Boni, 2020). This concept is explored in detail in **Chapter 5**.

In alignment with advances in FST justice research, there has been a shifting emphasis towards uncovering power dynamics in food systems. Challenges such as power distribution within the system, rather than falling under a specific system outcome area, have been used as a lens with which to assess the system outcomes, or alternatively, a manner in which food systems outcomes or governance can be improved (Clapp, 2021, Swinburn, 2019, Slater et al., 2026). Power and justice are much more difficult to measure, monitor, and address than issues around, for example, sustainability or food security. Approaching even more "simple" factors important in food systems research, such as food security, has been challenging given its varied definitions, attributes, and indicators (Tendall et al., 2015). Food security has taken years of debate to arrive at a widely accepted definition. Identifying, measuring, monitoring, and addressing challenges around justice and power in the system is even more difficult, not only due to a multiplicity of definitions and metrics associated with them, but also these factors are inherently difficult to uncover. Part of the power held by the powerful in the food system is also due to the opacity of resource distribution, decision making, and so on, so in addition to these factors being difficult to measure, they are also difficult to conceptualise (de Bruin et al., 2024). Power and justice share many challenges in the FST. This work

aims to be sensitive of power dynamics, but focuses on actor inclusion and how this can contribute to more just FSTs.

Table 2.4 Conceptualisations of actor focused food system reform movements and their approach to scale dynamics.

Focal Area	Emphasis	Description	Author(s)
Justice-focused approaches			
Just Food Systems Transformation	Transformation processes must integrate key elements of justice, which have been inconsistently defined. A just FST must attend to concepts of social differentiation, politics, power, and the roles of actors in the FST. Key words: **Justice, inclusion, recognition, decision making, ethics**	In order to achieve a just transition of the food system (defined as achieving 'sustainable and just food systems'), the FST must be inclusive. This is achieved by recognising actors that should be acknowledged as subjects of justice: actors with a particular role in the food system such as producers and consumers, marginalised peoples, Indigenous communities, those who have had negative consequences of the food system, future generations, and non-humans. Justice can be understood through several lenses including distributive, procedural, recognition, and historical. Justice implications of research must be addressed, as research can further exacerbate justice issues. Researchers must have a commitment to the ethics of transformative and just research. In consideration of scale and level, injustices are often viewed as systemic problems. Addressing scale, level, and justice issues within the food system are challenging given the tension between food being framed as a commodity and conceptualisations of justice that centre around collective rights and social justice.	de Bruin et al. (2024); Whitfield et al. (2021)
Social Justice in Food Systems	Justice issues are integrated and exist both across the system and based in the food system's social organisation. Key words: **Exploitation, opportunity, freedom**	Fundamentally, the agri-food system is socially organised. As such problems with this system are the result of social choices which are embodied in traditions, institutions, and economic and legal structures. Solutions appear to be locally oriented, for example by responding to epic food-system globalisation with local food campaigns and alternative agri-food institutions. Health, ecological, and justice challenges are not strategically or analytically separate.	Allen (2008)
Other key movements for food, agriculture and nutrition reform			
Agroecology	Interdisciplinary approach focused on reform and	Agroecology is participatory, requiring stakeholder engagement throughout the food value chain. It confronts political economic and power structures of the current industrial food	Bell and Bellon (2018),

Focal Area	Emphasis	Description	Author(s)
	stakeholder participation to achieve fairer outcomes. Key words: **Participation, fairness**	system and is understood as a combination of science, a set of agricultural practices, and a social movement towards fairer outcomes. Agroecology has tended to focus on the local level and is rooted in ideas of place and context.	Gliessman (2018), Wezel et al. (2009)
Alternative Food Networks	Creating a sustainable and ethical alternative to mainstream industrial food value chains. Key words: **Ethics, localisation, equity, context**	Alternative food networks include all food system activities, prioritising sustainability, local context, and social equity. They often include practices and activities at the local scale to counter industrial food processes with the aim of shortening the food supply chain. They focus on reducing environmental impact, supporting local economies, and increasing the ethics of food systems for human and non-human actors. Alternative food networks focus on local-level, anti-globalised and anti-industrialised food systems.	Goodman et al. (2012); Whatmore et al. (2003)
Food Democracy, Food Politics, and Food Citizenship	People-driven approach to reforming the concentration of power in industry and using people to drive the FST. Key words: **Power and empowerment, justice, inclusion, decision making**	These approaches are people-driven ways to understand the food system, or to elicit change in food systems. Justice (and concepts thereof) and power are particularly important for systems change, particularly the contrasting power between food industry and local or community-level actors. Individuals and communities must be empowered to drive systems change.	Bornemann and Weiland (2019); Leach (2012)
Food Justice	Addressing system wide inequalities and reforming them through a holistic, community-based approach.	Food justice aims to ensure equitable access to healthy, affordable, and culturally appropriate food for all people. It addresses the systemic inequities that disproportionately impact marginalised communities within the food system, and focus on challenges relating to food security, rights, land access, and environmental outcomes. The food justice movement promotes community level self-reliance, inclusivity, fair compensation, and environmental sustainability.	Alkon and Agyeman (2011); Gottlieb and Joshi (2010)

Focal Area	Emphasis	Description	Author(s)
	Key words: **systemic inequality, equity, rights, inclusivity**		
Food Sovereignty	Rights-based approach linked to justice, democracy, and empowerment over food production. Key words: **justice, democracy, empowerment**	When La Vía Campasina (1996) proposed the concept of food sovereignty, they indicated it was “directly linked to democracy and justice”. The food sovereignty approach suggests that examining cross-scale interactions may advance discussions on food security, food sovereignty and alternative food networks.	Wald and Hill (2016);Wittman et al. (2010); La Vía Campesina (1996); Sage (2014)

2.3.3.1 On Inclusion: Who Contributes to and Who Benefits from FSTs?

FSTs will have winners and losers, and so transformational processes are inherently conflictive (which is further exacerbated by the power imbalances that characterise the structure and function of food systems today)(Giesbers et al., 2025). Giesbers et al. (2025) posit that FST and inclusivity have fundamental tension between one another due to conflicting objectives of diverse stakeholders. Further, food systems are rife with power imbalances, inequities, and inequalities, which have largely been overlooked (Crivits and Mingolla, 2022, Giesbers et al., 2025, Hebinck et al., 2021a). These can only be addressed when diverse societal perspectives are integrated into the change processes that drive the transformation of food systems across all scales and levels, as this thesis aims to do (Giesbers et al., 2025, Hebinck et al., 2021a). The transformation must address these challenges within its processes, as a matter of morality, but also because transitions that lack adequate inclusion frequently lead to unpopular and impractical or unsustained outcomes (Giesbers et al., 2025, Leeuwis et al., 2021).

In the context of this multi-stakeholder and multi-viewpoint tension, Jacobi et al. (2022) argue that marginalised groups should specifically be included in knowledge creation and project initiatives aimed at sustainable development. Giesbers et al. (2025) state that this should occur even if it is at the expense of including others, in order to overcome structural disadvantages, as well as to level the playing field in contexts where there is likely uneven participation elsewhere to ensure that there is space for less powerful actors. This can improve the fairness of transition processes as well as ensuring interventions are more contextually or culturally appropriate (Giesbers et al., 2025, Huttunen et al., 2022, Leeuwis et al., 2021, Mercer-Mapstone et al., 2019). This participation must go beyond tokenism and enable stakeholders to hold legitimate power in change processes (Giesbers

et al., 2025, Kesby, 2003). If stakeholders are subject to changes but are not given agency over these changes, change processes can actually become disempowering (Giesbers et al., 2025, Kesby, 2003).

Consideration of whose knowledges and agendas are included in FST processes is important for answering **RQ2**, which discusses the benefits of bringing diverse perspectives into systems science and FSTs. This is discussed in more detail in the methodology section of this thesis as well as in **Chapter 5**. This section explores the merits of co-creation of knowledge and inclusive approaches to knowledge and agenda setting in FST processes.

2.4 Papua New Guinea Context

This section provides a brief overview of the literature on food systems in PNG to contextualise the development and environmental situation in the country. One of the biggest challenges and important contextual factors in PNG is wide-ranging data paucity. Research in PNG is logistically difficult, and even baseline data is uneven and inconsistent. For example, the official government population estimate is around 12 million people, however, estimates from the UN using satellite data suggest the population is actually closer to 17 million people, which would have a significant impact on national demography and development metrics (Laveil, 2023). Further, the economic conditions in PNG, particularly of rural farming communities, are seldom studied (Schmidt et al., 2020).

Given the population level reliance on the natural resource base paired with the limited infrastructure in PNG, the nation is one of the most vulnerable in the world to the impacts

of climate change when considering exposure, sensitivity, and adaptive capacity to climate impacts (Notre Dame Global Adaptation Initiative, 2025). Around 80% of the population depends on agriculture (subsistence and cash cropping) for their livelihoods (Bourke and Harwood, 2009, Lescuyer et al., 2018, Pham et al., 2021), yet they have little influence on the structure or function of the food system, and no say in processes around how the food system should transform.

The research conducted for this thesis worked across four unique rural communities in order to capture variation in commercial versus subsistence orientations of smallholder farmers. The goal with community selection was to compare smallholder farmers and communities that fit within different typologies (such as the Food and Agriculture Organisation of the UN (FAO) typologies) or which existed across different positions in the agrarian transition as described by Timmer (2009). The initial hypothesis was that farmer perspectives about environmental and economic decision making would change progressively in line with the agrarian transition and their respective downscaled typologies.

In the PNG context, agriculture is nationally important; the sector provides employment for about 80% of PNG's workforce, and between 80% and 90% of the population rely on subsistence agriculture for both income and direct consumption (Bourke and Harwood, 2009). Further demonstrating the degree of reliance, around 83% of all calories consumed in PNG were produced domestically (last updated 2009)(Bourke and Harwood, 2009). The vast majority of land is under customary tenure, with estimates ranging from 82% to 97%, and thus under management regimes determined largely by rural inhabitants (Chand and Yala, 2009, Filer, 2014, Kwapena, 2021). Despite this, there is an ever-present

tension between customary land tenure (controlled by clan structures and based on relationships, history, and use), coupled with an increasing pressure for economic development activities (including growing cocoa) that drive land commodification (Filer, 2014, Curry et al., 2012, Pamphilon et al., 2019). As a result, the agricultural frontier is expanding rapidly in PNG, and the country is facing a high level of deforestation due to agriculture, logging, and mining (World Resources Institute, 2025). PNG smallholders tend to use forest-fallow system for their subsistence food gardens, which are on small plots of land less than one hectare in size.

Cash cropping is the primary way for most rural Papua New Guineans to access income[5], which is vital for supplemental food during the 'lean season' between harvests (Chambers et al., 1981), as well as school fees and medical fees (Curry et al., 2012). Cash cropping and other non-farm enterprises (NFEs) are important for quality of life and nutritional outcomes in rural areas. For instance, households with NFEs have 26% more protein and 11% more kilocalories on a per person basis than households without NFEs (Schmidt et al., 2020). Dietary outcomes are highly complex though, and in some PNG communities with agricultural supply chain development, overall food security does not improve, but rather, diets become more diverse, attributing diversity increases to growing consumption of legumes, milk, and processed food, such as sweets, and oils (Songsermsawas et al., 2023). Pacific food systems are becoming more integrated into global food systems in terms of both production and consumption (Andrew et al., 2022). While this integration is increasing incomes as well as on-farm yields, productivity gains are not keeping up with population growth, and the gap is largely filled with low nutritional value and

[5] Mining is the main contributor to GDP, and although it usually occurs in rural areas, the financial benefits are largely gained outside of PNG and the contribution of mining to local employment is low (YAMARAK, L. & PARTON, K. A. 2023. Impacts of mining projects in Papua New Guinea on livelihoods and poverty in indigenous mining communities. *Mineral Economics,* 36**,** 13-27.)

processed foods (Andrew et al., 2022). PNG experiences problems with both over and under nutrition. Obesity has been steadily increasing since 2000, while at the same time, more than 57% of the population has experienced moderate to severe food insecurity (data from 2018 to 2020)(FAO, 2025). More than 56% of the population is multidimensionally poor, which is heavily concentrated in rural areas (2016 – 2018 data)(UNDP, 2023).

This thesis focuses on subsistence farmers who also grow cocoa as a cash crop. The cocoa sector in PNG has been rife with challenges since the accidental introduction of the cocoa pod borer pest, which has caused cocoa exports to decline since 2012 (Arias et al., 2025, Niogret et al., 2020). Today, cocoa only constitutes about .55% of all exports by value in PNG contributing to about 1% of the world's cocoa (about 35,000 metric tons in 2020/21)(Cocoa Board, 2023). There is substantial ambition to increase cocoa production to 310,000 metric tons by 2030 (Cocoa Board, 2023). Cocoa is one of the most important crops for smallholder livelihoods; around one million people in PNG depend directly on cocoa for income with cocoa smallholdings of about one hectare or less. For most farmers, the income this generates is inadequate (Lescuyer et al., 2018, Pham et al., 2021). While PNG's smallholders are often subsistence-based, they rely on cash to access supplemental food during *taim hangre*, medicine, and school fees.

There remain numerous and varied challenges throughout the cocoa supply chain (which is mapped in **Figure 2.2**). These challenges are largely described from a top-down perspective (Nelson et al., 2011). For instance, about 72% of PNG cocoa fermentaries are unregistered, which prohibits access to certification, in a context where certification is becoming increasingly a requirement for the world's largest cocoa buyers and simultaneously impossible for small farmers to achieve independently. Further, cocoa

production is a significant driver of land use change, where cocoa is often expanded into primary or secondary forest when smallholder farmers aim to increase yields (Curry et al., 2015, Scudder et al., 2022).

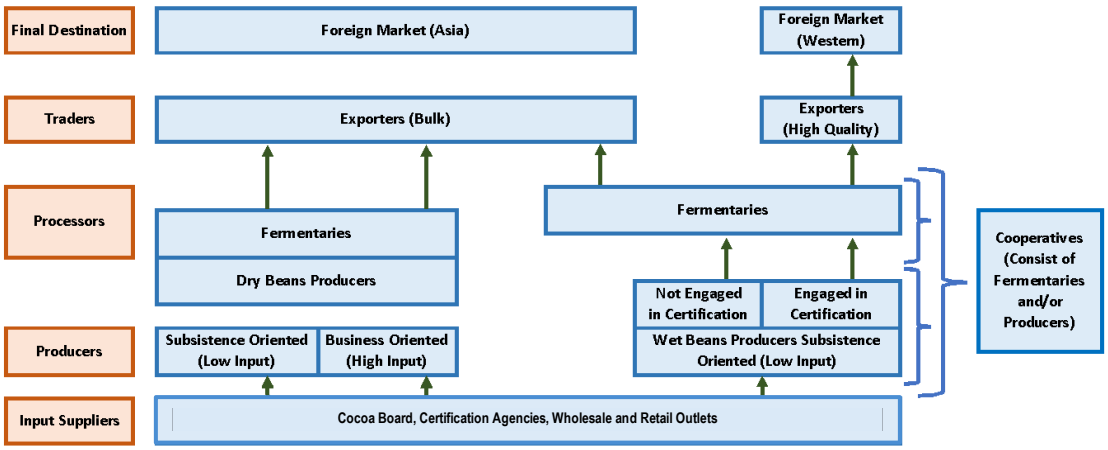


Figure 2.2 Graphic of the cocoa supply chain in PNG.
Orange squares are descriptors, while blue squares are the actors in PNG's cocoa supply chain. Adapted from Lescuyer et al. (2019).

2.5 Conclusion

This thesis contributes to research on FSTs, individual and system interactions though exploration of scale and level, participatory research with low-influence actors, and drivers of food system actor decision making. Drawing upon these concepts, this work builds a case for more just FSTs through the exploration of three primary RQs. It takes an approach to justice which focuses on inclusion of low-influence actors within transformational processes. While justice overall can incorporate numerous factors, such as power, recognition, and so on, the focus of this work is on inclusion in change processes themselves (including discourse, policy design, and all processes directed at transforming the food system). I note that including low-influence actors in these processes will not result in a just FST alone. However, this was chosen as the focal point

of this thesis on the basis that inclusion and justice are closely interlinked, and that inclusion is a necessary component of more just FSTs as well as a pragmatic way to orient towards impact work. This thesis aims to contribute to a baseline of knowledge which can provide academics and decision makers with the foundation to improve and integrate justice into FST processes.

The key gaps from this Literature Review show a need to conduct a detailed investigation into the dynamics of scale, level, and decision driving interactions in food systems which are explored in **RQ1** and **RQ3** as well as the need to bring the voices of low-influence actors to systems transformations, which are explored in **RQ2**. Lastly, there is a need identified here to investigate drivers for low-influence actors in the food system given the discourse on FSTs has largely been top-down. This thesis aims to systematically address each of these gaps in **Chapters 4, 5,** and **6** using the RQs reiterated below:

> **RQ 1:** How do actors and systems transformations processes interact in food systems? 1a. How can interactions across scale and level be conceptualised? 1b. How can this understanding inform more just FSTs?

> **RQ 2:** How do different methods of engagement with low-influence actors lead to different system understandings and just transformation options? 2a. How can low influence food system actors be engaged in processes aiming to transform systems? 2b. How can engagement with these low-influence actors contribute to achieving more just FSTs?

RQ 3: What can we learn about systems change by adding a drivers-focused approach to FSTs? 3a. What does it look like for systems change if we co-create knowledge that focuses on the perspectives on one low influence group of actors? 3b. What does this tell us for achieving more just FSTs?

3 Methodology and Methods

This section provides an overview of the overall guiding methodology used for this thesis, a brief description of research sites, and details the data collection process for fieldwork. Paper-specific methods for data collection and analysis are provided in **Chapters 4**, **5**, and **6**. Additionally, **Chapter 5** explores how different participatory and actor-driven methods can contribute to systems knowledges and understandings, as well as providing a comparative and reflexive assessment of these methods in enabling systems transformations. Further, the Appendices of this thesis explain in detail the pragmatic elements of how research and results dissemination were conducted with communities (**Appendices B**, **J**, and **K**), as well as providing a statement of researcher positionality and samples of direct workshop outputs (**Appendices B** and **E-I**, respectively).

This thesis used an actor-centric, justice-oriented and participatory systems methodology to treat food systems as dynamic SESs shaped by the interactions between actors, drivers, and feedbacks, across scales and levels. Epistemologically it assumes that systems knowledge is situated, partial, and shaped by power, and that engaging low-influence actors is necessary to make clear the systems dynamics that are often obscured in outcome-centric or more top-down analyses.

This thesis employed a case study with participatory approaches and knowledge co-creation with Papua New Guinean cocoa smallholders to engage low-influence actors in the food system, highlighting these views for systems change processes. By using an actor-centric, justice-oriented, and participatory systems approach with actors who have little influence over the structure and function of systems processes that are aligned with

dominant narratives around FSTs, this work investigates an important component of bringing inclusivity into the food systems framing that is oriented to informing more just FSTs. This type of research is needed in under-researched and data poor areas, such as rural PNG (Songsermsawas et al., 2023). In this thesis, inclusion is treated as a necessary condition for justice in FST processes. Inclusion determines who can shape problem framings, influence decisions, and bear the risks or benefits of transformation. Methodologically, this means prioritising approaches that enable low-influence actors to articulate their own understandings of drivers, feedbacks, and constraints, rather than treating them solely as data sources or implementation targets.

This research adopts a reflexive stance that recognises the role of the researcher as an actor within the system; I am part of the system I study rather than an external observer. As such, my presence, relationships, institutional positioning, and socio-cultural identity shaped the conditions of knowledge production, influencing what data were created, how they were interpreted, and whose voices were amplified. My positionality therefore includes a methodological commitment, acknowledging that research processes and outcomes are co-produced through situated interactions embedded in historical, cultural, and power-laden contexts, which are further explored in **Appendices A** and **J**.

3.1 Methodological Approach

The primary underpinning research logic in this work is that understanding and achieving more just FSTs requires centring low-influence actors while maintaining a whole systems view. Accordingly, the RQs focus on actor-centric perspectives of low-influence actors and how they can contribute to more just FSTs. This necessitated a methodology that focused on centring these low-influence actors in data and knowledge generation

processes while maintaining a focus on systems thinking and holistic systems approaches. It was vital to use methods that enabled this centring of perspectives with cocoa smallholder farmers that reduced barriers to involvement for target participants, some of which have had limited exposure to schooling and limited exposure to the Western World and Western scientific approaches, including Western researchers (particularly white researchers like me). Multiple different methods were selected, including interviews in conjunction with drawing methods, writing methods, and aural methods with the objective that the variety would provide a platform to involve participants with varying interests and capacities. Methods were prioritised that worked well across language and literacy barriers and that encouraged discourse among participants rather than placing research facilitators at the fore. Specific method choices were selected against practical, epistemic, and justice-oriented criteria. These were not assumed to remove power relations, although they did try to prioritise accessibility and contextual fit with systems insight. These methods complemented each other, each offering a unique approach with participants. For example, the workshops relied on conversational approaches in line with the highly aural tradition in PNG while also enabling more reserved participants to contribute through activities such as drawing and small group conversations. The design assumed that the variety offered would contribute to data richness as well as reducing some barriers associated with literacy, language, and unfamiliarity with formal research processes, while also enabling participants to articulate outcomes as well as relational and causal understandings of their food systems.

Method choices also involved compromises. Group activities privileged shared or negotiated realities, which may obscure disagreement, silence more reserved participants, or reproduce existing community social dynamics or hierarchies. Further, researcher

facilitation shaped the process, including through the framing of prompts, the selection and translation of concepts, and the conversion of workshop outputs into analytical representations. Alternative approaches, such as longer-term ethnography or multi-stakeholder forums, may have captured different aspects of low-influence actors' experiences (Chesluk and Youngblood, 2023, Elias, 2022). The methodological choices made here were not neutral, nor did they enable a "complete" system understanding; they should therefore be understood as both a purposive and practically-situated strategy for eliciting actor-centric systems knowledge.

To operationalise inclusive approaches aimed at engaging low-influence actors, participatory and co-creation methods were the foundation of data collection for this work. In these method types, participants play a key role in the knowledge creation processes, which can be particularly effective for engagement across contrasting power dynamics. A 2021 systematic literature review of existing evidence of knowledge co-creation processes in Sub-Saharan African agricultural contexts found that co-creation and participatory processes led to positive results such as improved yields, income, and environmental sustainability (Van Ewijk and Ros-Tonen, 2021). Co-creation, inclusive processes, and collective action can also harness the power of diverse perspectives and help to identify innovative solutions that would otherwise not be identified by individuals or top-down processes, which is particularly important for sustainability sciences aimed at transformation (Massari et al., 2023, Van Der Gaast et al., 2023, Jacobi et al., 2022). In establishing best-practices or frameworks to approach co-creation of knowledge, several principles are key, including formative evaluation and amplifying the perspectives of the lowest-power stakeholders (Charatsari et al., 2022, Schuck-Zöller et al., 2017). Charatsari et al. (2022) demonstrate that building social capital in co-creation of knowledge can also

improve farmer field school outcomes. They found that building this social capital, particularly prioritising bonding and connection, significantly contributed to knowledge co-creation and innovation, as well as improving on-farm outcomes. This study also catalogued the benefits of engaging farmers in inclusive diffusion of agricultural knowledge (such as knowledge co-creation) also improved climate resilience (Chandra et al., 2017).

This work then uses participatory and co-creative methods, orienting these methods towards systems thinking and whole systems transformation processes. Participatory approaches are useful for systems thinking (particularly directed at policy contexts), as they can co-create solutions to improve systems based on local and relevant needs, they can uncover patterns and system dynamics, lead to actionable insights, and inform the design of context-sensitive and targeted policy interventions (Eelderink et al., 2020, Kerr, 2025). Barbrook-Johnson and Penn (2022) show that participation brings credibility to systems approaches, offering detailed methods to engage system actors in mapping processes aimed at understanding complex systems. They detail the mechanics of these methods and review their merits and drawbacks, which was used to inform workshop design, and was a key component of data elicitation for this thesis (Barbrook-Johnson and Penn, 2022).

While participatory methods offer a suite of benefits, it is important to acknowledge their limitations, particularly as relevant in this thesis. In addition to the logistical challenges of participatory work which requires significant time and financial investment to visit communities and build rapport in person, there are also epistemic and justice-relevant challenges with this type of work. If participants are involved in change processes but

excluded from decision making, participatory processes can have adverse effects leading to disempowerment, loss of perceived agency, or research fatigue (Giesbers et al., 2025, Kesby, 2003, Clark, 2008). While the methods used here aimed to be power-sensitive, power dynamics were still present, both between the researcher and participants and within the social dynamics of participants, who were all from the same community and had longstanding relationships with each other. This was managed by ensuring one-to-one interaction prior to workshops took place with each and every participant through the interviews, and so I was familiar with all participants (and they, with me) prior to workshops. Additionally, I used a range of methods and prioritised rapport-building to support forms of participation that aligned with participants' preferences and comfort levels.

As a facilitator, I also made an effort to balance participant voices by keeping groups small and encouraging more reserved participants to contribute without putting them on the spot. During facilitation, I tried to support a balance in knowledge creation processes by using a variety of different methods (some aural, some pictorial, and some written). Despite this, my facilitation role still played a role in shaping the drivers and outcomes that were identified in the research; particularly in selecting the key nodes from Rich Pictures to be inserted into the IRDs. Additionally, in IRD creation, I was involved in conversations and in seeking consensus among the group for what the key nodes were and their direction of impact on one another. The detail on the specific methods used in both interviews and workshops is shown in **Section 3.3** and in **Chapter 5**.

3.1.1 Philosophical Stance

This thesis is underpinned primarily by a critical realist philosophical stance. It assumes that food systems are real, structured, and shaped by underlying drivers and feedbacks, while recognising that knowledge of these systems is socially situated and influenced by power and which actors are included in knowledge creation. This position supports the integration of mixed and qualitative methods to more thoroughly explore and understand underlying system dynamics, particularly through inclusion of low-influence actors whose perspectives are often overlooked. At the same time, the research adopts a pragmatic methodological orientation. Methods were selected for their epistemological alignment with systems thinking and justice-sensitive work and for their practical usefulness in the field context. For example, their ability to work across literacy barriers, facilitate co-creation of knowledge, and generate actionable insights in low-technology environments. In this sense, ontological debates are secondary to the broader aim of contributing to more just and effective FSTs. The mixed-methods design is motivated to be both philosophically and practically useful as a means of producing robust and applicable knowledge.

3.2 Research Sites

Four sites, shown on the map in **Figure 3.1**, and with brief food system and context descriptions in **Table 3.1**, were selected across PNG to capture a range of factors including reliance on subsistence for both food consumption and income versus reliance on cash cropping and store bought foods. The variety of sites was important given the need to unpack perceived drivers in line with the RQs, and work with communities that would be subject to unique drivers. This later provided an empirical basis for examining

how context of food system actors and scale-level interactions shape decision-making environments, which is a core concern of the cross-scale and cross-level framework (**Chapter 4**) and the FSC concept (**Chapter 6**). The initial intention was to recruit participants from different food system "typologies" (such as those designated from the FAO), scaled down from a regional or national level to a community or individual level (ex. farmers that were more commercialised participants in their food systems and farmers that were more traditional or subsistence-based participants in their food systems)(Marshall et al., 2021). These would be used to assess patterns in communities or individuals on the basis of their typology (although the 'typology' approach was later discarded in favour of a novel approach, which is presented in **Chapter 6**). Data were collected in accordance with the process detailed in **Section 3.3** in a consistent manner across the four sites and in keeping with the approved Central University Research Ethics Committee (CUREC) application with the SoGE (CUREC Approval: SoGE C1A 23 12 and SoGE C1A 23 12 Amendment 01, which was amended so that I could compensate participants for their role in the co-creation workshops).

The Madang Province communities were more densely populated, commercialised, connected, and aligned with more global and "modernised" cultural worldviews, whereas the Bougainville communities were more sparsely populated, disconnected (both physically and in terms of information and network coverage), and had cultural worldviews more aligned with "traditional" ways of living. For example, members of the Bougainville communities emphasised traditional medicines in daily life, used the sun as the primary indicator of time of day, and youth members of the community remained involved in the Upe (a traditional rite of passage or initiation for young men), which was not present in the Madang communities.

Ohu, in Madang Province, was characterised by a high prevalence of informal “shop food” consumption, relatively limited formal retail infrastructure, and moderate physical access to larger markets, being approximately 45 minutes from Madang Town by private transport. In this area, many families were moving away from cocoa, particularly towards betel nut. Rempi, also in Madang Province, was more commercially connected, with a high prevalence of formal retail outlets and comparatively good access to Madang Town via a well-maintained highway. The community had also been exposed to market development initiatives supported by FAO and ACIAR. In contrast, the two communities in Bougainville Province were considerably more remote. Tomasi-Makakao had low levels of both informal and formal food retail activity and relied on an eroded road connection to Buka Town, resulting in a journey of three to five hours by privately operated vehicles, with access often disrupted during the wet season. The community had nevertheless been involved in market development activities through ACIAR. Ubuko-Siato was the most isolated of the four communities, with similarly low retail presence but even more challenging access to Buka Town, requiring a six- to seven-hour journey by road or a combination of walking and boat transport. In Ubuko-Siato there was the highest prevalence of shyness with the research team, particularly in line with traditional beliefs around young men speaking with young women.

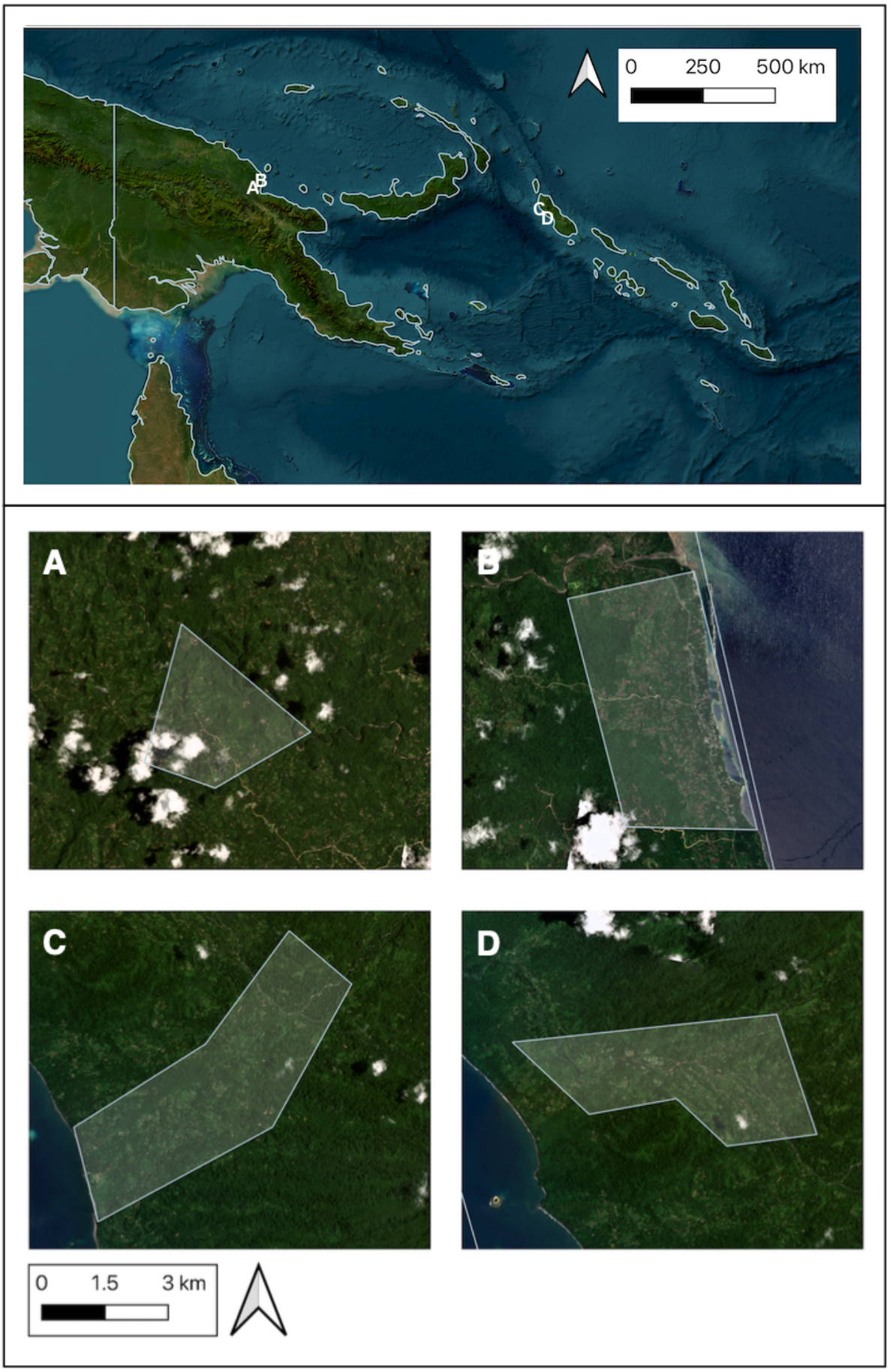


Figure 3.1 Data collection sites in four communities.
A. Ohu, Madang Province; B. Rempi, Madang Province; C. Tomasi-Makakoa, Bougainville Province, D. Ubuko-Siato, Bougainville Province and their relative position in PNG (Natural Earth, 2023, Planet Labs, 2023, QGIS Development Team, 2024).

Table 3.1 Overview of food system characteristics from each community.

Community	Prevalence of "shop food"	Prevalence of formal trade shops	Two-way market access/remoteness	Community cocoa investment/ presence
Ohu, Madang Province	High prevalence.	Low prevalence. Numerous irregular informal 'pop up' trade shops.	~ 45 minutes to Madang Town by privately run bus (two – three busses ran daily), dirt road.	No known market development project presence.
Rempi, Madang Province	Moderate prevalence.	High prevalence.	~ 30 minutes to Madang Town by privately run bus or Land Cruiser (many vehicles ran daily), paved highway.	Presence of market development projects from FAO and Australian Centre for International Agricultural Research (ACIAR).
Tomasi-Makakoa, Bougainville Province	Low prevalence.	Low prevalence.	Eroded dirt road. ~ 3 – 5 hours to Buka Town by four to five privately run 'ten seaters' (Land Cruisers retrofitted with bench seats) – *unreliable for days at a time during wet season.*	Presence of market development projects from ACIAR.
Ubuko-Siato, Bougainville Province	Low prevalence.	Low prevalence.	Eroded dirt road. ~ 6 – 7 hours to Buka Town by one or two privately run 'ten seaters' (Land Cruisers retrofitted with bench seats) – *unreliable for days at a time during wet season,* or by a combination of walking to a 'banana boat' pickup point. The boat takes several hours.	No market development project presence.

3.3 Sampling Strategy and Data Elicitation Process

Informed by principles of co-creation and participation, the research process involved interviews and participatory workshops, which occurred during research visits in which I briefly lived in each community. There are further notes on the practicalities and mechanics of conducting research in PNG, which I have been doing since 2019, as well as a statement about my positionality, included in **Appendix A** of this thesis.

I entered each community with a local member of that community who also acted as my field assistant, which was arranged prior to my travel to PNG. This person introduced me to the Clan leaders of that area. With their approval, I proceeded to walk around each community (which the research assistant and I divided into segments to ensure spatially representative sampling took place). We recruited participants, first consenting them to participating in research and ensuring that they were cocoa farming adults[6] that could represent their household. I went on to ask the participants questions in a semi-structured interview format that were developed based on themes in their food system (ex. a set of questions about their food security and diet followed by a set of questions about their environment, the full set of questions is shown in **Appendix C** of this thesis).

Interviews used a mixed questionnaire of categorical questions (starting with survey questions) followed by largely open-ended questions which used a flexible, participant-led approach to allow participants to drive the discussion before returning to the guiding questions (Garcia et al., 2012). The question categories also acted as a framework for post-interview coding. I first live translated and manually transcribed the interviews (n =

[6] They must either be currently farming cocoa or previously been farming cocoa.

160) writing the answers to each question theme in columns in Microsoft Excel. As themes emerged out of the first stage of descriptive codes, for example the view that conserving areas of bush was important primarily for the use of future resources, I would go back through all the environmentally themed questions and highlight the perspectives of (or count, depending on my objective) the participants that expressed that the main reason to conserve forest was for building materials or for future gardens, which I categorised as "future provision of resources". In this second step, patterns, themes, and categories were developed for analysis of system outcomes and drivers. The two step coding approach was used from Saldana (2011). This approach allowed me to stay close to the data using my underpinning food systems theoretical grounding while working directly with participant statements from interviews through many stages of transcription and coding. Further, this allowed me to work both systematically and adaptively with the data. The two cycle coding approach allowed for inductive first cycle codes to remain close to participants' meanings and maintain actor focus. It was then followed by second cycle of coding to identify higher order themes relevant to food system dynamics and policy interpretation. This approach was effective for negotiating between participant-centric, systems focused and policy relevant work that could fit in with the food systems frame underpinning the data collection and appropriate for answering the RQs proposed in this thesis.

After interviews were complete, I grouped participants into four groups of "regular farmers" and a group of "fermentary owners" for each community (five groups total for each community). These groups then each did a half-day participatory workshop, the methods of which are detailed in **Chapter 5**. Briefly, the workshops consisted of Rich Picturing which then seeded the creation of participatory Inter-Relationship Digraphs

(IRDs)(which were later grouped and converted into Participatory Systems Maps (PSMs), which is detailed in **Chapter 6**). As an intermediate activity between Rich Pictures and IRDs, participants also created "transformation statements" about initiatives they would like to see in their own community. Sample workshop outputs are shown in **Appendices E**, **F**, **G**, and **H**.

The interviews and workshops occurred within broader fieldwork contexts and relationships rather than operating as discrete data extraction events. As discussed further in **Appendix A**, my entry into each community depended on trusted local contacts, approval from Clan leaders, staying with host families, participating in everyday life where appropriate, and spending time in informal *tok stori* around formal data collection processes. These relationships shaped community engagement, trust, and participation. They also meant that data collection followed community rhythms rather than a fixed research schedule. For example, workshops were planned around community events, such as PNG Teacher's Day celebrations at the local school. Sometimes these began much later than planned because participants were attending to gardens or cocoa blocks, church, family obligations, weather, travel from distant locations or other community activities. Waiting, drinking coffee, talking informally, and allowing workshops to begin when a sufficient group had gathered were therefore part of adapting the research design to the context of this fieldwork.

Interviews and workshops created different kinds of participatory space. Interviews offered a relatively private setting in which participants could describe household food practices, income strategies, environmental changes, and uncertainty in their own terms. These were also shaped by my presence as a foreign researcher, the use of translation in

some cases, the food systems framing of the project, and participants' possible expectations of research or outside visitors. In contrast, workshops generated outputs collectively through drawing, storytelling, and facilitated discussion. Participants were separated by commercial orientation into groups of "regular farmers" and "fermentary owners" to allow comparison across different relationships to cocoa commercialisation. Often, prominent community members were in the "fermentary owners" group, which therefore also allowed separate space for more and less locally economically influential participants at the community level; this did not, however, completely remove power dynamics between participants. Participation within groups was still shaped by age, gender, confidence, education level, kinship, status, familiarity with me and the local research assistant, and willingness to speak in front of others. Some participants spoke at length, while others contributed through drawing, brief comments, agreement or disagreement, humour, or side conversations that were less visible in final outputs.

The workshop outputs are therefore interpreted as negotiated collective representations and thought guides rather than a comprehensive account of all participant views. The workshop format enabled participants to engage more in the method that best suited them. It also allowed attendees to challenge, refine, and build on each other's contributions, particularly through Rich Picturing and the creation of IRDs. While this surfaced trade-offs and causal relationships that were not visible in interviews alone, it could also flatten disagreement, privilege more confident speakers, and create pressure toward consensus. This reflects wider critiques of participatory research, where participation does not automatically redistribute power or produce more justice, and can also reproduce existing hierarchies (Cooke and Kothari, 2001; Dey de Pryck and Elias, 2023). I attempted to reduce these risks through using varied methods that relied on visual and oral methods,

conducting workshops in small groups, using locally-trusted partners, numerous participant-led activities, compensation for workshop time, and a post-workshop validation field trip. Throughout this process, my role remained consequential. I selected the methods, framed activities through food systems concepts, facilitated the workshops, interpreted, digitised and analysed outputs, and decided how findings were represented. The participatory design therefore strengthened the visibility of low-influence actor knowledge and perspectives, but did not eliminate researcher mediation or broader inequalities within the research process.

Validation and results dissemination occurred in 2025 to strengthen reciprocity and assess whether findings resonated with participant experiences. I returned to all four communities to share findings orally in Tok Pisin and through laminated Tok Pisin and English results sheets, which I distributed so they could remain in the communities and be shared around. These sessions were announced in advance, open to all community members, and structured as discussion forums where people could ask questions and respond to findings. Validation also had limits, with a relatively low turnout rate from original attendees. This depended on participant availability, mobility, communication access, and whether participants could be reached. Participant attendance was likely also correlated to the rapid increase in the price of cocoa, with many statements from locals saying that the cocoa farmers were always in their blocks now, trying to earn more income while the cocoa price was high. As such, validation was imperfect, and public agreement could not be assumed to represent every participant's private view. Further, this process did not transfer control over academic analysis and publishing or downstream policy uptake. Validation improved the credibility and reciprocity of the research, but did not

fully resolve the power and influence asymmetries inherent in researcher-led participatory work.

The data collection process is detailed in **Figure 3.2**. This process operationalised justice and the systems focus simultaneously by creating knowledge with low-influence actors that specifically investigated systemic drivers and outcomes. While the suite of methods used in this thesis are not intended to provide a complete or exhaustive representation of target community food systems, they do surface dynamics, constraints, and change pathways that are systematically obscured in outcome-centric or top-down approaches. By combining interviews, participatory workshops, and systems mapping within a justice-oriented framework, the thesis demonstrates how methodological choices shape not only what is known (the knowledge) about food systems, but which transformation pathways become visible and actionable.

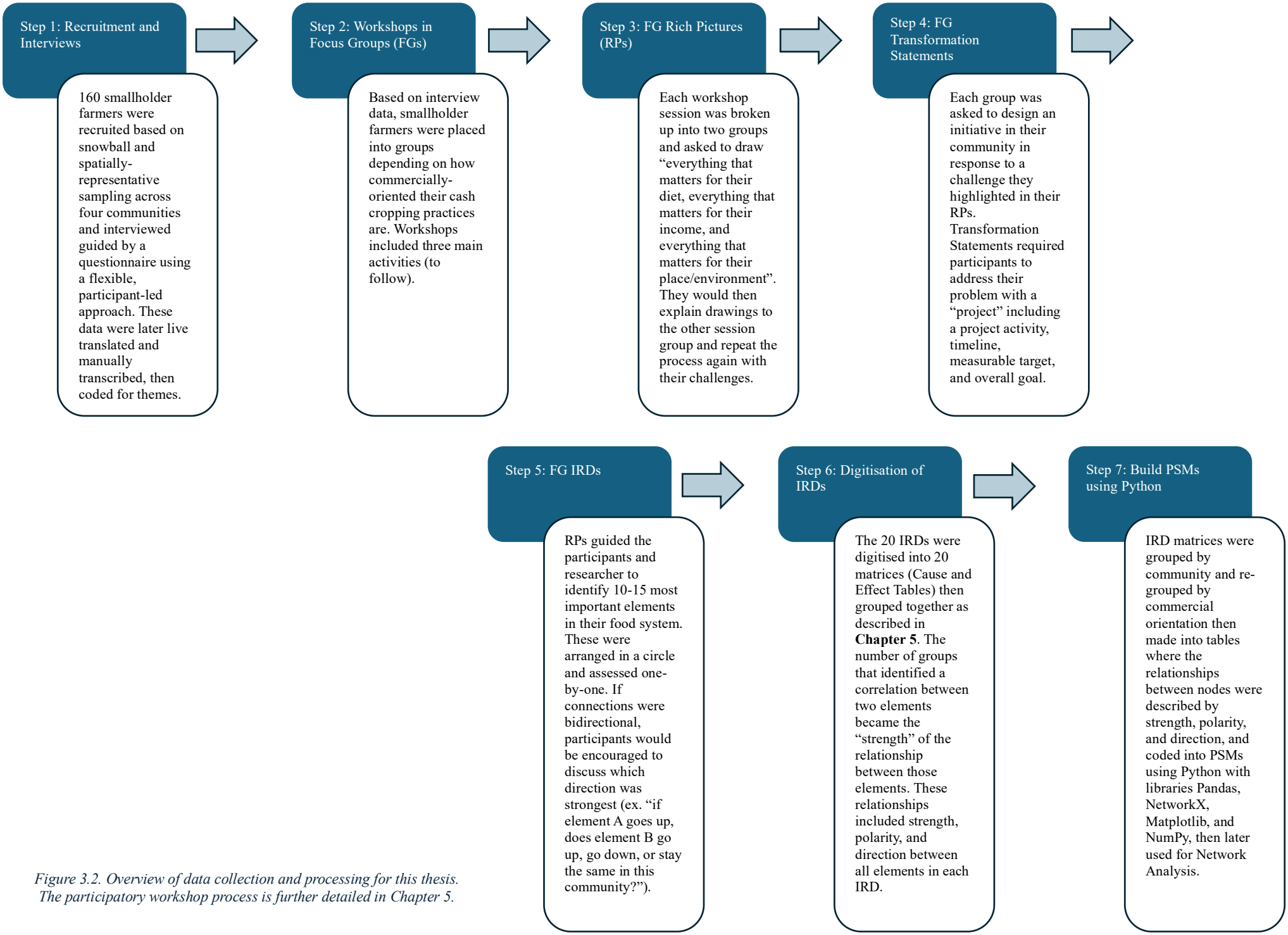


Figure 3.2. Overview of data collection and processing for this thesis. The participatory workshop process is further detailed in Chapter 5.

4 From Local Landscapes to Global: A Cross-Scale and Cross-Level Framework for a more Just Food Systems Transformation

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Linking Statement

Despite growing recognition that FSTs operate across multiple scales and levels, limited attention has been paid to how scale and level dynamics play out in these systems and how those dynamics influence system outcomes. There is also limited evidence in food systems science that illustrates why low-influence actors are important for cross-scale and cross-level outcomes as well as a gap between qualitative and quantitative systems approaches. This chapter addresses these gaps by examining how low-influence actors are important decision makers across scales and levels, thereby contributing to the thesis argument that justice in FSTs depends on how transformation processes are understood and structured across scales and levels and between different approaches to food systems science.

Building on the thesis's core argument that efficiency-first and top-down approaches to FST can obscure causality and reproduce inequities, **Chapter 4** uses an entry point of

level and scale for making inclusion of low-influence actors visible in how change actually happens in food systems. It demonstrates that low influence does not equate to low importance, showing that the low-influence actors in the case study are important decision makers in food systems across levels. This chapter develops a cross-scale, cross-level framework that links actors, activities, drivers/feedbacks, and outcomes; showing how outcomes at one level can become drivers at another. It uses smallholder perspectives in PNG to illustrate why low-influence actors are central to understanding system dynamics, rather than considering them as peripheral stakeholders or one dimensionally as target recipients of initiatives. This chapter hence lays the conceptual groundwork for the rest of the thesis, clarifying the mechanisms through which dynamics play out across scales and levels. It sets up the basis for analytical approaches in **Chapters 5** and **6** that develop justice-as-process in FSTs.

Abstract

Transforming food systems to improve socio-economic, environmental, and food security outcomes requires improved understanding of how system actors and outcomes interact across different scales and levels. To date, food systems science supporting the FST has focused on macro and global or planetary level outcomes, while actor-focused work has occurred at more granular levels in adjacent yet siloed disciplines. This paper develops a cross-scale and cross-level conceptual framework to link food system actors, activities, and system outcomes, emphasising inclusion and justice in transformation processes. The framework shows how outcomes at one level become drivers at another, offering a useful analytical approach for both researchers and decision makers. To illustrate its application, the framework is operationalised with a qualitative case study with Papua New Guinean cocoa smallholder farmers across four communities. Using semi-structured interviews (n

= 160), we analyse food system activities, drivers, and feedbacks across scales and levels. The results show that low-influence actors, despite limited power in formal governance, play critical roles in shaping food system outcomes, such as land use and food security. Cross-scale interactions, such as between national education policy, local land use decisions, and global market pressures, demonstrate how top-down interventions can reinforce challenges in the system, particularly for low-influence actors. By explicitly embedding scale, level, and actor inclusion into food-system analysis, the framework advances conceptual clarity, diagnostic precision, and coordination across research, policy, and governance domains needed for more just and effective FSTs. Lastly, it provides an update on food system activities and outcomes in remote PNG communities, for which published data are scarce.

4.1 Introduction

Food systems research is a rapidly evolving area due to the multiple challenges current food systems face such as globally insufficient food security and rapid land use change. Today the focus of food systems research is on understanding and promoting their 'transformation' broadly. Ingram and Thornton (2022) and Zurek (2022) clarify that 'transformation' specifically means transforming system outcomes and the structures that support these, rather than on transforming the structure of the system itself (Ingram and Thornton, 2022, Zurek et al., 2022). There has also been a recent emphasis on building food system resilience, which has been amplified since the COVID-19 pandemic (Tendall et al., 2015, Seekell et al., 2017, Van Wassenaer et al., 2021, Ben Hassen et al., 2025, Schneider et al., 2025, Ujjwal et al., 2024). System outcomes can be improved by changing policy signals aimed at transformation and increasing resilience, which lead food system actors to adapt their food system activities towards more resilient food

system outcomes (Ingram and Thornton, 2022). It follows that transformation research has focused on transformation from a "top-down" perspective, for instance, through processes that are driven by expert panels and through integrated policy or coordination of actors (although the definitions and understandings of these terms remain contentious)(Anggraeni et al., 2022, Edwards et al., 2024, Leeuwis et al., 2021). This approach may overlook the specific needs and goals of certain actor groups. While the more systemic and top-down approach lays a strong foundation for what is needed for FSTs in terms of shifting the system as a whole, if not done in an inclusive manner, transformations are at risk of reinforcing existing structures and power imbalances within the food system (Holt Giménez and Shattuck, 2011). This work encourages food system science to go beyond siloes to progress towards achieving transformation in a more just and inclusive manner. It attempts to create linkages between granular level food systems work (ex. such as in community food systems) that usually sits within more socially-focused disciplines and higher-level work (ex. such as in planetary scale food systems) that usually sits within natural sciences.

To bridge this gap, the research here aims to establish a more nuanced understanding of how food system activities, drivers, and outcomes are interconnected across various scales (ex. spatial, temporal, governance) and levels (ex. local, global, short term, long term). Food systems research to date has not thoroughly investigated scale and level dynamics, and thus this work aims to improve this knowledge in order to enable improved diagnosis and management of food systems processes and challenges. Importantly, it focuses attention onto scale and level as central elements of FST processes to shed light on which system actors benefit from or are hindered by scale or level strategies or

positionings within the system, and it investigates the vital nexus of individual actors/actor groups and systems change for achieving more just and inclusive FSTs.

FST processes must be inclusive of all actors within the system and in order for these processes to be more just, they should explicitly include low-influence actors. Low-influence actors are the focal point in this work, as they have little influence over system structure and function, and hence may be excluded from processes aiming to transform system outcomes. Despite this, the framework and its application to the PNG case study will demonstrate how low-influence actors can be important decision makers for system outcomes across scales and levels. Meaningful inclusion of diverse actors is vital for supporting FST processes that are more just, sustainable, and inclusive (Giesbers et al., 2025). This will also help to address the inequities that characterise the structure and function of current systems. For instance, cross-scale and cross-level interactions are critical to ensuring that diverse actors are included in decision-making processes. This work then facilitates an approach to analysing food systems across scales and levels which can be used to guide thinking on connections between system drivers and outcomes through actors and activities (which later give rise to outcomes). Further, we apply an actor inclusion lens to cross-scale and cross-level interactions, analysing how actor influence shapes who benefits from transformation processes and who may be excluded. This aims to contribute to more just processes (in consultations, policy design, management regimes, and so on) that aim to transform food systems.

Using a case study with Papua New Guinean cocoa smallholder farmers, this work explores how food system science can bridge siloed approaches and drive just and inclusive transformation. This new analytical approach examines how cross-scale and

cross-level interactions drive smallholder activities and shape food system outcomes at the local level and beyond, and further, how these can guide decision making at other scales and levels.

4.2 Food Systems Across Scales and Levels

While it is well established that food systems exist across many scales and levels and that these scales and levels interact, evidence is emerging that demonstrates the interconnected nature of food systems at different levels or across different scales and the implications thereof. Scale is defined "as the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon" and level is defined as "the units of analysis that are located at different positions on a scale" (Cash et al., 2006, Gibson et al., 2000). Food systems have been shown as linked across levels through nestedness or tele-connectedness/tele-coupling, where interactions occur through environmental and socioeconomic dimensions across time and space (Eakin et al., 2009, Millington et al., 2017). More commonly, however, these linkages are shown through the interaction between different scales or levels. Scale and level interactions occur due to feedbacks (Ericksen, 2008), particularly feedbacks between drivers and response variables (Schulterbrandt Gragg et al., 2018), or emerge as patterns when working from finer levels, upward (Schulterbrandt Gragg et al., 2018, Coelho and Ruth, 2006). Cross-scale and cross-level interactions also manifest as drivers, activities and outcomes across analytical scales, for example, institutional, ecological and social (Ericksen, 2008). Others note the importance of driver interactions and separately state the importance of drivers of food system outcomes across scales and levels, but do not specify a linkage between drivers across scales and levels of food systems (Moragues-Faus et al., 2017).

Although not specifically addressing scale or levels for food systems, Cash et al. (2006) detailed the dynamics of scale and level and cross-scale, cross-level interactions in systems thinking approaches, which informed numerous formative pieces of research about food systems and the FST (though scale and level issues are not the primary focal point of these works)(Ericksen, 2008, Zurek et al., 2022, Allen and Prosperi, 2016, Béné et al., 2019b, Tendall et al., 2015, Foran et al., 2014, Ingram, 2011). Cash et al. (2006) describe several key points which are highlighted in the food systems scholarship: Firstly, the designation between cross-scale and cross-level: cross-level interactions are those among levels within a scale; cross-scale interactions are those across different scales (Cash et al., 2006). Food systems have important interactions between scales such as spatial, temporal and jurisdictional and simultaneously across level. For example, at the levels of landscape, regional and global spatial scale, there are complex interactions with temporal scale on daily, seasonal, annual and multi-year levels. Consider that over time, change occurs at different rates, both slow, cumulative change and fast change (or alternatively, shocks and stresses); these variables determine land use and resource extraction rates, such as grazing regime or water harvest (see Lovell et al., 2002 for further details)(Lovell et al., 2002, Ingram, 2011). Contemporary food systems are characterised by interactions between processes and actors across scales as well as cross-scale and cross-level feedbacks (Cash et al., 2006, Allen and Prosperi, 2016, Ericksen, 2008, Tendall et al., 2015, Ingram, 2011, Zurek et al., 2022, Zurek and Henrichs, 2007), however, further parsing out of the nature and dynamics of these interactions has not been explored.

Secondly, challenges of scale arise in food systems through ignorance, mismatch, and plurality (Cash et al., 2006). Ignorance, where issues of scale and level complexity are

ignored or misunderstood; mismatch, where there are boundary issues and disconnection between different levels and scales, and plurality, where an assumption that a single, correct, or best characterisation of scale and level challenges is applied to a whole system (Cash et al., 2006). These three challenge types arise in food systems (Zurek et al., 2022); mismatch is a particularly important challenge given the diversity of food system processes and outcomes which have contrasting social, economic and environmental characteristics and which cross scales of time, space, and jurisdiction (Ericksen, 2008, Zurek et al., 2022, Allen and Prosperi, 2016, Béné et al., 2019b, Tendall et al., 2015, Ingram, 2011).

Beyond Cash, Geels also conducts broader systems research with relevant cross-scale and cross-level analysis (Geels, 2002, Geels, 2011, Geels et al., 2016), although this has been less frequently applied to food systems (Anderson et al., 2019, Conti et al., 2021, Gaitán-Cremaschi et al., 2019). Geels' work notes that particularly in the context of sustainability transitions (akin to the processes needed to achieve the FST), in technological transitions and MLPs, there is an alignment of processes whereby transitions occur when developments at different levels align (Geels, 2002). MLP frameworks demonstrate that change processes arise through interactions within and among three levels of analysis: niches, socio-technical regimes and a socio-technical landscape (El Bilali, 2019). This alignment creates windows of opportunity for niche innovations (system changes) to break through, as well as alterations to non-linear dynamics in systems, where transitions are non-linear processes which involve complex interactions and feedback loops between levels (Geels, 2002).

In a critique of MLP frameworks, Geels (2011) notes that in the case of sustainability transitions, 'lack of agency' is criticised, and that in response, the interactions between different levels must be analysed; this is imperative for agri-food sustainability transitions, which require a deeper understanding of different social and technical system levels and cross-level interactions (which in the MLP discourse characterised as landscape-niche-regime interactions)(El Bilali, 2019). Geels goes on to describe the role of agency and power struggles in systems transitions, highlighting how different actors influence transition processes (Geels et al., 2016), which is a significant challenge in transforming food systems (Clapp et al., 2025). Further, the multi-level perspective on system innovation applied to food systems indicates the connections from regime to niche and landscape; the socio-technical landscape is beyond the direct influence of actors at niche and regime level, which creates opportunity for change processes (Geels, 2011, Leeuwis et al., 2021). For example, the greater impacts of COVID-19 resulted in pressure on food systems, which has impacts at landscape level and subsequent consequences beyond the biomedical domain, further resulting in an abrupt crisis as well as long term more gradual implications across food systems (Leeuwis et al., 2021, Van der Ploeg, 2020).

Both Cash and Geels address system dynamics across scales and levels but differ in how they treat actor agency and feedback dynamics. While Cash et al. (2006) provide a structural and analytical basis for addressing scale and level, the MLP framing brings in the role of actors within systems. Integrating these perspectives and applying a lens that focuses on justice and inclusion shows how FSTs can integrate both a structural and relational process and review asymmetries across levels, which is particularly important

for actor influence and in considering what drives processes across scales and levels in the food system.

Outside of acknowledging the importance of working across scale and across level (although using various analytical and discursive approaches), little food systems work demonstrates how the linkages between scales and levels operate, with most research addressing these issues under the limitations of 'fit for purpose'. For example, for the purpose of measuring resilience at a local level and its contribution to system-wide resilience, the individual actor level can be combined with emergent properties of food systems (Béné et al., 2023). However, global level conceptions of food system transition have failed to connect to the local level and guide local-level responses (Carlsson et al., 2017). Further, scale transferability is a challenge in linking data, which is often available at national levels, to sub-national level intervention and not linked to local-scale transformation (Carlsson et al., 2017).

4.3 Towards a Cross-Scale Conceptual Framework

While the literature demonstrates the importance of analysis across scale and across level, few explicit connections therein have been established to inform FSTs. This framework explicitly focuses attention onto actor inclusion and dynamic food system interactions, which lead to system outcomes across levels and scales. **Figure 4.1** shows how system drivers and outcomes are connected in the food system concept at large, and **Figure 4.2** demonstrates a conceptual frame of how linkages between levels can be understood for many scales, using the language of system drivers, feedbacks, and outcomes. These connections cover system drivers, feedbacks, and outcomes in all outcome areas (food and nutrition security, environmental sustainability, and economic and social wellbeing).

As illustrated in **Figure 4.2**, food system outcomes from the level that individuals or groups of individuals operate at become drivers at the community level; food system outcomes at the community level become drivers at the landscape or country level; food system outcomes from the landscape level become drivers at the community level, and food system outcomes from the community level can also become drivers at the landscape level, noting that when outcomes become drivers, this occurs through the process of feedbacks (Hasnain and Hill, 2025). Further, scale is key in understanding linkages between system actors and their relation to system influence, given that the highest level that an actor operates at is closely linked to their influence over the structure and function of the system and its transformation.

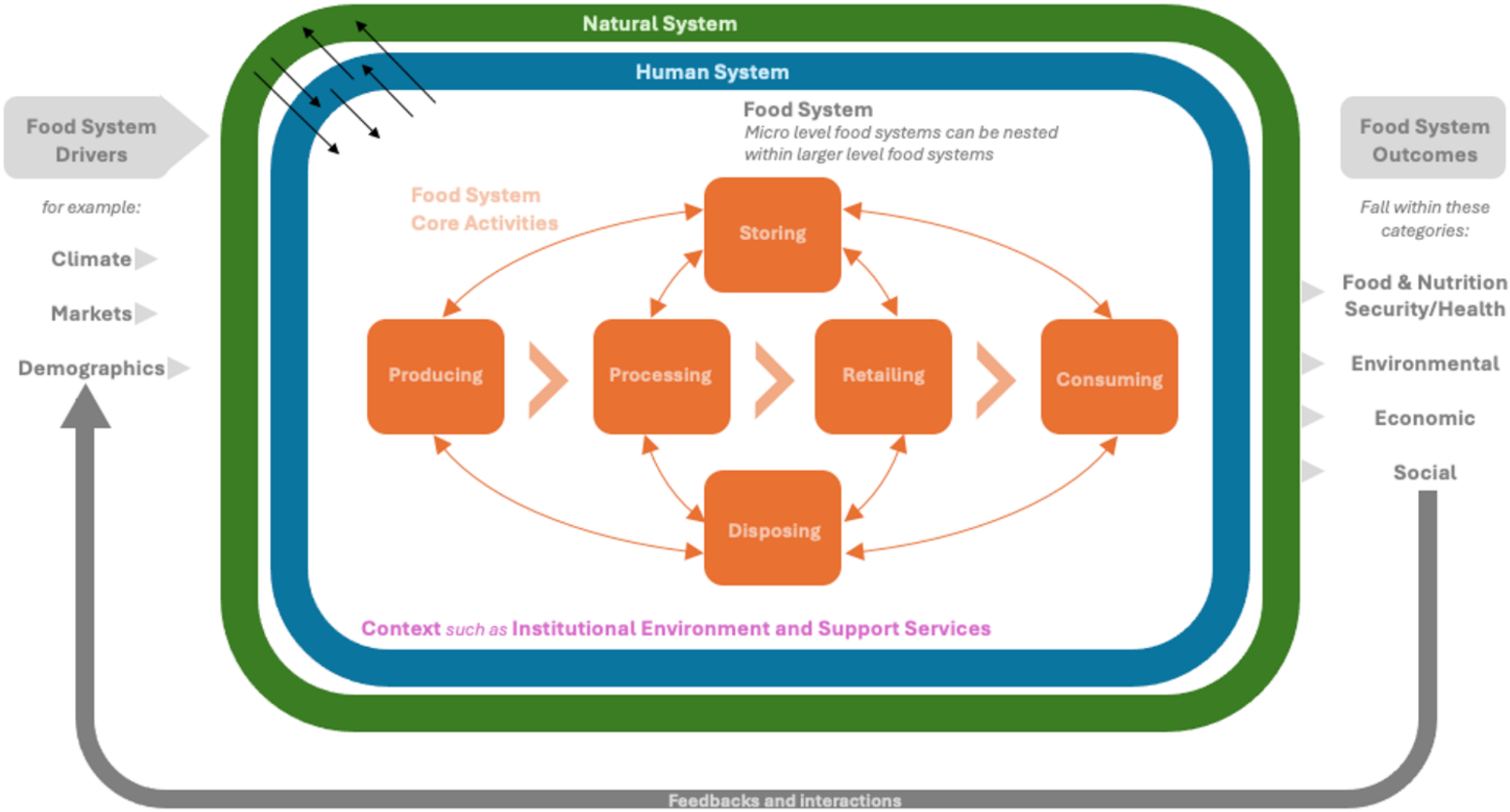


Figure 4.1 Conceptualisation of a food system.
This system can be analysed with regard to different scales and also functions at many levels as both systems and their nested systems, adapted from Woodhill (2019).

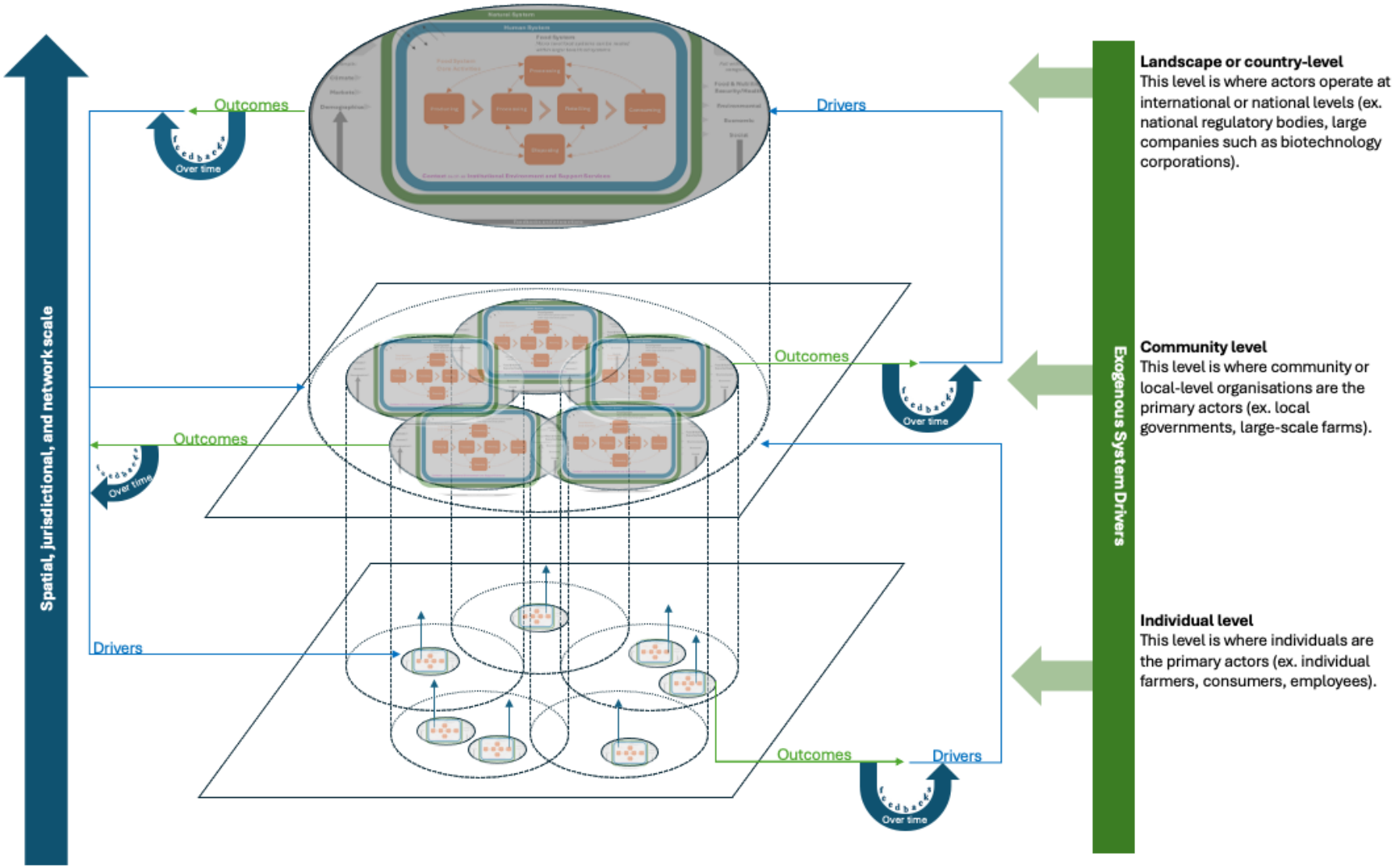


Figure 4.2 Cross-scale and cross-level food system dynamic conceptualisation.
Figure to be read from the bottom, up. Each circle can be its own food system at its own level, which is nested within a larger food system (any food system sits within a natural and human system at the relevant level). Outcomes from the individual level become drivers at the community level. Outcomes from the community level become drivers at the landscape or country level. Outcomes from the landscape level become drivers at the community level, and outcomes from the community level become drivers at the landscape level. Outcomes are mediated by feedbacks. This is applied to the spatial, jurisdictional, and network scales for food systems and can be extrapolated across different levels and the scales detailed in this paper. The layered cylinders draw on an illustration of nestedness from Geels (2002) which is directed at systems change, but instead applies it to how system levels and their interactions can be understood in food systems and how systems at different levels are interconnected.

In designating food systems as the "global food system" and nested "sub-national" or "local food systems" the conceptualisations of these systems have been organised in accordance with spatial, jurisdictional, institutional, management, network, and knowledge scales. For example, consider the network scale: in the conceptualisation of the "global food system," food system activities, outcomes, drivers, etc., are analysed and measured in terms of society or trans-society linkages (such as the flow of food related goods or labour between countries, or a given country's land use emissions in an emissions trading scheme). In contrast, in the conceptualisation of "local food systems," in the network scale, they would be analysed and measured in terms of distribution of familial labour, food and labour sharing within the community, and so on. Temporal scale is more difficult to analyse, as it is not directly addressed within the construction of the "food systems" concept or most food system conceptualisations. Hence, the temporal scale is incorporated in this framework by capturing time and temporal delays as they transition from becoming system outcomes of one system to a driver of a system at a different level through feedbacks.

All scales and levels can interact. **Figure 4.2** shows how cross-level interactions occur in food systems and the nested food systems within the larger system; **Figure 4.3**, adopted from Cash et al. (2006), demonstrates the scales implicit in the food systems conceptual framing. It shows that food systems exist across spatial, jurisdictional, institutional, management, network, temporal, and knowledge/belief scales. Food systems research requires explicit analysis and integration across all of these scales and at all levels, noting that interactions within the food system and between food systems and other systems may occur across multiple levels and interacting scales simultaneously. **Figure 4.3** also provides an example of how scale and level interact

through cross-level, multi-scale interactions and cross-level, cross scale interactions, which is explored further in the results section of this paper using a case study with smallholder farmers in PNG.

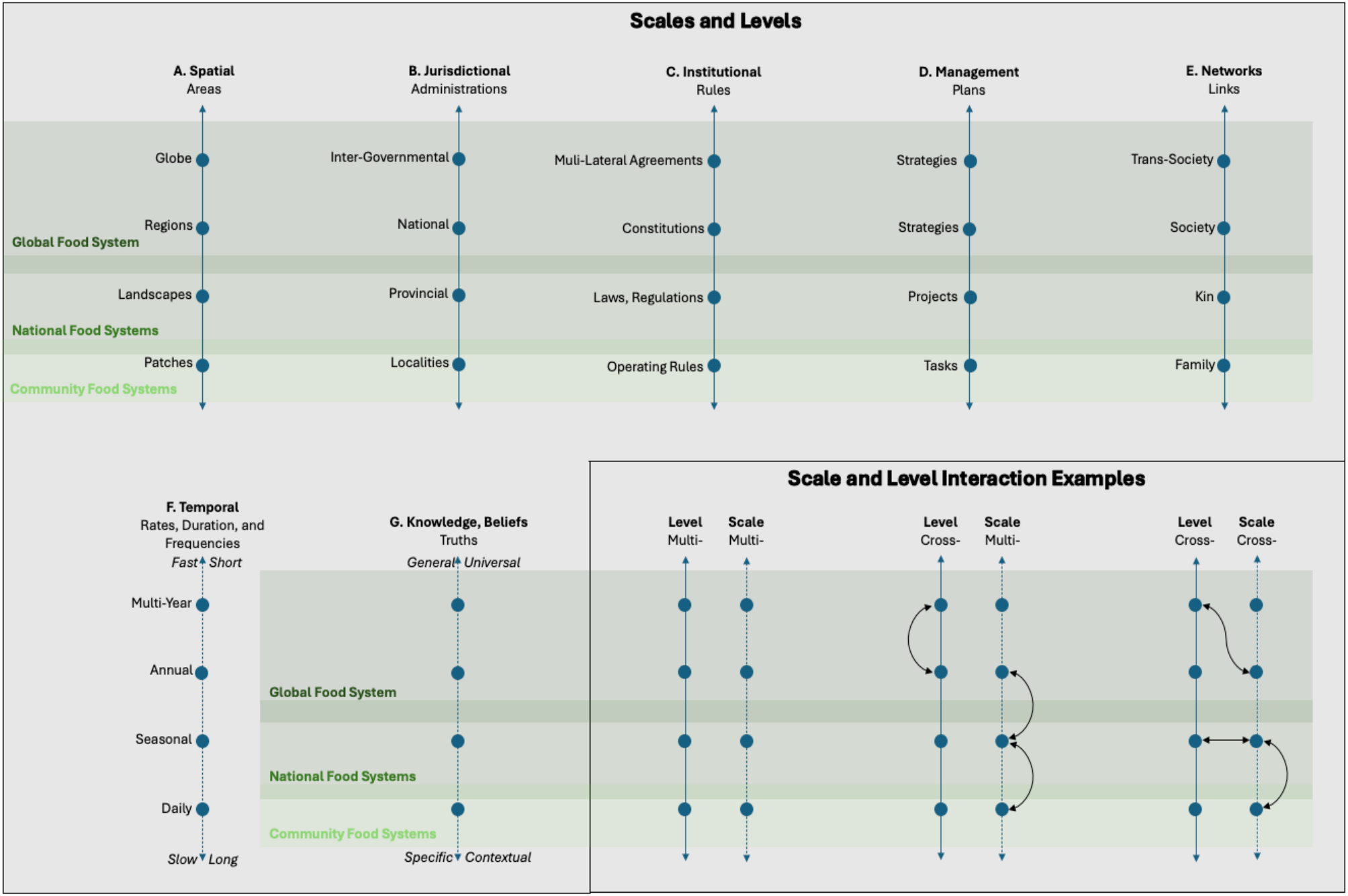


Figure 4.3 Scales applicable to the food systems concept and potential scale-level interactions. Adapted from Cash et al. (2006).

4.4 Case Study

In order to highlight cross-scale and cross-level interactions, a case of the Papua New Guinean cocoa sector illustrates this conceptual framework in empirical terms.

4.4.1 Methods

4.4.1.1 Selection of Case

PNG is largely agrarian nation, which is under 82% – 97% customary land tenure (Filer, 2014, Chand and Yala, 2009, Kwapena, 2021). The agriculture sector employs about 80% of PNG's workforce, and between 80% and 90% of the population rely on subsistence agriculture (World Bank, 2014). More than 150,000 families (~10% of the total population) in PNG rely on cocoa smallholdings as their primary source of income (Lescuyer et al., 2018). There are numerous and variable modes of cocoa production in the country. However, cocoa is predominantly produced under a model of low inputs and low yields; smallholders tend to be oriented to subsistence rather than the business of cash cropping, focusing their labour on growing food to eat directly. They then spend the minority of their time on cash cropping, which helps smallholders access supplemental food, particularly during hunger season ("*taim hangre")*, for medicine, and school fees (Lescuyer et al., 2018). Most cocoa farmers in PNG have less than one hectare of cocoa and the income this generates is inadequate (Lescuyer et al., 2018, Pham et al., 2021). This context provides a useful case study because the smallholders worked with here are key decision makers. In PNG, smallholders are usually customary landowners, and so they decide how land is used, including cutting or preserving primary forest. Despite their key role as land managers, they do not have significant influence over other food system outcomes. Additionally, their perspectives may not be in line with national or subnational

agendas, and so they may be overlooked in processes aimed at transformation. Cocoa farmers were specifically interviewed given the increasing interest in the commodity in PNG and its connection to potential land use change.

4.4.1.2 Data Collection

Data were collected in late 2023 from 160 smallholder farmers (some who also owned a cocoa fermentary) across four communities in PNG, which were selected to capture variations in remoteness, population density, and subsistence or commercial orientation, as shown in **Figure 4.4**.

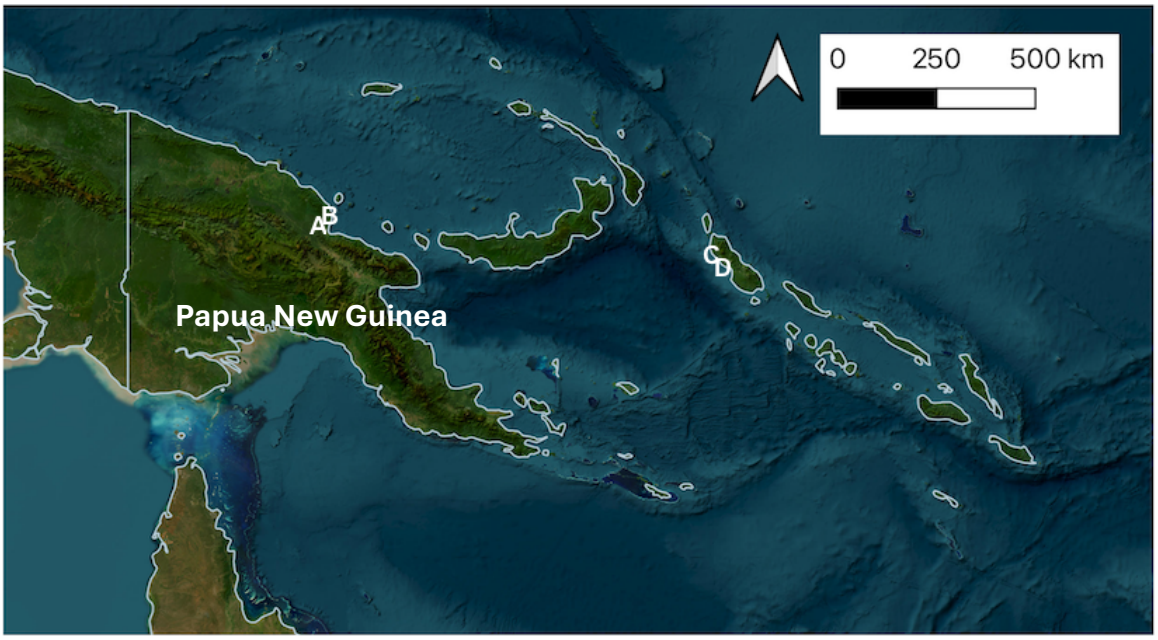


Figure 4.4 Data collection sites in four communities.
A. Ohu, Madang Province; B. Rempi, Madang Province; C. Tomasi-Makakoa, Bougainville Province, D. Ubuko-Siato, Bougainville Province and their relative position in PNG (Natural Earth, 2023, Planet Labs, 2023, QGIS Development Team, 2024).

This work focuses on interview data collected, however, a variety of co-creation workshop methods were also used during this work to triangulate data and to reduce researcher bias. The position of the lead author is a white, Western academic, and so numerous efforts were made to ensure participants were comfortable and researcher bias addressed. The research team was introduced to Clan Chiefs through existing and trusted

community relationships, and the presence of a researcher was announced to each community. The researchers walked through each community area with a local assistant (a trusted community member local to that area). Each interview would start with the interviewer offering around coffee and biscuits, and building culturally appropriate rapport before beginning the consenting and interview process.

Within communities, due to the often physically difficult nature of reaching potential research subjects through cocoa blocks and jungle and given the hamlet structure of settlements dotted across the landscape without roads, selected snowball sampling was employed. This ensured access to a diversity of participants to mitigate incomplete knowledge; for example, in each community, a range of households were selected to include fermentary owners and subsistence-oriented farmers. To mitigate the non-random nature of this sampling strategy, equal representation from all geographical segments of the community was reached with guidance from the local research assistant. The study here does not claim to be statistically representative of all PNG cocoa smallholders, but is appropriate for cross-scale cross-level qualitative inference and for illustrating the proposed conceptual framework. Households were approached by the research team and if they opted in, were asked to choose one adult to answer questions about food and cash crops. In PNG, land is passed through matrilineal and patrilineal pathways depending on the sub-region. Generally, more males answered in the communities where there was patrilineal passage of land and the gender ratio of respondents was more equal in regions with matrilineal passage of land. Often both male and female heads of household would be present throughout the interview process and provide input on an ad hoc basis at participant discretion.

In each of the four communities, 40 smallholder farmers were interviewed (n = 160) and interviews were audio recorded. To get a broader systems view, an additional eight interviews were conducted: two with commercial cocoa buyers (Agmark and Eliven), two with Cocoa Board offices for Madang and Bougainville, two local government representatives, and two community conservationists. The interviews of smallholder farmers used semi-structured interviews with a flexible, participant-led approach, in which participants drove the conversation with their priorities, and which allowed for follow-up questions relevant to food system outcomes if appropriate. Due to this, not every interviewer answered every question, and so number of respondents for each answer is provided in the results section of this paper. This methodology was particularly useful in the exploration of soft systems and to accommodate research participants which is useful in the PNG context (Kusenbach, 2003). Interviews conducted with other food system actors to get a wider system view were loosely structured but focused on priorities, challenges, and changes for the relevant system outcome (ex. the 'environmental condition' system outcome for the conservationist participants). Interviews with smallholders were held in mixed English and usually Tok Pisin, while interviews with cocoa buyers and the Cocoa Board were in English. Tok Pisin interviews were supported by a local translator and the lead author translated and manually transcribed all interview recordings using a gisted approach according to Paulus et al. (2014). The list of guiding questions from interviews is included in **Appendix C**. Participant answers were then assessed for emergent themes and manually coded in excel by the lead author to identify numerical data. A two-step coding approach was used according to Saldana (2011). For the coding, by way of example, when farmers were asked "if you were in charge of a big piece of land, what would you do with it?", answers were open ended, but emergent codes were categorised and then counted (answers to this question were often about using that

land for three purposes: cash cropping, gardening, or preservation, so these were categorised and counted). The coded interview data were then analysed and described using the food systems outcomes framing in conjunction with the cross-scale and cross-level framework created in this work. We analysed food system outcomes, drivers, and feedbacks across the scales and levels detailed in **Figures 4.2** and **4.3**, applying them to the PNG case to illustrate how this framework can lead to improved understanding of scale level dynamics in the case study food system.

4.5 Results

Given the paucity of published data about rural food systems in PNG, the results first show the baseline information of food system activities, drivers, and outcomes (by outcome area), then go on to detail the interactions in terms of the cross-scale and cross-level framing.

4.5.1 Key Definitions

Food system drivers are described here as "elements which influence food system activities" and outcomes are "the consequences [or] the ways in which key identifiers of food systems progress" (Woodhill, 2019). Food system activities are undertaken by different actors, including primary production, processing, retailing and consuming along with storage and disposal" (Woodhill, 2019). We consider food systems as nested within higher level food systems as well as within other systems (Walloth, 2016); nested systems are systems that contain other systems and are also contained by other systems, so for instance, a community-level food system may be nested within a national food system,

but also nested within the natural and human systems of that place, as previously shown in **Figure 4.2**.

4.5.2 Overview of Food System Activities, Drivers, and Outcomes Among Community-based Participants

4.5.2.1 Food System Activities

The food system activities in case study communities include production, processing, retailing, distribution, consumption, and waste disposal or use, all within the bounds of the community (the community food system has a complete set of system activities). It is nested within the larger sub-national, national, and international food systems, and is subject to the outcomes of those systems, which become drivers from these systems into the community level food system. Additionally, the food systems in communities gives rise to outcomes which then become drivers at the higher levels over time.

At the community level, food is not only important for personal or household consumption, but it also enables income generation and a plethora of social and cultural outcomes through its distribution, processing, and direct sale. At the community level, system activities include food consumption and production of food and cash crops as well as processing, retailing, distributing, and waste (either by burial or repurposing as animal feed). In addition to cross-scale and cross-level interactions, there are direct two-way interactions between the community-level food system and the globalised food system: 1. By purchase of "shop foods" in towns that are then taken to the community for sale or consumption, and 2. By taking crops grown and food otherwise acquired in the community to towns for sale into the local market (ex. vegetables, fish) or global market

(ex. commodity crops like cocoa). In line with norms for remote PNG communities, all respondents across the study areas were multi-actors within the system, growing food (subsistence and cash crops) for household consumption and for income (n = 160). There were also participants who practiced food processing: 22 respondents owned and ran cocoa fermentaries. Additionally, many participants informally sold cassava cakes and other simple processed foods in the market, however the extent of this was not captured, as it was usually only done on an ad hoc basis, such that it did not contribute significantly to income over the course of the year. Four participants owned and ran trade shops in their communities, and three were smallholder farmers that were also distributors, earning income by freighting goods by car or boat between towns and communities. An overview of respondents is shown in **Table 4.1**.

Table 4.1 Composition of respondents in each community.
Note, Ohu and Rempi practice patrilineal passage of land ownership whereas Tomasi-Makakoa and Ubuko-Siato practice matrilineal passage of land, which was reflected in the gender composition of respondents.

	Ohu	**Rempi**	**Tomasi-Makakoa**	**Ubuko-Siato**
Sample Size	n = 40	n = 40	n = 40	n = 40
Local vs. Immigrated to the Community	37:3	34:6	33:7	36:4
Men vs. Women	28:12	32:8	16:22	16:22
Age 20 - 29	5	2	4	1
Age 30 - 39	10	11	12	15
Age 40 - 49	15	16	15	4
Age 50 - 59	6	7	6	12
Age > 60	4	4	3	8

4.5.2.2 Food and Nutrition Security Outcomes

PNG communities have long practiced mixed farming, whereby some land is used for subsistence (food "gardens") and other land is used for cash cropping, usually cocoa, coconut, coffee, and sporadic oil palm, which has increased in some parts of the country in recent years, particularly in the island provinces. Estimates indicate that in PNG, about 28% of the population is undernourished, childhood stunting is near 50%, and about half of adults experience overweight and obesity (Global Hunger Index, 2025, Global Nutrition Report, 2022). All respondents across the study area depended on garden food for subsistence (n = 160). While remote communities tend to be subsistence-focused, most also supplement their diets with "shop foods," primarily rice, sugar, cooking oil, seasonings, and coffee. Shop foods are consumed once or more per week by 94% of respondents, with a median consumption of 2.0 consumption events per week (n=156). Meats can be locally sourced such as by river or ocean fish, and occasionally bushmeat (such as cuscus). Shop-sourced meat is most often tinned fish and occasionally tinned red meat (although tinned red meat tends to be extremely expensive). Some households also have poultry or pigs, which along with garden food, they consume or sell, depending on their needs (n=10).

Food security data in PNG are inconsistent and difficult to capture. From the 1960s and as recently as 2007, researchers described PNG as having "subsistence affluence", whereby although the regions were cash poor, it was said that people ate what they grew and grew enough not to be hungry (Conroy, 2012, Fisk, 1962). Despite this, national surveys in 1996 and 2009 indicated widespread hunger or malnutrition (Jayanthan et al., 2012, Temu and Saweri, 2001). *Taim bilong hangre* (often shortened to *taim hangre*), when garden food is scarce, was found to be common, although difficult to capture its

extent. Due to a diversity of coping strategies and varying meaning behind *taim bilong hangre*, many respondents did not indicate they struggle with *taim bilong hangre* when asked what their challenges were in relation to food. *Taim bilong hangre* means that garden food (or sometimes only the main staple food, sweet potato) is scarce, but does not always mean that households are short on food given they can acquire it from other sources. When *taim bilong hangre* was mentioned by respondents, they would often follow up with a plethora of coping strategies, such as relying on shop food, different crops, wild foods, and occasionally food sharing. While food sharing was rarely provided as an answer about coping strategies, it was observed during community stays and has previously been recorded as a helpful strategy (Bourke and Harwood, 2009). Qualitative answers indicate that caloric needs may be met through sufficient access to starchy foods; when self-assessed, participants do not say they are struggling *taim bilong hangre*, however they do indicate that protein intake declines, and is accessed infrequently (often from shop-foods). A farmer distilled a commonly shared assessment of *taim bilong hangre* for those in the community:

> "*If I don't take care of my garden, then taim bilong hangre comes up. Before, it didn't come up too much, because we have yam, Singapore, cassava, banana, but now it comes up more because of changes in the weather. Nothing grows in the garden when the weather is bad. Now, when taim bilong hangre comes up, I can still get some food from the garden, or get some rice from the store, or share some food. We get enough food to eat.*" – Participant 123, Ubuko-Siato, male smallholder farmer, born 1972

Despite a widespread claim of generally stable food supply, when asked what challenges the community faced in terms of the food gardens, some respondents brought up garden food theft from others in the community as a big issue (n = 16), implying that food shortages may occur:

> "*People are stealing food because they don't have gardens. They have enough land but they don't do enough work*." – Participant 45, Rempi, male smallholder farmer, born 1957

A summary of food and nutrition security outcomes is shown in **Table 4.2**. Note, the purpose of this research was not to get a full picture of food and nutrition security and its dynamics, but rather to capture a view from smallholders about their food system outcomes, inclusive of overall food and nutrition security.

Table 4.2 Summary of food and nutrition security food system outcomes in each community.

	Ohu	**Rempi**	**Tomasi-Makakoa**	**Ubuko-Siato**
Sample Size	n = 40	n = 40	n = 40	n = 40
Average number of shop food consumption events per week	4.6	3.2	2.3	1.4
Median number of shop food consumption events per week	4.8	2.5	1.0	1.0
Min number of shop food consumption events per week	1.0	0.5	0.0	0.0
Max number of shop food consumption events per week	7.0	7.0	7.0	5.0
Sample standard deviation number of shop food consumption events per week	2.1	2.3	2.1	1.0
Individuals saying 'taim bilong hangre' comes up more now than when they were a child*	n = 32	n = 25	n = 31	n = 39
Yes (comes up more)	44%	68%	52%	64%
No (does not come up more)	56%	32%	48%	36%

* Note, there was no statistically significant correlation by age, Pearson's correlation = 0.14, p = .13, n = 127.

4.5.2.3 Environmental Sustainability Outcomes

In PNG, 82% – 97% of land is under customary tenure, where land is owned collectively by Clans (Filer, 2014, Chand and Yala, 2009, Kwapena, 2021); these land rights are recognised under the PNG constitution, and this results in most Papua New Guineans, particularly locals to a given area (non-migrants) having rights to land use and decision making about their land (although decision making that involves cutting primary forest sometimes involves Clan leadership and traditional governance processes). It is not

common for individuals to have a land title, although the PNG Government is now encouraging landowners to register their land. Respondents were 89% local to their communities and 11% had immigrated from elsewhere in PNG to the area they were currently living, usually due to marriage (nationally, about 85% of Papua New Guineans live in remote communities). Land use change data are not available at the granularity of the community level, however, nationally, PNG lost 1.87 Mha of tree cover between 2001 and 2023, equivalent to a 4.4% decrease in tree cover since 2000 (World Resources Institute, 2025). The primary driver of tree cover loss was shifting agriculture; in 2023, the most recently reported year, 83.6 kha of tree cover loss occurred, where 73.5 kha of loss was accounted for by shifting agriculture and 9.87 kha of loss was accounted for by logging/forestry. At the community level, this aligns with respondents who emphasised their need to access income by using the natural resource base and various land use practices; in addition to 100% of respondents relying on natural resources for direct dietary consumption, 95% rely on agricultural products as their primary source of income (n = 160).

Throughout the interviews, 50% mentioned concern that there will be a land squeeze in the future (often in the context of the population becoming “too high” and being short on land); 14% mentioned that there is a current land squeeze in their community; and 35% did not mention a concern with land availability (n = 108). Further, 79% stated that the primary reason to conserve land is provision of future resources (n = 98). While provision of future resources was consistently the reason to conserve forest across all communities, the tone of reasoning varied by remoteness of communities. While less remote communities tended to focus on more tangible resource access, for example, access to

timber for building and land for making gardens, more remote communities highlighted a more complex view of future resources and their cultural beliefs:

> "*The bush is important because it keeps the water cold... I plant lots of trees in the bush, so that there is big bush in the future. I think we need to keep the bush so we can get medicine. We get lots of medicine from in there for when we're sick. It's our custom, the Upe, to be in the bush, so we need the bush for Upe. If we run out of bush, then our culture, our Upe, our medicine, will run out.*" – Participant 159, Ubuko-Siato, male smallholder farmer, born 1973

'Place' which can be regarded broadly for food systems analysis as land and natural resources (and the right to use these), is extremely important to Papua New Guineans in both an environmental and a social sense. *Papa graun* (where there is patrilineal passage of land), or *mama graun* (where there is matrilineal passage of land) indicate the importance of environmental sustainability as a food system outcome and integrate the ideas of natural resource access rights, land ownership, stewardship, and a deep connection to cultural and ancestorial areas, including special sites. When respondents were asked if place was important to them, 97% said yes (n = 102) and 76% said they wanted their children to stay in their place when they grow up (n = 106). Further, out of 96 respondents that answered about concerns about the future environmental condition of their place, 61% were worried, 22% were not sure, and 16% were not worried about the future environmental condition of their place.

> Regarding children: "*I want them to stay here, the land and the resources are for them. I am happy for them to come up farmers. If*

> *they get another job, I still want them to come back to their land.*" – Participant 140, Tomasi-Makakoa, female smallholder farmer, born 1981

While place and environmental condition were important, along with the right to use land and water as resources, there was also a complex relationship between producing food and the interaction between food production and the natural resource base. For example, the perceived relationship between cocoa and condition of the environment was highly heterogenous. When asked which land uses impacted the condition of the environment most, 9% of participants indicated that cocoa has the most negative impact on the condition of the environment, 12% indicated that food gardens have the most negative impact on the condition of the environment, 54% indicated that the negative impact is the same, as it becomes a problem whenever trees (from secondary or primary forest) are cut down, but also, 25% of respondents indicated that cocoa and gardens have no impact on the condition of the environment at all (n = 102). Some respondents took the position further, opining that cocoa improves the condition of the environment:

> "*The cash crops don't ruin the environment. I think they actually help the soil… because we leave [cocoa] in one spot for many years, and the soil nutrients come back when we do that.*" – Participant 122, Tomasi-Makakoa, male smallholder farmer, born 1980

When considering their own potential future actions, just under 50% of respondents were interested in further expanding their cocoa, and another 30% had lost or were losing interest in cocoa and wanting to expand into further into another commodity, such as betel

nut (n=158). A summary of environmental outcomes as reported by smallholder farmers in this study is shown in **Table 4.3**.

Table 4.3 Overview of environmental food system outcome views of smallholder cocoa farmers. As interviews used a flexible, participant-led approach, the total number of respondents to each question is included on a question-by-question basis.

	Ohu	**Rempi**	**Tomasi-Makakoa**	**Ubuko-Siato**
Expressed concern with clearing primary forest during interview	50% (n = 40)	30% (n = 40)	65% (n = 40)	68% (n = 40)
Individuals stating their 'place' is important to them	98% (n = 40)	100% (n = 39)	92% (n = 38)	95% (n = 40)
Individuals wishing their children or decedents to stay in their place	62% (n = 37)	77% (n = 39)	79% (n = 39)	82% (n = 39)
Main reason to conserve land is provision of future resources	78% (n = 32)	81% (n = 36)	66% (n = 38)	72% (n = 39)
Perceived impact of activities on environment	n = 36	n = 34	n = 39	n = 40
Only cocoa negatively impacts health of environment	0%	0%	13%	23%
Only gardens negatively impact health of environment	14%	6%	3%	15%
Cocoa and gardens both negatively impact health of environment	72%	38%	49%	38%
Neither cocoa nor gardens negatively impact health of environment	6%	47%	21%	25%
Individuals concerned about the future health of the environment in their place	n = 29	n = 33	n = 40	n = 39

	Ohu	Rempi	Tomasi-Makakoa	Ubuko-Siato
Yes	83%	58%	53%	56%
No	3%	18%	25%	18%
Don't know	21%	27%	25%	26%
Individuals assessed for land squeeze	n = 36	n = 38	n = 40	n = 40
Mention of land squeeze throughout interview - emphasis on future	25%	34%	50%	53%
Mention of land squeeze throughout interview - emphasis on current	53%	24%	10%	15%
No mention of land squeeze throughout interview	22%	42%	40%	33%

4.5.2.4 Economic Outcomes

In remote PNG communities, food systems economic outcomes are extremely important. While cocoa is largely second to a subsistence focus, this research engaged with a range of participants including those who have invested significantly into cocoa (such as by purchasing and operating a cocoa fermentary), and those who focused on expanding their cocoa blocks significantly, as well as those who were subsistence-focused with little emphasis on cash cropping. Participants were asked how many cocoa trees they have at the present time, but due to pest pressures which had caused many farmers to opt for different crops instead of cocoa (discussed later in this paper), they were also asked about the maximum number of cocoa trees they had at any one time, as well as factors around reinvesting in their cocoa block in order to capture subsistence or commercial orientation.

The median number of cocoa trees (at each farmer's peak time) was 400, however, this ranged by communities (largely due to land availability); respondents had as few as 19 trees to as many as 3980 trees. In line with PNG norms, most respondents were subsistence focused and did not engage with cocoa in a very business-oriented matter (low input, low output model of growing). Social capital is high in PNG, with Clan structures remaining strong, particularly in remote areas, and many rely on the labour of family and Clan members for cash cropping practices (occasionally compensating them in cash or cooking for them). 38 participants indicated they reinvested funds to expand their cocoa or make it more productive, including 22 who invested significant funds to build and operate a cocoa fermentary. The cost of establishing a cocoa fermentary is about 5,000 PNG Kina (PGK); as a reference point, the living income in rural PNG was estimated to be PGK 1,593 per month in 2020 (Global Living Wage Coalition, 2021).

All respondents across the study area depended primarily on garden food, practice cash cropping, and sold food (either garden food or cash crops) for income (n = 160), 85% of these relied on community-based food system activities as their only source of income, and 15% relied on food system activities as an additional source of income (ex. a community school teacher may earn just as much or more from cocoa as they earn from teaching). Off-farm incomes tend to be low, for example, salary was usually less important than cash crop income; 16 respondents had off-farm income. Money is often shared during times of hardship, such as when a family or Clan member needs to pay hospital fees. A summary of economic food system outcomes as reported by smallholder farmers in this study is shown in **Table 4.4**.

Table 4.4 Summary of economic and social food system outcomes in each community.

	Ohu	Rempi	Tomasi-Makakoa	Ubuko-Siato
Current primary source of income (count of total answered)	n = 38	n = 40	n = 40	n = 40
Betel nut	82%	35%	13%	17%
Cocoa	8%	15%	52%	70%
Not betel nut or cocoa	10%	50%*	35%	13%
Median number of cocoa trees at peak	284	300	400	700
Min number of cocoa trees at peak	28	40	19	150
Max number of cocoa trees at peak	3000	3500	3980	3500

* Rempi was the only region assessed that had high non-cocoa, non-betel nut primary income, which came from coconut. Coconut was the primary income source for 17 respondents.

4.5.2.5 Multi-Level, Cross-Level, Multi-Scale, and Cross-Scale Drivers and Outcomes

There are numerous multi-scale, cross-scale, multi-level, and cross-level drivers and outcomes from nested food systems. Several key interactions arose from smallholder farmer interviews in PNG about their perspectives, and how these perspectives can act as both direct and indirect drivers and that demonstrate how cross-scale and cross-level interactions lead to outcomes at different levels. The conceptual framework is applied to this context and several of these perspectives are highlighted to show how cross scale and cross level dynamics can manifest in the case study. For smallholder farmers, many drivers manifest in decision making related to use of the natural resource base, particularly land use, which is largely demonstrated through interactions between spatial and other scales.

4.5.2.6 Drivers and Outcomes Contributing to Food Security

As noted previously, in the context of PNG, most people in remote communities are multi-actors within the food system, undertaking many activities and engaging with food systems in multiple roles (ex. as consumers, producers, processors, and/or distributors). One of the main outcomes of these activities is food security, which can be both indirectly and directly achieved through using land for food production and by livelihood activities which result in income generation (ex. cash cropping or selling fish), which then is used in large part to acquire additional or different food. Smallholder farmer interviews showed that there are numerous interactions between scale and level which contribute to food security. For instance, the interaction between network, institutional, and spatial scales: Family and Clan dynamics contribute to Clan leadership (each community has a group of Clan leaders from multiple families); the Clans contribute to the institutional environments, whereby they have a rule-making and enforcing remit in the communities. The Clan leaders in a given area determine operating rules for communal resource use and land use, and so this determines how patches of land are managed across landscapes (this includes provision of land itself as well as hunting/timber access, and whether primary forest can be cleared for cash cropping or gardens). Selected cross-scale and cross-level interaction examples that contribute to food security and that arose from smallholder farmer interviews are shown in the schematic in **Figure 4.5** and described in **Table 4.5**. In addition to these scale and level interactions, there is another interaction with the knowledge/beliefs scale, given that the decisions Clan leaders make together about use of space are informed by highly contextual historical and cultural beliefs, particularly relating to place, future resource availability, and reciprocity with the natural environment. A final set of complex examples from driver interactions that are indirect drivers are shared in the remainder of this section, with the schematic applied to illustrate

the complex driver and outcome connections that result in land use change across patch and landscape levels in the following section.

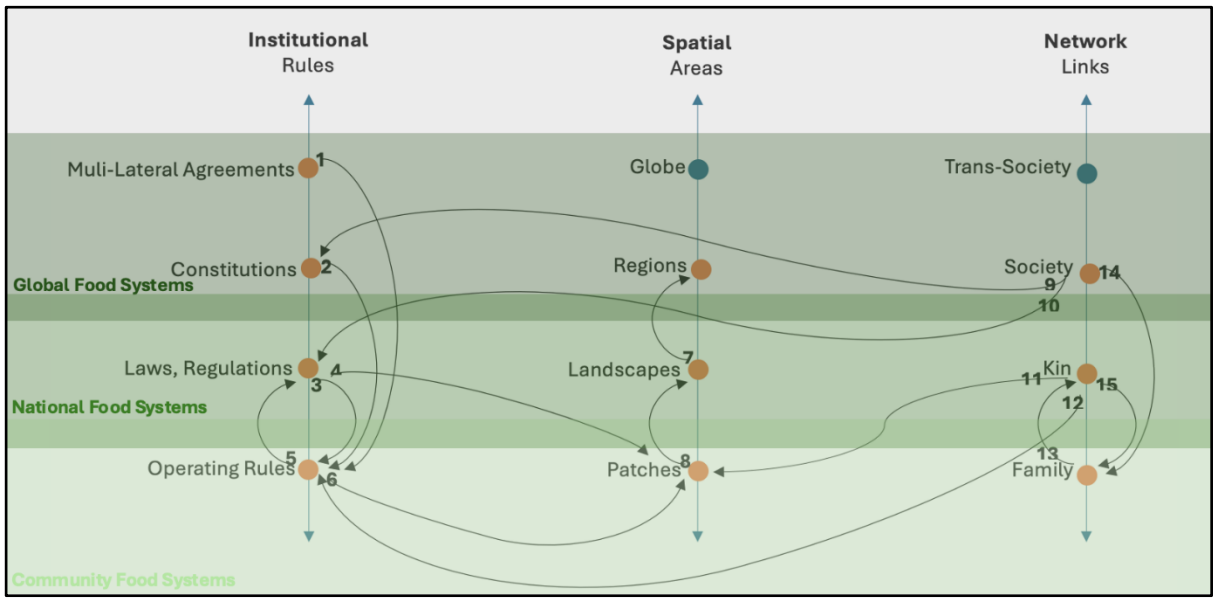


Figure 4.5 Schematic of scale and level interactions contributing to household food security informed by smallholder farmers interviews.
This is not intended to be an exhaustive list of interactions contributing to food security. Note that interactions are labelled 1 to 15 (the number of each arrow is at its origin point) and is described in the Table 4.5 where descriptions explain each cross-scale and cross-level dynamic contributing to food security that arose from participant interviews.

Table 4.5 Cross-level and cross-scale interactions contributing to household food security informed by smallholder farmers interviews.
This is not intended to be an exhaustive list of interactions contributing to food security. Note that interactions are labelled 1 to 15 (the number of each arrow is at its origin point) in Figure 4.5. The scale or level in the column two contributes to the scale or level in column three.

Interaction Label	**From: Scale or Level**	**To: Scale or Level**	**Relevant Smallholder Perspective Arising From Interview**
1	Multilateral Agreements	Operating Rules	Multilateral agreements, such as receipt of aid influences local food systems where interventions do or do no occur, and which subsequently influence the operating rules at the community level. For example, if the community has access to market development stimulus, it will change dynamics of how support is managed through the communities, which is often implemented on the basis of which parts of the community have accessed benefits or not. In the case study, one of the communities assessed in this research received aid from the Australian Government in the form of a tractor, which reduced the reliance on kin to assist with cocoa planting and market access (cocoa bags can now be carried by one tractor rather than a group of people). This then contributes to changes in community income generation, labour sharing, and trade-offs with garden food production.
2	Constitutions	Operating Rules	The PNG constitution makes provision for customary land tenure, which is then managed at the Clan level, who establishes operating rules at the community for how land is managed, including if it is available for using as cash cropping lands, gardens, for hunting land, or as preserved as bush, which all contribute to food security through income generation, production of garden vegetables/stables, or wild-sourced protein availability.
3	Laws, Regulations	Operating Rules	The PNG constitution makes provision for customary land tenure, which has led to laws and regulations on land management (ex. PNG Land Act 1996, which regulates land ownership and use in the country). This informs and interacts with operating rules at the community scale and the way that Clan leaders can manage land.
4	Laws, Regulations	Patches	In PNG, land ownership is highly fragmented, communally owned by Clans and also individually owned by members of the community. Members of the community and Clan leaders, at the spatial scale, determine how their land is used on a patch level, subject to the national land management laws and regulations (this distinguishes between the rules about land use, and in turn, how that land is used in practice).
5	Operating Rules	Laws, Regulations	The operating rules, including about how land is managed and perceived, and about how aid is administered, for example, inform how laws and regulations get created and enforced.

Interaction Label	From: Scale or Level	To: Scale or Level	Relevant Smallholder Perspective Arising From Interview
6	Operating Rules	Patches	The operating rules as set out by Clan leaders determine, at the spatial scale, how land is used in practice.
7	Landscapes	Regions	Across spatial scale, regions are made up of landscapes, and so when there are changes in many landscapes, these contribute to regional level change.
8	Patches	Landscapes	Across spatial scale, patches are made up of landscapes, and so when there are changes over many patches, these contribute to landscape level change.
9	Society	Constitutions	The way in which societies function determine how constitution, laws, and regulations are created and enforced.
10	Society	Laws, Regulations	*Ibid.*
11	Kin	Patches	Land use decisions of Clan-owned land is determined by a group of Clan leaders.
12	Kin	Operating Rules	The operating rules in a given community, including natural resource use, is managed by Clan leaders.
13	Family	Kin	Many families contribute to kin and Clan make-up and dynamics, inclusive of resource use and sharing.
14	Society	Family	Societal dynamics influence how families function inclusive of resource use and sharing.
15	Kin	Family	Kin and Clan dynamics influence how families function inclusive of resource use and sharing.

4.5.3 Indirect Drivers Contributing to Land Use Change

4.5.3.1 School Fees and Land Use

School fees were shown to be an important indirect driver of system outcomes, which demonstrated connections between spatial, jurisdictional, institutional and knowledge/belief scales as described in **Figure 4.6**. These have numerous interactions both across levels and scales. Whilst all smallholder farmer respondents stated the need for some cash, school fees had an additional impact for respondents who had responsibility for school-aged children. When asked about challenges in the community or questions around their sources of income, smallholder farmers often brought up that they needed to pursue cash cropping to pay school fees for their children or other family members, and that paying school fees was a challenge for them (26%, n =156). Under the Tuition Fee Free scheme that the national PNG government has implemented, there is no school tuition, however, parents must finance their children's education through payments (indirect costs) made outside of schools for items such as project fees, uniforms, lunch, and transportation. Additionally, there is some agricultural education in schools, particularly in high schools, but given school fees are higher at higher levels, and that there are few high schools across the country (so they are more difficult to reach) few people tend to get educated beyond elementary levels in remote communities. Further, when asked to rank the most significant barriers to best practices for growing cocoa, 43% said knowledge was the biggest barrier (this was followed by labour limitations at 23%, access to inputs at 21%, and concerns for the environment at 13%; n = 101).

Given that so many Papua New Guinean's rely on agriculture as their primary source of income (over 80% nationally), it is logical that in order to send children to school, land use change may occur in areas all across the country, resulting in impacts at the patch

level, with many patches contributing to landscape level change. Further applied to the conceptual framework in this paper, outcomes in policy, such as education fee changes from the national level, feeds back downwards, resulting in behavioural change in the communities and at the personal decision making level when considering land use. Additioinally, while money is important for school fees, there is also a widespread perception that cocoa can act as a proxy for money (or future money). This perception that having a cocoa block means you can access cash in the future results in a land use 'savings account' further extenuates this dynamic.

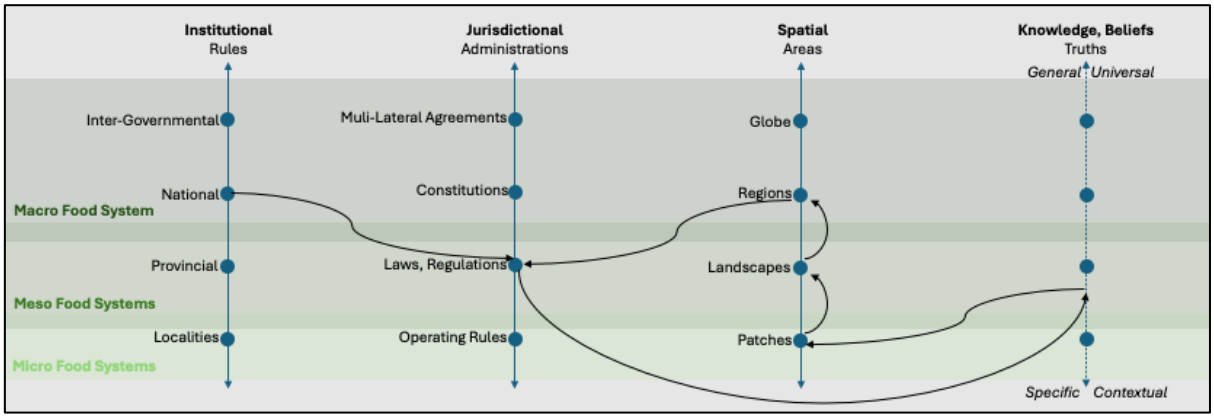


Figure 4.6 Cross-scale and cross-level/multi-scale and multi-level interactions.
These demonstrate how school fee laws and regulations that come from the national level drive knowledge and beliefs that result in smallholder farmers changing their patch-level land use, which contributes to an outcome of landscape and regional land use change, which in turn drives changes to policies regulating land use.

4.5.3.2 Birthright (the Right to Use Resources)

The majority of respondents stated that they care greatly about environmental condition, with 97% of respondents saying that place is important to them (n = 102) and 96% feeling responsible to look after their place (n = 105). Additionally, recall that 76% said they wanted their children to stay in their place when they grow up (n = 106). Further, out of 96 respondents that answered about concerns about the future environmental condition of their place, 61% were worried about the future environmental condition. About 80%

of respondents (n=106) express that the reason to conserve land is related to future resource provision, particularly building materials, which come from the forest.

Thus, consider the interaction between the scale of knowledge and beliefs and the institutional scale, where actors within the system, as well as external to it, make rules that govern the way that actors conduct food systems activities. In communities, Clan leaders and social factors determine operating rules for resource stewardship, which interacts with laws and regulations, as well as the PNG Constitution, including in the way that the PNG government interacts with macro level institutions, such as aid engagement, or programs such as Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+). This is also where community conservationists mobilise, impacting the knowledge and beliefs of local farmers:

> "*We don't have shifting cultivation anymore, we use one spot now, because we don't want to ruin the environment [cut primary forest]… I'm a Clan Chief, so I spread the awareness that we should keep farming in the same spot*." – Participant 148, male smallholder born 1971

Further, there is a widespread belief in PNG that birthright is not only linked to ownership of particular land and water (their "place"), but there is also the right to use the resources of that place, and that resources are there to be used and sometimes replaced. For example, historically the forest-fallow system has been used in many areas across PNG. As this system is used in the context of high regional population growth and where the regional

populations have access to and determine the regime of natural resource use, there are broad impacts of how resources are used, particularly land use regime.

4.5.3.3 Changing Social Dynamics

Pacific food systems have become progressively more integrated into global food regimes over time (Andrew et al., 2022). In the years of the contemporary global food regime (since trade liberalisation under the World Trade Organization), food systems across the Pacific have become more exposed to high-level forces, more reliant on imported food, and have become less healthy (Andrew et al., 2022). Evidence in communities in support of this is fragmented, and although many case studies at local levels have provided support for this narrative, broad patterns in the dimensions of food systems are poorly described and lacking in measurable outcomes (Andrew et al., 2022). Change appears to be more connected to the food environment from the consumption side rather than the production side, given that most cash cropping activities remain low input and low output, even in the 2020s. While 56% of respondents noted that there has not been any change in the extent of cash cropping over their lifetime, they have always needed *some* cash (n= 102). In two communities with relatively easy market access, instance of shop food consumption median was 4.6 and 3.2 consumption events per week, whereas in communities that had difficult access to market, consumption events per week median was 2.3 and 1.4 (n= 40 per community, total of 160).

Urbanisation and modernisation have resulted in numerous sociocultural changes, as well as changes across food system outcome areas. As well as changes to nutritional outcomes, these changing social dynamics may also result in changed land management regimes. Several elders noted that the traditional ways were being lost, and that the Clan leaders

were not as powerful as in the past. There was also a commonly held belief that Clan leaders were the ones to make all decisions about clearing of virgin forest (whether on Clan land or individual land), but several respondents said when they wanted to plant cocoa or otherwise clear virgin forest, they did not ask anyone (including the elders). This was because participants viewed it as 'their land' (passed down from their parents), not Clan land, indicating another interaction between the knowledge/beliefs scale and land use on the spatial scale.

4.5.3.4 Pest Pressures

Discussions with smallholder farmers revealed that cocoa farming was largely not considered important for way of life or identity, but it was pragmatic and the main way to generate income. Nearly all respondents discussed pest pressures, particularly cocoa bod borer (CPB), which has been rife in PNG since its accidental introduction around 2006. The Cocoa Board of PNG indicate "CPB is here to stay". As pest pressures have mounted, many farmers have migrated to other cash crops, namely growing betel nut, where they abandon their old cocoa blocks and cut new areas for betel nut expansion. Due to extreme resource constraints (one Cocoa Board official indicated that they only get about 10% of their needed budget to operate), they are largely unable to sufficiently support smallholder farmers. This gives rise to a scale interaction between the management and spatial scale, such that CPB reduction activities are not sufficiently undertaken, which drives both poor environmental and economic outcomes, and where land use change increases and profits from cocoa throughout the value chain decline. The transition to betel nut not only changes land use, but it also increases circulation (and hence consumption) of that betel nut, which is a

public health risk. Additionally, betel nut is an unregulated product, so it does not contribute to tax revenue.

> *"I started a fermentary in 2010. This community had eight fermenteries before, but five have gone run down. We only have three remaining. The rest, they couldn't keep going because there was too much CPB."* – Participant 42, Rempi, male smallholder farmer and fermentary owner, born 1960

Due to decreased interest in cocoa at the community level, cocoa buyers are facing the challenge of supply. Both cocoa buying companies interviewed indicated that their biggest challenge is securing adequate supply. They are in a race to the top, trying to secure supply by establishing incentive schemes. This is resulting in a response from some growers in renewed interest in cocoa. This shows an interaction between the jurisdictional and institutional scales, where Cocoa Boards are resourced, and consequently spatial and temporal scale interactions where patches are changed in their land management, contributing to landscape level land use change.

4.6 Discussion

As illustrated in the case study, food systems are subject to dynamics across scale and level. As such, they face challenges that are inherently multi-scalar and multi-level, such as heterogenous and varying impacts from climate change, uneven actor influence over system structure and function leading to inequities, and the need to address a breadth of relevant policy areas in which food systems may operate or are regulated (ex. land use, trade, employment, etc.). Cross-scale and cross-level dynamics mediate how food system

actor decisions accumulate to drive change across scales and levels (ex. patch and landscape change), and expose why top-down interventions both inside and outside the food domain (such as in funding policy around Commodity Boards and extension resourcing) can result in inequities and perverse outcomes from the food system. These cross-scale and cross-level dynamics also shape who can influence broad systemic change within transformation processes. In the PNG case, national-level and global-level actors such as the PNG Cocoa Board or multilateral/bilateral aid donors set the conditions under which smallholders make daily decisions, yet those smallholders, who hold critical local knowledge and make key decisions in their communities, often have limited influence on the conditions or agendas that impact them and that they affect in turn. This asymmetry underscores the importance of analysing FSTs not only as structural processes but as avenues for mainstreaming justice and inclusion.

In order to effectively solve challenges in the food system, and to govern FSTs, problems must be properly and precisely defined. Geels (2011) calls for an investigation into how regime reconfiguration at a finer level contributes to higher level changes in the landscape; the case study here provides explicit analysis of scale and level dynamics, highlighting their importance, particularly for natural resource management and land use. This work enables more precise problem understanding of complex food systems challenges (and hence can support improved governance, policy, and management). It also highlights how consideration of scale and level issues (including consideration of which actors are included as key decision makers) are particularly relevant for, and may identify ways in which levers for change or improvements to FST processes can be made. For instance, the case study from this paper demonstrated how decisions external to the defined food system, such as in education policy, may influence food system drivers of

low-influence actors. This in turn shapes system outcomes across scale and level, as is the case with how school fees result in driving land use change in various land use contexts in areas across PNG, which accumulates from patch to landscape level.

Food systems sit within natural and human systems at any given level. There is a unique set of drivers acting on food systems at any level that creates the decision-making space at that level, and which connects dynamics both across scale and level, which may otherwise be unclear or misunderstood. These dynamics contribute to the determination of the structure and function of the system, and are therefore important to understand and analyse for processes aiming to transform system outcomes. For instance, in designing projects or policies aiming to reform food system outcomes, and to monitor and evaluate those outcomes, decision makers must consider the dynamics of cross-scale and cross-level interactions, and the actors that do (and do not) benefit from interventions. Given the nature of these dynamics and their importance in shaping the decision-making space, they are particularly important for actors in the system and the way that actors relate to one another. To highlight an example from the case study, consider the cross-scale, cross-level, and multi-level interaction resulting from the introduction of a tractor within a community: the intervention aimed to reduce labour and improve economic outcomes, however, there were numerous external outcomes, such as the resulting change in social dynamics and community cohesion from reduced reliance on labour sharing.

Actors and their relationships with one another influence the structure and function of the food system, and hence influence system outcomes, usually in line with the level they operate at: global actors, such as the UN and Multinationals, of which there are very few, have a high level of influence over the system; in contrast, actors which are numerous,

such as peasant farmers or smallholders, have little influence over system structure and function given they act at the individual or more granular level on each scale (Clapp et al., 2025, Van Den Akker et al., 2024). The relationship between actor influence over system structure and function contributes to the discourse and policy that leads to system outcomes. An important component of power in the food system is this influence. In the global level food system, outcomes depend on the agendas of actors which gain or use influence from or otherwise leverage scalar strategy (the ability of high level actors to use their operating level to shape system-wide rules and resource flows), for instance, in negotiations relating to pricing or other efficiencies.

These actor dynamics lead to inadvertent power imbalances in the system which dictate which actor interests are prioritised, and hence, the unequal distribution of benefits and burdens that shape the system in its current state. This is demonstrated in the PNG case, where decisions by cocoa buying companies and the PNG Cocoa Board relating to pest management education shape the dynamics which create the decision space for smallholder farmers, and are a primary driver of their collective land use practices where they expand their cocoa (or not) or explore alternative income streams, such as betel nut. In the PNG cocoa system, high level cocoa buyers and the PNG Cocoa Board shape market incentives and pest management strategies, while smallholders, despite being numerous, essential, and key decision makers in their community, have limited capacity to influence such decisions. This inequity constrains their ability to benefit from transformation processes and perpetuates dependence on top-down structures. Recognising and addressing such imbalances throughout FST processes is key to achieving a more inclusive and just transformation.

Further, this framework can help to illustrate where in the system power and influence reside, and on that basis, improve the precision of problem understanding, leading to the identification of pathways for transformation in a more inclusive and actor-led approach, contributing to more diverse actor inclusion in initiatives aimed at transforming food systems. It can also help to diagnose policy mismatch across levels, such as where macro-level land use policies may conflict with local governance practices. Additionally, it can guide approaches to analysing who may benefit or lose out in land use decisions in response to policies targeted at different levels. Lastly, it supports existing social science research that demonstrates that cultural values and knowledge systems should be aligned with top-down policies, particularly those that may directly or indirectly drive changes in land use and the natural resource base; this further illustrates the need to bridge gaps between social and natural sciences for the FST. The application of the conceptual framework to the PNG case illustrates mechanisms and plausible pathways for change in FSTs, although it cannot produce statistically representative estimates of PNG or the global cocoa sector, which operates under numerous modalities, and often in more commercialised contexts.

Beyond the analytical utility of the framework, this work also invites reflection on the responsibilities of researchers and practitioners engaged in FST processes. As researchers and academics, we can emphasise critical inquiry into this topic, answering questions such as who the beneficiaries will be from FST processes at different scales and levels, important indirect drivers, or what outcomes may arise from strategic engagement with or intervention at different scales or levels. In order for the FST to be more just, it needs to be more inclusive of diverse and low influence (or low power) actors. Integrating elements of inclusion, equity, and aiming to achieve more just processes alters what food

systems practitioners and decision makers measure and prioritise (ex. by investigating distributional outcomes, metrics around representation, and systemic trade-offs, and unintended consequences for low-influence actors). We aim to bring attention to gaps in food system research and knowledge which has not yet thoroughly addressed cross-scale and cross-level dynamics, and seek to drive critical discussion about issues of justice and marginalisation, using this work to shed light on which actors/actor groups and actor types influence FST discourse, initiatives, and their monitoring and evaluation. We posit that these processes consider cross-scale and cross-level analyses as a mechanism for considering the relationship between target actors and inclusive systems change, and further to make power dynamics in the FST more transparent.

We recognise the position we have as one of privilege but also one of responsibility and thus aim to promote the position that notions around justice and inclusion should not be only a matter of academic debate but rather a process that those engaged with the FST in any way should universally seek, not just for themselves, but for all actors within the system. It requires an ongoing questioning of the status quo, particularly relating to issues of power and influence, including the status quo of research processes and conceptions of knowledge and knowledge holders. We consider our perspective as researchers not outside of the system we discuss, but part of it and encourage other researchers (and food system participants) to include consideration of all actors (institutional, human, and non-human) and their relationships with one another including how this connects to the FST process and to the politics therein. We also encourage building on this framework to support efforts at bridging gaps between qualitative and quantitative work within food systems sciences to contribute to real action on the FST.

4.7 Conclusion

This paper provides a conceptual framework and applies it to a case study to analyse how scale and level dynamics shape FSTs and the importance of integrating inclusion for more just FST processes. Operationalising these interactions remains challenging, but the framework offers a foundation for improving FST processes through developing more precise problem understandings. From the case selection here, we show that low-influence actors are not passive recipients of transformation but active and important decision makers in systems, whose land use behaviours collectively respond to, and shape system outcomes. Recognising their agency as key decision makers and addressing the structural barriers that limit their participation in FSTs is imperative for more just and inclusive change processes. Improved food system policy and practice may be enabled by the ability to enhance coherence which results from bringing attention to scale and level. Not only is this process important in its own right, but more inclusive FST processes will likely also result in more efficacy in system interventions and more sustainable uptake of reform, in turn leading to improved resilience and system outcomes.

Building on these insights, focused attention on scale and level dynamics reveals that they are extremely important to integrate into transformation processes, particularly to encourage the FST to improve in matters of diverse actor inclusion and its contribution to more just and power sensitive FSTs. A focus on scale and level also reveals food system actor dynamics, even with the relatively confined case study employed here, which ranges from those in charge of setting global land use policy which interacts with communities (ex. UN REDD+), to smallholder farmers, large corporations, processors, and many others in between. To address issues of power dynamics and promote the mainstreaming of inclusion of low-influence actors to contribute to more just FST processes, this work

proposes we build on the understanding of cross-scale and cross-level actor dynamics. We also propose progress towards an actor-centred theory of change for the FST, its governance, and monitoring and evaluation.

As yet, little research has assessed the impact of food systems structure and function on the distribution of power and the possible implications on the system (Caron et al., 2018, Hainzelin et al., 2023, Dury et al., 2023, Clapp, 2021). Further work towards conceptualising both power within the FST as well as more effectively providing data-driven linkages between micro-level, actor-focused pathways to change and macro-level change is needed to further advance this topic. Additionally, more consideration of "Knowledge and Beliefs" scale interactions is extremely important, given that the majority of food system actors are operating under their own sets of either personal or institutional knowledge and beliefs which inform all interactions with other scales and levels. Research should also investigate elements of temporal scale in food systems so that they can be integrated into the discourse around transforming system outcomes and deepen understanding of both fast and slow (or delayed) dynamics between actors and outcomes across the temporal scale.

4.8 Author Attribution

Genia Hill: (~85%) Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. Monika Zurek: (10%) Writing – review & editing, Supervision. Michael Obersteiner: (5%) Supervision.

4.9 Funding and Conflict of Interest

There are no conflicts of interest for the research in this chapter. Data were collected with scholarship funding for the first author from the Ramsay Centre (Australia) and fieldwork was conducted with the assistance of grants from Jesus College Oxford, the University of Oxford SoGE, the University of Oxford Environmental Change Institute, and the Royal Geographical Society.

5 Exploring Participatory Methods for Achieving More Just Processes in Food Systems Transformations

Linking Statement

While participatory approaches are widely advocated in food systems research, there remains insufficient examination of how specific methodological design choices shape whose knowledge is legitimised and which system perspectives are prioritised. This chapter contributes to the thesis by demonstrating that participatory and co-creative work is not methodologically neutral, but actively determines justice-relevant dimensions of inclusion, recognition, and influence within transformation processes. It further demonstrates the linkages between individuals and low-influence actors to FSTs and the utility of systems science approaches.

As **Chapter 4** establishes why actor perspectives and cross-scale, cross-level interactions are fundamental for justice and low-influence actor inclusion in transformation, **Chapter 5** turns to the practical question of how those perspectives can be meaningfully brought into the processes that shape FST agendas and the systems knowledge which underlies these agendas. Through a reflexive comparison of participatory workshop methods, alongside interviews, this chapter treats method choice as a consequential part of transformation itself. It shows that methods influence how problems are understood, defined, and bounded, as well as which trade-offs are surfaced, and which futures are visible and actionable. In doing so, **Chapter 5** provides the methodological bridge in the

thread of this thesis. It uses the PNG case study to operationalise inclusion as a fundamental and political choice rather than a normative add on. It provides the groundwork for the shift in **Chapter 6** from outcomes-focused systems understandings toward explaining systems not by how they exist, but why they exist as they do, through an investigation of drivers and feedbacks for shaping actor decision contexts.

Abstract

Food systems must be transformed to be more just, healthy, and sustainable (both economically and environmentally). Due to the enormous scope of change required, the FST literature to date has focused on coordination of actors and efficiency. While this is an important focal point for achieving change, in order for that change to be more just, it must also be inclusive of actors across all FST processes, particularly low-influence actors that may be otherwise left behind in efficient change processes. Recent calls have encouraged diverse stakeholder inclusion and participatory approaches, however, *how* to go about this for the purpose of facilitating FSTs remains relatively unexplored and there has been a lack of comparative evidence on participatory methods aimed at engaging low-influence actors. Using a justice-oriented participatory systems approach in a case study with PNG cocoa smallholder farmers across four communities, this paper investigates and compares a suite of participatory methods used to elicit system drivers, outcomes, and feedbacks. It goes on to explore each method and the implications of each for systems understandings and how participatory methods can shape transformation processes in data-poor contexts. Methods are reflexively compared for their transformative potential and their use in enabling more just processes around FSTs. Methods which relied less on research facilitators were found to be most useful in problem framing by shedding light on trade-offs, blind spots, or assumptions from top-down perspectives which were only

informed by interviews and/or literature. Further, this work explores how these methods contribute to or constrain justice-oriented transformation research, showing context-appropriate pathways for systems transformations.

5.1 Introduction

Sweeping changes are needed to improve the food system, which performs poorly across food system outcome areas: modern food systems fail to support a sufficiently healthy and well-nourished global population, they operate beyond several planetary boundaries, and they perpetuate cycles of poverty and inequity (Webb et al., 2020). Out of the necessity of addressing the large scope of food system challenges, FSTs have focused mainly on improving system outcomes and on efficiency at the cost of including diverse and low influence stakeholders in processes about how the food system should be transformed (Anggraeni et al., 2022, Leeuwis et al., 2021). This approach has been imperative to gain momentum and progress much needed system-wide shifts in order to improve food system analysis, intervention design, and change processes that will transform these systems, however, more robust inclusion is needed from actors throughout the system.

Calls are increasing to ensure that FSTs are more inclusive and more just (Allen, 2008, Allen, 2010, de Bruin et al., 2024), however, there is limited research on how to achieve this and limited empirical evidence providing cases for a more inclusive and just FSTs. Here we introduce the literature relevant to actor inclusion in FSTs, FST justice, and integrate this with a case of Papua New Guinean smallholder farmers that practice subsistence and cocoa cash cropping. PNG cocoa smallholder farmers provide a useful case study as they are landowners and key decision makers for local level agriculture and

land use practices, but they also have little influence over the structure and function of their food system at large. The PNG case study demonstrates how integrating the perspectives of low influence stakeholders into FST discourse can shed light on dynamics of the system that would not otherwise be explicit from top-down approaches (such as drivers of productivity, market participation, and environmental interactions). It can also contribute to a more robust understanding of systems and inclusive levers for change for processes that aim to transform the food system.

Ingram and Thornton (2022) posited that the transformation will not happen spontaneously, but rather, that outcomes will change when actors change their activities, and that actors will change their activities in response to drivers, which are changed by policy. Thus, in order to integrate FST priorities with justice at the fore, and to enable a more inclusive transformation, this paper takes an inclusive, actor-centric and justice-oriented participatory systems approach to change processes. These processes aim to support more just transformations that are a) seeking to achieve all food system outcomes for everyone, and b) inclusive of all system actors, including low-influence actors, in the discourse and processes aiming to transform the food system. Actors are any group of stakeholders that participate in food systems including human and non-human entities, such as animals, ecosystems, and institutions.

Food systems that do not result in food and nutrition security for everyone, environmental sustainability, and fair or sufficient economic and social outcomes for everyone involved in the food system, are not achieving outcomes in a just manner (Conti et al., 2025). Integrating justice and inclusion into all processes of FSTs can enable diverse actors to shape decisions, leading to more balanced and equitable system outcomes (Allen, 2008,

Allen, 2010, de Bruin et al., 2024). Although inclusion is increasingly called for in FST research, little comparative evidence shows how participatory methods can engage low-influence actors to improve system understandings and shape transformation processes. The literature on justice in the context of FSTs addresses distributive, procedural, recognition, social, and historical dimensions of justice. Importantly, this body of work is specifically concerned with transformational processes, rather than adjacent but distinct frameworks such as agroecology, food democracy, or food sovereignty (Allen, 2008, de Bruin et al., 2024, Whitfield et al., 2021).

Jacobi et al. (2022) suggest particular consideration of actors from vulnerable groups is needed from the start of all sustainable development projects, including those aiming to improve ecosystem, employment, and food security outcomes (Jacobi et al., 2022). An understanding of the interests and roles of actors in the food system must be developed in order to facilitate governance and management approaches that address the diversity of food systems outcomes and challenges in each outcome area (Giesbers et al., 2025, Huttunen et al., 2022, Leeuwis et al., 2021).

This work frames the case study actor group as “low-influence actors in the food system” recognising that they are critical decision makers at local levels, but have little influence over the structure and function of the regional and national food systems and their perspectives may not be considered (or are minimally considered) in the dominant policy agendas at sub-national, national, and global levels. In other works, these actors may be framed as “marginalised” or “low power” actors, as well described by Indigeneity, smallholdings, or peasant farming in unique contexts. For this work, these concepts will be integrated as appropriate for the PNG context in a manner that is both scale and level

sensitive: smallholder farmers in PNG are largely from their local area – the majority of the population could be considered “Indigenous”, both by ancestry and by their ongoing relationships to land, language, and custom[7], however, they do not have a high degree of influence over their food system structure and function. As such, the case study group will be described as smallholder farmers or low-influence actors in this work.

To date, considerations for the food system to mainstream justice within its’ processes are scarce, with little evidence on food security issues as a key component of sustainability transitions (El Bilali, 2019, Kaljonen et al., 2021) and with explicit calls for inequality and justice considerations for the FST (Hebinck et al., 2021a). This also requires reflexivity on the types of knowledge that are regarded in the FST, which must also be more inclusive, particularly of smallholders, Indigenous groups, and marginalised/low influence groups (Jacobi et al., 2022, Brock et al., 2024). Increasing participation and involving diverse stakeholders as co-producers of knowledge can enhance the relevance of research in its target area and reinforce capacities for innovation and adaptation (Brock et al., 2024). Further, engaging with diverse forms of knowledge and a wide range of knowledge holders leads to improved outcomes for the communities that sustain global food systems and steward the environment, whose knowledge has been historically overlooked (Brock et al., 2024).

This paper uses principles of co-creation and a justice-oriented participatory systems approach with Papua New Guinean cocoa smallholders to explore the implications of

[7] PNG’s Constitution and domestic laws do not contain a formal definition of "Indigenous" and rather consider “custom”, which “means the customs and usages of indigenous inhabitants of the country existing in relation to the matter in question at the time when and the place in relation to which the matter arises, regardless of whether or not the custom or usage has existed from time immemorial” GOVERNMENT OF PAPUA NEW GUINEA 1975. Constitution of the Independent State of Papua New Guinea. Port Moresby: Government of Papua New Guinea.

participatory research aimed at engaging low influence stakeholders in systems transformations and highlights the views of an actor group in change processes. The PNG case was selected as smallholders there have little influence over the broad suite of food system outcomes, but as the country is largely under customary land tenure, they make key decisions about land use, agricultural and food systems in their communities, and collectively, across the landscape (Hill et al., 2026). Using the PNG cocoa sector case study, and an entry point into systems change that focuses on inclusion and system actors, this research answers the RQs: "How do different methods for engagement lead to different system understandings and just transformation options?", "How can low influence food system actors be engaged in processes aiming to transform the system?", and "How can engagement with these low-influence actors contribute to achieving more 'just' FSTs?"

5.2 Methods

5.2.1 Rationale

An increasingly prominent avenue for encouraging inclusive approaches which aim to engage low-influence actors and enable more just FSTs is participatory and co-creation methods. Co-creation of knowledge, whereby stakeholders are a key part of knowledge creation processes, can be effective for engaging stakeholders with contrasting power dynamics. Co-creation, inclusive processes, and collective action, if set up carefully and in a power-sensitive manner can also harness the power of diverse perspectives and help to identify innovative solutions that would otherwise not be identified by individuals or top-down processes, which is particularly important for sustainability sciences aimed at transformation (Massari et al., 2023, Van Der Gaast et al., 2023, Jacobi et al., 2022). Best

practice in co-creation also stresses the importance of amplifying the perspectives of the lowest-power stakeholders (Charatsari et al., 2022, Schuck-Zöller et al., 2017). These strategies have resulted in improved diffusion of agricultural knowledge through communities (Charatsari et al., 2022) and improved climate resilience (Chandra et al., 2017).

While inclusivity which employs co-creation approaches is practically beneficial, it also provides epistemological value. Across disciplines, diverse stakeholder inclusion, particularly of actors who may otherwise be overlooked, adds to the plurality of knowledge, contributing to insights that would not otherwise be apparent from top-down approaches (Walker and Boni, 2020). In the PNG case, this is particularly true for bringing Local (or otherwise considered "Indigenous") knowledges into the systems context. Further, in sustainability research, the research process itself can contribute to epistemic injustices, where the plurality of knowledge is marginalised or discredited (Walker and Boni, 2020, Woroniecki et al., 2020), and so robust inclusive co-creation processes are needed to address knowledge plurality. Further, inclusive and participatory approaches enable more scope for researcher reflexivity (Phillips et al., 2013).

The evaluation of methods in this chapter was developed reflexively and abductively, rather than through a fully pre-specified evaluation framework. The research design was theoretically informed before fieldwork by literature on food systems, drivers, outcomes, feedbacks, food environments, typologies, scale and level, justice, participatory research, and co-creation of knowledge, which shaped the selection of interviews and participatory systems methods. However, the comparative assessment of these methods was developed iteratively through the fieldwork and analysis process. This included observing how

participants responded to different activities, comparing the kinds of system elements and relationships generated by each method, reflecting on the degree of researcher facilitation required, and assessing how each method enabled participants to shape problem framing, system boundaries, trade-offs, and possible transformation pathways. The methodological comparison presented here should therefore be read as a situated and reflexive evaluation, shaped by participant outputs and responses but also by the researcher's role in designing, facilitating, analysing, and representing the methods.

5.2.2 Case Study and Site Selection

Data were collected and validated in 2023-25 from 160 smallholder farmers (some who also owned a cocoa fermentary) across four communities in PNG (n = 40 farmers per community), which were selected to capture variations in remoteness, population density, and subsistence or commercial orientation, as shown in **Figure 5.1.** For the data collection process, the lead researcher stayed in each community, hosted by a local research contact. The community attributes are briefly described in **Table 5.1**, originally from Hill et al. (2025).

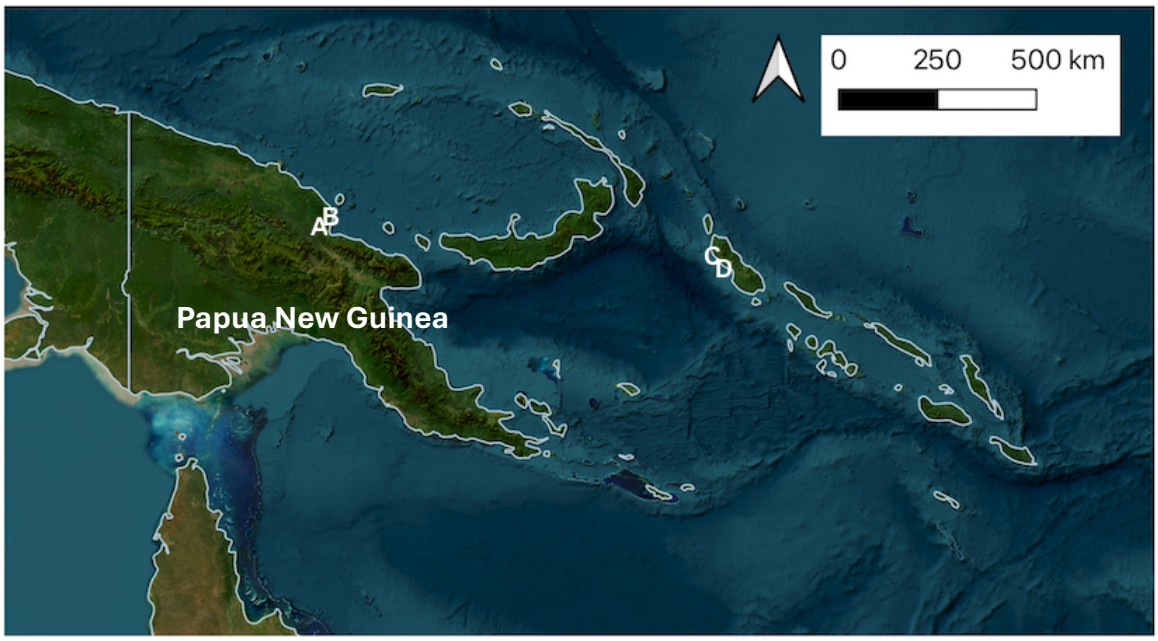


Figure 5.1 Data collection sites in four communities.
A. Ohu, Madang Province; B. Rempi, Madang Province; C. Tomasi-Makakoa, Bougainville Province, D. Ubuko-Siato, Bougainville Province and their relative position in PNG (Natural Earth, 2023, Planet Labs, 2023, QGIS Development Team, 2024).

Table 5.1 Community descriptions.

Community	**Prevalence of "shop food"**	**Prevalence of formal trade shops**	**Two-way market access/remoteness**	**Community investment/ presence**
Ohu, Madang Province	High prevalence.	Low prevalence. Numerous irregular informal 'pop up' trade shops.	~ 45 minutes to Madang Town by privately run bus (two – three busses ran daily), dirt road.	No known market development project presence.
Rempi, Madang Province	Moderate prevalence.	High prevalence.	~ 30 minutes to Madang Town by privately run bus or Land Cruiser (many vehicles ran daily), paved highway.	Presence of market development projects from FAO and ACIAR.
Tomasi-Makakoa, Bougainville Province	Low prevalence.	Low prevalence.	Eroded dirt road. ~ 3 – 5 hours to Buka Town by four to five privately run 'ten seaters' (Land Cruisers retrofitted with bench seats).	Presence of market development projects from ACIAR.

Community	Prevalence of "shop food"	Prevalence of formal trade shops	Two-way market access/remoteness	Community investment/ presence
Ubuko-Siato, Bougainville Province	Low prevalence.	Low prevalence.	Eroded dirt road. ~ 6 – 7 hours to Buka Town by one or two privately run 'ten seaters' (Land Cruisers retrofitted with bench seats) or by a combination of walking to a 'banana boat' pickup point. The boat takes several hours.	No market development project presence.

5.2.3 Sampling and Participants

Within communities, due to the often physically difficult nature of reaching potential research subjects through cocoa blocks and jungle and given the hamlet structure of settlements dotted across the landscape without roads, selected snowball sampling was employed in conjunction with spatially-representative sampling. This ensured access to a diversity of stakeholders to mitigate incomplete knowledge; for example, in each community, a range of households were selected to include fermentary owners and subsistence-oriented farmers. To mitigate the non-random nature of this sampling strategy, equal representation from all geographical segments of the community were reached with guidance from a local field assistant. Snowball sampling was based on a set of inclusion-exclusion criteria, ensuring participants were over the age of 18 and were either currently or previously growing cocoa.

5.2.4 Data Collection

Data collection followed the process detailed in **Figure 5.2**, which is described in the following section. Note, in each community, a participant feedback mechanism was availed to participants in the form of an anonymous "suggestion box" to give feedback to

the research facilitator. Despite its availability, feedback in this manner was not provided from participants.

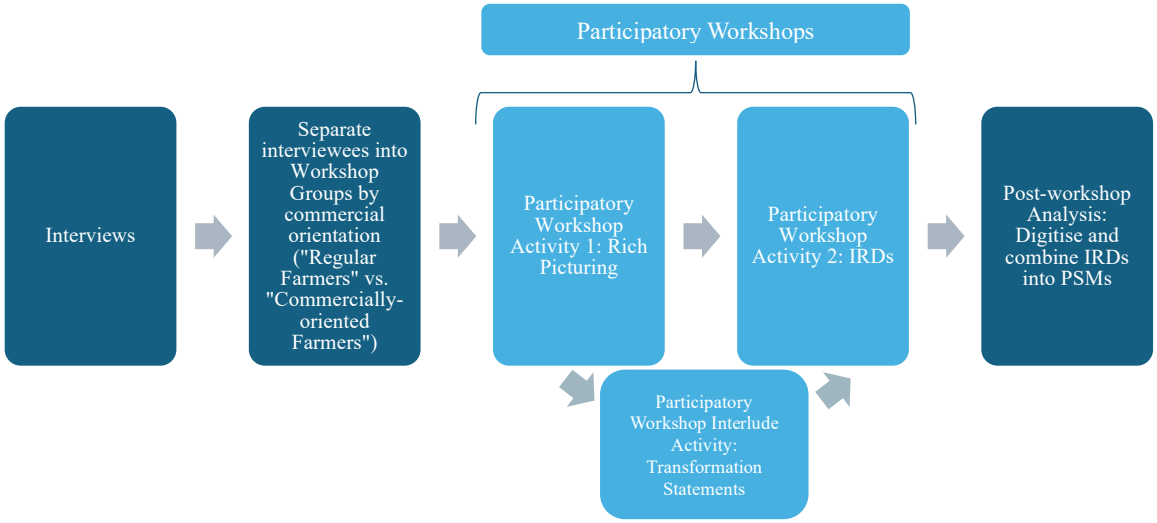


Figure 5.2 Visual representation of method process for data collection and processing.

The use of various methods and their comparison is not intended to evaluate all possible participatory methods for FSTs, but to examine how a deliberately selected suite of methods shaped the inclusion of low-influence actors and the kinds of systems knowledge produced. The methods were chosen because they moved progressively from relatively researcher-led elicitation to more participant-led and collectively structured forms of knowledge creation. Interviews allowed for individual accounts of food system understandings; Rich Pictures enabled participants to represent system relationships visually and discursively; Transformation Statements surfaced desired futures and locally meaningful change priorities; and IRDs/PSMs formalised perceived causal relationships and trade-offs.

5.2.4.1 Interviews

After familiarisation with each community and its Clan Chiefs, the researcher team then conducted 40 interviews with smallholder farmers, which were roughly one hour each.

Interviews were guided by a questionnaire and conducted with the assistance of a local translator using a mix of English, Tok Pisin, and supplemented with the relevant local language when needed (PNG has over 800 local languages, so these varied for each community). Interview topics were organised by food system outcomes. Basic demographic information was collected followed by information about farmers and their perceived income and cash cropping activities, food production and consumption activities, and environmental/place activities as well as changes and challenges across these areas. All interviews were recorded and manually transcribed by the researcher using a gisted approach according to Paulus et al. (2014).

5.2.4.2 Co-Creation Workshops

After interviews were completed (n = 160 farmers, 22 of which also owned fermentaries), participants were separated into groups based on how commercially-oriented their cash cropping practices were, and they were invited to attend half day workshops in these groups. If smallholder farmers had invested significantly into their cash crops, usually by purchasing materials for and building/operating a cocoa fermentary, they were put into one workshop group (usually four – six individuals, designated as "fermentary owners"), whereas the other groups, designated as "regular farmers" were assembled according to their schedules and availability. Workshops consisted of several activities using co-creation and systems methods, including Rich Picturing and creation of IRDs (see **Figure 5.2**). These methods were initially scoped from Barbrook-Johnson and Penn (2022) which was motivated by the need for participatory methods that gleaned a systems view and were also culturally appropriate in the PNG context with participants across a range of formal educational backgrounds and literacy training. This would allow for principles of co-creation to be used, where the researcher acted as a facilitator and listener, and

workshop participants shared their knowledge and perspectives. Exact methods of Rich Picturing and creation of PSMs (by means of IRDs as described by De Pinho (2017)) were selected because they could be used in the remote context of PNG where only analogue methods were available. Methods that were largely pictorially-based or aural were selected for inclusivity and cultural appropriateness.

Workshop groups ranged from three to ten participants (the average group size was six participants, with 127 participants attending workshops). Participants had previously been interviewed about their perspectives on activities and outcomes in their food systems. Workshops were set up as follows: after culturally appropriate rapport building activities (introductions, conversations (‘*tok stori*’), and participant coffee drinking), workshop groups were divided in half and created Rich Pictures and transformation statements in small groups, iteratively sharing with the rest of the workshop attendees, then as a whole workshop group, participants would collectively create an IRD. After each workshop, participants were compensated for their time the equivalent standard rate of one full day of labour in a cocoa block. Much of the workshop data collection drew upon methods detailed in a guide by De Pinho (2017) and IRD analysis was done with reference to Barbrook-Johnson and Penn (2022) and their chapter on PSMs.

5.2.4.2.1 Rich Pictures

As a priming activity, workshop participants were asked to draw in groups with blue and green pen ‘everything that matters for their diet’, ‘everything that matters for their income’, and ‘everything that matters for their environment and their place’, and to draw arrows to represent connections between elements in their drawing. This prompt aimed to capture participant views of their food system with a focus on food system outcomes

areas and what drives these. When these systems drawings were complete, each group would present to the other group and the research team, explaining their Rich Pictures. The groups would then be asked to go back over their drawing with red pens, and write or draw in problems and challenges they experience everywhere in the system. Groups would subsequently present their additions to other attendees. Rich Pictures were particularly useful in ensuring a platform where there were language or literacy barriers. Two example Rich Pictures are shown in **Figure 5.3** (37 total Rich Pictures were generated through workshops). See **Appendix F** for sample RPs.

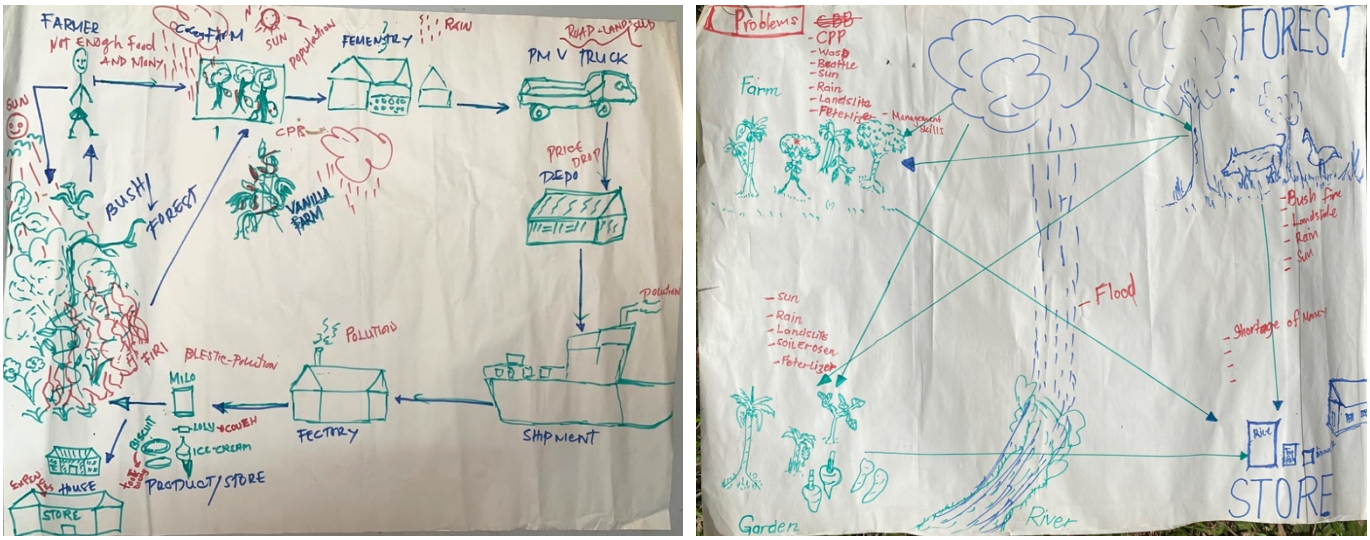


Figure 5.3 Rich Picture examples from workshops.

5.2.4.2.2 Participatory Systems Maps

After group presentations, 10 – 14 of the most important elements from all the Rich Pictures were decided between the research team and workshop participants. These elements were then placed in a circle on a whiteboard, and the group would systematically discuss each element one-by-one to assess whether each element impacted the other elements, and in which direction, which resulted in the creation of an IRD (20 total IRDs were created in workshops; see **Appendix H** for sample IRDs). Bidirectional arrows were discouraged according to De Pinho (2017), although where the group disagreed about

which arrow direction was stronger between factors, this was allowed and designated with a dashed line. By way of example, where one element is “amount of cocoa produced” and another is “amount of farmer income”, focus groups would discuss “if amount of cocoa production went up in your community, would the amount of farmer income in your community go up, go down, or stay the same?”. This was systematically assessed by focus groups one-by-one for each element in the diagram.

IRDs were subsequently digitised into a matrix and converted into Cause-Effect-Strength tables where strength was the total number of workshop groups that indicated a relationship between factors. Strength was captured as the sum of groups that characterised a relationship, however, if a certain relationship was characterised by disagreement, where some groups would characterise a positive cause-effect relationship and other groups would characterise a negative cause-effect relationship, this was

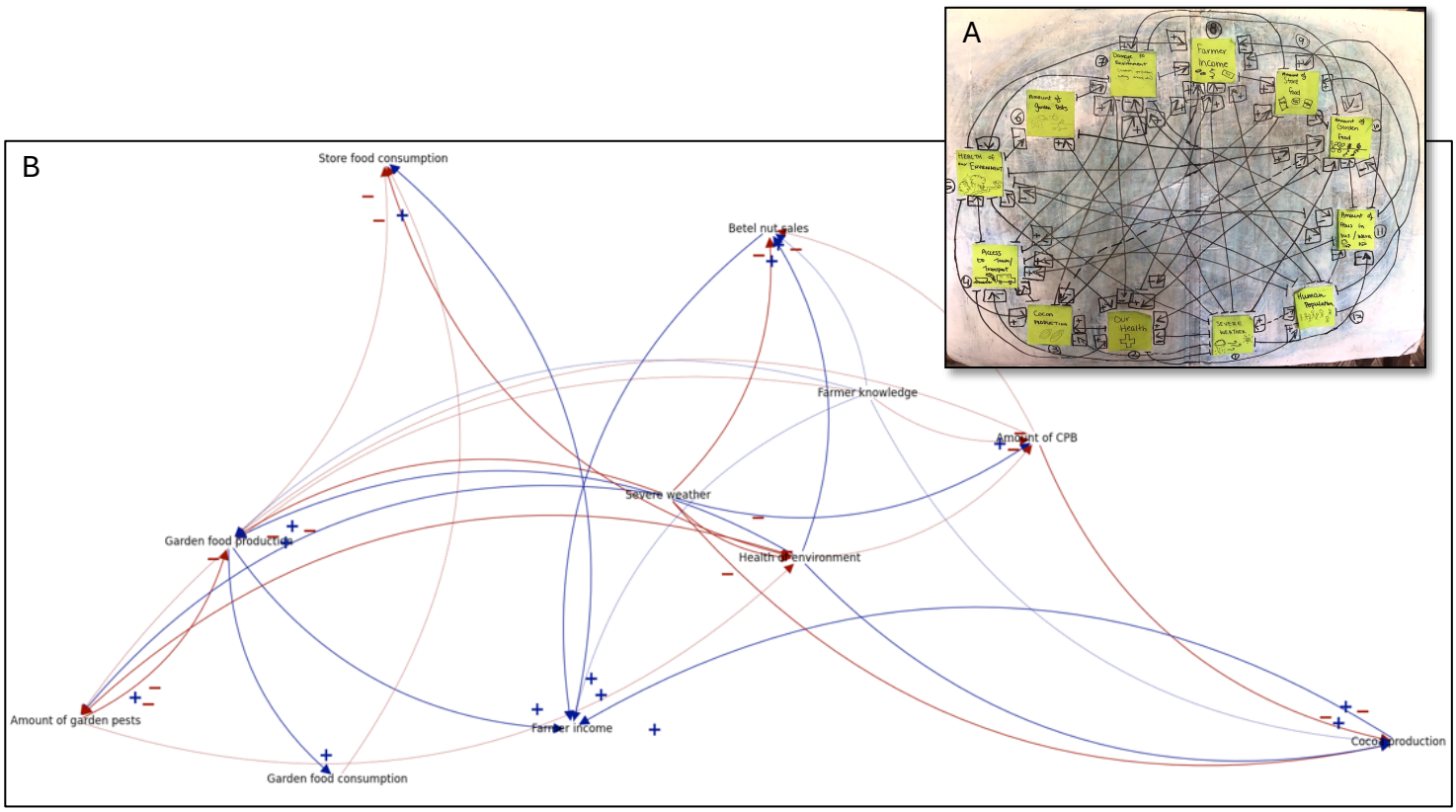


Figure 5.4A and 5.4B IRDs and PSMs.
4A. IRDs were created with workshop groups then digitised and grouped together to create PSMs (Such as in 4B, which were grouped my community and by commercial orientation. Shown here is the PSM of all farmer groups from Ohu.

highlighted to be further discussed in the results section of this work. Cause-Effect-Strength tables were then input to create PSMs using Python with libraries Pandas, NetworkX, Matplotlib, and NumPy (Hagberg et al., 2008, McKinney, 2010, Hunter, 2007, Harris et al., 2020). Cause-Effect-Strength tables and their resulting PSMs were grouped in several ways: 1. All fermentary owner groups (n = 4 groups) and all non-fermentary owner groups (n = 16 groups), and 2. By region (n = 5 groups per region). An example IRD and the PSM it contributed to are shown in **Figure 5.4**. PSMs were analysed using a network analysis approach, where measures of centrality were calculated using the NetworkX library (Hagberg et al., 2008)(See **Appendix I** for sample PSMs). PSMs were used in favour of causal loop diagrams (CLDs) or other participatory mapping techniques because PSMs are more directly representative of participant views. While CLDs are highly useful in uncovering the feedbacks and dynamics of complex systems, the development of CLDs usually involves an additional step of interpretation in which participant contributions are translated into causal structures with reinforcing or balancing feedback loops. This process can create more researcher influence over how relationships are represented. For this research, minimising this interpretive step and preserving participants' views as directly as possible was considered a higher priority than developing a more formal representation of system dynamics required for other participatory-based methods.

5.2.4.2.3 Transformation Statements

As an interlude between Rich Pictures and creation of the PSMs, participants were asked (in their same groups) to highlight one of the problems/difficulties (challenges) in their Rich Picture that they would like to see addressed in their community. This included the following (1) What problem/difficulty would you like to reduce?, (2) What is something

you would like to do to reduce this problem/difficulty?, (3) By what time would you like to complete this project?, (4) What goal do you have in this project?, and (5) What is the overarching goal that you'd like this project to achieve? See **Appendix G** for sample Transformation Statements.

5.3 Results

Results aim to capture smallholder farmer views of their food systems, including system drivers, activities, and outcomes; these are presented according to the methods in which data were collected, then reflexively compared and analysed in the Discussion.

Rich Pictures created during workshops demonstrated key elements of the system as well as key challenges. Elements repeated throughout the pictures included the surrounding environment, food sources, and socio-economic or human-related factors as detailed in **Table 5.2**. Challenge themes also arose across the pictures, primarily relating to weather, pests and plant disease, environmental factors, insufficient income or bank access, insufficient food supply, and insufficient access to cash cropping resources (knowledge, tools, fertiliser). Rich Pictures were highly effective at engaging research participants and in soliciting direct engagement from nearly every workshop attendee. The Rich Picture results acted as seed elements for PSMs.

Table 5.2 Rich Picture depictions summary.

Thematic Area	**Figure Featuring in Rich Pictures**
Surrounding Environment	Bush, forest, trees, rivers, animals, gardens, housing, roads
Food Sources	Store food, garden food (taro, sweet potato, yams), animals, fish
Socio-economic or Human-related Elements	Money, people, health
Weather	Flooding, too much sun, rain-induced landslides

Pests and Plant Disease	Cocoa pod borer, insects, yellow leaves
Environmental/space Factors	Insufficient land availability, too much tree cutting, pollution, overpopulation, bush fires (deliberately lit)
Other: Insufficient income or bank access, insufficient food supply, insufficient access to cash cropping resources (knowledge, tools, fertilisers).	

PSMs were used to assess the dynamics of the food system as understood by smallholder farmers and were separated to show causal relationships as perceived across each community and re-grouped according to each group's commerciality (whether they were "regular farmers" or had invested in commercialising their cocoa through establishing a cocoa fermentary, designated as "fermentary owners"). Overall, groups identified 26 key elements of their food system, detailed in **Table 5.3**, which became nodes in the PSMs; the relationships connecting nodes to one another are designated as edges. All groups identified several common challenges in their food system including severe weather, indicators of the healthiness or damage to their local environment, cash cropping (either in general or separated into betel nut and cocoa production), farmer income, garden food production and/or consumption, and store food consumption. Different groupings attributed varying importance of each element. Note that some elements were coded together in the analysis of PSMs by group, such as "garden food production", "garden food consumption" and "garden food production and consumption". While some groups wanted these as stand-alone elements, other groups combined them as they were considered sufficiently synonymous or directly linked and functionally the same. These factors were coded with consideration of double counting and ensuring that coding factors together did not conceal any key causal relationships or trade-offs. Biophysical and health related drivers came through strongly in this method. While all participants took part in the discussions, one or two participants tended to lead each discussion in generating IRDs.

Table 5.3 Elements identified by workshop participants.
Repeating elements that 15 or more groups used in their IRDs are bolded.

Food System Elements	
• Amount of garden pests	• Our health
• Food supply	• Access to transport
• **Health of environment**	• Disease/pests
• Amount of CPB	• Cash crop production
• Garden food production	• Local market processing
• Garden food consumption	• Price of store goods
• **Store food consumption**	• Cash crop price
• **Severe weather**	• Population (no. of people)
• Cocoa production	• Amount of animals in the bush/river
• **Farmer income**	• Damage to environment
• Betel nut sales	• Garden food production and consumption (synonymous)
• Community cocoa fermenting	
• Available land	• Cocoa quality
• Farmer knowledge	

Assessing the variation in nodes and relationships for each map demonstrated several key differences both across communities and commercial orientations (Rodrigues, 2018). Out-degree centrality in each map was used as the best indicator of system drivers. Degree centrality is an indexed count of the number of connections that a node has to other notes; out-degree specifically refers to the number of outgoing connections from a node (Macau, 2018, Brass and Borgatti, 2020 pp. 11). We interpret these as food system drivers given that nodes and edges were evaluated by participants as causal mechanisms, so nodes that have the most causal factors (edges) towards other nodes (or system elements) are system drivers; this was adapted from De Pinho (2017) who indicated that drivers were the elements with the most edges originated. Out-degree centrality systematically identified the three strongest perceived system drivers for each community group, which are detailed in **Table 5.4**. Out-degree centrality where the same smallholder farmers were re-grouped based on their commercial orientation is shown in **Table 5.5**. A comparison of

these shows that farmers categorised by commerciality rather than community context perceived the strongest three drivers of their food system as “severe weather”, “our health”, and “health of environment.” There was greater variation in driver assessment based on the community context rather than commercial orientation. Three quarters of communities identified “severe weather” and “health of environment” as key drivers, however, there were variations in the perceived importance of “farmer knowledge”, “farmer income”, “our health”, and “garden food production and consumption”. This suggests that while regular farmers and fermentary owners do not have substantial variation in their perceptions of what drives a system, communities tend to have more variation in their perceived system drivers. Thus, the broader community surroundings more consistently shaped driver perception rather than commercial orientation, which was an inconsistent indicator of system drivers.

Table 5.4 The strongest three drivers of system structure and function as perceived by smallholder cocoa farmers across each community.
The contrast with Table 5.5 indicates community context is a more important driving force on food systems outcomes, rather than commercial orientation.

Community	Node
Ohu (↑shop food/↓remote → ↓shop food/↑remote)	Severe weather
	Farmer knowledge
	Health of environment
Rempi	Our health
	Farmer income
	Farmer knowledge
Tomasi-Makakoa	Severe weather
	Health of environment
	Our health
Ubuko-Siato	Severe weather
	Health of environment
	Garden food production and consumption

Table 5.5 The strongest three drivers of system structure and function as perceived by smallholder cocoa farmers across different commercial orientations.

Farmer Type	Node
Fermentary Owners	Severe weather
	Our health
	Health of environment
Regular Farmers	Severe weather
	Our health
	Health of environment

Beyond direct driver analysis, several comparisons can be made across the PSMs overall. In looking across community systems to draw comparisons, the more remote communities (Tomasi-Makakoa and Ubuko-Siato) reported more and stronger relationships than more geographically connected communities (Ohu and Rempi), suggesting they view their food systems as more interconnected, whereas communities closer to towns showed fewer strong connections between nodes of their food system overall.

Given the method of map creation, it is important to highlight the most contentious relationships, which were assigned by some groups with positive polarity and other groups as negative polarity, and which could potentially result in a null (or low strength of cause-effect relationship). These are detailed in **Table 5.6**.

Table 5.6 The most contentious relationships across all groups.
These are detailed for relationships that had less than 75% consensus for their answers

Relationship	Variance	Explanation
Store Food Consumption ↔ Our Health	Positive: 3 Negative: 8 Disagreement within group: 5	The impact of store food on human health was by far the most contentious relationship across all causal relationships discussed. While some groups thought it was generally good to have increased food supply, there was also a widespread perception that too much shop food (white rice, oil, tinned fish, and tinned meat) can be detrimental to health. Despite this, it is still often preferred because it is easier to cook and because many people (particularly children) prefer the taste.
Severe Weather ↔ Store Food Consumption	Positive: 2 Negative: 4 Disagreement within group: 0	Groups disagreed on whether severe weather caused store food consumption to go up or down, and there was no distinct pattern as to which groups (by geography or commercial orientation) considered a relationship in either direction. Store food consumption is a result of numerous factors (access to town to get the store, access to cash, as well as preference, and if you have children that prefer it), which may explain why there was no distinct pattern in this relationship.
Population ↔ Store Food Consumption	Positive: 4 Negative: 3 Disagreement within group: 0	The impacts of population growth were difficult to discuss, in large part because of interpretation of causal factors and perceptions of group factors vs. individual factors. For example, consider the manner in which the causal question was asked for population factors: "as population goes up in the community, does farmer income go up, go down, or stay the same in the community?" While some groups interpreted this as overall income for the community, others interpreted this as income for the community on an individual basis. This is a potential flaw in the research design which was not clear until after data were collected. These were left in because it is important to raise the point that "population" was not considered a key factor in the more connected communities, but it was a concern/factor that 9/10 groups in the two communities that were more remote contexts.
Population ↔ Cocoa Production	Positive: 3 Negative: 3 Disagreement within group: 1	
Population ↔ Farmer Income	Positive: 2 Negative: 5 Disagreement within group: 0	

Relationship	Variance	Explanation
Health of Environment ↔ Disease/Pests	Positive: 3 Negative: 2 Disagreement within group: 0	Some groups thought that in a healthy environment there were more insects or pests around while others thought there were fewer. There was no trend in perceived correlation between Health of Environment and its impact on Disease/Pests across community or farmer orientation.

Transformation Statements were analysed for themes as shown in **Table 5.7**. Income generation was the most prominent challenge addressed, followed by dual income/diet interventions (ex. improving garden food productivity, which can be used for sale and/or consumption), conservation of bush land, and lastly, improvements directed at diet, clean water access, and peace (regarding land disputes).

Table 5.7 Themes arising from transformation statement activity.

Theme	Regular Farmers	Fermentary Owners	Total
Income	11/27	5/7	16/34
Diet	1/27	0/7	1/34
Income and Diet Combined	7/27	1/7	8/34
Conservation	4/27	0/7	4/34
Other	2 (water)/27 1 (peace)/27	1 (connectivity)/7	3/34
Total	27	7	34

5.4 Discussion

This research highlights the views of the heterogeneous actor group, “smallholder cocoa farmers” in PNG to understand the problem context in the PNG smallholding cocoa sector and the importance of low-influence actor perspectives for higher level systems change (and more just processes aimed at this change). It shows how this understanding can lead to more just and participant-driven processes aiming to transform the system and identify effective and inclusive/justice-orientated intervention points. The results revealed key

findings from across four communities, for example, participants identified ecological and health-related drivers as most influential for overall food system functioning. This revealed an emphasis on environmental and wellbeing outcomes over purely economic outcomes from participant perspectives.

The suite of methods led to unique focal points of the system, as detailed in **Table 5.8**. Beyond the information that were shown from each type of data collection method, these methods each lead to different systems understandings, detailed in **Table 5.9**. While interviews are not inherently methodologically oriented towards transformation, they enable a vital baseline of information and provide a contrast to the more novel co-creative workshop methods explored in this work. These system understandings were analysed using the food systems definitions of outcomes, drivers, and feedbacks from Hasnain and Hill (2025).

Table 5.8 Methods and which unique elements/factors they revealed.

Interviews	**Transformation Statements**	**RPs**	**PSMs**
Demonstrated underlying factors which did not come through later in workshop methods. Also showed where there was limited knowledge of factors underlying challenges and dynamics (allowed for "I don't know" instead of blanks/absence of information).	Demonstrated opportunities for community-led innovation (often low cost and implementable) across outcome categories from food systems. Allowed for identification of desirable community-led interventions.	Showed perceived key elements and the interactions between system elements with each other (and occasionally between actors and elements). Highlighted key challenge areas.	Highlighted causal relationships between key elements and challenged previous statements or assumed knowledge from interviews.

Table 5.9 Different stakeholder consultation methods lead to different understandings of the food system.

Interviews	**Transformation Statements**	**RPs**	**PSMs**
Showed the intricacy of systems as SESs, although not inherently a systems approach. Focus on **actors** and **outcomes**, also shedding light on **drivers** but demonstrating where understanding of external drivers was limited. Limited capture of perceived trade-offs and no co-creation component.	Looked broadly across system activities to focus on system **activities** and **outcomes**. Focus on system activities.	Often aligned with value chain interactions and system networks. Focuses on **activities** and **outcomes**. In most cases drew a narrow system boundary. Rarely focused on human actors or institutions (systems were often drawn without people or only the research participant).	Led to rich discussion on drivers/causal factors and interactions as well as highlighting points of disagreement in a given context. Highlighted trade-offs and levers for change, as well as which elements were the **drivers** of the system and which were the main **outcomes** of the system as perceived by participants.

Each of the methods employed were useful for bringing in low-influence actors into the discussion around the FST and its processes. The methods gave unique insights to the food system, its structure, dynamics, and system processes. They also offered unique foci, which could be used fit for purpose. For example, if a transformation initiative at the policy level aimed to change system outcomes, using target stakeholder interviews in conjunction with PSMs prior to implementation would shed light on system drivers, which could contribute to the identification of effective leverage points for policy intervention. Likewise, for implementing initiatives seeking to impact activities in the community using community-led interventions, Transformation Statements would be a useful method of consultation. In terms of transformational potential, interviews, which are a long-tested method, can be extractive and limit meaningful stakeholder participation in contrast to participatory methods, which participants often indicated were both

interesting and educational, despite those same participants being the ones that generated knowledge in workshops. Transformation Statements, Rich Pictures, and PSMs encouraged agency of ideas, ownership of future options, and participant-led problem understanding. Rich Pictures and PSMs were particularly useful for their transformative potential given their ability to explicitly identify drivers, leverage points, and feedback loops in a stakeholder-driven manner. These were not only useful for potential to contribute to transformation itself, but also for integrating different participant or stakeholder group perspectives into transformational processes, such as consultations directed at policy revision. Note that despite actor types being an important consideration for the data elicitation process in this work, no method resulted in a focus specifically on system actors and their dynamics within the system.

The comparative efficacy of each method can be evaluated in terms of process effectiveness, output effectiveness, and epistemic effectiveness, detailed in **Table 5.10**. These dimensions of effectiveness were used because they address participation and stakeholder inclusion as a process, a practice towards transformation implementation, and a politics; they capture elements such as participant representativeness, process transparency, and links to decision making (Rowe and Frewer, 2000). The table shows that one of the most effective factors of the participatory methods used was encouraging discussion between participants. These discussions were often where some of the richest points arose; these were also beneficial for reducing active influence from researchers in discussions. Methods with low facilitator input, such as Rich Pictures, scored highest in epistemic and process effectiveness, while PSMs scored highly for driving participant-led discussions that generated qualitative and quantitative data.

Process effectiveness captures how the method was conducted (ex. did it enable equitable participation, did it support deliberation/discussion, were stakeholders meaningfully involved)(Chilvers, 2009). Output effectiveness evaluates the extent to which participatory research leads to immediate substantive products, such as policy recommendations, which arise from participatory work and later lead to outcomes (Burgess and Chilvers, 2006). Those outcomes in term are evaluated for outcome (or transformative) effectiveness of longer-term, impacts of outputs, such as behavioural change, changes to resource flows, or the accumulation of social capital (Burgess and Chilvers, 2006), however, for output effectiveness, this can only be evaluated for each method provided it is used with a longitudinal research design and targeted workshop design that solicits data on outcomes (outside the scope of this work). Drawing on principles of epistemic justice, epistemic effectiveness evaluates how each method contributes to and builds capacity for new or diverse types of knowledge being brought in to problem or system understandings (Temper and Del Bene, 2016).

Table 5.10 Evaluation of efficacy of different participatory methods used in participatory workshops and interviews.

	Interviews	**Transformation Statements**	**RPs**	**PSMs**
Process Effectiveness	**Medium/High:** While all participants were given space to individually engage in interviews and gave individual participants a platform for their own unique perspective, this method also had the most active role for the researcher, leading to potential biases both epistemologically and due to positionality.	**Low/Medium:** This method relied more on written rather than oral or pictural engagement, so was less ideal for the PNG setting, where at least one participant in each group needed to have confident writing skills as well as the confidence to suggest projects with transformative potential. Despite this, the tool provoked rich discussion between participants about changes they would like to see in their communities.	**High:** This method elicited a high level of engagement from all participants with minimal input from researchers/ facilitators. Picture creation led to robust discussion between participants while drawing, as well as afterwards, when each group explained their pictures to other workshop attendees.	**Low/Medium:** As this method was implemented in groups, each group tended to have one or two participants that dominated the conversation; it was challenging to ensure that all participants were able to contribute. Despite this, the conversation that occurred between participants was rich in demonstrating how causal dynamics are perceived within a community and between individual stakeholders.
Output Effectiveness	**Medium/High:** Can provide data from all individuals consulted which leads to immediate, substantive outputs, although these are limited in how participatory they are in nature.	**Medium:** Can provide data from workshop participants that lead to immediate substantive outputs, although somewhat limited in how participatory those data are due to factors of process effectiveness.	**Medium/High:** The pictures themselves provide rich outputs, but these were often messy and difficult to analyse *per se*. However, with an aural explanation from participants, outputs gave rich information for analysis of pictures as well as providing inputs for determining key elements of PSMs.	**High:** This method produced outputs which enabled both qualitative and quantitative analysis. This richness provides wide support to aid in the creation of substantive research findings that highlight stakeholder perspectives.

	Interviews	Transformation Statements	RPs	PSMs
Epistemic Effectiveness	**Low/Medium:** While knowledge was created that included the perspective of all participants, this was done explicitly and directly through the lens of questions asked by the interviewer (and hence, include epistemological biases).	**Low/Medium:** Directly provided knowledge about priorities of knowledge holders without direct facilitator input.	**High:** This method brought in different knowledges in a manner that was highly effective for centring participants in the problem understanding.	**High:** Highly valuable for bringing in new and different types of knowledge in a systematic, rigorous manner, marrying up scientific and local/ traditional knowledges.
Benefits	Enables a platform even for the quietest participants and those least likely to engage. Tried and tested method used across different research types.	Gave direct insights into how participants want to see direct and transformative change. Shed light on what kinds of initiatives would be viewed as "transformative" from participant perspectives.	Highly inclusionary with very high levels of interest and engagement from nearly all workshop participants.	Participants often said they learned a lot from creating these maps and thinking about the interconnected nature and trade-offs in their community. Data created were rigorous and able to be quantitively analysed.
Challenges/ Limitations	Difficult to provide sufficient space for the interviewee to drive the narrative of knowledge creation and reduce the prominence of the interviewer role.	Process was somewhat difficult to explain to participants. The dynamics of knowledge generation were such that often one or two participants would take charge of the statements and engagement from other attendees was light. While change processes were prioritised, this provoked very little discussion on trade-offs or downsides of initiatives.	Difficult or messy to analyse pictures alone – greatly benefits from aural explanation of pictures.	Often dominated by one or two participants with the loudest voice in the discussion. The process was somewhat tedious for participants going through every element one-by-one was repetitive

In addition to contributing to identification of useful interventions or policy change, there is epistemological value in integrating diverse knowledges for system understanding, particularly through workshop methods used here. Given the epistemological limitations that no single actor (or actor group) can know the whole system, bringing in diverse or overlooked actor's ways of knowing elicits a more holistic, more complete view of the system and its dynamics, additionally contributing to epistemic justice (Temper and Del Bene, 2016). The literature on justice, specifically for the FST, addresses distributive, procedural, recognition, social and historical dimensions of justice (note, this is specifically aimed at transformation of food systems and not the related concepts of agroecology, food democracy, and food sovereignty, etc.)(Allen, 2008, de Bruin et al., 2024, Whitfield et al., 2021). Drawing on this literature and its approaches to justice, through our highlighted case, we posit that inclusion of low-influence actors is an imperative first step in addressing these dimensions of justice.

Further, it is vital to integrate inclusion through diverse dimensions of justice within the various processes (ranging from discourse to decision making and beyond) into transformational processes. The work demonstrated that including low-influence actors in processes directed at the FST is an important first step in enabling meaningful participation in how food systems change will occur and which stakeholders contribute to the transformation agenda and subsequent change processes. For example, the results demonstrated that useful levers for change in Ohu and Rempi, identified by a stakeholder-led assessment of systemic drivers, may be directed towards farmer knowledge; in contrast, levers for change in Tomasi-Makakoa and Ubuko-Siato may be directed towards building adaptation to severe weather. Additionally, inclusivity, particularly of actor groups that may otherwise be excluded, increases the epistemic justice by acknowledging,

valuing, and integrating plurality of knowledges and ways of knowing. This arose in workshop methods, for example, in the PSM creation process. A more complete understanding of the system elements and trade-offs became clear, and additional factors such as the important role of geographical context rather than commercial orientation emerged. The PSM method also enabled participants to play a more direct role in data analysis further supporting the stakeholder role and it's epistemic contribution.

In addition to the contribution of co-created knowledge to more inclusive and just systems transformations, bringing a multitude of perspectives into FST processes showed expansion of the problem frame, shedding light on trade-offs, blind spots, or assumptions from top-down perspectives only informed by literature or solely by interviews. This allowed for a more robust exploration and analysis from the systems perspective. For example, in interviews, respondents rarely mentioned the use of inputs in their cocoa farming, however, in subsequent discussions around trade-offs during the PSMs, participants would often bring up how increased income can help increase cocoa yields through increased ability to purchase inputs.

The other key insight from using this suite of methods is the role the researcher plays in generation of knowledge and the biases that may be present across methods. Participatory Action Research (PAR) has an acknowledged Global North bias; when PAR is directed at change processes, there is particular need to pay more attention to 'risk' (including which actors are exposed to risk)(Lake and Wendland 2018). The workshop methods allowed for the researchers to step back and take on a facilitator role, although bias can never be completely removed. In the Rich Picturing, participants were particularly independent, and through both the pictural representations and oral explanations of their

systems, were able to demonstrate what they viewed as key areas and challenges in their system. Further, when these were converted to IRDs, this enabled participants to drive the next step of analysis in which participants dictated which of those key elements were most important to them, and how they were related to one another. Processing these IRDs into PSMs, rather than CLDs, or other participatory-driven representations, enabled the direct views of participants as results, rather than those requiring a higher degree of researcher interpretation, for example, to force feedback loops where none had organically arisen. The role of the researcher of course impacted this work, for example, during the prompts for workshop activities, which were oriented at food system outcomes and had inherent biases towards "systems science" which is subject to values-laden perspectives, particularly relating to protecting "the environment" and "stakeholders".

More inclusive stakeholder engagement methods and participatory research, along with its evaluation, in order to investigate food system change, are needed particularly in under-researched and data poor areas, such as rural PNG. This area is greatly limited by a complex set of challenges, such as low levels of training availability and little financial capacity, as well as limited infrastructure and highly remote communities dotted throughout a rugged landscape (Songsermsawas et al., 2023). For the FST to be both effective and just, participation cannot be an afterthought. Knowledge must be advanced in this area, and it must shape how we know the system before we attempt to change it. The following section distils methodological lessons for researchers and practitioners in designing stakeholder inclusive processes for systems transformation.

5.4.1 Methodological Implications

This research offers novel comparative empirical evaluations of participatory methods for actor-inclusive FST research. While grounded in the case of PNG cocoa smallholdings,

the methodological insights presented here are transferable to other food systems that are characterised by data scarcity, power asymmetries, and increasing pressures from globalisation and climate change. Using a justice-oriented participatory systems approach, the findings demonstrate that method choice shapes which aspects of the system are revealed, whose knowledge is legitimised, and how complex problems can be variously understood. Interviews generated baseline understandings of outcomes, drivers, and feedbacks; Transformation Statements surfaced community agency and participants' visions of change; Rich Pictures captured contextual complexity and system dynamics/challenges; PSMs formalized causal structures and made trade-offs explicit. Methods with less researcher mediation tended to foster greater participant ownership, stronger engagement, and epistemic diversity, while more structured tools provided analytical clarity and transferability. In combination, these insights suggest that carefully selecting a mixture of participatory methods can contribute to justice through actor inclusivity; it can also improve epistemological rigour in systems science, enabling diverse and justice-oriented understandings (as well as pathways for change), and subsequent systematic analysis. Future research should integrate participatory methods according to explicit transformational objectives and justice goals, ensuring that methodological design itself becomes a lever for more just FSTs.

5.5 Conclusion

This study demonstrates that participatory methods such as Rich Picturing and PSM provide deeper systems insights and also enable processes that build epistemic justice and inclusion in FST research. Food systems change across levels will have winners and losers, and so FST processes are inherently conflictive (which is further exacerbated by the power imbalances that characterise the structure and function of food systems today

(Giesbers et al., 2025)). The FST and inclusivity have fundamental tension between one another due to conflicting objectives of diverse stakeholders throughout the system. Further, food systems are rife with power imbalances, inequities, and inequalities, which have largely been overlooked (Crivits and Mingolla, 2022, Giesbers et al., 2025, Hebinck et al., 2021a). These can only be addressed when diverse societal perspectives are integrated into the change processes that drive the transformation of food systems across all scales and levels (Giesbers et al., 2025, Hebinck et al., 2021a). The transformation must address these challenges within its processes, as a matter of morality, but also because transitions that lack adequate inclusion frequently lead to unpopular and impractical or unsustained outcomes and further marginalise low-influence actors and their knowledge (Giesbers et al., 2025, Leeuwis et al., 2021).

Marginalised groups should specifically be included (Jacobi et al., 2022, Giesbers et al., 2025). In order to overcome structural disadvantages, as well as to level the playing field in contexts where there is likely uneven participation, and to ensure that there is space for less powerful actors (Giesbers et al., 2025, Huttunen et al., 2022, Leeuwis et al., 2021, Mercer-Mapstone et al., 2019). This can improve the fairness of transition processes as well as ensuring interventions are more contextually and culturally appropriate. Participation must go beyond tokenism and enable stakeholders to hold legitimate power in change processes (Giesbers et al., 2025, Kesby, 2003). If stakeholders are subject to changes but not given agency over these changes, change processes can actually become disempowering or drive an agenda that is not in line with participant views or priorities (Giesbers et al., 2025, Kesby, 2003, Woroniecki et al., 2020).

The results generated here demonstrate the assertions of Brock et al. (2024), Giesbers et al. (2025), and Jacobi et al. (2022) and their advocacy for the inclusion of marginalised or low-influence actors in discourse, knowledge, and change processes supporting the FST. We demonstrate that there are both epistemological and ethical merits to more diverse inclusion practices for systems change processes. Transformation of the system is not a passive process. It will be undertaken by food system actors changing their food system activities. As such, for the transformation to be effective, as well as just and inclusive, it should make efforts to improve diversity of stakeholders (and knowledge holders) engaged in its' processes. I propose that in order to achieve a more just and inclusive transformation, research and practice integrates a more holistic understanding of varied systems perspectives, particularly from those that FST initiatives are targeting. The methods through which these systems perspectives are engaged determines how systems contexts are understood, so it is vital that intervention design and stakeholder consultations are both considered and transparent, particularly when those consultations contribute to policy and project design, implementation, and measurement. This research recommends that policy makers take this further, integrating understanding of diverse perspectives, not just into the design of interventions, but into the design of monitoring and evaluation, and in applying learnings across intervention contexts. Findings from this study underscore that participatory method selection should be both purpose-driven and justice-aware. In practice and research both, methods should be chosen not only for their analytical value but for the forms of participation, agency, and epistemic recognition they enable.

In taking pro-inclusion and justice-oriented participatory systems approaches, the enabling factors of more just transformational process increases by putting the spotlight

on vulnerable peoples and their issues, and then continuing to engage throughout FST process initiatives. It is noted, however, that the approach is restricted in that the boundary of system understanding is limited and cannot be extrapolated beyond target actor groups. For instance, these data do not shed any light on what drives other actors in the system – even those that may interact with smallholder farmers. Despite this, consideration of one group, although this group is actually highly heterogenous, can be useful for amplifying the priorities of actors that are not usually considered in the conversation as a way to promote processes of justice and inclusion in the FST and as a way to understand cross-scale and cross-level interactions that contribute to whole-system shifts.

Further, it is vital to engage with the limitations and biases in this work due to the positionality of the researchers, noting that despite efforts to reduce bias, eliminating it completely is impossible. As researchers we aim to bring attention to gaps in knowledge and also to drive critical discussion about issues of justice and marginalisation. I recognise my privilege and position as a researcher, and aim to promote just processes in FSTs and transformational research. I would like to note that the creation of knowledge for this article would not be possible without the generosity of research participants. Due to the nature of analysis and publication requirements, and with limitations in technology and information access in these communities, engaging with participants throughout the publication process was impossible. Further, these methods were not sufficient for including all system actors, particularly those actors that cannot attend or participate in workshops due to accessibility needs. These methods of inclusion are limited in that they still exclude other key food system stakeholders that nonetheless play a vital role in the food system: non-human actors (such as ‘the environment’, institutions, or animals).

Broadly, more work is needed to unpack the practical elements of integrating more just processes into the FST, as well as producing work where actor-focus in FSTs is generated and evaluated. While evidence is beginning to emerge addressing power disparities and influence in the system, this must be further developed with empirical support and directed at policy change processes (Clapp et al., 2025, Conti et al., 2025). Going beyond participatory research, we encourage research to address power relations and/or bring power considerations in to the decision-making space. There must also be further consideration of low-influence actors, particularly new and/or more effective ways to include low-influence actors, as well as other marginalised groups, including non-human food system actors. Structured evaluation is also needed for these method types and in the creation of novel participatory methods given the paucity of research in this area. Further, engaging these actors is vital in establishing systems understandings, and further work is needed to continue engagement throughout change processes.

The work in PNG, which is relatively data poor, contributes to the evidence base there, where they are highly vulnerable to the impacts of climate change, and where transformative initiatives have a history of poor results (for example, see Hughes (2003)). Further research is still needed in the PNG context, which has highly heterogeneous food systems, most of which are under-researched. For the FST to be effective and just, inclusion cannot remain rhetorical or theoretical. Participatory research, particularly that engages low-influence actors, contributes both the analytical and ethical foundations for more just FSTs by making explicit how diverse actors define, understand, and contribute to system change. Participatory approaches that centre low-influence actors are not only ethical imperatives, but practical tools for revealing the system dynamics necessary for just and enduring transformation.

5.6 Author Attribution

Genia Hill – 100%

5.7 Funding and Conflict of Interest

There are no conflicts of interest for the research in this chapter. Data were collected with scholarship funding for the first author from the Ramsay Centre (Australia) and fieldwork was conducted with the assistance of grants from Jesus College Oxford, the University of Oxford SoGE, the University of Oxford Environmental Change Institute, and the Royal Geographical Society.

6 Beyond Typologies: Introducing the 'Food Systems Context' for More Just Transformations

Linking Statement

Existing food systems analyses often rely on typologies or high-level/top-down frameworks that capture measurable attributes and systems outcomes, but do not capture the drivers and feedbacks which cause systems to change. This chapter addresses this limitation by introducing the "Food Systems Context" lens, which reveals how actor decisions are vital for understanding food systems.

With the foundation of the cross-scale and cross-level framing of **Chapter 4** and the participatory, justice-focused methodology evaluation for systems transformations in **Chapter 5**, **Chapter 6** advances the thesis's central pivot: moving beyond outcome-focused typologies toward explaining why food systems take the structures and function they do. Indeed, typologies are appropriate for understanding food systems (understanding the "what"), but to progress beyond that, to *transformation* of these systems, an understanding of why systems are the way they are is necessary (understanding the "why"). **Chapter 6** introduces the "Food System Context" (FSC) as the interacting set of drivers shaping actor decision-making. This arose from post-fieldwork analysis, which revealed that communities could not be fit into the typologies pre-defined by the FAO. The chapter uses a mixed-methods approach that draws directly on the participatory foundations established in **Chapter 5**, to surface important system factors that typology approaches can miss. By explicitly linking drivers and feedbacks analysis back to low-influence perspectives, **Chapter 6** develops the cohesive message

of the thesis, that justice is not an add-on to be evaluated as an outcome, or after outcomes are measured, but is built in through the way systems are understood, bounded, and acted upon in transformational processes.

Abstract

Efforts to transform the food system are urgently needed, yet they are constrained by how researchers and practitioners conceptualise the food domain, which is highly reliant on measurable indicators and outcomes-based approaches, such as typologies. These approaches are important for understanding the state of systems and how systems change over time, but are limited in that they cannot answer *why* food systems have a given structure or function, nor can they elicit change processes. FSTs must hence fully integrate drivers and feedbacks as key focal points, taking a more robust and holistic food systems approach. This research proposes a new analytical lens, the "Food Systems Context" (FSC), which builds on the Food Environments concept and applies it to food systems decision making. The FSC *is the result of the complex set of drivers influencing any food system actor, and forms the environment in which actors choose to undertake activities which later result in food system outcomes*. We illustrate the epistemological merits of the FSC using the case of Papua New Guinean cocoa smallholders and analysis of their perceived food system drivers. Further, we show that using the FSC approach with low-influence actors can provide a pathway for enabling FST processes to be more just and inclusive. Adopting this approach can enable researchers and practitioners to identify pathways for more just and inclusive transformations that typology-based approaches may overlook.

6.1 Introduction

Global food systems face complex and interconnected challenges across food security/health, environmental, economic, and social outcomes, prompting a need for urgent FSTs. Efforts to support policy making and to improve the food system have tended to focus on outcomes ('what we get' out of food system activities (Ingram, 2011)), and particularly on their measurable components (ex. Hebinck et al. (2021b) and Movilla-Pateiro et al. (2021)). Webb et al. (2023, p. 04) posit that outcomes are "*endpoints that represent measured or estimated various forms of positive or negative effects*", while Blackstone et al. (2024) advocate the importance of metrics across all system outcome areas, particularly emphasising the need for creating metrics for social outcomes, which are usually more difficult to measure.

Much of the typology-based and outcome-focused work today, such as from the FAO, have improved understanding of food system structure and function but are descriptive of the system rather than explaining why the system has a given structure or function. With this descriptive limitation, they do not shed light on how systems can (or should) be changed or transformed.

Transformation of the food system requires transforming system outcomes, which happens as the result of actors undertaking activities differently (Ingram and Thornton, 2022). However, actors change activities in response to changing drivers, and policy signals are the primary mechanism to change drivers, where "*drivers represent forces that exert influence on the sustained structure, function, and trajectory of a food system"* (Ingram and Thornton, 2022, Hasnain and Hill, 2025, p. 243). Thus, in order to focus on transforming the system, this requires an understanding (and subsequent change) in

drivers and the response they elicit by system actors. This work therefore introduces the FSC, which provides an analytical lens to focus on drivers and their feedbacks as an entry point towards enabling change processes to occur. Further, we illustrate the FSC in practice, drawing on an example with cocoa smallholder farmers in PNG. This context highlights, through the FSC framing, how including low-influence actors and their decision making can provide a pathway not only for FSTs, but also for more just and inclusive transformations.

The FSC lens was developed through an abductive approach (Timmermans and Tavory, 2022). It is theoretically informed by relevant literatures on food systems, but empirically grounded in the analysis of interviews and participatory workshop outputs created with PNG cocoa smallholders. The chapter uses the case study not just as an illustration of a pre-existing framework, or as a purely inductive grounded theory exercise, but rather as the empirical and analytical basis through which the FSC lens was developed and demonstrated. The sections that follow introduce the evolution of the outcome and typology focused frameworks in use today, providing a foundation for the FSC as a new conceptual lens. We go on to demonstrate application of the FSC using the PNG case.

6.2 Literature Review

This literature review investigates how the prevailing outcomes-focused frameworks, typologies approaches, and food environment literature intersect with more holistic food systems approaches which integrate outcomes, drivers, feedbacks, and actor contexts. We show that while outcomes-focused frameworks have advanced knowledge and understanding of system performance, they are limited in that they cannot explain why systems take a given structure or function, nor do they shed light on how transformations

can occur. This gap motivates the need for the analytical lens provided by the FSC. At the same time, the FSC also addresses gaps in the FST literature which previously have focused on efficiency and systemic shifts, and that to date have not sufficiently focused on actor inclusion and just transformations.

Theoretical approaches to food systems research have been generally aligned in that the system is composed of key elements and their interlinkages, usually described by drivers, outcomes, feedbacks, actors and activities (Béné et al., 2019b, Ericksen, 2008, Pingault et al., 2017, Woodhill, 2019, Zurek et al., 2015, Nguyen, 2018, Global Panel on Agriculture Food Systems for Nutrition, 2014). The precise composition and dynamics of these elements have been debated, but they all acknowledge that these systems must be improved in all areas.

The need for vast and transformative improvements, the "Food System Transformation," is widely accepted and seen as urgent, although the literature determining precisely what "transformation" means has been less aligned. Creating clarity in this discourse, Ingram and Thornton (2022) explained that transforming the food system requires transforming system outcomes. Thus, the FST necessitates achieving better food security, socio-economic, and environmental outcomes. In recent years, the most prominent research seeking to transform food systems has focused on outcomes in areas such as food security/nutrition and its relationship with environmental sustainability (particularly in pursuit of diets that are more environmentally sustainable)(El Bilali et al., 2019, Gerten et al., 2020, Wezel et al., 2020, Willett et al., 2019). These works (for example, Gerten et al., 2020, Wezel et al., 2020, Willett et al., 2019) have tended to focus on planetary/global level challenges and widespread solutions or global goals rather than finer level food

systems or the interactions between levels of the food system (Gerten et al., 2020, Wezel et al., 2020, Willett et al., 2019). While the literature on food regimes does address the broader context for food systems at the global scale and then look to finer levels (Friedmann, 2009), it does not address drivers and feedbacks, which is crucial for analysis of food system function, particularly across scales and levels (Hill et al., 2025).

In the case of food systems research and practice, typology models have been used to frame FST processes at high levels for example, by the FAO (FAO, 2024, Marshall et al., 2021). These are useful for categorising how food systems develop and tend to change over time, or for framing how food system interventions can and should be managed. These typologies are not necessarily progressive; they do not assert that one typology transforms into the next typology, but rather, as nations and their economies change, several parts of their food systems also tend to change, such as the character of their food environment and supply chains. FAO food system typologies classify countries into categories such as rural and traditional, informal and expanding, emerging and diversifying, and modernising and formalising, based on shared structural characteristics such as agricultural productivity and dietary diversity (Marshall et al., 2021, Global Alliance for Improved Nutrition, 2025).

Although holistic food system typologies are relatively few and recent (previously typologies would have focused on parts of the food system, such as agricultural system, but not address the food system as a whole), they focus on metrics such as overall proportional contribution of agriculture to gross domestic product, agricultural production efficiency, prominence and dependence of food markets and supermarkets (FAO, 2024, Marshall et al., 2021). These typologies were used for reference points in

this work as they were the first to assess the whole food system, rather than just production or consumption models. They are part of the FAO's approach to working in countries including PNG. These typologies are aligned with agrarian transition theory, which explains the changes over time that tend to occur at national levels (at least in regimes where land is commodified), where countries that are dominated by small-scale, traditional farming tend to change towards large-scale, commercial agriculture over time; this is paired with urbanisation and shifts of rural labour into non-agricultural sectors (Timmer, 2009, Bernstein, 2016).

While typologies reveal patterns in structure, performance, and challenges of food systems, as well as well as helping researchers and policy makers understand the complex interactions and dynamics between food system components and activities, they do not reveal why given systems have particular qualities. Further, these framings are focused on system outcomes rather than system drivers. While this focus on food system outcomes is useful, particularly for understanding change over time or in response to initiatives or interventions, it does not facilitate the determination of the feedbacks and drivers which actually shape the system outcomes or explain why systems have their structures or functions.

The focus on outcomes is logical for a number of reasons. Food systems are complex adaptive systems, and so identifying and understanding system outcomes is a clear way to understand a system's functionality, rather than getting lost within the dynamics of the system, which are often highly complex. Further, with the need for research to be policy-relevant and the need for policy to be built on evidence-based results, outcomes are much easier to create indices and metrics than other key food system elements such as drivers

and feedbacks, and hence, they provide much needed, measurable evidence. Lastly, for both policy and research, there is a need to compare across the numerous levels, scales, and contexts at which food systems function (ex. comparing national food systems to one another). This also requires standardised indicators, which is most clearly done with measurable outcomes. The multi-scalar and multi-level dimensions and complexities of food systems mean that an outcomes focus is the easiest way to understand and to track performance of the system. As such, in an effort to understand and help improve food systems, typology models organised according to system outcomes have been employed, such as by the FAO.

The FAO Food System Typologies aim to support context-specific analyses by helping policymakers to identify effective policy levers for transforming food systems (Arslan et al., 2024). These typologies are created from a set of variables capturing the number of supermarkets per 100,000 people, percentage of population in urban areas, value added per worker in agriculture, and percentage of calories not from staple foods (Marshall et al., 2021, Arslan et al., 2024). While typology models such as this are effective at measuring systems output or change over time, they do not help diagnose the reason for system changes or help to create understanding about how systems can and should transform. Beyond typologies, in practice, food systems often tend to be categorised or described by their scale and level or according to their commercial focus, such as "community food systems", the "global food system", or "industrial food systems" (Berman, 2011, Monteiro et al., 2013, Rotz and Fraser, 2015). Typologies and other outcomes-focused approaches highlight the broader limitation they work within, which is that they do not fully integrate the system's dynamic processes, and which are shaped

by system drivers and feedbacks. This is particularly important for research and practice that is not only motivated by understanding food systems, but by transforming them.

In contrast to global level typologies, the food environments literature has been developed to apply to much more localised contexts with a particular focus on the food consumption part of the system. The food environment concept has been thoroughly described and explored in recent years (Cifuentes and Sonnino, 2024, Downs et al., 2020, Fanzo et al., 2020, Herrero et al., 2023). The food environment along with individual factors (such as economic or cognitive factors), and consumer behaviour shape the diet that is consumed (Fanzo et al., 2020). Downs et al. (2020) describe the food environment as "the consumer interface with the food system that encompasses the availability, affordability, convenience, and desirability of foods"; the interface also includes factors such as food cultures and advertising. Linking food environments and the food systems framing, high-level policy-oriented work such as the Food Systems Dashboard (see Fanzo et al. (2020)) describe the food environment as capturing food availability and affordability in combination with the properties of food, and with additional factors such as properties of food vendors and food messaging. They go on and apply the food systems frame, positing that the food environment is a key driver of diets (Fanzo et al., 2020).

Cifuentes and Sonnino (2024) describe the food environments-food systems linkages through the entry point of food system actors. They indicate that food environments are where food systems and individuals interact (Cifuentes and Sonnino, 2024). In this approach, it is implicit that the most important activity and outcome from a food system is food consumption (resulting in food access or food security outcomes). This limits acknowledgement that food plays numerous other important roles throughout the system

beyond sustenance, particularly for livelihoods and environmental condition. The food environment term is limited in that it addresses actors only in the consumption dimension. To date, there is no similar term to "food environment" that describes the drivers of decision-making behaviours for other food systems actors, such as producers, processors, or distributors. Thus, food environment cannot be extrapolated to another food system actors and activities. A focus instead on drivers and feedbacks can be useful in determining non-consumption related actor behaviour, which is particularly important for economic and environmental dimensions of food systems.

6.3 Towards a Food Systems Context

By extending the food environment concept to all food system actors and activities, we move from a 'food environment' to a 'food systems context'. The FSC is an analytic lens for diagnosing change pathways that typologies overlook; it applies to all food systems actors and describes their decision-making context. The FSC *is the result of the complex set of drivers influencing any food system actor, and forms the environment in which actors choose to undertake activities which later result in food system outcomes*; it is shown in **Figure 6.1**. The FSC is important for understanding the dynamics of food systems beyond consumption and for supporting transformational processes through robust analysis.

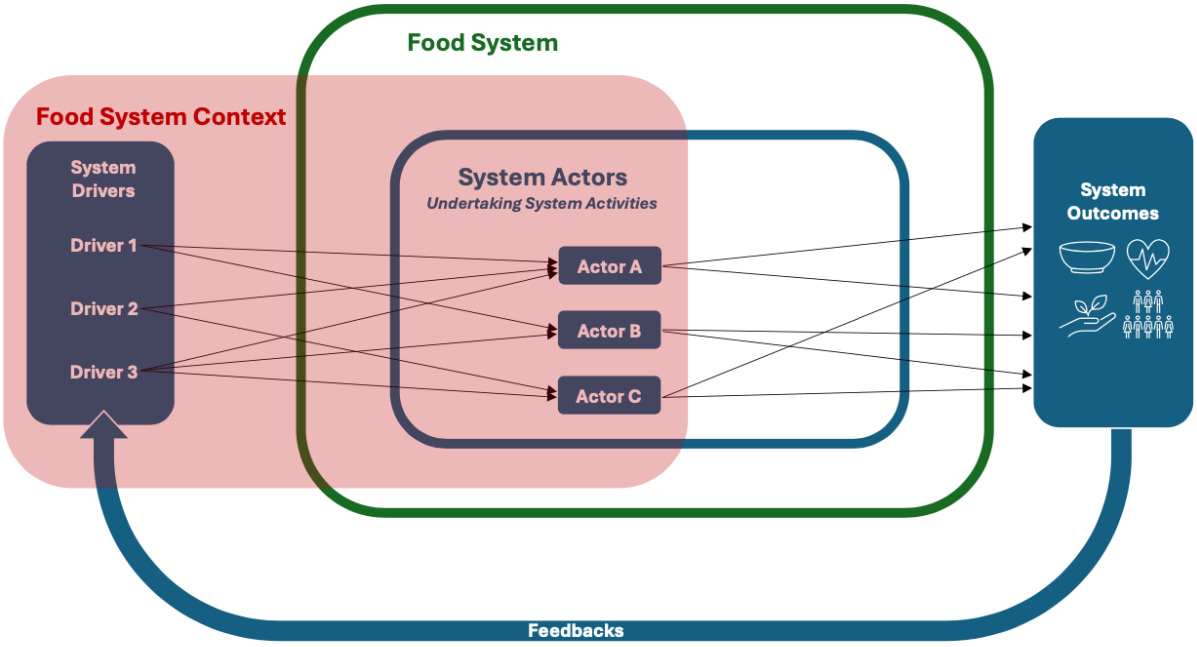


Figure 6.1 Graphical representation of the Food Systems Context.
While this shows driver influence on actors, in contrast, typologies focus on system outcomes.

Food system drivers and their feedbacks are key elements of the food system and in understanding the FSC. Numerous prominent conceptual frames directed at decision makers in the policy domain describe drivers, each in a unique manner. Hasnain and Hill (2025) conducted a review of many of these conceptual frameworks and how they define drivers and feedbacks, arriving at definitions based on these various frames. Drivers are defined in the Introduction of this work; further, they *give rise to outcomes mediated by actors/activities within the system, across scales and levels* (Hasnain and Hill, 2025, p. 249). Feedbacks "occur when a process interacts with a system component and the response then produces another reaction" (Ericksen, 2008, p. 237) and are the mediator between outcomes and drivers (Hasnain and Hill, 2025). Drivers predominantly fall under several categories such as global environmental change (ex. climate change, biodiversity loss), socio-economic drivers (changes in markets, migration, policy, conflict), 'natural'

drivers (biophysical events), and driver interactions (Béné et al., 2019b, Ericksen, 2008, Fanzo et al., 2021, Pingault et al., 2017, Stefanovic et al., 2020).

The food system has enumerable food system actors all facing different drivers. For this work, we use a case study with Papua New Guinean cocoa smallholder farmers. This case study enables us to explore how a drivers- and feedbacks-focused approach to the FST (mobilising the FSC concept) can reveal insights about systems change, examined through the perspective of one (albeit heterogeneous) actor group. By working with low-influence actors, it also allows us to investigate the implications of addressing this gap not for systems transformation alone, but for a more inclusive and justice-focused systems transformations.

The focus on actors and drivers for transforming the food system through the FSC approach lends itself to the question of exactly which actors to consider, as well as which drivers and feedbacks (including drivers for whom, and drivers of which activities). This work operationalises inclusion of low-influence actors as a key element of justice, noting this does not comprehensively address justice in FSTs, but rather, contributes to more just FSTs. Inclusion of actors with little influence over the structure and function of the system (and whose perspectives on transformation may not be aligned with or considered by decision makers at higher levels), is a priority for supporting FSTs to be more just, hence why this work engages with "low-influence actors" (Brock et al., 2024, Giesbers et al., 2025, Jacobi et al., 2022). While justice and actor inclusion have long been important in movements with proximity to FSTs (ex. agroecology and food sovereignty), these have not been a primary focal area in FST research and practice. FSTs have instead been focused on challenges such as resilience building and navigating the difficult trade-offs

between adequate nutrition for the global population and ecological-environmental degradation (or planetary limits) to provide that nutrition. Justice has been analysed through distributive, procedural, recognition, and historical lenses to inform FSTs (de Bruin et al., 2024, Whitfield et al., 2021), however, there remains a gap in operationalising these through FST processes. The FSC addresses this gap by orienting an actor-focused approach to transformation, explaining why actors respond to their decision-making environment. Because FSC depends on identifying the drivers that shape actor choices, robust FSC analysis requires meaningful inclusion of all actor perspectives in a system (including those with low influence). This contributes to procedural, recognition, and epistemic justices and addresses key constraints that remain invisible and leads to interventions that may be misdirected.

6.4 Methods

6.4.1 Selection of Case

The selected case and mixed methods research design were used here to demonstrate how the FSC lens can reveal the way that drivers and feedbacks shape actor decision-making and lead to important food system outcomes. The selected methods were used because they create empirical evidence which emphasises creating knowledge with participants to investigate their perceived drivers and to centre their perspectives in the research narrative. The research design used knowledge co-creation principles, with researchers serving as facilitators and participants as knowledge holders and sharers.

Data were collected from across four subsistence-based farming communities in PNG that also practice cocoa (and some betel nut) cash cropping. PNG smallholder cocoa

farmers provide a useful case to illustrate the FSC given they are multi-actors in their systems (producers of food for subsistence and cash, distributors, processors, and consumers). They are also customary landowners, so are key decision makers across food system outcome areas across levels and scales (see (Hill et al., 2025)), as well as being some of the most vulnerable to climate impacts in the world (Notre Dame Global Adaptation Initiative, 2025). These complexities, among others, make the multiple drivers forming their specific FSC a particularly compelling case in evaluating elements that address a diverse range of system outcomes ranging from food security to land use change.

In the case study communities, cocoa and betel nut cash cropping is the most common way to access a cash income, while subsistence farming and foraging, fishing, and hunting are the main components of their diets. PNG is primarily an agrarian nation, with a large part of the population living in rural areas and a heavy reliance on subsistence agriculture, which is often supplemented with cash crops for income. Around 150,000 out of 8,000,000 Papua New Guineans grow cocoa, mostly on blocks less than one hectare in size (Lescuyer et al., 2018, Pham et al., 2021). In PNG, the vast majority (estimates range from 82% – 97%) of land is under customary land tenure arrangements (Chand and Yala, 2009, Filer, 2014, Kwapena, 2021). Most Papua New Guineans have land rights or access through their ancestors, which is very important for resource use and cultural value (Kwapena, 2021). This is captured through the concepts of "*mama graun, papa graun, and ples*" (Tok Pisin for ancestral lands or place). Although there is significant cultural value in forest, PNG is experiencing rapid land use change, primarily due to logging and agricultural expansion (Global Forest Watch, 2025).

PNG has numerous gaps in data availability and research, and the nation is facing acute challenges across all food system outcome areas (Schmidt et al., 2020, Songsermsawas et al., 2023). The global food typologies map published by Marshall et al. (2021) classified 155 countries, but did not initially include PNG, although as part of the subsequent Food Systems Dashboard, PNG was classified as 'Informal and Expanding'. This implies that agriculture and food consumption is beginning to commercialise (The Global Alliance for Improved Nutrition, 2024). However, despite this national classification, rural areas of PNG tend to be aligned with the "Rural and Traditional" typology described by The Global Alliance for Improved Nutrition (2024).

6.4.2 Data Analysis Approach

The development of the FSC lens followed an abductive analytical process, which iterated between theory, analysis of empirical material, and methodological reflection (Timmermans and Tavory, 2022). Fieldwork, questionnaire design, and workshop design were informed by, and conducted on the basis of food systems literature on drivers, outcomes, feedbacks, food environments, typologies, scale and level, justice, participatory research, and co-creation of knowledge. These concepts were also informed by initial interest in comparing communities and participants through existing food systems typology approaches in line with agrarian transformation theory (Timmer, 2009). The FSC concept emerged during transcription, coding, participatory systems mapping analysis, and comparison across communities, as the empirical material increasingly suggested that existing typology framings could not describe some features of the case and were unable to explain why actors made particular production, consumption, and land use decisions. In this chapter, the empirical material is therefore used both to develop and demonstrate the FSC lens.

Validation sessions and results discussions provided a further check of the empirical interpretation. These sessions helped assess whether the drivers and relationships identified through the analysis reflected participant experiences and community-level concerns. This validation should not be understood as a formal test of the FSC or as a generalisable framework. It does not remove the researcher's interpretive role in naming, bounding, and theorising the FSC. The framework is therefore presented as a theoretically informed and empirically grounded analytical lens, demonstrated through the PNG case, rather than as a fully participant-generated theory or a universally validated model.

The data analysis for this work looked at food system outcomes and drivers, with a specific focus on drivers (and the feedbacks that influence them) in order to understand what influences decision making. The driver investigation used multiple approaches for data collection and analysis including interviews and workshops with smallholder farmers; the workshops included Rich Picturing, Transformation Statements, and creation of IRDs (which later were analysed to become PSMs). Integration of drivers and feedbacks alongside outcomes to determine FSC could occur using a variety of methods. We chose co-creative methods due to the specific case study participants and specific interest in justice as part of FSTs. The detailed methods used for interviews and workshops were further described in **Chapter 5**. Interview approach and workshops design ensured diverse actor participation, with attention to local language facilitation, oral and picture focused activities and community validation of findings. This participatory orientation aligns with the emphasis in the FSC approach on actor inclusion and sensitive of the positionality of both researchers and knowledge holders/participants.

6.4.3 Interviews and Factor Analysis of Mixed Data

Semi-structured interviews were conducted across four communities with 40 participants in each community (total n = 160). Due to the logistical challenges of working in remote PNG (ex. no street addresses, unbridged rivers, and thick jungle), participants were recruited using a combination of snowball and spatially representative sampling. Interview questions were structured around food system themes, whereby participants were asked about their food security, economic, and environmental perspectives. Early interview questions captured basic demographic and quantitative data, such as age, education, number of times cocoa trees under management, and frequency of shop food consumption. Later interview questions were open ended to allow research participants flexibility and space to discuss their priorities, challenges, and changes to their food system activities and outcomes. For example, "between now and when you started your own garden, have there been any changes in the way you do your gardening?" and "is it important to conserve some big bush (virgin forest), and if yes, why?". For the latter question, despite the second part of the question being open ended, respondents would often answer according to two or three categories of answer (ex. so that there are resources for future generations, or for building materials). These were manually coded on a question-by question basis into categorical answers using a two cycle approach as detailed by Saldana (2011). The Guiding Questionnaire is in **Appendix C**.

Both categorical (ex. gender, commercial orientation) and continuous variables (ex. shop food consumption events each week or number of cocoa trees under management) were then used as inputs in the Factor Analysis of Mixed Data (FAMD). This method was used to explore perceived drivers from coded interview data, determining the principal components of both continuous and categorical variables (Kassambara, 2017). The

FAMD was conducted according to Kassambara (2017) and used the factoextra and FactoMineR packages in R Studio Version 4.5.0 (Kassambara and Mundt, 2016, Lê et al., 2008).

6.4.4 Participatory Systems Maps and Network Analysis

PSMs were created in participatory workshops according to De Pinho (2017) and Barbrook-Johnson and Penn (2022). This method is particularly useful for working with participants that may have literacy or numeracy barriers and keeps participant perspectives centred in research outputs, maintaining orientation towards a systems view. PSMs were used instead of other systems methods that require more researcher input, such as CLDs, in order to reduce researcher biases and present direct participant outputs. Key elements of food systems were identified by participants in workshop groups, then groups systematically (one-by-one) determined the relationships between these key elements. Maps were grouped together: 20 total workshop group maps, five per community, 16 maps were regular farmers and four were fermentary owner maps. Maps were digitised and nodes were evaluated using a network analysis which looked at out-degree centrality to identify system drivers and in degree centrality to identify system outcomes (De Pinho, 2017). In-degree and out-degree centrality were used descriptively to characterise perceived system drivers and outcomes from IRDs, rather than to identify leverage points or infer causal impact. We therefore avoid interpreting centrality as a measure of intervention effectiveness (Crielaard et al., 2023).

PSMs and FAMD were complementary; while PSMs used causal structures to surface drivers, the FAMD enabled identification of key information for the FSC through an assessment of interview data. In the FAMD, interview data were analysed to determine

which factors explain variance among other factors discussed in interviews (or which factors explained the most variance in other assessed factors). In contrast, the PSMs captured the relational and systems dynamic aspects of these perceptions. Integrating these analyses allowed the research to triangulate the participant driver dimensions which shape the FSC.

6.5 Results

These results demonstrate the application of the FSC framework to the PNG case, which reveals key drivers and feedbacks shaping the decision-making space which typology-based approaches do not capture. After presenting basic demographic findings, the results go on to present case study communities comparing typology-based indicators and a drivers and feedbacks focused FSC analysis to show how the FSC lens can explain system functioning beyond what typologies can describe. Basic demographic and brief food system outcome data of respondents are captured in **Table 6.1**.

Table 6.1 Basic demographic data of respondents across communities and key factors around their food production and consumption.
Metrics about cocoa trees are a proxy, demonstrating how commercially focused each community is in terms of production and shop food consumption is a proxy for how involved each community is with consuming food from more commercialised, global supply chains as opposed to subsistence-based consumption.

	Ohu	**Rempi**	**Tomasi-Makakoa**	**Ubuko-Siato**
Sample Size	40	40	40	40
Local vs. Immigrated to the Community	37:3	34:6	33:7	36:4
Men vs. Women	28:12	32:8	16:22	16:22
Age				
20 - 29	n = 5	n = 2	n = 4	n = 1
30 - 39	n = 10	n = 11	n = 12	n = 15
40 - 49	n = 15	n = 16	n = 15	n = 4
50 - 59	n = 6	n = 7	n = 6	n = 12
> 60	n = 4	n = 4	n = 3	n = 8
Average number of cocoa trees at peak	434	734	575	874

	Ohu	Rempi	Tomasi-Makakoa	Ubuko-Siato
Min number of cocoa trees at peak	28	40	19	150
Max number of cocoa trees at peak	3000	3500	3980	3500
Average number of shop food consumption events per week	4.6	3.2	2.3	1.4
Min number of shop food consumption events per week	1	0.5	0	0
Max number of shop food consumption events per week	7	7	7	5

To describe the communities, we used the food systems typologies from Marshall et al. (2021) and scaled them down to the community level in PNG using the indicators and criteria provided in the **Chapter Annex**. The relevant scaled-down typologies in this work are 'rural and traditional' and 'informal and expanding'. The rural and traditional typology is best characterised by smallholder farming, low yields, and limited infrastructure, with most food sold locally in informal markets and with significant seasonal variation. Informal and expanding is best described by rising incomes and urbanisation, leading to a mix of informal fresh food markets and formal shops selling processed and packaged goods with limited quality control and regulation.

The FAMD (see **Figure 6.2**) indicates two primary dimensions. The first dimension captures the main pattern of variation across all variables (i.e. the combination of variables that together explain the greatest amount of overall variance in the dataset); the second dimension captures the next most important pattern of variation after removing what has been explained by the first dimension. The first dimension was dominated by environmental and structural factors (important in the FSC), particularly community remoteness, market access, and livelihood orientation. The second dimension reflected individual and demographic factors, such as age, gender, and education.

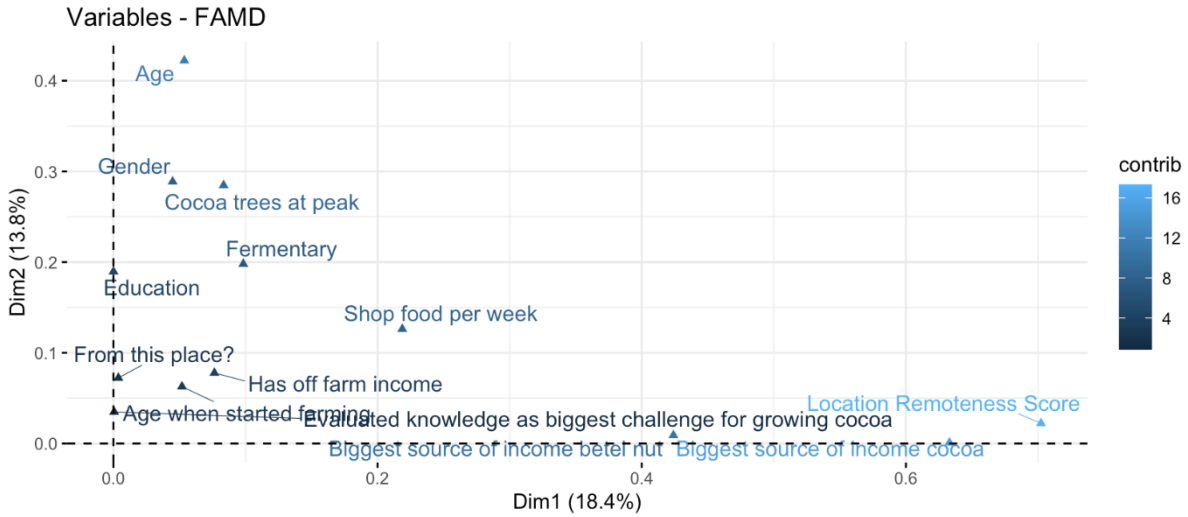


Figure 6.2 FAMD analysis indicates that remoteness is the biggest determinant of other factors when 13 variables were considered.

The results of this FAMD indicate the importance of the FSC approach. It shows the link between food environment and consumption behaviours, but also shows the broader FSC in determining upstream behaviours (food system activities) undertaken by smallholders in other parts of their food system, such as land use change and economic undertakings. This suggests that the broader factors highlighted by the FAMD which are important in the more holistic FSC understanding, lead to a better understanding of how system outcomes are shaped. For example, along with RPs, it highlights that remoteness was a dominant driver shaping food system actor behaviour including production and consumption decisions. Within the FSC lens, this shows how context drives actors leading to both nutritional and environmental systems outcomes.

Each community food system is then categorised in **Table 6.2**, which also compares typologies to the results from the network analysis which showed drivers and outcomes from smallholder perspectives shared in PSMs with key factors from the FAMD (here, the FSC is explored using a combination of findings from PSMs and FAMD). Across the

four communities in this work, typology-based classifications aligned broadly with food environment indicators (such as shop food consumption), but did not align with commerciality indicators, failing to capture the drivers identified in the FSC analysis. The analytical tension is apparent: typologies explain *what* the outcomes are at the community level, whereas the more inclusive approach from an FSC analysis can better explain *why* outcomes are what they are (what drives the activities that lead to outcomes). **Table 6.2** shows that the results used to determine food systems typologies contrast to the drivers and outcomes approach, and demonstrates the limitations of typologies. Typologies lack the nuance of the more holistic systems work. The typology approach cannot capture the decision-making context for key food system actors. In contrast, the systemic approach which uses the FSC can shed light on actor decision-making across different levels of food systems (from smallholders to policy makers), revealing why food system actors undertake given activities and hence why given system outcomes occur. The comparison in the table is not intended to reject food system typologies, nor to create a local typology of the case study communities. Rather, it clarifies the boundaries of typological analysis, particularly for the transformation of food systems. Typologies are useful for organising measurable attributes and outcomes into comparative categories, and hence contribute to understanding context. However, these are insufficient when treated as explanations of food system structure and function because they do not adequately capture the interacting drivers and feedbacks that shape actor decision-making. The community-level indicators used here, including cocoa commerciality and shop food consumption, are used as typology-relevant comparators: they show what classification can reveal, before the analysis turns to why those patterns emerge. In the case illustrated here, these indicators captured some differences between communities, but they did not align neatly with existing typology categories or explain the drivers that produced those differences. This

reinforces the limits (rather than the rejection) of typological analysis. The FSC hence treats typology-relevant indicators as partial evidence of a broader decision-making context, not as categories into which communities should be placed. Its contribution is to move from classifying observable attributes and outcomes toward transformative initiatives that consider the drivers, feedbacks, and contextual conditions that shape why food systems function as they do.

Table 6.2 Food system potential scaled-down typologies compared to drivers and outcomes (using the more holistic FSC approach) as perceived by smallholder farmers in each community. Note the FSC columns show increased variation between communities, highlighting the importance of context where it cannot be differentiated with a typology approach.

Community	**Adapted Food System Typology Descriptor**							***Most important drivers and outcomes for smallholder behaviour (FSC Approach)***		
	Prevalence of formal trade shops in community	**Community proximity to urban area**	**Individual average and Median number of cocoa trees**	**Individual smallholders that reinvest income in cocoa**	**External investment presence in cocoa**	**Individual prevalence of "shop food" consumption**	**Typology Equivalent**	**Top 3 Drivers (Nodes with out-degree centrality)**	**Top 3 Outcomes (Nodes with in-degree centrality)**	Contextual factors: community remoteness, market access, and livelihood orientation.
Ohu, Madang	Low prevalence. Numerous irregular informal 'pop up' trade shops.	~ 45 minutes to Madang Town by privately run bus (two – three busses run daily), dirt road.	Average = 343 Median = 284	6/40 said yes	No known market development project presence.	Average = 4.6 times per week Median = 4.8 times per week	Potentially: Informal and expanding	Severe weather Farmer knowledge Health of environment	Garden food production Cocoa production Farmer income	
Rempi, Madang	High prevalence.	~ 30 minutes to Madang Town by privately run bus or Land Cruiser (many vehicles run daily), paved highway.	Average = 734 Median = 300	4/40 said yes	Presence of market development projects from FAO and ACIAR.	Average = 3.2 times per week Median = 2.5 times per week	Potentially: Informal and expanding	Farmer knowledge Farmer income Severe weather	Cash crop production Health of environment Our health	

Tomasi-Makakoa, Bougainville	Low prevalence.	Eroded dirt road. ~ 3 – 5+ hours to Buka Town by four to five privately run 'ten seaters' (Land Cruisers retrofitted with bench seats).	Average = 575 Median = 400	13/40 said yes	Presence of market development projects from ACIAR.	Average = 2.3 times per week Median = 1 time per week	Potentially: Rural and traditional	Severe weather Health of environment Our health	Our health Farmer income Garden food production and consumption	Contextual factors…
Ubuko-Siato, Bougainville	Low prevalence.	Eroded dirt road. ~ 6 – 7 hours to Buka Town by one or two privately run 'ten seaters' or by a combination of walking to a 'banana boat' pickup point. The boat takes several hours.	Average = 874 Median = 700	8/40 said yes	No market development projects presence.	Average = 1.4 times per week Median = 1 time per week	Potentially: Rural and traditional	Severe weather Health of environment Damage to environment	Farmer income Our health Damage to environment	

6.6 Discussion

This research shows in the selected case the improved nuance a FSC approach offers over typology approaches alone. Here, we interpret the empirical findings from the case study through the FSC lens and show how low-influence actor inclusion can advance understanding of the processes leading to food system outcomes. We go on to explore how the FSC approach used with low-influence actors can contribute to more just and inclusive FSTs.

The analysis found that in the context of remote communities in PNG, drivers shaping the food system at the community level, such as 'remoteness' are more important for determining system actor behaviour than the typology model that best describes that community, which is based on their outcomes alone. For example, there is a decoupling between actor production and consumption patterns, where the most commercialised actors (cash-focused cocoa farmers) in the most remote context eat less shop food (cash-sourced food rather than "free", garden sourced food) than the least commercialised actors in the less remote contexts. Across different communities, environmental and human health, severe weather, farmer knowledge, and health were consistently perceived as major drivers shaping food system dynamics.

These findings also reveal a level and scale mismatch whereby interventions in the food systems domain are designed through understanding at national and sub-national levels, but in practical terms, are implemented at community level (for more on scale and level mismatch in the food system, see Hill et al. (2025)). This is important for systems understandings and resulting policy and governance, as the FSC helps bridge this gap by translating local-level, driver-based insights into a useful analytical approach for higher-

level decision-making. While typology and outcome-focused frameworks remain useful for comparison, they are limited in capturing the interacting processes that determine how systems function. The FSC complements these by revealing why systems take their particular forms and hence informs transformational processes.

The activities that system actors undertake are not simply a function of the system that they exist within, but rather, these actions are the result of complex interactions between drivers and their feedbacks, and secondarily, the positionality of that actor. Analysis from the PNG case showed that factors such as remoteness and commercial orientation proved more influential in shaping smallholder behaviour than typological or individual characteristics. The FSC approach integrates the dynamism of drivers and feedbacks to explain why systems take their current structure and function, taking a whole systems approach (including the complex dynamics of the system), shifting analysis from more static typological approaches that have dominated FSTs to date. This was evident in the PNG case in how drivers such as remoteness mediated flows of knowledge and information, two-way market access, and even cultural norms, thereby being a key determinant in all food systems activities, including production and consumption behaviours. Further, during community visits in 2025 to validate this work, the importance of feedbacks was demonstrated when the high price of cocoa led to increasing expansion of cocoa blocks into the agricultural frontier as well as increased use of pesticides. This shows the important connection between outcomes and drivers as mediated by feedbacks.

Recognising the FSC enables a more nuanced understanding of food system dynamics, further enabling researchers and practitioners to diagnose the underlying causes of system

outcomes and identify more context-appropriate levers for transformation. Importantly, the FSC also distinguishes between temporally stable and more plastic system factors, helping identify where transformation levers actually exist and which elements of a system are likely to be difficult to change.

6.6.1 Food Systems Context and Just Food Systems Transformations

In order to achieve just transformation of the food system, the FST must recognise and integrate diverse system actors into all transformative processes and its enablers, including knowledge creation underpinning transformations, policy reform, project design, and so on (Brock et al., 2024). Efforts must be made to ensure actors who may be otherwise overlooked are included in FSTs, such as marginalised peoples, Indigenous communities, those who have had negative consequences of the food system, future generations, and non-humans (Giesbers et al., 2025, Jacobi et al., 2022).

Through the FSC, we demonstrate that inclusion of low-influence actors is not only a moral imperative but also an epistemological and practical necessity for achieving effective transformation, as it improves the precision of system understanding. By situating actors and their activities within the drivers and feedbacks that shape their decision-making, the FSC shows how influence over system structure and function shape transformation processes. These findings reinforce that transforming food systems requires reassessing policies that determine the drivers of the system, and which in turn shape actor decision-making (Ingram and Thornton, 2022). The FSC illustrates that these policy signals should be created with inclusion of priorities from all actors within the system, particularly actors that may otherwise be excluded from the transformation

agenda. FSC provides a structured way to diagnose the processes that give rise to system outcomes and to target interventions and their intended recipients accordingly.

Transformation of the system is not a passive process. It will be undertaken by food system actors changing their food system activities. As such, for the transformation to be effective, as well as just and inclusive, research and practice should make efforts to improve diversity of participants engaged in transformational processes. We propose that to achieve a more just and inclusive transformation, research and practice should integrate a holistic understanding of drivers and feedbacks, particularly as perceived by those that initiatives are targeting. Without just and inclusive processes driving the FST, power imbalances will be further exacerbated, and food system outcomes will continue to be inequitable and unsustainable

The importance of FSC paired with decision maker positionality further demonstrates the importance of food system actors within an actor group responding to the FSC. For instance, the FAMD analysis used here, when combined with the out-degree centrality network analysis, demonstrated the importance of FSC paired with demographic factors as the key variables which explain other variables within the system. It showed that as demographic shifts occur over time, and as participation in the cash economy likely increases, this leads to identification of interventions such as ecosystem services payments or development of revenue from more environmentally sustainable practices (such as sustainable tourism). These may become increasingly important as the decision space shifts simultaneously with demographic factors.

In addition to using participatory approaches in identifying interventions that have widespread benefits across food system outcome areas, a benefit of including low-influence actors in the systems transformation discourse is the enhancement of effectiveness of interventions and improving decision making and reducing implementation risk reduction of interventions or ownership of participant-driven initiatives. This is particularly needed in the Pacific, where transformative initiatives, at least those funded by foreign aid, have largely failed (Hughes, 2003).

6.7 Conclusion

This paper introduced the FSC as a lens to investigate FSTs that holistically integrates drivers, feedbacks, and their interactions with actors to elicit system outcomes and to explain why food systems function as they do. True systemic approaches that increase attention on drivers and feedbacks, particularly that impact low-influence actor decision making, are important for achieving more just, inclusive, and effective FSTs. This is both a moral imperative and necessary for achieving a better balance between food system outcomes.

Incorporating the FSC into policy design and evaluation shifts attention from measuring outcomes to understanding the drivers that shape them in specific interventions. This approach allows decision makers to identify where and how change processes can be most effectively and equitably implemented, particularly for low-influence actors. When looking towards policy evaluation and in designing interventions to support transformation processes, the FSC, which advocates for a more holistic and true “food systems” approach whereby drivers and feedbacks are also considered alongside outcomes in a systematic manner, may be a more useful analytical approach than

assessing the state of food system outcomes alone. This new approach reveals *why* systems have their given structures and dynamics, and hence, potentially useful intervention points. Used in conjunction with other decision support tools, such as the Sustainability Compass (Hebinck et al., 2021b), this work finds that holistic systems approaches are beneficial for identifying bottom-up levers for change and for integrating justice considerations into both research and policy.

Broadly, more work is also needed to unpack the practical elements of integrating more just processes into the FST. While evidence is beginning to emerge addressing power disparities and influence in the system, this must be further developed with empirical support and directed at policy change processes (Clapp et al., 2025, Conti et al., 2025). There must also be further consideration of low-influence actors, particularly including non-human food system actors. FSTs must begin not with outcomes but with the contextual forces that shape them; the FSC addresses this challenge, identifying that determining *why* systems function as they do can unlock more just, inclusive, and effective pathways for change.

6.8 Author Attribution

Genia Hill: (~75%) Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. Saher Hasnain: (15%) Writing – review & editing. Monika Zurek: (5%) Writing – review & editing, Supervision. Michael Obersteiner: (5%) Methodology, Supervision.

6.9 Funding and Conflict of Interest

There are no conflicts of interest for the research in this chapter. Data were collected with scholarship funding for the first author from the Ramsay Centre (Australia) and fieldwork was conducted with the assistance of grants from Jesus College Oxford, the University of Oxford SoGE, the University of Oxford Environmental Change Institute, and the Royal Geographical Society.

6.10 Chapter Annex

Annex Table 6.3 shows how this work adapts the national food systems typologies approach from Marshall et al. (2021) to the community level in PNG and the proxies that are used in order to evaluate typologies as this more granular level. The community level scaling from national typologies is intended only to be illustrative.

Table 6.3 Typology and proxy variables scaled down from national to community level.

Variable from Marshall et al. (2021) Typology Model	**Community Level Proxy Variable Used in this Work**	**Food System Element Captured**
Supermarkets per 100,000 people	• Prevalence of formal trade shops	Physical access and availability to a wide variety of foods.
Percentage of population in urban areas	• Proximity to urban area	Urbanisation is an effective proxy for both reliance on purchased food and complex supply chains, as well as instance of agricultural employment compared to alternative (and more commercialised) models of employment.
Value added per worker in agriculture	• Number of cocoa trees • Prevalence of smallholder	Emphasis on commercialised agriculture compared to subsistence agriculture, which demonstrates rural and structural transitions. This has implications for food supply chains, nutrition, and livelihoods.

Variable from Marshall et al. (2021) Typology Model	Community Level Proxy Variable Used in this Work	Food System Element Captured
	reinvestment in cocoa • External investment presence in cocoa	
Percentage of calories not from staple foods	• Prevalence of "shop food" consumption	Dietary diversity and the shift towards less healthy, more processed foods.

7 Conclusion

7.1 Summary and Synthesis of Research

This thesis aims to challenge the current 'efficiency-first' paradigms associated with FSTs, and investigates how justice considerations can be integrated into processes directed at transforming food systems. Efficiency-focused and top-down approaches risk reinforcing inequities in transformational processes and leave unanswered why systems function as they do. This thesis explains why system outcomes arise by centring actor decision contexts and feedbacks across levels and scales, and shows this is essential for more just FSTs. Taken together, the chapters in this thesis show that prevailing approaches to FSTs are limited because they have an incomplete picture of both how and why change occurs. By privileging outcomes, efficiency, and coordination at higher levels, dominant approaches to FSTs overlook the contexts in which decisions are made, the actors who enact change (as well as their knowledges), and the cross-scale, cross-level dynamics through which outcomes are produced.

This work argues that transformative action must not come at the cost of further sidelining food system actors that have historically experienced (and continue to presently experience) marginalisation in the food system. At the same time, the research seeks to shed light on why these sidelined actors are vital decision makers and must be brought into transformational processes including research, knowledge creation, discourse, and policy building. FST research itself needs to change how it understands causality, agency, knowledge, and justice.

The research in this thesis focused on the role of low-influence actors in FSTs, using a case study with smallholders in PNG that practice mixed cocoa and subsistence farming. In doing so it also sought to provide empirical evidence that can contribute to policy-relevant insights as well as interdisciplinary and methodological advancements for supporting more just FSTs that result in a better balance between system outcomes in economic, environmental, social and food security domains. While low-influence actor inclusion alone does not make the FST more just, it is a key component in improving transformational processes. This thesis shows that low-influence actors are vital decision makers locally (ex. in their land use activities in response to school fee needs) but have little influence over broader food system structure, function, and policy agendas.

This chapter considers the findings of the thesis papers and the implications for FST research. The main contributions of each empirical chapter are summarised then synthesised to evaluate how the research objectives were met. The section then goes on to assess the implications of this work for policy, governance, and intervention design. It then details the relevant caveats and limitations. Lastly, some final considerations are offered for how the interdisciplinary insights from the preceding chapters can help address research gaps and accelerate integration of justice into FST efforts, concluding this chapter and the overall thesis with future research directions.

7.1.1 Key Contributions of Research Papers

This thesis draws on a case study with smallholder cocoa farmers across four communities in PNG to answer RQs through a food systems theoretical lens, focusing on achieving more just processes aimed at transforming those systems. This thesis includes three papers, each providing theoretical, methodological, and empirical contributions that

each answer a different main RQ as shown in **Table 7.1**. Taking an entry point of scale and level in FSTs, **Chapter 4** offers a novel theoretical approach to these interactions in food systems and investigates the relationship between individual food system actors and systems change. The empirical evidence from this paper takes a particular focus on how scale and level dynamics play out in food systems and how particular consideration of these dynamics as perceived by low-influence actors can provide an avenue for improving justice and actor inclusion in FST processes. **Chapter 5** then provides a reflexive comparison of data elicitation methods from participatory workshops (in addition to more traditional interview approaches), investigating these strategies for their systems transformation potential. Again, the work engages with low-influence actors in the food system, specifically assessing how these actor types can become involved with knowledge co-creation and FST processes. **Chapter 6** then advances current food systems paradigms which focus on outcomes, bringing in system actors to help advance understanding of *why* food systems take a given structure and function by looking at how drivers and feedbacks shape actor decision making. This chapter argues that outcomes-based and typology-focused approaches are descriptive but often cannot explain the dynamics of food systems and how they change. This limitation is not merely methodological; it constrains how justice can be conceptualised and enacted in FSTs. It broadens the "food environments" concept to diverse food system actors by introducing the "Food System Context" (FSC) as the set of interacting drivers shaping actor decision-making, offering an approach to identify intervention points that typology approaches may miss. Further, the chapter explicitly links FSC to justice by again centring low-influence actor perspectives, demonstrating how bringing these in can enable more inclusive and effective transformation pathways otherwise unclear from typology or outcomes-focused approaches.

Table 7.1 Chapter outline of this thesis, the RQs each chapter answers, and the theoretical, methodological, and empirical contribution of each chapter.

Paper	**RQs**	**Key contributions and findings**
Chapter 4: From Local to Global: A Cross-Scale and Cross-Level Framework Toward a More Just Food Systems Transformation	RQ 1: How do actors and systems transformations processes interact in food systems? 1a. How can interactions across scale and level be conceptualised? 1b. How can this understanding inform more just FSTs?	**Contribution to theory:** This chapter reveals the cross-scale and cross-level dynamics in food systems, illustrating how outcomes become drivers through feedbacks across levels and for different scales. **Methodological contribution:** A conceptual framework explicitly links actors, activities, drivers/feedbacks, and outcomes so that outcomes at one level can be analysed as drivers at another. It makes inclusion/justice (especially of low-influence actors) an explicit part of food-systems dynamics across scales and levels. **Empirical findings:** Operationalises the framework through a qualitative case study (semi-structured interviews with 160 smallholders across four communities plus additional system-actor interviews, followed by thematic coding) to trace cross-scale and cross-level interactions and show how top-down interventions can unintentionally reinforce constraints for low-influence actors, and shows how low-influence actors can be key decision makers for outcomes at higher levels. Scale and level linkages demonstrate the need to link qualitative and quantitative food systems sciences.
Chapter 5: Exploring Participatory Methods for Achieving More Just Processes in Food Systems Transformations	RQ 2: How do different methods of engagement with low-influence actors lead to different system understandings and just transformation options? 2a. How can low influence food system actors be engaged in processes aiming to transform systems? 2b. How can engagement with these low-influence actors contribute to achieving more just FSTs?	**Contribution to theory:** Diverse actor inclusion is necessary for systems change, particularly to encourage more just systems transformations. Systems science methods directed at engaging with actors who do not have high levels of influence of system structure and function are assessed for their potential contributions to systemic transformation. **Methodological contribution:** This paper details participatory methods that can be used with low-influence actors and that are directed at systems science: Rich Picturing, PSM, and creation of Transformation Statements. These are also systematically compared with each other and more normative interview techniques. **Empirical findings:** Methods requiring less involvement from research facilitators were the most helpful for problem framing. They surfaced key trade-offs, blind spots, and assumptions embedded in top-down perspectives drawn mainly from the literature or by interviews in which facilitators played a major role. The evaluation also highlighted how these methods can either enable or limit justice-oriented transformation research, and identified context-appropriate pathways for systems change.
Chapter 6: Beyond	RQ 3: What can we learn about systems change by adding a	**Contribution to theory:** Taking a new approach that moves beyond outcomes-focused typology models, this paper shifts the focal point of food systems analysis to drivers and feedbacks. In doing so, it coins and develops the term “Food

Paper	RQs	Key contributions and findings
Typologies: Introducing the 'Food System Context' for More Just Transformations	drivers-focused approach to FSTs? 3a. What does it look like for systems change if we co-create knowledge that focuses on the perspectives on one low influence group of actors? 3b. What does this tell us for achieving more just FSTs?	Systems Context" to advance the "food environments" concept and unpack dynamics around decision making of diverse actors throughout the system. **Methodological contribution:** This paper uses a mixed methods approach with a focus on food systems drivers and feedbacks, marrying the participatory methods from Chapter 5 with Factor Analysis of Mixed Data and Network Analysis to conduct a triangulated analysis of drivers and feedbacks as perceived by PNG cocoa farmers. **Empirical findings:** The FSC is illustrated using a case with PNG cocoa farmers. The case study shows that FSC approach is more nuanced than typologies alone, demonstrating that key factors that drive decision making for cocoa farmers are more related to factors such as remoteness rather than how commercially oriented they are. The FSC lens also shows using the PNG data that there was a "decoupling" between production-side food system actor behaviour and consumption side food system actor behaviour that did not align with the agrarian transformation proposed by Timmer (2009), demonstrating the need for a drivers-focused approach to actor decision making.

7.1.2 Synthesis of Insights Across the Thesis Papers

This thesis explores overall questions around justice and actor inclusion in processes aiming to transform the food system with RQs that use actor perspectives as an entry point. Through low-influence actor inclusion, it focuses on the role of drivers and feedbacks in the decision-making space for smallholder cocoa-subsistence farmers in PNG. It demonstrates that justice is a process in FSTs. It shows "what counts" as the system problem and boundary, and on that basis, the feasible solution set. This depends on who is engaged and how, and which shapes whose values, objectives, and priorities are represented and embedded in transformation agendas. This means that exclusion is not an apolitical omission of actors, but rather, it is a mechanism that shapes how problems are understood and prioritised. Through both methodological and empirical evidence, this work shows that methods are not neutral, rather, they are mechanisms that decide what becomes "knowledge" as well as which futures become visible and actionable. It also shows that when methods and evaluation strategies privilege what is measurable at higher levels (usually through an outcomes focus), this can systematically reproduce the omissions and trade-offs that transformation claims to overcome.

7.1.2.1 Food Systems Transformations and Dynamics

The RQs in this thesis address the interactions between actors and systems transformations (**Chapter 4**), systems transformations-focused methods of engagement with actors (**Chapter 5**), and an exploration of why systems function as they do, which uses a new conceptual approach (the "FSC") that focuses on systems drivers and feedbacks that shape system outcomes through actors and activities (**Chapter 6**). Together, these led to more thorough and holistic systems understanding, and in turn, to

identification of potential change pathways that contextualise interventions that have the capacity to be more sustained and that are less likely to further marginalise the actors subject to these interventions. This shifts justice from an evaluative afterthought to a design requirement while interventions that ignore context, feedbacks, and low influence decision makers are more likely to fail and risk deepening inequities or resulting in unforeseen trade-offs.

Across the three papers, the empirical findings show that when PNG cocoa farmers were engaged as analytical contributors rather than research subjects, different system drivers come into view. This shed light on important system dynamics that were previously opaque. In **Chapter 4**, farmers linked school fees, customary land rights, and birthright to access resources directly to cocoa expansion and land use change, illustrating how individual-level outcomes became community- and landscape-level drivers through feedbacks, and conversely, how outcomes at higher levels (such as changes in education policy) lead to drivers at more granular levels, causing these farmers to respond in their land use decisions. In **Chapter 5**, participatory workshops surfaced trade-offs around forest conservation, use of the natural resource base, and income generation that were muted in more top-down processes, such as researcher-led interviews. In **Chapter 6**, the FSC analysis revealed that factors such as remoteness, rather than degree of commercial orientation (which was aligned with typology approaches), was a primary driver of smallholder decision making. These findings collectively demonstrate that system boundaries and feasible intervention pathways shift depending on whose perspectives are included and how knowledge about a system is produced.

The papers are unified in the treatment of justice as a process to achieve a better balance between food system outcomes, rather than a static outcome of the system or a steady state that can be achieved. Resulting from the synthesis of findings in this thesis, "justice as process" refers to the ways in which FSTs are structured, mediated, and enacted through knowledge creation, decision-making practices, participation mechanisms, methodological choices, and contextual conditions. Rather than treating justice as a lens applied after analysis or as a normative lens used to evaluate outcomes, justice as process integrates justice dimensions into how transformation pathways are identified and implemented. This considers, for example, who is able to participate, at which scales and levels, through what methods, and under which structural constraints. In this framing, justice is not an outcome that can be appended to transformation, but a property of the processes through which change is deliberated, prioritised, and implemented. Across **Chapters 4**, **5**, and **6**, justice as process is shown to be conditioned by scale, mediated by methods and knowledges, and embedded within FSCs.

Justice therefore is built into the mechanisms through which knowledge is produced and decisions are made (explicitly shown in **Chapter 5**), and must be integrated early as transformational processes occur. The papers develop this concept by taking actor-centric approaches to systems transformations. Taken together, the thesis argues that a just FST requires shifting from outcomes and efficiency-first paradigms toward actor-centred, scale and level sensitive analysis of drivers and feedbacks, and by embedding meaningful participation of low-influence actors. The important dynamics these approaches reveal are surfaced in **Chapters 4** and **6**. Without mainstreaming justice as a process, transformation risks being ineffective and reproducing existing power imbalances, and leading to FST initiatives that result in further perverse system outcomes. This can be

applicable, for instance, to an example project results framework (such as that highlighted in **Appendix B**). This example application shows that there must be explicitly protected space for target actors in initiatives (in projects or in policy reform) that includes target actor priorities, visioning, and ways of knowing.

This thesis shows through both theoretical and empirical evidence that "low influence" does not equate to "low importance" for food systems and their transformations. Treating low-influence actors as peripheral stakeholders or "target beneficiaries", therefore functions as an epistemic filter that removes critical causal information about how the system works and where interventions will land. The papers show that food system actors, even those with little influence over system structure and function, are vital decision makers, contributing to important food system outcomes across levels and scales. They are both (1) responding to a complex set of drivers and feedbacks that are highly contextual and (2) key agents of change. On this basis, it is vital that low-influence actors are brought in to all the processes that will contribute to systems transformations, ranging from policy building processes to intervention design, discourse, identification of levers for change, and knowledge production in ways that are both sensitive to scale and level dynamics and sensitive to the specificities of the relevant decision-making context. For example, in the case study context, before an intervention such as those that occurred in Rempi (for example, the ACIAR project), carving out space for target stakeholders to identify context appropriate indicators and objectives to be integrated with the relevant project design and results framework.

Further, the papers taken together show that justice considerations are not just a moral imperative of improving conditions of food systems for both people and planet, but also

for efficacy of interventions and initiatives, completeness of knowledge, and true "systems science" approaches. It is apparent that top-down approaches are epistemologically limited because they only show a very small part of the system. This collapses a common false choice where justice is not in tension with effectiveness in FSTs, but rather, it is one of its enabling conditions. Top-down approaches cannot generate complete systems understandings (although given the complexity of food systems, a "complete" understanding of the system is impossible)(Checkland and Poulter, 2020). Further, these top-down approaches can generate perverse outcomes and reinforce inequities when cross-scale and cross-level dynamics and low-influence actors are ignored. This is demonstrated in findings from **Chapters 4**, **5**, and **6**, whereby bringing in previously overlooked perspectives illustrates how more complete systems understandings contributes to epistemological improvements in systems science. Through improved system understanding, just processes may improve the outcomes of change initiatives, actually improving efficacy rather than being at odds with it.

Lastly, by treating justice as a process, through which system dynamics and knowledges are surfaced, the three papers reveal that systems change is highly complex and context dependent. While the empirical findings are context specific, the treatment of justice as a process through inclusion of actors throughout FST processes, can be extrapolated across contexts. Further, inclusion of low-influence actors can shed light on systems dynamics, which is vital to integrate into FST processes and understandings. The transferable insight is therefore about transformative processes themselves: they must be designed to learn from, and adapt to, feedbacks and drivers as they emerge from the vast range of actors in the system. The importance of FSTs is both upwards into the "systems-wide view", looking towards broad and sweeping change in order to understand the complexity of

sustained structural drivers that are globally relevant and interconnected and temporally enduring, while also integrating the complexity of investigating more granular dynamics, that can be fast and highly localised.

7.1.2.2 Contributions to Theoretical Foundations

Taken together, this work also contributes to the foundational frameworks that this thesis drew upon from Foresight for Food (Woodhill, 2019), Béné et al. (2019b), and Caron et al. (2018). It further bolsters the Foresight for Food approach, showing that actors are a key part of FSTs. This work advances Foresight for Food in demonstrating not just the importance of actors, but the dynamics of how unique actors are important for transformation in the context of complex sets of feedbacks and drivers. Building on the work of Caron et al. (2018), this work also shows that food systems actors have multiple (sometimes conflicting) goals and FSTs contribute to several SDGs across several scales and levels. The complexity of addressing food system challenges across SDG areas requires addressing complex and interconnected feedbacks and drivers as shown in **Chapters 4** and **6**. The FSC, along with analysis of scale and level in systems, can be a useful tool in addressing all SDGs, particularly SDGs 2, 8, 10, 12, and 13[8]. Lastly, Bene's focal point on bringing drivers into the main conversation on FSTs is advanced by investigating exactly how drivers and actors interact as the primary path of understanding the dynamics of how food system outcomes arise through evidence offered in **Chapters 4**, **5**, and **6**. For example, drivers that led actors to create rule structures for land use (**Chapter 4**), drivers that led actors to consume and produce food with contrasting foci in terms of commerciality (**Chapter 6**), and drivers that were hidden from top-down

[8] SDG2: Zero hunger; SDG8: Decent work and economic growth; SDG10: Reduced inequalities; SDG12: Responsible consumption and production; SDG13: Climate action.

processes, such as perceived relationships between health and amount of shop food consumed. Unpacking these factors is important for evaluating and assessing not just how systems can change, but how they can change in a more just way that brings in more complete knowledges from different sources and includes actors that have a history of being marginalised by the powerful actors in food systems. Collectively, these contributions suggest that actor-centred approaches are not an alternative lens through which to analyse FSTs, rather, they are foundational to making transformation knowable (and therefore doable) and governable.

7.1.2.3 Justice Dimensions

Across the papers, the thesis contributes to multiple dimensions of justice in FSTs. It advances epistemological and recognition dimensions of justice by demonstrating that participatory systems methods with specific (often overlooked) groups generate forms of knowledge about drivers and feedbacks that are marginalised or invisible in top-down, outcome-centric approaches (as shown in **Chapter 5**). For example, including cocoa smallholders in systems understandings illustrated the explicit connection between education policy and land use change. Further, in terms of procedural justice, it shows that how actors are engaged, particularly whether methods are facilitator dominated or participant-led, shapes what is visible, how problems are bounded, and whose priorities are embedded in transformation agendas (**Chapters 4** and **5**). Recognition justice is advanced by centring the perceived drivers and constraints of cocoa smallholders in PNG, whose knowledge is often overlooked in national and international food policy discourse and its reform, as well as using empirical evidence to show that their decisions are important for broader food system agendas (**Chapters 4** and **6**). Finally, although the thesis does not directly touch on how resources can or should be distributed and

redistributed, it highlights how distributional justice outcomes are shaped by cross-scale feedbacks. For example, how education policy and cocoa price volatility influence land use and livelihood decisions (as shown in **Chapter 4** and **6**).

While this thesis offers an avenue for more just FSTs, we note that inclusion is necessary for achieving more just FSTs, but it alone is not sufficient for just transformations. For this, research, practice, and policy still must grapple with power, recognition, distribution, and decision making in food systems and their transformation. Models of actor engagement must be intentional, power-sensitive, co-creative (not extractive consultation), scale and level sensitive, and they must be designed to fit the specific context and constraints of their scope while remaining transparent about whose knowledge and perspectives are represented or prioritised. In summary, without inclusion of low-influence actors, FSTs remain partial, but with it, the deeper work of power, recognition, and redistribution becomes actionable rather than rhetorical.

7.2 Implications for Policy, Governance, and Intervention Design

7.2.1 Overall Policy Relevance

Several key conclusions arise when considering how this research can contribute to policy, governance, and intervention design, both extrapolated across various food systems contexts and applied directly to the PNG case.

In terms of extrapolation of this work across contexts, an example of how the findings of this thesis can be used to guide the way that project results are tracked; **Appendix B** illustrates an example of how this could be done in a hypothetical project results

framework. This example is not intended as a fully specified or generalisable results framework, but as a demonstration of how justice-oriented, actor-derived insights from this thesis could inform project design and evaluation. This provides steps beyond contemporary initiatives to benefit low-influence actors in the food system, such as commodity certification schemes, and demonstrates how integration of a range of perspectives throughout the food system can be conducted with special considerations for the inclusion of low-influence actors and their perspectives in transformational initiatives.

The PNG case demonstrates that policy shifts framed at national or international levels can translate into local drivers in unexpected ways. For example, the cocoa price boom in early 2024 altered pesticide application use, illustrating how higher-level economic signals become local environmental feedbacks. Without mechanisms to capture these evolving feedbacks from farmers themselves, interventions risk reinforcing unintended environmental, social, health and economic outcomes for some food system actors. Designing interventions around bottom-up change pathways identified through participatory rather than outcomes-focused typology classifications and interviews alone provides a more context-sensitive pathway that may benefit system outcomes where they have otherwise failed. Further, the integration of justice, specifically as a process in the transformation of food systems, can be broadly applicable across a range of contexts. By taking an actor-focused approach that brings in actor perspectives as an analytical tool in FSTs, this reveals that there are important dynamics driven by decision makers at all levels of food systems, which are vital in understanding system outcomes. This is particularly relevant in scale and level dynamics, as well as an analysis of how FSC shapes food system outcomes.

The actor-centric focus in FSTs which leads to the "justice as process" approach can be applied across FSCs, as it is aimed at sustainability transition. It can also become embedded in how researchers and practitioners consider knowledge and systems understanding, as well as being integrated into any initiatives that involve "stakeholder consultations" by broadening the scope of who is usually considered a stakeholder and consideration of what they can contribute to FST processes. Further, policy plays an important role in the FSC by shaping the structural drivers that enable transformation pathways, including market incentives, governance arrangements, and participation requirements in policy or project creation. Actioning the FSC thus requires policy approaches that move beyond isolated interventions toward context-sensitive, cross-level, and cross-scale coordination that explicitly recognises how decisions at national and global levels influence the decision making space and resulting actions of actors throughout the system.

This work shows that bringing in system actors, particularly those with little influence over the structure and function of the system, can reveal dynamics and factors of the system that may otherwise be overlooked; these actors and their perspectives can be excluded from systems understandings or excluded from transformational initiatives or policies, leading to less-complete systems understandings and result in initiatives that are more likely to not be taken up or adopted and to be both unsustained and unsustainable. These low-influence actors can be highly variable, working throughout food systems, ranging from food producers and processors, to those working in waste management, as well as consumers.

The lesson that "actors with little influence are not actors with little importance" carries both moral and epistemological implications, as demonstrated across all three papers. Attending to low-influence actors enabled a more thorough and holistic understanding of the system, which in turn revealed change pathways grounded in the contextual realities that shape actor decision making. Integrating these perspectives into the design of policies and interventions can help address blind spots inherent in more outcomes-focused approaches, which often lack sufficient contextual depth (for example, by applying the FSC framework to strengthen systems understanding to inform policy). This finding has direct relevance for governance and policy: empirical evidence shows that low-influence actors are not peripheral participants but essential decision-makers. Consequently, high-level decision-makers must meaningfully include low-influence actors if they aim to develop more complete and effective understandings of the systems they aim to transform through policy reform.

Based on these findings, this work suggests that initiatives from the governments aimed at transforming all or parts of food systems, both in terms of domestic projects directed inwards at all levels of government, as well as international aid, must have more thorough consultations with low-influence actors and/or subjects of initiatives *before* the project design phase. These consultations should go beyond government representatives and involve project design teams working with target communities. They must also create space for alternative knowledges and perspectives when identifying indicators, metrics and other tracking tools for transformational policy and initiatives.

As shown in **Chapter 6**, a useful model in the above proposed changes, would be to shift from an outcomes focus to a FSC approach for changing policies and interventions. In

taking this new approach, answering questions such as which contextual drivers are targeted in change, for whom, and with what feedback effects, would help in ensuring changes are more sensitive to issues of justice in FSTs. As such, the findings from this thesis suggest that interventions should be designed around bottom-up change pathways that typology approaches may miss. While this will likely add upfront cost, it may help to increase the long term sustainability and uptake of such initiatives.

Likewise, more thorough consultation with low-influence actors should be key in domestic policy changes at all levels. For example, in various settings across the world (ex. in the Finnish Sámi Parliament Act), where Indigenous communities must be consulted with in the case of policy changes. While the details of these various arrangements are outside the scope of this thesis, the normative idea is that voices of the communities that are often overlooked should be systematically and specifically included in policy decisions, particularly policy decisions that will impact those communities, and with a view of sustainable systems transformations.

Further, I propose that the scale and level dynamics revealed in **Chapter 4** supported by the FSC in **Chapter 6** are made explicit in interventions, such that governance and initiatives bring in scale and level as important contextual drivers of actor decision making in systems transformations during the early stages of governance reform or intervention design.

This would necessitate that governance and initiatives aim to anticipate and account for how international or national changes may translate into local drivers and challenges, and how local outcomes may in turn become higher level drivers through feedback

mechanisms. This would require the operationalisation of inclusion as a design principle, the benefits of which are shown in **Chapter 5**, which goes beyond the use of participatory research for its moral benefits, but show its contribution towards holistic systems science epistemologies. This reiterates that methodological choices are political, and demonstrates that explicitly treating low-influence actors as agents of just processes rather than research itself as a possible site of injustice if it sidelines knowledge holders. It advocates justice as process, such that the processes of transformation avoid economically, socially, and environmentally unsustainable outcomes and unintentionally reinforce burdens for low-influence actors. Beyond that, participation of low-influence actors must be embedded into monitoring and evaluation frameworks, and additionally be brought into a wide set of indicators aiming for transformations of food systems across levels.

7.2.2 Papua New Guinea Policy Context

Several conclusions arise from the empirical findings of this work which are directly relevant for the PNG policy context. Food systems and the cocoa supply chain in PNG are most often described using top-down approaches, and with limited consultation from low-influence actors. The papers presented in this thesis address this gap by centring knowledge and perceived drivers and feedbacks of smallholder and subsistence farmers.

Briefly discussed in **Chapter 6**, the importance of feedbacks was demonstrated in the system activities undertaken by smallholder farmers. For example, an important feedback dynamic that became apparent late in my Doctor of Philosophy (DPhil), which resulted in increased pesticide application was due to the cocoa price boom in early 2024 (after the participatory modelling workshops took place). Conducting fieldwork across four

communities revealed that what appeared in national statistics as “cocoa expansion” or “land use change” was experienced locally as a strategy to meet current and future school fee requirements. These decisions were not merely economic calculations but embedded in social and intergenerational responsibilities. Further, this change from smallholders resulted in a decline in river water quality (reported to me during community discussions in 2025), which for the poorest families was their only source of water, including drinking water, and for all families in the community, their source of washing water and an important source of foods for dietary consumption and sale[9]. In my earlier visits, farmers had reported impact to the water supply from chemicals due to people upstream using treated mosquito nets, usually to catch prawns; however, in later visits, water pollution became a more prolific issue with the increased application of pesticides to clear grass in cocoa blocks, providing a lower labour option that would help to increase cocoa yields.

Another important challenge that came up throughout interviews and participatory workshops, as shown in **Chapters 5** and **6**, was farmer knowledge. In interviews and informal conversations with community members, limited knowledge often arose as a barrier to good farming practices, both for cash cropping and production of garden food. If follows, then, that knowledge dissemination must be improved, particularly where farmers are left to intuit their farming practices or have very limited exposure to extension education, which focuses on production rather than safeguarding for people and environmental condition (for instance, 41/101 farmers that ranked their key challenges with growing cocoa said that “lack of knowledge” was their biggest issue, and often, respondents also said they had never received any extension advice in their life). Further,

[9] I have been visiting the most remote communities in this thesis since my master’s research fieldwork in 2019. At that time, river fish were abundant and readily available. Since then, I have personally witnessed the gradual decline of these fish, with many community members reporting in interviews and informal conversations that river fish are more and more difficult to find.

Chapter 4 solidifies this challenge from the perspective of other system actors. For instance, the Cocoa Board regional offices indicated during interviews that they get as little as 10% of their operating budget actually distributed to support their operations, and so they are forced to focus on compliance rather than extension, and can only fulfill a limited set of activities that are supposed to be in their remit.

The findings from these chapters demonstrate that throughout food systems, both in PNG and beyond, there is an urgent need to integrate drivers, feedbacks, and actor context into research, intervention, and policy design. Here, several examples of potential levers are shared. One useful intervention point may be in engaging children in agricultural education. School attendance is important for families, as shown in **Chapter 4**. While some students in upper primary and higher levels of school get some education on agricultural extension, it may be useful to move this earlier in the curriculum, particularly as in remote areas, older children do not often continue with schooling after grade eight (which may continue to be a challenge under the new 1-6-6- structure reform for PNG schools). Further reforms that may also be useful relate to the implementation of co-op models and other models aligned with social cohesion. Where these existed in the Bougainville communities and in Rempi, they were reported to be useful by their participants, and additionally, amplified smallholder access to Cocoa Board knowledge resources.

7.3 Implications for Research

This thesis aimed to address one small component of the big and messy challenge that is transforming the food system towards being more just and inclusive. In doing so, across the papers in this thesis, there was a proven need to focus on context and drivers for

decision makers in the food system across level, scale, and with consideration of food system dynamics as well as the knowledge underpinning these systems. The gaps, open questions, and future research directions are presented according to the theoretical and methodological components of this work, then separately with regard to the empirical evidence presented throughout.

The theoretical and methodological evidence highlight the needs for linking co-creative and justice-oriented research to systems change. Not only does this contribute evidence that motivates the need to build bridges between qualitative and quantitative work, as shown in **Chapter 4**, but it also highlights the need for the transformative potential of participatory methods discussed in **Chapter 5** to be better resourced, institutionalised, and made decision relevant without becoming extractive or tokenistic. This includes throughout transformation processes, as well as in subsequent monitoring and evaluation efforts. The cumulative findings from this work also highlight the need to make minimum conditions for participation transparent; namely, for policy change or intervention design and implementation, what level, and from what diversity of actors, is participation "enough"? What trade-offs, between efficiency and inclusion are "optimal", for what, and for whom?

Both theoretical and empirical evidence demonstrate that drivers and actor responses to those drivers can be highly complex due to feedbacks (or perceived feedbacks and drivers). Despite thorough interviews and the triangulation of perspectives through workshops, cocoa price was not often stated as a significant driver of farmer behaviour (although it did come up occasionally during the creation of interrelationship digraphs). Interestingly, however, there was a cocoa price spike in early 2024, immediately after

workshops were conducted at the end of 2023. When I returned in 2025 to validate the participatory models and circulate preliminary results from the data collection period, there were lots of community level discussions around rapidly increasing use of pesticides. Particularly in the more remote contexts, cocoa was not only expanding, but smallholders started to use pesticides for the first time in an effort to increase yields. This created challenges with downstream communities, who rely on clean river water for drinking and washing.

Empirical evidence suggests that further research needs to be done to improve clarity in this decision-making context (and perhaps, to further develop the empirical details for the FSC and subsequent "testing" of the FSC concept). It would also be useful to explore the intersection of scale and level dynamics along with the FSC with other actors in the system, for example, further investigation into the "missing middle" of the food system or with non-human actors in the food system, which are both often overlooked, and so a vital component of further justice-focused research. This would also be useful to compare driver landscapes and to further operationalise justice in FST processes with additional empirical grounding. Empirically, this work also shows that "justice" remains hard to conceptualise and particularly difficult to measure. More empirical work is needed on power, influence, and inclusion, and how these can support interventions and policy change processes. This work could be particularly useful in actioning the FSC and further conducting research into FSCs by making visible the contextual drivers, feedback dynamics, and power relations that structure FSTs, while critically interrogating whose knowledge informs pathway design, linking findings from **Chapters 4**, **5**, and **6**. In this sense, research is not only diagnostic but foundational. Through methodological choices

and actor engagement, it can either reproduce existing exclusions or power dynamics in the system, or it can support more reflexive, justice-oriented transformation processes.

Lastly, bridging theoretical, methodological, and empirical elements of this work, this thesis shows that assumptions about the agrarian transition processes may not be an effective way to understand system dynamics and their potential transformation, and so, future work could explore which contextual drivers, such as education costs, pests, market governance, and land tenure, better predict outcomes, informing decision pathways more effectively than linear typology narratives. Alternatively, typology approaches could be reformed such that they are more contextually sensitive and bring in multi-actor views from across levels and the perceived drivers and feedbacks that determine key actor decisions. Future research would also benefit from more engagement with the temporal element of scale in sustainability transitions. This remains an important gap in the food systems literature, which has a complex set of both slow and fast dynamics that are interconnected.

7.4 Caveats and Limitations

The caveats and limitations of this thesis were explored in the relevant empirical chapters. Broader limitations which cut across this research project as a whole are detailed in this section. Doing systems oriented work with data generated by communities must consider which findings from this work can be generalisable, and which cannot.

While the theoretical and methodological findings can be useful across contexts, evidence presented was highly contextual. Specific empirical limitations were largely due to the nature of data collection. Taking the systems approach highlights the importance of

dynamics that drive outcomes, however, the interaction between the temporal scale and the dynamics of the system remained a challenge throughout the work in this thesis.

While **Chapter 4** shows that feedbacks over time link levels (including across the temporal scale), this was difficult to address in data collection. Due to the cost, time, and emissions associated with visiting remote parts of PNG, periods of data collection were concentrated throughout the doctoral research, which led to data collection that primarily captured brief snapshots in time, rather than longitudinal research, which may have revealed different dynamics of the system. When perspectives were gathered during workshops, participants chose whether or not to join after their experience in their interview. While the turn out rate was good (about 80% of interviewees attended subsequent workshops), this influenced participation of those who had care responsibilities or those with accessibility needs due to workshop locations, which were usually in a central part of each community, but still a long walk for some. Lastly, in terms of pragmatic limitations, I tended to end interviews if they went much over an hour, as I wanted to minimise undue disruption, particularly as interviews often took participants away from their direct livelihood activities.

My data collection and analysis were inevitably shaped by my theoretical background as a conservation biologist and experience in the sustainable development sector, as well as by my intersecting identities including my gender, nationality, socioeconomic class, and broader worldview. This is further discussed in **Appendix A**, where I detail some notes on conducting fieldwork in PNG and provide a Statement of Positionality. In order to address my biases, I conducted research in the same place I had previously visited during my master's, so that at least in some of the communities, I had longstanding relationships

and cultural knowledge which could be somewhat extrapolated to living in the other community contexts in PNG. In each of the sites, I paid a family to stay in their home with them so that I could spend time with each community and get to know them and their lived experience, although this was by no means a thorough ethnography. Further, I learned Tok Pisin, which was imperfect, but a great benefit, particularly for working with the more remote communities, where people tended to be shyer with me. Further, I worked alongside local researchers. Although "food systems" is a niche, so I do not have directly aligned academic interests with my PNG colleagues, we continue to explore ways that we can publish together and advance academic collaboration. I was also limited in my ability to bring in people in PNG to analysis and publishing, particularly in remote communities with little technology access. The research context also meant it was impossible to make analysis highly iterative and interactive, as due to the difficulty of contacting these communities, fieldwork had to be conducted in several blocks.

The low-influence, actor-centred approach used in this thesis amplifies priorities that are often excluded; it provides an additional view to add to systems understanding, but this approach (along with all approaches in systems science) cannot explain "the whole system" (indeed, a whole system can never be completely understood). Further, while this foregrounds a group of low-influence actors and their perceived drivers, it cannot bring in the views of other actors, even interacting ones, which are directly part of the local food system of focus. While this foregrounding is important for the justice concerns that are central to this thesis, it speaks to the tension between inclusion and amplification of low influence voices with systemic approaches as well as the many competing viewpoints and priorities held by the complex set of actors with competing objectives in the food system.

There were necessary limitations within the research design which generated the data underpinning the three papers in this thesis. Although I made significant effort to reduce bias and triangulate findings as discussed in **Chapter 3** and **5**, some limitations, particularly due to logistical factors, were unavoidable. One of the strengths of this thesis is that information was created through both interviews and workshop methods, which bolstered each other, resulting in a depth and breadth of findings across the four community areas. The data collected were primarily qualitative, and so there are limitations in how the data can be extrapolated. The subsequent analysis was sensitive to the limited sample size, particularly in looking at the mixed methods approaches during FAMD (using Principal Component Analysis with mixed data types) and Network Analysis. As such, this work does not aim to provide statistically representative findings that represent the PNG cocoa sector as a whole, however, it provides insights from across a range of specific contexts within the PNG cocoa sector. PNG is a large and highly heterogenous country with multiple complex and interconnecting challenges, so extrapolating the empirical findings is limited in the national context. Further, in reference to limitations of the research design process, the flexible approach in the underlying interview data mean that not all participants answered all questions, and so denominators vary across questions. Where this arose in the numerical representation of results, the specific number of respondents is shown transparently on a question-by-question basis. This also is apparent in the limitations of "scale transferability" and the needs for "fit for purpose" governance and initiatives, which remains a challenge for linking national data and typologies to local intervention needs.

7.5 Closing Statement

Taken together, this thesis argues that the limits of prevailing FST agendas are in part due to a lack of meaningful low-influence actor inclusion. So far, these agendas have focused on the need to emphasise efficiency, coordination, and outcomes, which is necessary to shift the whole system, but in doing so, low-influence actors have been marginalised and excluded from FST processes. Despite the efforts to shift the whole system, food system challenges persist today and continue to worsen in dimensions such as environmental impact and the welfare of food system actors. This is not due to a lack of ambition, but a gap in understanding of how change is produced: outcomes emerge through contextual decisions, shaped by drivers and cross-scale, cross-level feedbacks, and enacted by actors whose perspectives and knowledges are often treated as peripheral. Across the three papers, this thesis shows that justice is not an optional normative add-on to transformation, but a property of transformation itself and a process which can be built, or eroded, through how problems are bounded, whose perspectives are recognised or prioritised, and how interventions engage with the feedbacks and drivers that generate outcomes. A particular focus was taken throughout this work on co-creation. This sheds light on why methods matter: they are not neutral instruments for describing systems, they are the mechanisms that determine how knowledge comes to exist and subsequently, which pathways for transformation become actionable and which futures can be governed toward. A just FST is not only assessed by its system outcomes, but by the processes within that transformation, because the process is not the path to justice, but rather, it is where justice is made.

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ChatGPT Education Edition was used in a limited capacity during the preparation of this thesis to support language refinement, editorial clarity, and formatting tasks. All substantive intellectual contributions, including conceptual development, theoretical framing, research design, data collection, analysis, interpretation, and argumentation, are the sole work of the author except in the chapters where noted otherwise, and where contributions were made by co-authors. Any AI-assisted outputs were critically reviewed, edited, and verified by the author to ensure accuracy, originality, and alignment with the research.

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Appendices

Supplementary information to support this thesis is provided in the appendices listed below:

- Appendix A: Notes on Conducting Research in Papua New Guinea and Statement of Positionality
- Appendix B: Results Framework for a Justice-Oriented Intervention in a Remote Papua New Guinea Food System
- Appendix C: Guiding Questionnaire for Interviews
- Appendix D: Interview Codes
- Appendix E: Participatory Workshop Outline
- Appendix F: Sample Rich Picture Outputs
- Appendix G: Sample Transformation Statement Outputs
- Appendix H: Sample Inter-Relationship Digraph Outputs
- Appendix I: Sample Participatory Systems Maps Outputs
- Appendix J: Conducting Justice-Sensitive and Ethical Research
- Appendix K: Results Dissemination Sheet
- Appendix L: Teamwork Contributions Alongside This Thesis



Figure A1 Research participants take a break from chopping sago palm to drink coffee, eat Cabin Biscuits, and to do an interview with me. Note, Cabin Biscuits (and other savoury crackers) are common in remote areas as they are cheap, easy to transport, long lasting, and extremely calorie dense (one packet, which is usually eaten as one serving, is 490 calories). They also represent the nature of the shifting food system as it becomes more globally integrated.

Appendix A: Notes on Conducting Research in Papua New Guinea and Statement of Positionality

Working in PNG is a rich yet challenging context. While some moments were deeply joyful (like bathing in the river under the stars and working with lovely people in some of the most remote and beautiful parts of the world), there were also numerous difficulties in conducting this work, both logistically and socially. This section explores the "under the hood" elements of what I did, summarises the practicalities of fieldwork in PNG, and details my own position as a researcher. I deliberately weave together fieldwork practicalities and positionality as this mirrors the reality of my fieldwork, in which my position shaped both my daily way of life, progression through fieldwork, and the resulting scientific processes of data collection/creation and analysis.

I first started research in PNG during my Master's Degree in 2018 and 2019, where I conducted research with communities in Bougainville looking at their remote community food system vulnerabilities to climate change. I was fortunate to have an "in": One of my colleagues at the University of Queensland (UQ) is a local of Bougainville, and was completing his PhD in biology at the same time as I was conducting my Master's studies there. He invited me to his community, where he was trying to build up a research presence to establish the Kunua Conservation Network (KCN). He is a prominent member of his community, so due to this and his work establishing a broad range of research in the region for KCN, my work in the Bougainville communities was welcomed, and I was able to continue work there as the entry point for my doctoral studies. I was fortunate that I could use the cultural and contextual knowledge from conducting fieldwork during my Master's degree to inform my approach and RQs for the

DPhil. In addition to the Bougainville sites I worked at during my masters, I brought in additional communities for the DPhil work, which I contacted through the Binatang Research Centre (BRC) near Madang via connections I had at Oxford. For safety, practicality, and social reasons, having an "in" for communities while doing work in PNG is vital. A useful entry point is by working with a trusted member of the target community, in my case, as established by UQ/KCN and BRC.

In each community where I worked, I stayed in the home of the person I was working with (in the BRC-connected communities, this person was also my local research assistant). I contributed to housework while not out doing data collection (which largely meant helping the women cook dinner and wash dishes), and immersed myself in their daily life activities, such as singing songs with children after dinner and going to church with my host family on Sundays.

In a culture that has a strong oral tradition of *tok stori* (telling stories), I would spend time chatting with community members (most often women) about our lives and families. During later community visits, I made sure to bring photos of my life and family in Oxford and Australia, which was always met with great interest. It helped that after some time in the field, I was able to converse in Tok Pisin, which got better the longer I spent in PNG, and made a noticeable difference in my interactions as I became more proficient. I also always took the time to go to the local school and speak at assembly (and bring some small gifts such as coloured pencils) as well as speaking at any relevant community



Figure A2 Weekly church in Bougainville.

events. Throughout the project I tried to reduce extractive dynamics by prioritising relationship-building, everyday reciprocity in host households and the community, and by designing interviews/workshops to follow local priorities and daily rhythm, while recognising that these steps do not remove the underlying power asymmetries that exist during this type of work.

In addition to social engagement while spending time in these communities, I also worked on building rapport during interviews and workshops, which was important in conducting people-centred work. During interviews, I would walk around the cocoa blocks and hamlets with a thermos full of hot water, reusable mugs that I would wash each night, and a stash of coffee, Cabin biscuits, and pop up hand fans, so that when I greeted someone for an interview, no matter where we were, I could give them a coffee, a snack, and a small gift (pictured below, part B). Further, each workshop started with a period of telling

stories and drinking coffee and eating snacks (pictured below, parts B and C). I note from this period of data creation, as well as from subsequent analysis, that as a researcher and facilitator, I too am part of "the system," and that my position informs how the data were created and understood.



Figure A3 A. A research participant enjoys Cabin Biscuits and coffee during an interview. B. A research participant fans herself during a workshop on a hot day. C. Research participants drinking coffee while creating Rich Pictures together.

In order to address the power dynamics that characterised this work (both during official "data creation and collection" activities, and during my stay in each community), I took numerous efforts to reduce harm. While these don't erase power differences, I feel they are important for conducting justice-oriented work. This included conducting a long and comprehensive oral consenting process during interviews (160 times!) and providing verbal reassurance throughout interviews, where participants seemed tentative or not confident in their interactions. I deliberately prioritised flexibility during my interview

process and used a flexible, participant-led interview approach, so that the participants could direct the conversation, expand on topics where they were comfortable and interested, and minimise discussion where they were less interested in a conversational manner that was organic. Interviews also prioritised the time, space, and social comfort of participants, who sometimes opted to do interviews in their hamlets, in their cocoa blocks, sometimes alone, and sometimes while sitting in a group. In workshops, I also took a friendly approach, using methods that were compatible with oral cultures (including lots of activities centred around speaking and groupwork) as well as visual and drawing methods that had a low barrier to entry. I made an effort to ensure that all participants had pens available to them and didn't feel under the scrutiny of me constantly watching them often reminding them that "*olgeta, yupela i gat plenti save, mi no gat dispela save*" – you all are knowledgeable, it's not me that has this knowledge! This is further discussed in the reflexive evaluation of participatory methods in **Chapter 5**. I felt given the politics and importance of methods choices in systems transformation research, this needed the emphasis and space of a devoted research article and chapter of this thesis. Lastly, after data were analysed, I returned to the communities and discussed findings with participants, other community members, and local collaborators in line with my views on conducting justice-sensitive and ethical research, which is further detailed in **Appendix I**.

In engaging with these communities, they were all so kind and generous to me, and I plan to continue collaborating with them in future. Working in PNG and Bougainville is fantastic, the people are lovely (as well as interested in research because many have never met a researcher before), the landscape is beautiful, and fieldwork was novel and exciting. Despite this, it also takes lots of patience, grit, preparation, waiting around (I reemphasise

patience here), logistical hiccups, and a higher-than-most tolerance for a range of risks. There were times when I had to wait hours in sweltering heat for overloaded and subsequently cancelled flights, times where I had to rely on my host family to help me cross flooded rivers with my laptop and field gear to take boat transport when car transports couldn't get to communities because of weather, and times where I had to sleep on a floor (on a flattened cardboard box, thank goodness!) for weeks at a time, because of miscommunications about field set-ups and supplies. Although I experienced this as somewhat of an 'adventure'; for locals in these communities, this is the daily reality of infrastructure gaps and climate risk.

As I complete this thesis, I reflect on my time in PNG with happiness and nostalgia, but I also continue to wonder if these communities I loved enjoyed having me there: a white Australian researcher with enormous privilege, a high level of education, and seemingly boundless access to resources. During my first doctoral visit to Bougainville, I met a young child who was my namesake. She was born during the last few days of my Master's community visit, which I took as a sign that at least some community members are happy to have me there. Despite this, I still faced challenges with community research involvement, sometimes with very few (or no) participants attending workshops. Further, some researchers at Oxford have shared the idea with me that it's inappropriate and neocolonial to conduct research outside of one's "own country." I continue to grapple with these ideas of whether or not I should do work of this nature in PNG, and am not sure I will ever arrive at a firm answer.

Beyond my presence in these spaces, in conducting this research, it is important to note the numerous challenges they face due to weather – challenges which are now increasing

due to climate change. Much of life there is ruled by the logistical implications of rain: children can only get to and from school when the rivers aren't flooded (they must cross on foot), and accessing food gardens is also often impossible during those times (the food itself can also be damaged due to too much rain). For my own work, recruiting research participants and workshop participation was also largely weather dependent, with community members staying close to home in times of heavy rain. Further, accessing town to sell cash crops or get store food, going to hospital (especially during a complex labour delivery), or even accessing banking and network coverage, depends on road access and river crossings. It can take several days to get in and out of these communities, with vehicles not being able to travel due to flooded river crossings.

While the physical and mobility challenges were intense, navigating social dynamics was even trickier. These ranged from different gender and timekeeping norms to the enormously complex colonial relationship between Australia and PNG. During this project, I noted my position in terms of my institutional affiliation, my disciplinary lens training, gender, language ability, class, resource access, and relationship to collaborators. These factors affected what people told me, who felt comfortable speaking, and what I could physically access.

My work is focused on listening and taking a community-first (rather than a researcher-led) approach to thinking about problems and their solutions, so I found it extremely difficult when I was told that women must be subservient to men during community church sessions, or that there were places in the bush and in the community that I wasn't allowed to go, because they were special places reserved for the men. Again, I find myself

grappling with these issues and not arriving at any exact answers. Further, I was faced with my nationality positionality as an Australian head-on.

PNG has had a long and complicated colonial influence. The first attempt at Western colonisation occurred by the British in 1793; Christian missionaries started operations there in 1871 and maintain substantial presence today[10]. Colonial rule officially ended with the Australian Colonial Administration, which lasted from 1906 until PNG's independence in 1975[11]. During my community visits, many Papua New Guineans told me they feel that Australia is their "big cousin" or that they wish PNG were a state of Australia. Others shared the sentiment of "in the times before, when the white men were here 'helping' us" (a direct quote!) and that conditions were better back then – although I note this may have been expressed to me wholly or at least in part due to my position as a white Australian researcher. The relatively recent Australian Colonial Administration impacts persist today: the oldest members of the communities I worked with went to school under the Australian curriculum, and asked to sing classic Australian folk songs with me, like 'Waltzing Matilda.' Today, Australia is PNG's largest bilateral development partner, with Australia's bilateral allocation to PNG at around $600 million AUD each year[12]. Around the communities, there are omnipresent signs of Australian Aid, near hospitals, schools, and on capacity building and government documents. Over the course of my degree, the PukPuk Treaty was also agreed between Australia and PNG (signed in 2025)[13]; some of the Papua New Guineans I spoke to saw this as an attempt from Australia to control PNG. While I don't claim to have any of "the answers" to any of this grappling,

[10] https://www.britannica.com/place/Papua-New-Guinea/The-colonial-period
[11] *Ibid*
[12] https://www.dfat.gov.au/geo/papua-new-guinea/development-assistance
[13] https://www.dfat.gov.au/countries/papua-new-guinea/papua-new-guinea-australia-mutual-defence-treaty

I believe it is important to note that this relationship is complex and dynamic, and important to acknowledge in this work.

Appendix B: Results Framework for a Justice-Oriented Intervention in a Remote Papua New Guinea Food System

In this section, I have developed the key components of an example log frame with indicators for a Project Results framework that could be used for a food systems project in remote PNG. This is an example of how the findings from this thesis could be applied in a real project setting. The project is not a real project, but I used the Transformation Statements generated in this thesis to guide the design of how the example project could have progress measured. The interview and participatory methods conducted in this thesis could be an example baseline study appropriate in designing such an intervention as it shows how knowledge that is created with communities is useful in developing more holistic systems understandings. These baselines and embedding more inclusive processes before the project design and inception phase is one of the key recommendations arising from this thesis, which is shown to be relevant in considering what can (and should) be included in a project results framework.

Based on the findings of this thesis, low-influence actors, particularly those that are the subjects of initiatives, should be included in all stages of projects or policy changes, including before design. This means taking grounded approaches to project design and spending time understanding community challenges and priorities before project design. Further, projects, initiatives, policy reform, etc., must create allowances for bringing in new types of knowledge and systems understandings to consultation processes, ensuring those become not just "considerations" for project aims, but a key part of results frameworks, as illustrated in the example here.

The Project log frame presented here has indicators for each targeted Outcome with targets and milestones, while Output level indicators would be defined during annual work planning by the project management unit, with additional allowances for some Outcome and Output level indicators to be created with target recipients of the project.

As is common in these types of projects, the data sources would include i) project reports and ii) official national documents and records (Bills submitted to Parliament, Audit Reports, etc.). The Project would also iii) implement dedicated tools for gauging public consent to the project and its progress (including novel progress indicators created with target stakeholders), and iv) keep track of its own deliverables (ex. various technical reports). Further, this new type of framework would rely more heavily on qualitative information produced with target beneficiaries in line with cultural norms; it is this sort of contextual allowance that must be made by project funders to take the next steps towards more just FSTs, and towards improving contextual approaches to projects that aim to improve project efficacy. Lastly, adaptive management must also be built into the project design so that appropriate responses can accommodate for novel data sources created in collaboration with target communities. Details of tracking log frame indicators are presented on the next pages.

Table A1 Sample results project framework.

Indicators and assumptions	**Indicator definition and unit of measurement**	**Data collection methods and sources**
Project objective: To increase food security and food-derived income for remote communities while reducing expansion of agriculture into primary forest by reducing food losses due to pest damage		
Outcome 1. Community led pest management Activity examples: Teaching of teachers in low-tech solutions to reduce pests in gardens, community designed activities		
Indicator Example 1.1: Number of participating households adopting a community led pest management package (locally defined minimum set)	To be decided upon community consultation (ex. number of household per clan, per geographical region, etc.)	Field verification + farmer practice logs + peer monitors
Indicator Example 1.2: Pest damage score on priority crops (community-defined scale)	To be decided upon community consultation (ex. yield loss using community led metric)	Field transects + participatory scoring mechanisms
Indicator 1.3: At least one protected indicator under this outcome to be agreed upon during pre-design community consultations and with data collection methods and sources decided by the community integrating how community members want to assess performance of their own community led pest management package		
Outcome 2: Increase local food availability via loss reduction, storage, and "missing middle" solutions Activity examples: Establishing aggregation opportunities (such as cooperatives) for transport and sale of food in town and to negotiate favourable sale terms, increase local basic processing (ex. low technology food drying), education on food processing/preservation and financial and business literacy for establishing and maintaining cooperatives, community designed activities		
Indicator Example 2.1: Reduction in postharvest losses attributable to pests	Percentage + additional metric described by target participants	Storage sampling + household diaries + market quality checks
Indicator Example 2.2: Number of functioning aggregation / cooperative marketing arrangements with transparent rules and inclusive membership	Total number + mixed qualitative and quantitative assessment of "level of "functioning"' as assessed by target participants	Coop records + governance audits + mixed methods assessment from target participants
Indicator 2.3: At least one protected indicator under this outcome to be agreed upon during pre-design community consultations and with data collection methods and sources decided by the community		
Outcome 3: Community led forest management system Activities: Education on new laws around land registration, forum for community land use, community designed activities		
Indicator Example 3.1: Annual forest-to-agriculture conversion in target landscapes	Primary forest cleared: ha/year Secondary forest cleared: ha/year and supporting participatory qualitative feedback	Remote sensing + participatory ground-truthing + narrative development and forum around new causal drivers
Indicator Example 3.2: "Procedural fairness" score and inclusion metric for land-use decisions	Qualitative assessment based on stakeholder interviews	Consent/fairness surveys + deliberative scoring + diversity of community members taking part in community forums + narrative data

Indicators and assumptions	Indicator definition and unit of measurement	Data collection methods and sources
Indicator 3.3: At least one protected indicator under this outcome to be agreed upon during community consultations and with data collection methods and sources decided by the community around how they want forest management priorities to be progressed		
Outcome 4: Community-designed outcome. This slot is protected for an outcome which must be created during pre-design community consultations Protected activities to be agreed upon during community consultations using a pre-defined and protected portion of the project budget		
Two to three protected indicators to be agreed upon during community consultations. Further supporting indicators to be brought in from the project management unit or design team		

Appendix C: Guiding Questionnaire for Interviews

The first questions in the interviews largely targeted basic demographic factors or those that helped me understand how "commercially-oriented" the participant was, then as the interview proceeded it transitioned to the go-along approach.

Demographic Questions

- Year born
- Year started farming (cash crops and subsistence)
- Household size (total), (number of adults), (number of children)
- Gender
- Level of education
- Leadership role in clan/community (if applicable)
- From this place?
- Other demographic notes:

Financial Food System Outcomes

- Do you sell your cocoa beans wet or dry?
- Do you have (or have you previously had) a fermentary?
- Do you reinvest any of your cocoa income to further expand your cocoa?
- Do you add inputs to your cocoa?
- How many bags of cocoa do you sell and how often?
- How many cocoa trees do you have?
- What is the largest number of cocoa trees you've had at one time?
- Do you have problems with CPB?

- Do you do anything to reduce CPB?
- Other CPB notes
- Have you given up on cocoa at present?
- How many days in one week do you work in your cocoa block?
- How many days in one week do you work on harvesting from your cocoa block?
- Do you employ (or otherwise compensate) others to help in your cocoa block? (if yes, please detail this)
- What was on your cocoa block before it was cocoa?
- How do you learn what to do with your cocoa?
- What are the details of your cocoa selling arrangement (Who do you sell to? Person or company? What price do they give you? Etc.).
- Since you started cash cropping, what are the biggest changes?
- What are your biggest cocoa and cash crop challenges?
- Please rank cocoa challenges for getting the strongest cocoa (concern for cocoa's impact on the health of the environment in this place, the amount of labour/limitations on labour that cocoa takes to grow and sell, limitations on access to the 'things you need' to grow cocoa well, such as fertiliser or tools, or a lack of knowledge on how to grow cocoa)
- Please rank income sources in terms of what gives you the most annual income
- Do you have any sources of off-farm income?
- Since you have started farming, have there been changes in your income? If so, please explain this.

<u>Food Security/Health Outcomes</u>

- What do you normally eat in an average week?

- How many times in an average week do you eat food from the shop?
- What do you normally eat from the shop?
- Since farming, what has changed with your gardens and garden food production?
- Since farming, have there been any changes in your fallowing period?
- Since farming, have you changed any of the methods you use on the farm?
- Has *taim hangre* become harder?
- Do you struggle with TBH?
- Is TBH different now than when you were a child?
- What are the biggest challenges for subsistence food production for you/in your garden?
- What do you think are the biggest challenges for subsistence food production for the community?
- Since you were a child, have you noticed any changes in the weather in this place? What changes?
- (If changes noted), do you have a way to help your gardens or crops from the changing weather?
- Do you have a way to help your soil?

<u>Environmental Outcomes</u>

- Is this place important to you? (if yes, why?)
- Do you feel a sense of responsibility to take care of the environment in this place?
- Do you think the environment in your place is healthy (the whole place, for example, the bush, the river, the cocoa blocks, the gardens, the community)?
- Do you want your children to stay in this place when they grow up?
- When your children are grown, what would you like them to do?

- Is land for cash crops or land for subsistence more important?
- Do you think the food gardens and cash cropping blocks have an impact on the healthiness of environment/the condition of the environment in this place?
- Do you have any concerns about the future health of this place?
- Do you have any concerns about the future health of this place?
- If you were in charge of a big piece of land, what would you do to manage it?
- Do you think you may run out of bush in the future?
- Is it important to conserve some land? Why?

Appendix D: Interview Codes

Manual first and second round codes from longform interview answers are listed below. The coded data were non-categorical and non-numerical (only longform qualitative answers were analysed according to these codes, as other data had answers that didn't need coding, such as numerical or categorical answers from interviews in which categories were pre-defined). Discussion points that were categorised as only "yes/no", were also not included here as there was only one layer of coding needed for those data.

TableA2 Qualitative coding information.

First Round Code	**Second Round Code**	**Code explainer/additional notes**
Cocoa interest level		If they talk in their interview about expanding cocoa or trying to increase production currently/in the near future/or the recent past, they're gaining interest; if they've cut down all their trees entirely, they've lost interest; if they still farm cocoa but are cutting it down or giving up or talking about leaving the cocoa and shifting focus to something else, then they're losing interest; if they don't talk about any change in interest level or activity, then 'no real change'.
	lost interest	
	losing interest	
	gaining interest/expanding cocoa	
	no real change in interest level (still selling, not expanding, not giving up)	
	other	
Clearing primary forest – for what purpose		
	garden	
	old plantation	
	other	
Primary concern around cocoa growing		

	lack of knowledge	
	impact of cocoa on environment	
	lack of access to inputs	
	lack of labour available	
	other	
Taim bilong hangre		
	harder than before	
	not harder than before	
	struggle with taim bilong hangre	
	other	
Coping strategies for taim bilong hangre		
	shop food	
	different crops	
	wild foods	
	sago	
	food sharing	
	other	
Land use priority		If they explain the process of blocking up land for all three purposes and each purpose (cash cropping, garden, conservation), then say “land budget”.
	land budget	
	develop for cash crops	
	conservation	
	gardening	
	two reasons	If two reasons, these were tracked for which two reasons and counted.

Land squeeze		If this was it mentioned throughout the interview, record if this was in the context of current or future land squeeze? This included if participants started discussing "population getting too high" resulting in not enough land.
	emphasis on future	
	emphasis on current	
	not mentioned at all throughout interview	
Food system activities impacting environment		
	cocoa/cash crops	
	gardens	
	both (same)	
	no impact from cash crops or gardens	
Conservation of land - reasoning		
	resource use for future	Future resource use catches all natural resource use -- including timber for building houses, gardens, land for cash crops, and 'so my children can use it'.
	other	

Appendix E: Participatory Workshop Outline

Introduction – About 10 minutes (although waiting for enough participants to show up can take up to two hours)

- Coffee and biscuits, storytelling.
- Introduction to who I am and where I am from.
- Workshop overview (three activities, about three hours in total).
- Participation and consent reminder.

I. Activity I: Rich Picturing – About 45 minutes

- Rich Picturing explanation: The first activity is a drawing activity. It's a way for me to understand your community and what's important here. There are no correct answers! It's about your knowledge – you are the experts about this community (not me!).
- Lay out two sheets of A1 paper with a pile of blue and green pens on each sheet. Let people divide into two groups on their own (in the case of an exceptionally large or small workshop attendance, provide one or three sheets of paper instead, such that there are around five or six participants working on each picture).
- First prompt: "*Draw everything that matters for your income, everything that matters for your diet, and everything that matters for your place and environment here in this community. Draw arrows between different parts of your picture where there are connections.*"
- Wait for people to warm up (it takes ~5 minutes for people to start drawing). Let them draw for around 20 or 30 minutes (don't hover too

much!). If they'd like more time, let them have it. If needed, remind them that there are no right answers.

- Once this version of pictures are complete, ask each group to explain their picture to the other groups and research facilitator.
- Second prompt (while distributing red pens to the group): "*Now, look at your whole picture. Take red pens and draw the problems and challenges you experience on all parts of the picture.*" Then allow 10 to 15 minutes for people to draw challenges. Again, if they want more time, allow them what they need.
- Once this is finished, invite each group to explain their challenges and problems that they drew in the picture.

II. Activity II: Transformation Statements – About 20 minutes

- Distribute whiteboard to each group (the same groups that did the Rich Pictures) with pens, explaining that this is a writing activity.
- Prompt: "*Choose one of the challenges or difficulties from the Rich Pictures. Design a project that you would like to see in your community which would help you with the selected challenge or difficulty.*" Provide an example project with all relevant details. The project needs to address the following:
    - What problem/difficulty would you like to reduce?
    - What is something you would like to do to reduce this problem/difficulty? Put a target number to achieve action on this problem (This is your "project"):
    - By what time would you like to complete this project?

    - What goal do you have in this project? Put a target number for your goal.
    - What is the overarching goal that you'd like this project to achieve?
- Each group then explains their project to the rest of the workshop group.

III. Activity III: IRDs – About 60 minutes

- For the last activity, everyone in the workshop comes together and we do the activity as one (the mechanics are led by the research facilitator, but the causation discussion is led by the participants).
- Discussion about which factors are the most important from their picture (help participants choose 10 – 15 based on the Rich Picturing discussion).
- Lay out the key elements (represented in words and pictures) in a circle on a whiteboard.
- Go through one-by-one and ask "if [Element A] goes up, does [Element B] go up, go down, or stay the same?". This must be done with every element in the image with every single other element in the whole picture (one by one), and is a very repetitive task. Explain that the geographical scope is "within the community"[14]. Be patient and listen to the discussion, ensuring that everyone is expressing their opinion (even the quieter participants!). Draw the arrow of the strongest direction between the two elements once there is consensus. If there isn't consensus, draw a dashed

[14] In hindsight, it may have been useful to make the activity more defined around a time period. For example, if element A is about the population of the community, it is useful to think about population going up, down, or staying the same, over a defined period, and how that would affect other elements of the community food system.

line and double arrow between those two elements and take note of the disagreement so that it can be recorded in workshop results.

IV. Discussion – About 5 to 15 minutes

- Q&A Session driven by participants (and any other information they'd like to talk to me about).

V. Closing – About 5 minutes

- Thank you for participating. Explain that without their knowledge, my work would be impossible.
- Shake hands and pay everyone for their participation, explaining that I want to pay them for their time working with me today, as I know it took them away from their cocoa blocks.

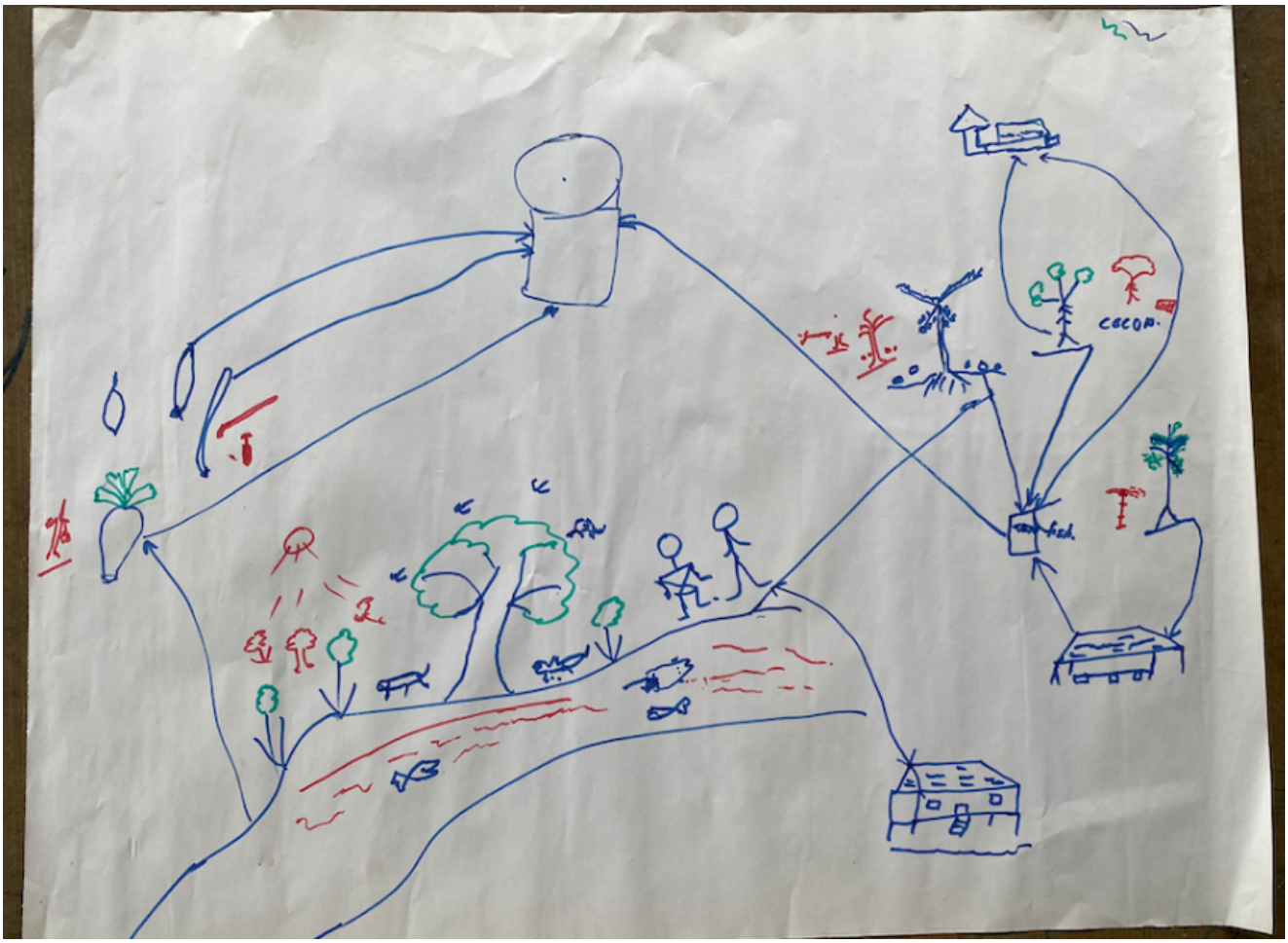
Appendix F: Sample Rich Picture Outputs

Workshop 2: 2 October 2023, Ohu

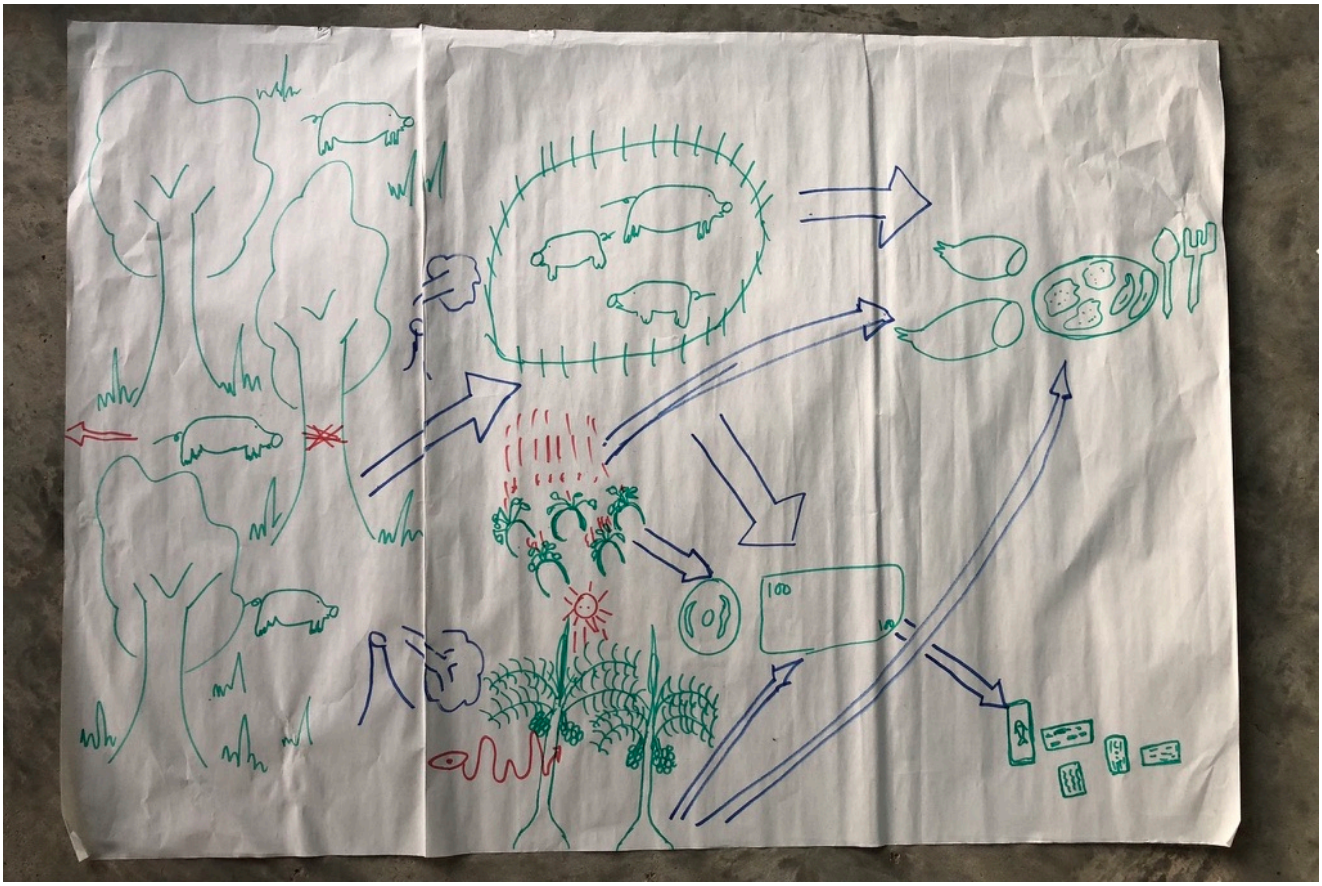


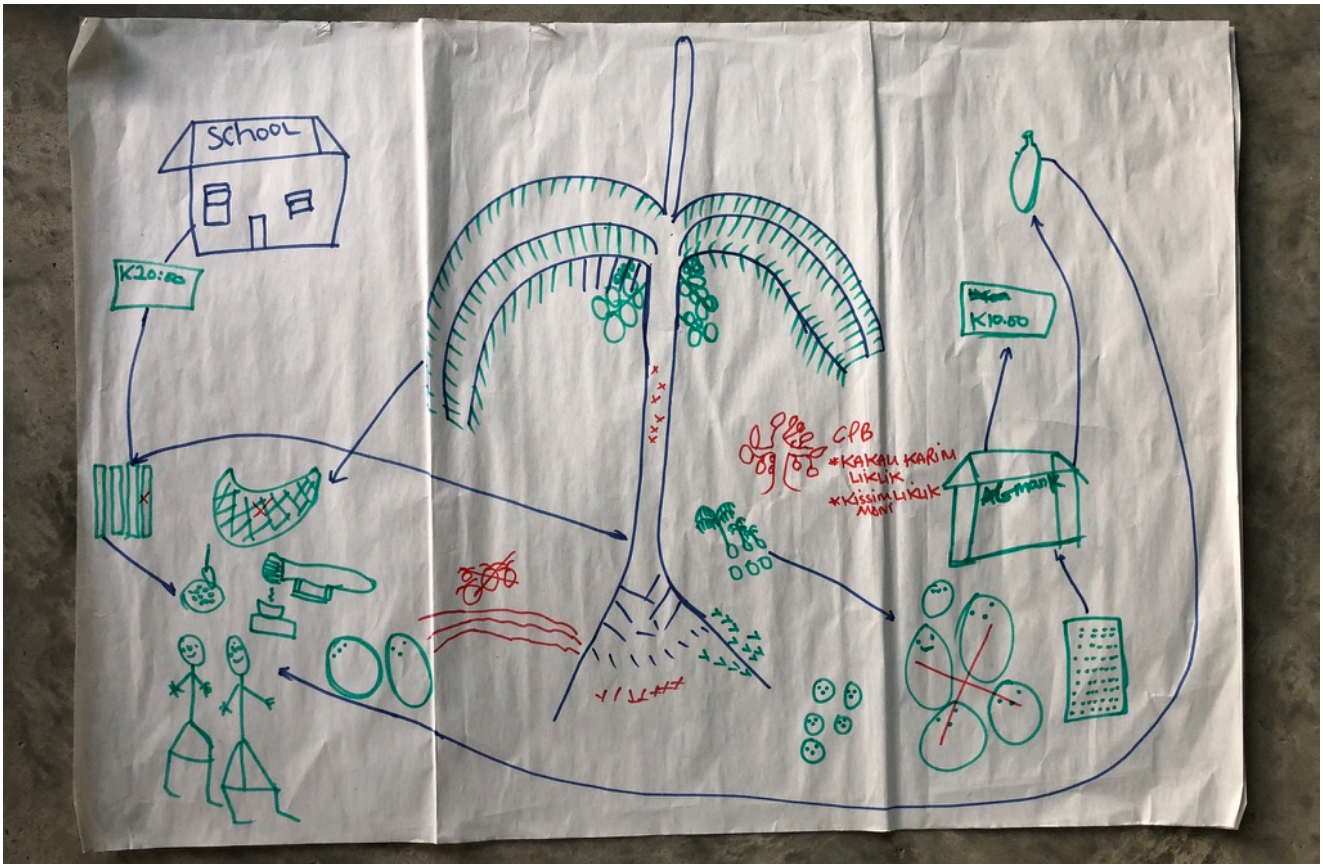


Workshop 7: 16 October 2023, Rempi

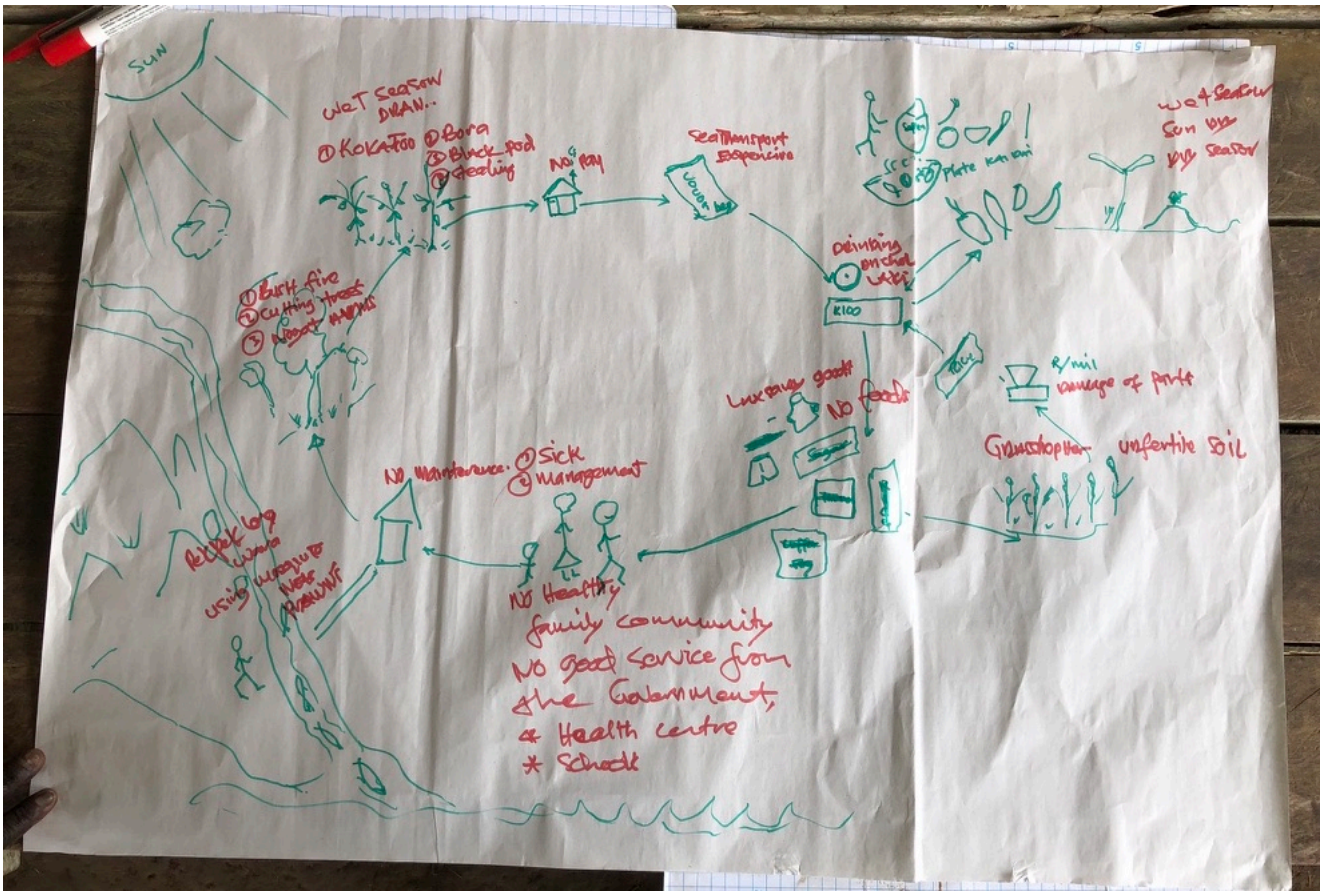


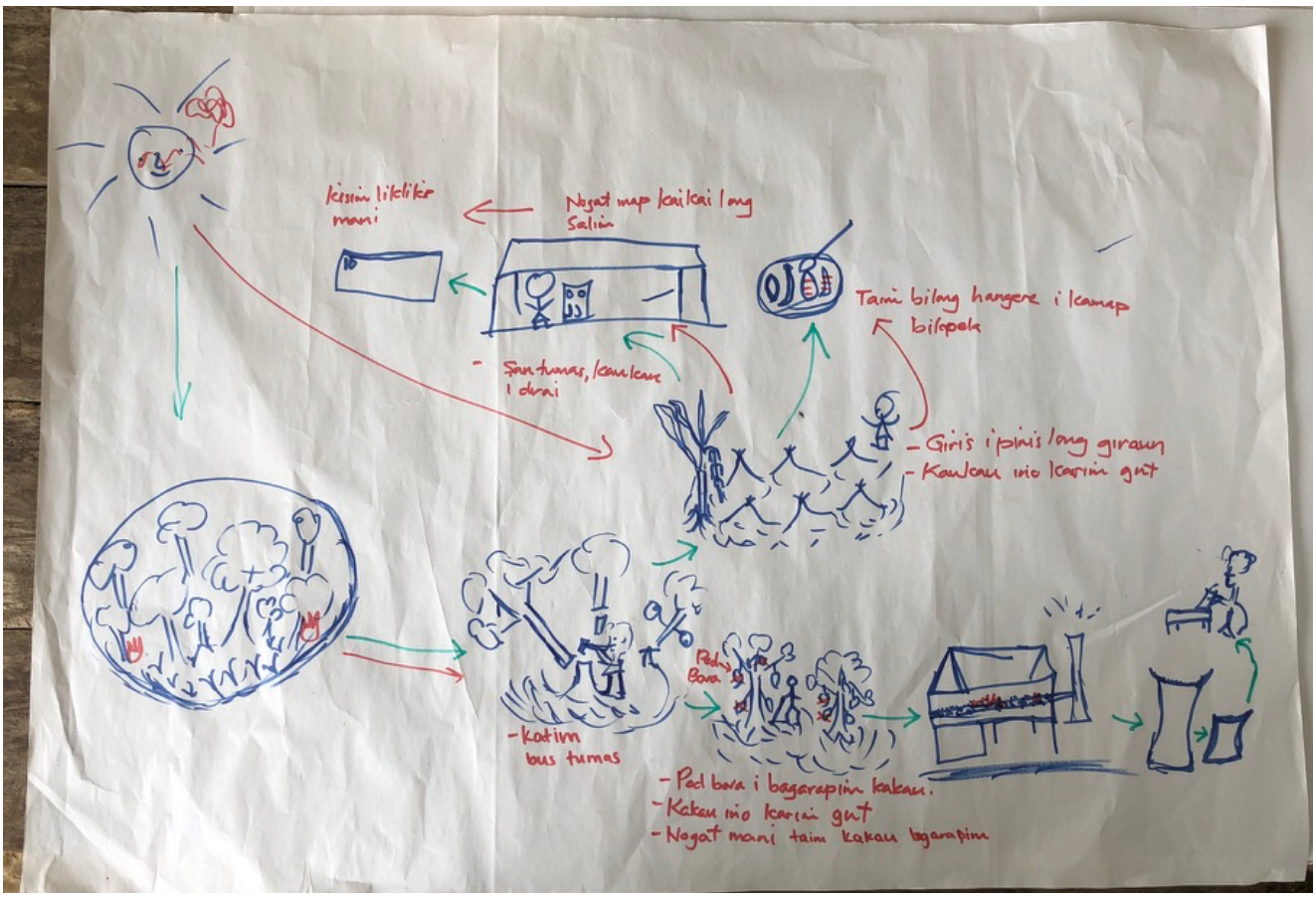
Workshop 14: 15 November, Tomasi-Makakoa)





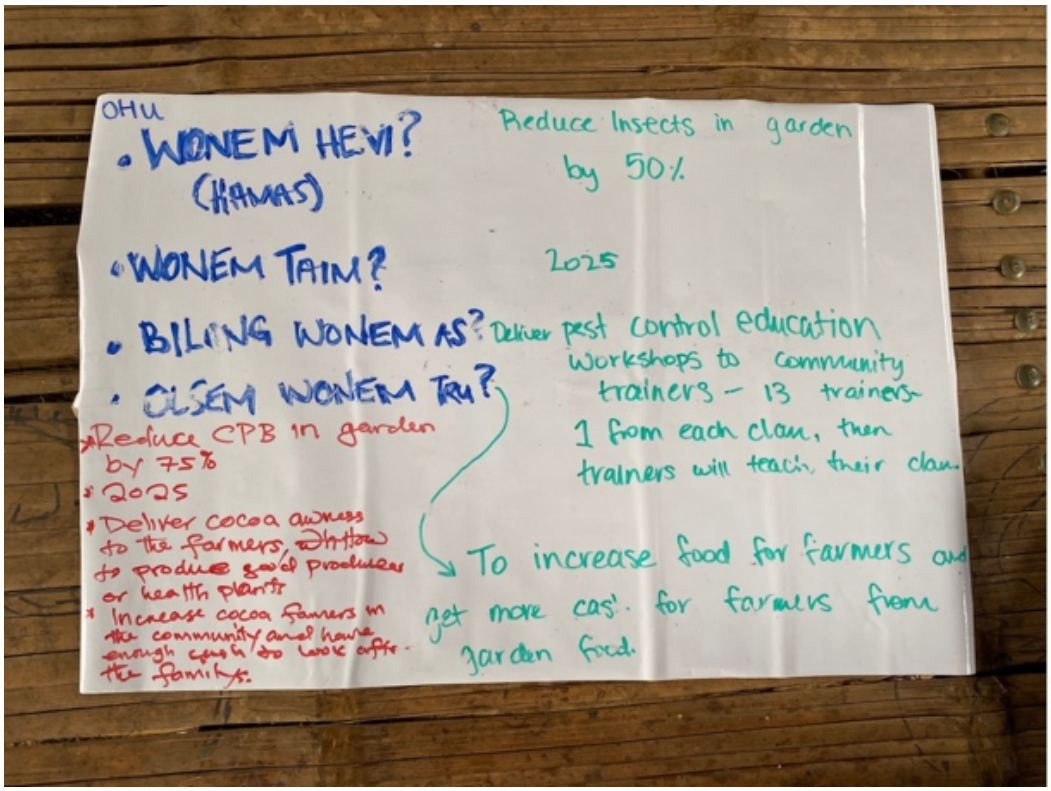
Workshop 15: 22 November 2023, Siato-Ubuko





Appendix G: Sample Transformation Statement Outputs

Workshop 3: 3 October 2023, Ohu



What problem/difficulty would you like to address?
Garden pests.

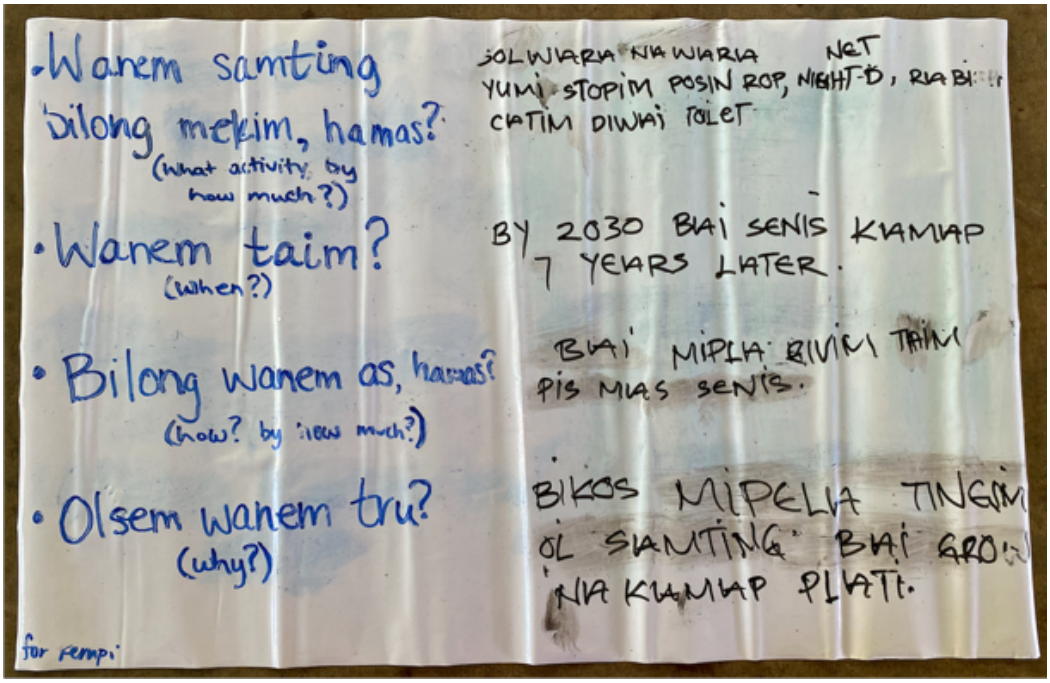
What is something you would like to do to reduce this problem/difficulty*? Put a target number to achieve action on this problem (This is your "project")*:
Reduce pests in gardens by 75%. To do this, the project will deliver pest control education workshops to community trainers – 13 trainers (1 from each clan), then trainers will teach their clan members.

Over what time period would you like to complete this project?
2025.

What goal do you have in this project? *Put a target number for your goal.*
Train 13 farmers.

What is the overarching goal that you'd like this project to achieve?
To increase food for farmers and get more money for farmers from garden food.

Workshop 8: 17 October 2023, Rempi



What problem/difficulty would you like to address?
Water quality (ocean and freshwater rivers in the community).

What is something you would like to do to reduce this problem/difficulty*? Put a target number to achieve action on this problem (This is your "project")*:
Education program to stop "poison rope*" fishing, stop going fishing at night with nets, stop cutting trees near the river, and stop going to the toilet in the river.

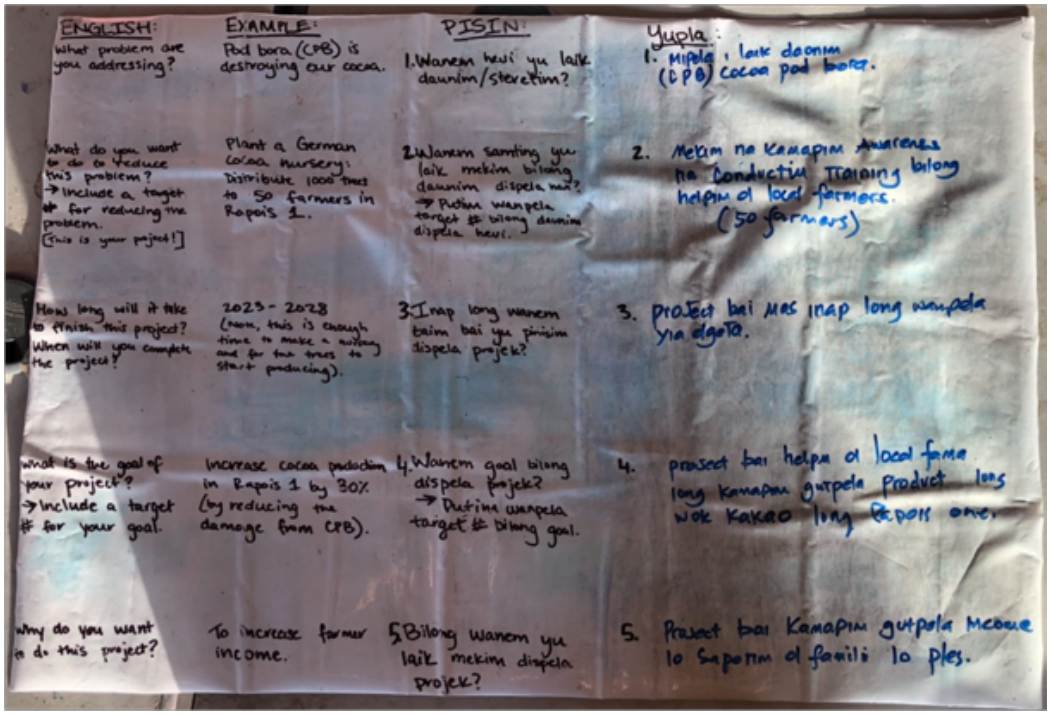
Over what time period would you like to complete this project?
Water to be clean an improved by 2030.

What goal do you have in this project? *Put a target number for your goal.*
Improve the fish [population] in our river.

What is the overarching goal that you'd like this project to achieve?
To improve community health.

* Note, poison rope fishing uses the naturally occurring Derriss Root plant. The roots of which are mashed with a rock into a white pulp which is then jammed into the coral by a fishermen swimming down to the reef top. The pulp of the Derriss Root contains the poison Rotenon, which kills small fish and coral polyps. But forces larger fish to the surface where they are easily caught. With no real awareness of the destructive impact of the Rotenon, poison rope fishing can appear to be a very effective way to catch fish. However, the reality is that it is destructive.

Workshop 14: 15 November 2023, Tomasi-Makakoa



What problem/difficulty would you like to reduce?
Reduce CPB

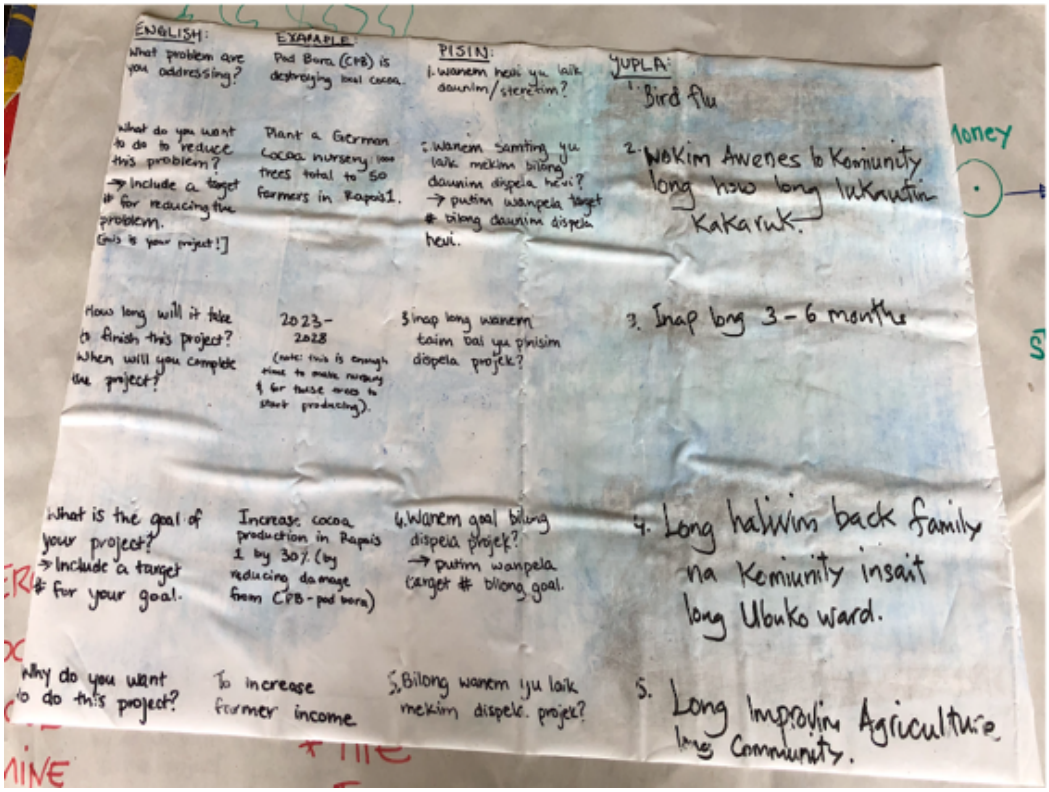
What is something you would like to do to reduce this problem/difficulty? Put a target number to achieve action on this problem (This is your "project"):
Increase awareness by conducting trainings to help 50 farmers (in the area).

By what time would you like to complete this project?
This project will be complete in one year.

What goal do you have in this project? Put a target number for your goal.
The project will help local farmers to increase good cocoa products in throughout one target district (Rapois 1).

What is the overarching goal that you'd like this project to achieve?
This project will increase income and support for families in this area.

Workshop 19: 27 November 2023, Ubuko-Siato



What problem/difficulty would you like to address?
Bird flu.

What is something you would like to do to reduce this problem/difficulty*? Put a target number to achieve action on this problem (This is your "project")*:
Increase knowledge and awareness in the community on how to look after chickens.

Over what time period would you like to complete this project?
3 – 6 months.

What goal do you have in this project? *Put a target number for your goal.*
To help the communities in the Ubuko ward.

What is the overarching goal that you'd like this project to achieve?
To improve agriculture in the communities.

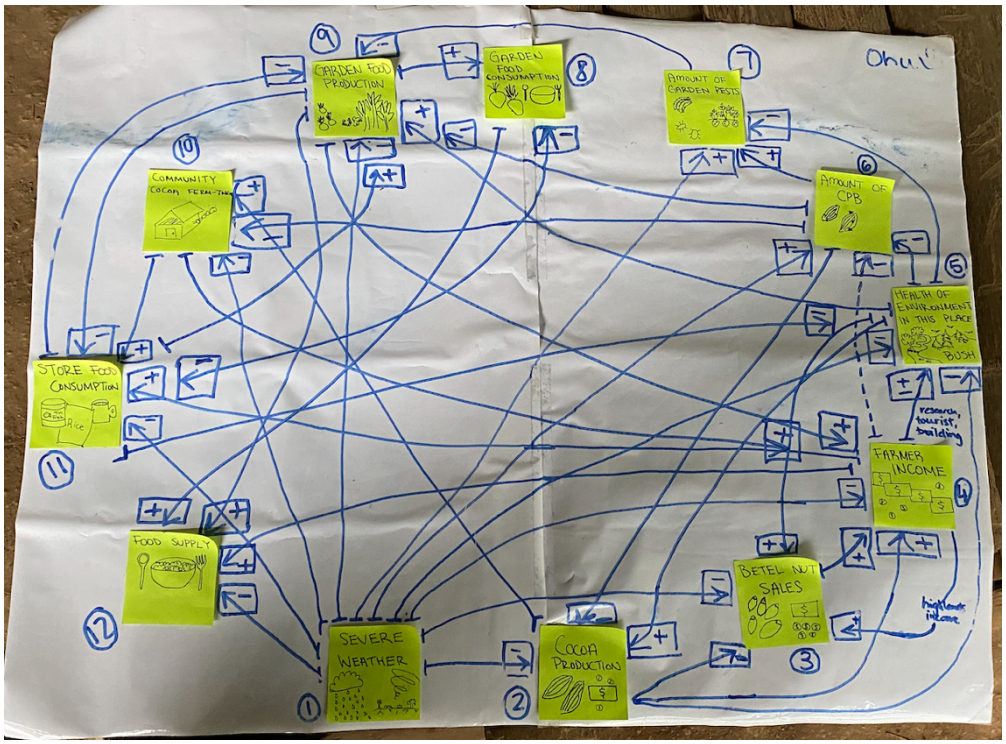
Appendix H: Sample Inter-Relationship Digraph Outputs

All IRDs were created by hand. While I did the drawing, each group would discuss among themselves and determine the direction of arrows in a systematic one-by-one process.

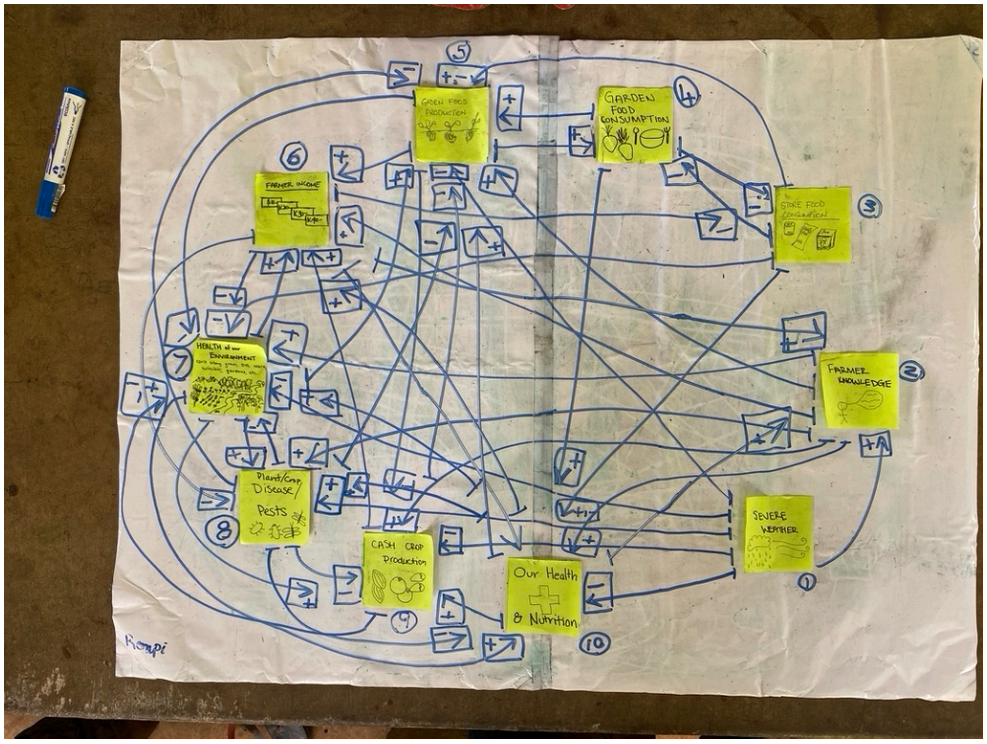


Figure A4 Creating an IRD by hand in Ohu.

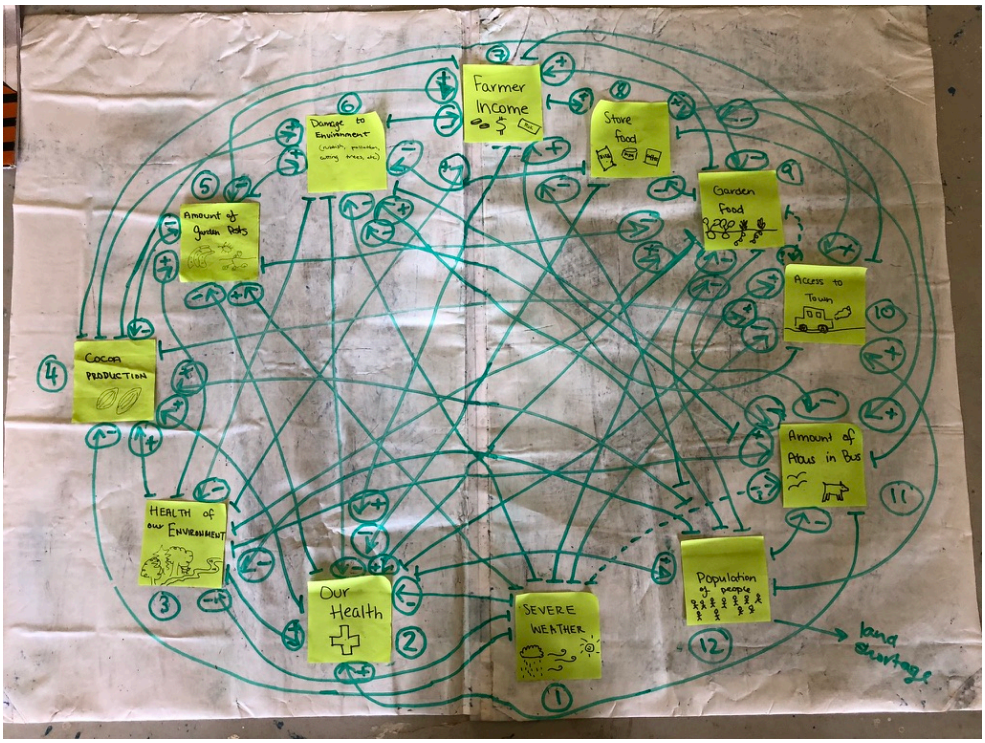
Workshop 2: 2 October 2023, Ohu



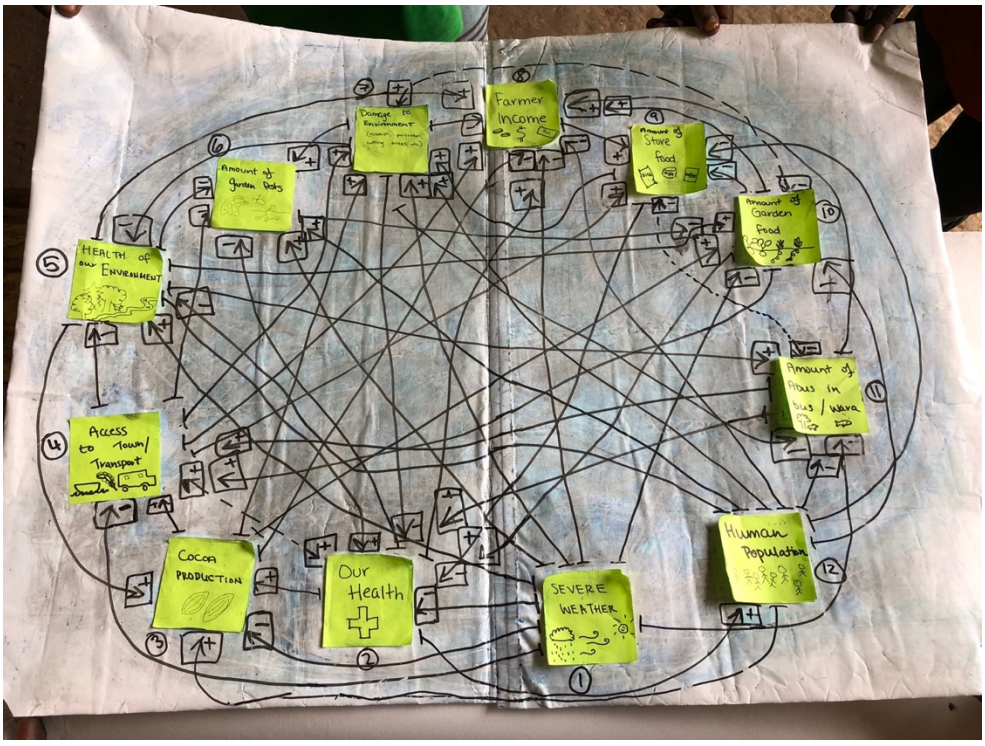
Workshop 8: 17 October 2023, Rempi



Workshop 11: 12 November, Tomasi-Makakoa

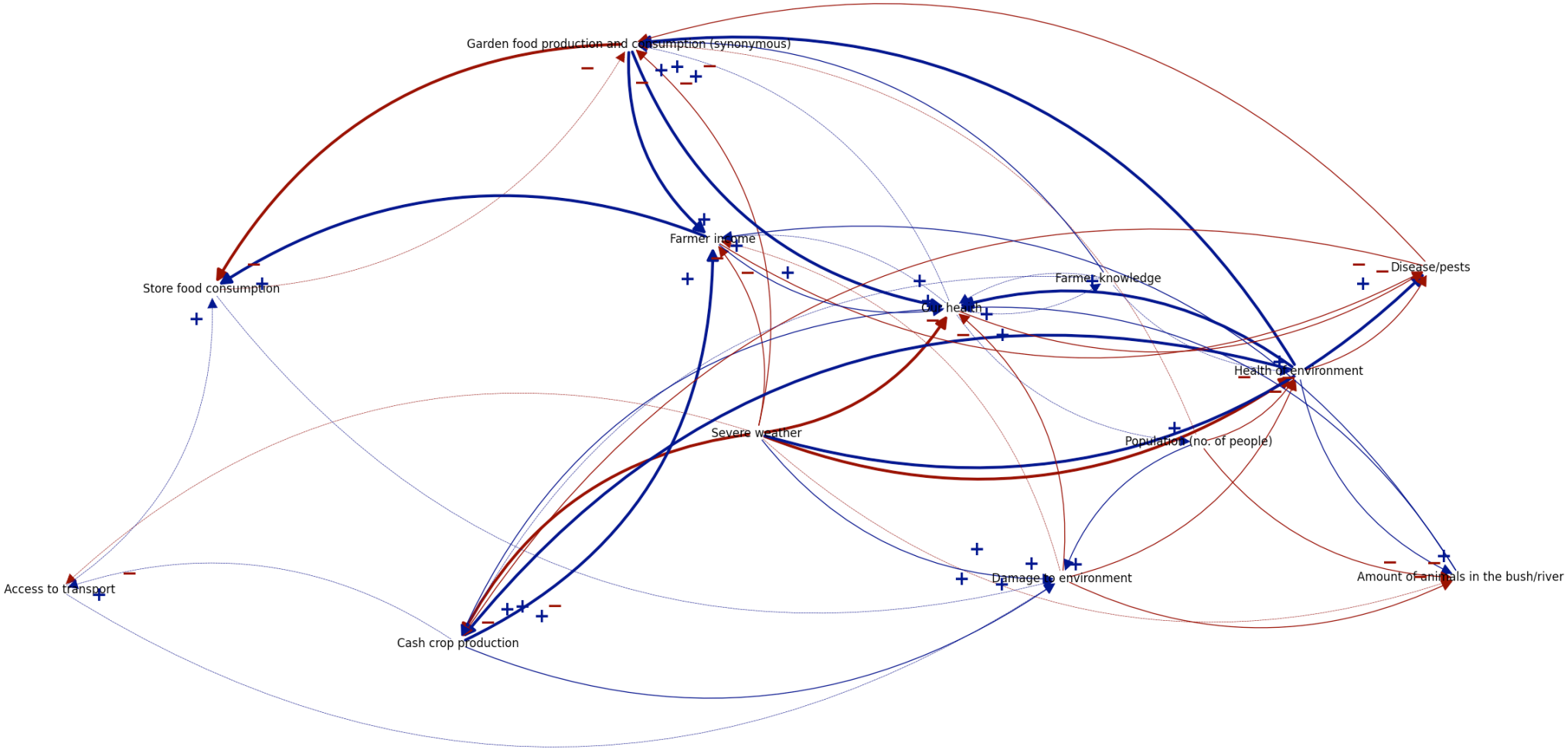


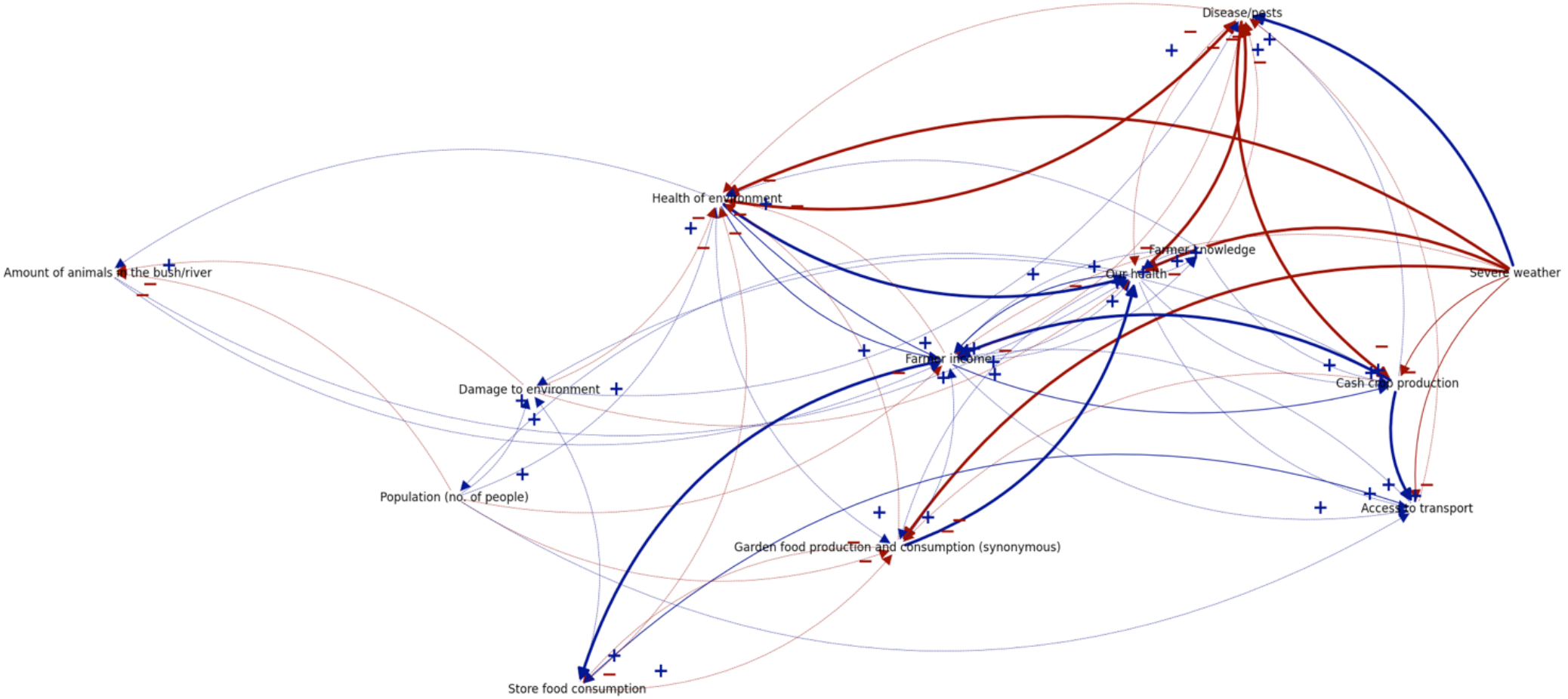
Workshop 18: 24 November 2023, Ubuko-Siato



Appendix I: Sample Participatory Systems Maps Outputs

PSMs grouped by focus groups that were composed of “regular farmers” (top, n = 16) compared with “fermentary owners” (bottom, n = 4). Stronger relationships (indicated by a higher number of groups) are indicated with darker/ thicker arrows.




Disease/pests
Health of environment
Amount of animals in the bush/river
Farmer knowledge
Our health
Severe weather
Farmer income
Damage to environment
Cash crop production
Population (no. of people)
Access to transport
Garden food production and consumption (synonymous)
Store food consumption

Appendix J: Conducting Justice-Sensitive and Ethical Research

An important part of this thesis was ensuring data collection was completed in an ethical and justice-aligned manner. The work was informed by Picot and Grasham (2022)[15] and additionally took several measures to ensure aligned principles throughout the work, which were detailed in **Appendix A**.

During the data collection phase of this work, I compensated participants for their time in the half day workshops (equivalent of one full day of labour in a cocoa block). This required an additional request through the CUREC committee and was not covered by my funding bodies, so was funded by me directly. In addition to travelling for data collection, I visited to PNG to circulate results of fieldwork and validate research findings at the end of 2025. While this required carbon intensive flying, I believe it was a vital component of the research process. All too often, researchers take information from communities to produce knowledge without sharing results. I travelled to the research communities and conducted findings workshops in Tok Pixin, sharing results and confirming the findings of analysis. The contents of these workshops is detailed in the Results Dissemination Sheet in **Appendix K**, of which I distributed laminated copies to communities in both English and Tok Pisin in addition to the oral workshop delivery.

Further, while I was in country, I was able to share my findings with the PNG National Research Institute at the end of 2025. The latter will pave the way for linking with appropriate policy bodies to write a relevant policy brief arising from this work.

[15] PICOT, L. & GRASHAM, C. F. 2022. Code of conduct for ethical fieldwork.

Appendix K: Results Dissemination Sheet

The following pages were distributed to the communities where I conducted research for this thesis. In addition to providing laminated copies in both English and Tok Pisin to be available for the reference of community members, I led a workshop (which was announced in advance and open to all community members) that talked through the contents of the sheet and acted as a community-wide discussion forum. At the end of each section, community members asked questions, and at the end of the workshop, we did a long "question and answer" discussion. The topics ranged from what children should eat before school to discussions on increasing chemical use in cocoa blocks and water quality. In addition to the following pages, I also supplied the community with as much information as I could find on community grant applications (such as from Digicel and Steamships), as this was something I was asked a lot about during the data collection phase of my fieldwork.

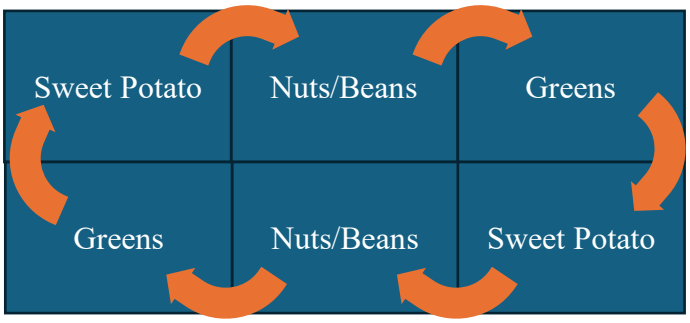
This information was provided by Genia Hill, an Australian PhD student from Oxford University in England for work which was conducted 2023 – 2025. Genia can be best reached at genia.hill@gmail.com. You can also try WhatsApp, although this phone number may change: +447774144084 (England) or +61403673327 (Australia).

These learnings are taken from work in the following communities Ohu and Rempi (near Madang Town) and Tomasi, Makakoa, Ubuko and Siato (on the West Coast of Bougainville). These communities help their gardens, their place, their finances, and their diet in many ways. Below are some of the things people did to help in their place. Note that in PNG and Bougainville, in the future, your weather will get hotter and rainier, and the seasons will get more confused, so it is good to build strong and well prepared communities.

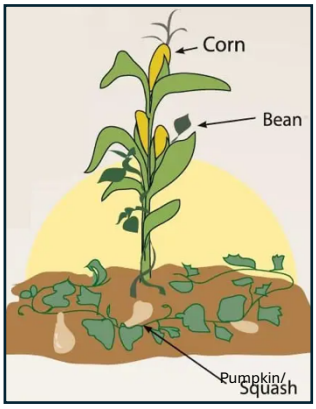
Learnings from Interviews

Garden

Some farmers said that these activities helped soil quality: planting nuts and beans after sweet potato/root crops, and rotating nuts and beans in different spots in the garden. Some also interplant pumpkin, beans, and corn. Some farmers had a challenge with peanuts getting stolen. Beans (such as soya beans, lima beans, or pidgin peas) are also helpful for soil health and because they have to be cooked before eating, so they may be stolen less often.



or



Some farmers also found that using mulch helped with soil quality, especially when the sun is too hot.

> Mulch is made from plant materials that cover the soil to keep it cool and moist. It can be made using dry grass, leaves, banana stems, coconut husks, or garden waste. First, collect the materials and let them dry a little. Then break them into pieces and spread them on the ground around crops (not over the top of them) about 5–10 cm thick. Mulch helps to add nutrients to the soil as it rots. Avoid using diseased plants. Replace mulch when it breaks down.

Some farmers found that building drains helps to reduce impacts of too much rain. Some also found that planting bamboo or big trees around the garden helps reduce landslides.

Some farmers found that building further away from the river/creek helped to reduce impacts of flooding.

Diet and Health

Some community advisers said to avoid too much betel nut (chewing can cause cancer). Betel nut can especially be harmful for children.

Some community advisers said to try to eat protein regularly. If you cannot get protein from animal foods or eggs, you can also get protein from peanuts and beans, which can help your diet and help your soil health.

Some community advisers said that garden food is healthier than store food. Sweet potato, taro, and cassava are much healthier than rice. Too much rice without balance from vegetables and protein can be harmful to health.

Income and Cash Cropping

Some farmers said these rules help them best look after their cocoa to grow the most pods and earn the most income. It is much better to put more work into the cocoa you have already and to manage it properly (and get higher yields). It is worse for income and for your place to clear more bush and plant more cocoa that you don't put much labour into, and that has low yields. Some from Cocoa Board also advised that cocoa is not productive when it gets too old, so it is good to gradually replace old trees with younger trees. Cocoa Board also said they will only help organised groups (cooperatives), not individuals, so if you want help from them, you must organise in groups. Basic rules to help cocoa come up strong and yield well:

- Keep your block clean of scrub and bush.
- Prune your cocoa regularly.
- If you have CPB, prune these pods and bury them at least 30 cm below the ground. Do not throw empty pods on the ground or in the water.
- Use good planting materials and maintain tree spacing.

Some community advisers said it is good to have some variety in how you earn money. For example, a bit of cocoa and some poultry instead of putting all your labour and money into cocoa or all your labour and money into poultry.

Some farmers said it was useful to make groups or cooperatives within their communities, especially to help with getting advice/education on cocoa. The Cocoa Board has advised they are more willing to provide advice to help groups and they are not able to help individual farmers.

Some farmers said it was useful save a bit of money every time they earn some. Then they were able to re-invest it so that they could earn more later (see example in the blue box on the next page).

Example: Re-investment and Saving



Peter is a smallholder cocoa farmer. Every time he sold his cocoa last year, he kept aside 10 Kina from his earnings instead of spending it all. He sold cocoa 40 times over the course of the year.

40 sales total, saving 10 Kina each time, means he saved 400 Kina!

After one year, he had saved enough money to buy a new pruning saw and bush knife. With these tools, Peter was able to clean his cocoa block properly and prune his trees at the right time.

Because his trees were healthier, they grew more pods. In the next season, Peter earned more money than before. Peter keeps saving and reinvesting what he saves up, so that over time, he can earn even more income.

Place and Environment:

Some community members said it is good to plant species of local trees near your river or creek to help keep it stay clean. It is also good to plant plenty of shade trees near your home to stay cool.

Some community members said it is good to minimise cutting trees to help the air, the water, the soil, and the animals in your community and to help for the future. They advised that if you must cut one tree (ex. to build your house), do not cut on the ridges or near the river/creek. If you cut, you must plant ten (10) trees to replace every tree you cut. Avoid cutting virgin forest. If you must cut bush, cut secondary forest and try not to cut big bush.

Some community members said it was best not to use pesticides or sprays (or to use them as little as possible), saying that it made their local chickens sick and their children unwell if they were exposed to any of the spray or fumes.

Some community members advised to not go to the toilet in the river. If you do not have access to a toilet, bury your waste at least 20 cm (at least the length of an adult hand) under the soil, and at least 200 steps away from the closest river.

Some community members advised to not throw rubbish in the water or in the bush. It is best to collect rubbish and bury it deep in a pit, far from gardens and water sources. Burning plastic can make fumes that make the air bad, so avoid burning plastic. Batteries are special and cannot be buried because they have chemicals inside them. Keep empty batteries in a sealed container (such as a water bottle) and keep the sealed container up high, away from children and animals. Take the container to town and dispose of it there.

Learnings from Workshops

Workshop findings will be shared with your local Member of Parliament and the Cocoa Board after we discuss them together.

From mapping exercises conducted with members in each community, we learned about the biggest challenges, influences, and more important results of farming and gardening. Every community had a unique set of maps. We found that it didn't matter as much whether you were a farmer or a fermentary owner, but what mattered more was the community context. **This tells us that governments and institutions helping communities must consult with farmers more before designing farming interventions so they can learn what your community wants and needs.**

Community	Important driving factors (biggest "causes")	Important outcomes (most important results from your farming and cash cropping practices)
Ohu	Severe weather	Garden food production
	Farmer knowledge	Cocoa production
	Health of environment	Farmer income
Rempi	Our health	Cash crop production
	Farmer income	Health of environment
	Farmer knowledge	Our health
Tomasi and Makakoa	Severe weather	Our health
	Health of environment	Farmer income
	Our health	Garden food production & consumption
Ubuko and Siato	Severe weather	Farmer income
	Health of environment	Our health
	Garden food production & consumption	Damage to environment

From transformation statements, we learned what kinds of interventions you want to see in your community. This told us that some of the most important interventions needed are to help your income.

Theme	Regular Farmers	Fermentary Owners	Total
Improving Income	11/27	5/7	16/34
Improving Diet	1/27	0/7	1/34
Improving Income and Diet Combined	7/27	1/7	8/34
Improving Conservation	4/27	0/7	4/34
Other	2 (water)/27 1 (peace)/27	1 (connectivity)/7	3/34

Community Grants

There was a lot of interest from members of all the communities about how to apply for Community Grants, such as through Digicel and through your church. I have provided printouts with details and application forms.

Appendix L: Teamwork Contributions Alongside This Thesis

Alongside the production of this thesis, I was fortunate to contribute to additional projects both academically and with impact projects alongside Fiji National University (FNU), Monash University and the Green Climate Fund/Secretariat of the Pacific Regional Environment Programme (for the Republic of Nauru). The abstracts of the academic articles are copied below. While these works are not directly part of this thesis, they supported the thinking that went into the development of this work.

Academic Contributions:

- Hasnain, S., **Hill, G.,** 2025. A Case for Clarity: Defining Food System Drivers, Outcomes, and Feedbacks. *The International Journal of Sociology of Agriculture and Food , 31(1), pp.235-253.*
- Picot, L.E., **Hill, G.,** Sarpong, B., Obeng, A.A., Mensah, F.K., Adjei, K.A., Adjei, R.K., Malhi, Y. and McDermott, C.L., 2024. Cocoa vs. food crops: smallholders' seasonal food access and extension support for climate adaptation in Ghana. *Climate and Development*, *17*(6), pp.505-517.

Impact Work:

- RONAdapt 2025 (in partnership with Paul Dargusch, Mavis Depaune, and Tyrone Deiye and the Nauru Department of Climate Change and Natural Resources). Alongside RONAdapt 2025, I also supported work on Climate Change Capacity Building Plan with Nauruan stakeholders, a national Climate Change Communications Strategy, and an Audit of Climate Documentation and Green Climate Fund Readiness for the Republic of Nauru.
- Collaboration with FNU to develop a concept note and plan for the FNU Climate Smart Melanesian Indigenous Foods Centre.

A Case for Clarity: Defining Food System Drivers, Outcomes, and Feedbacks

Saher Hasnain and **Genia Hill**

Note that Table 1 from this paper is copied below to add background information which supports the Literature Review of this thesis.

Abstract: Food systems frameworks are useful analytical tools for understanding the functioning of a complex set of activities, stakeholders, and system outcomes, and for developing interventions for more desirable futures. Despite the rapid proliferation of food systems framings in recent decades, the field remains under-theorised with inconsistent and ambiguous terminology for core concepts like 'drivers', 'outcomes', and 'feedbacks'. This lack of clarity hinders effective communication, research, and intervention design. This paper argues that clarifying these terms is essential for advancing food systems understanding and informing transformative action. We begin by critically examining how these terms are currently used in the food systems literature, highlighting inconsistencies and potential implications. Drawing upon geography literature, which usefully examines spatial dynamics, scale, and human-environment interactions, we then explore how analogous concepts are employed, seeking potential cross-disciplinary learning and enrichment. Geographical perspectives, with their emphasis on spatial dynamics, scale, and human-environment interactions, offer valuable insights for refining our understanding of food system processes. Drawing on this interdisciplinary exploration, we propose that researchers more clearly indicate how the key concepts of 'drivers', 'outcomes', and 'feedbacks' within food systems analyses are being used and offer a distillation of their relationships with each other as key system

elements. This will promote more rigorous and consistent approaches to studying food system dynamics, facilitating more effective research, policy development, and practical interventions. Ultimately, this paper underscores the importance of terminological clarity and interdisciplinary collaboration for addressing the complex challenges facing food systems and achieving a more just and sustainable food future.

Table A3 From Hasnain and Hill, 2025. Selected food systems frameworks and how they represent or define drivers, outcomes, and feedbacks.

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
Acharya et al., 2014. Centre for Integrated Modeling of Sustainable Agriculture and Nutrition Security (CIMSANS) project	Access, behaviour, business opportunity, nutrition opportunity, fisheries and nutrition policies.	Visualisation of conceptual framework does not label drivers, but shows an enabling environment which leads to system shape and dynamics.	Social outcomes, nutrition and sustainability outcomes, and food system resilience. The overarching 'goal' is to achieve sustainable nutrition security.	Visualisation of conceptual framework does not label outcomes. The system's goal is achieving sustainable nutrition security.	System elements are interconnected through linkages.	Visualisation of conceptual framework does not label feedbacks, but shows how system elements are directly interconnected through linkages. Arrows between consumers/consumption and food chain actors, and food chain actors and producers. Arrow towards system goal of sustainable nutrition security.

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
Béné et al., 2019. Food systems framework in *Understanding food systems drivers: A critical review of the literature*	Driver categories of production / supply, distribution / trade, and consumption / demand.	Shown as boxes that interact with each other (production / supply drivers, distribution / supply drivers, consumption / demand drivers). These drivers interact and have a 'durable effect' on food system actors and activities.	Nutrition, food security and health; environment; social; and economic outcomes, and that these different outcomes are characterized by synergies and trade-offs.	Outcomes are shown to arise from food system actors, food environments, and consumers. Outcomes interact with each other through trade-offs and synergies, and additionally, they connect to feedbacks.	Feedbacks are often nonlinear and connect outcomes and drivers.	Feedbacks labelled, showing connections between outcomes and drivers. Different arrows indicating feedback, durable effects, interactions, impacts and influence and trade-offs and synergies.
Brunori et al., 2015. Assessment of the impact of drivers of change on Europe's food and nutrition security (TRANSMANGO)	Biophysical, socio-cultural, economic, political, technological (depicted outside the overarching system of food regime).	Drivers come from outside the food system regime and are connected to the food system regime through impacting it, and from feedbacks back to the drivers from the	Food security, environmental security and other social interests Outcomes are discussed, particularly with reference to food system vulnerability.	Arise as a direct result of food system actors and activities. They fall under categories of food and nutrition security, socio-economic welfare, and	Feedbacks and impacts have a delay between drivers and food system regime, arrows indicating coordination, interaction and interconnectedness,	Feedbacks arise from the food system regime and with a one-way arrow, feedback to drivers (with or without delay). Feedbacks also arise from food system

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
		regime. Drivers are independent or overlapping, falling under categories of bio-physical, socio-cultural, economic, political, and technological.	Similarly to Ericksen, 2008, outcomes arise from food system activities (their contributions to food security, environmental security, and socio-economic welfare).	environmental security.	flow resources and services, and food system outcomes.	outcomes (within the food system regime) and with a one-way arrow, feedback to institutions, assets, and actors/activities (with or without a delay).
Ericksen, 2008. Global Environment Change and Food Systems (GECAFS) Programme	Global environmental change, socio-economic drivers, 'natural' drivers, and driver interactions.	Drivers arise through feedbacks and fall under categories 'global environmental change' drivers and socioeconomic drivers. These interact and influence food system activities and food system outcomes directly. This visual	The three categories of outcomes considered in this framework—food security, environmental security, and social welfare often trade-off with one another across level. Outcomes are also drivers of global	Outcomes contribute to social welfare, food security, and environmental security/natural capital. These outcomes interact with each other with bi-directional arrows and also feedback from outcomes to drivers.	Feedbacks are non-linear and connect outcomes to drivers.	Feedbacks are socio-economic or environmental, arising from food system activities or outcomes and resulting in drivers on the system; feedbacks connect from outcomes to drivers. There are arrows between

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
		depiction does not show the food system as nested within natural or social systems, so it is unclear whether drivers are endogenous or exogenous to the system, or both.	environmental change and create feedback loops.			drivers, activities and outcomes.
Fanzo et al, 2021. Food Systems for 2030 framework	Biophysical, climate, and environment, income growth and distribution, politics and leadership, sociocultural dynamics, population growth, migration, and conflict, globalization and trade, land use and	Drivers influence components of the food system, policies, SDGs, and sustainability and resilience. There is no connection in the conceptual framework visualisation between drivers and outcomes.	Outcomes are not explicitly defined but they are grouped into three thematic areas (1) Diets, nutrition, and health; (2) Environment and climate; and (3)	Outcomes are depicted to arise from the components of the food system (supply chains, food environments, etc.) and policies, SDGs, and sustainability and resilience. There is no connection in the	Components of the food system have feedback loops with each other and with the drivers and outcomes.	Feedbacks are not labelled or the focus of the conceptual framework visualisation, however each element of the system has an outward arrow from it into the rest of the system.

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
	urbanization. Drivers are processes, and the components have feedback loops with each other and with the drivers and outcomes. Drivers can influence the directionality and dynamism of interactions between actors and components, which can help or hinder transformation.		Livelihoods, poverty, and equity. Cross-cutting areas focus on (4) Governance and (5) Resilience and sustainability.	conceptual framework visualisation between drivers and outcomes.		
Global Panel on Agriculture and Food Systems for Nutrition (GLOPAN), 2016. Food systems framework	Drivers of food system exist outside of the food system and broadly exert influence on it.	It is unclear in the visual representation if the drivers are completely external to the system. The food supply system appears	Diet quality as a focal outcome.	The middle (potentially the target) of the system and sub-systems.	Not explicitly discussed.	Double-headed arrows between the four subsystems.

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
		embedded within the drivers of the food system.				
HLPE, 2017. Nutrition and food systems. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. HLPE Report 12.	Biophysical and environmental, innovation, technology and infrastructure, political and economic, socio-cultural, and demographic	Drivers arise from outcomes via feedbacks. Drivers fall within five categories that act on food supply chains: food environments, and consumer behaviour; Biophysical and environmental drivers; Innovation, technology and infrastructure drivers; Political and economic drivers; Socio-cultural drivers; Demographic drivers.	Outcome areas are: nutrition and health outcomes, environmental outcomes, economic outcomes, and social equity outcomes.	Focus on Nutrition and health outcomes. Other dimensions are captured as impacts: social, economic, and environmental.	There are feedbacks between political, programme and institutional actions and drivers, nutrition and health outcomes, impacts and drivers, impacts and political, programme and institutional actions, and between drivers and the linked systems.	Feedbacks connect outcomes and impacts in a uni-directional arrow back to drivers. There is also a bi-directional connection from food supply chains, food environments, and consumer behaviour with biophysical and environmental drivers and the SDGs through the medium of 'political, programme and institutional actions'.

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
Nguyen, 2018. Food and Agriculture Organization (FAO) food system	Not explicitly named as drivers. Natural elements (air soils ecosystems and genetics, water, climate) and societal elements (organizations, policies, laws and regulations, infrastructures, socio-cultural norms) as the outer most rings of a nested system.	There are no drivers explicitly named in the conceptual visualisation, however, the core system interacts with natural elements and societal elements through bi-directional arrows.	The food system wheel has goals and 'performance' instead of outcomes. These goals are poverty reduction, food security and nutrition; the performance of the system refers to three dimensions of sustainability: economic, social, and environmental.	Central to the core system are highlighted elements: sustainability performance, and poverty reduction,	Feedbacks connect societal and natural elements between each other and the core food system.	Feedbacks are not explicitly labelled in the visualisation, however, there are bi-directional arrows between natural elements and societal elements with the core system.
Parsons et al., 2019. City, University of London's Centre for Food Policy's food system map	'Dimensions' of economics, politics, the environment, health, and society functioning as drivers	Drivers and outcomes are the dimensions that shape and are shaped by the food supply chain: health, politics,	Drivers and outcomes are the dimensions that shape the food supply chain: health, politics, environment, society,	Drivers and outcomes are the dimensions that shape and are shaped by the food supply chain: health, politics,	Each dimension feeds into the food chain dimension, which connects back.	As drivers and outcomes are represented by the same part of the figure, there are numerous bi-

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
	and outcomes. Drivers are the factors that 'push or pull' the food supply chain of food system activities.	environment, society, and economy.	and economy. While drivers and outcomes are typically portrayed as separate, this approach posits that drivers can also be outcomes, and outcomes, drivers.	environment, society, and economy.		directional arrows between the driver/outcome combined dimensions and the food chain.
Stefanovic et al., 2020. Food System Outcomes: An Overview and the Contribution to Food Systems Transformation	Drivers are comprised of interactions within and between Bio-geophysical and human environments as well as interactions and feedbacks between them.	No conceptual framework visualisation.	Outcomes arise from food system activities. They note that although the classification of outcomes vary from author to author, regardless of the differences the outcome categories can generally be assigned to four broad	No conceptual framework visualisation.	Feedbacks are the interactions between all elements of the food system	No conceptual framework visualisation.

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
			groups: food and nutrition security (or health pillar) and the three pillars of sustainability, namely environmental, social and economic.			
Webb et al. 2023. Measurement of diets that are healthy, environmentally sustainable, affordable, and equitable: A scoping review of metrics, findings, and research gaps	Drivers are not the focal area of this paper.	No conceptual framework visualisation.	Categorised as the dimensions of sustainable healthy diets: planetary health, human health, economic, and social outcomes.	No conceptual framework visualisation of the food system, but a chord diagram demonstrating how outcomes are interconnected.	Feedbacks are not the focal point of this paper however they are mentioned as the mediator linking climate and ecology, human health and nutrition, food prices, and social justice.	No conceptual framework visualisation.
Westhoek et al.,(2016). United	Biophysical and socio-economic drivers.	Socio-economic drivers arise from	Outcomes related to social factors feedback	Food system outcomes contribute to	Feedbacks connect drivers, activities,	Depicted as one way arrows between

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
Nations Environment Program International Resources Panel		social food system outcomes and in turn impact food system activities ; these interact with natural resources to influence food system activities.	to social-economic drivers while the outcomes related to environmental factors feedback to natural resources.	environmental factors, food security, and societal factors. These feedback with unidirectional arrow to natural resources and socio-economic drivers.	environment, and natural resources.	outcomes and natural resources and socio-economic drivers. There are also bi-directional arrows between natural resources and food system activities, food system activities and outcomes, and food system activities and socio-economic drivers.
Woodhill, 2019. Foresight4Food	Demographics and development, consumption, technology, markets, climate and environment, policy and geopolitics.	Drivers are exogenous, acting on the whole natural system and nested human and food systems. Outcomes	Economic and social well-being, food and nutrition security, and environmental sustainability.	Economic and social well-being, food and nutrition security, and environmental sustainability. Outcomes arise externally to the	Feedbacks (feedback loops) connect the wider interactions between human and natural systems.	Between Food, Human, and Natural Systems, and from Outcomes to Drivers.

Author(s) and Title	'Drivers' Representation (Narrative)	'Drivers' Representation (Conceptual framework visualisation)	'Outcomes' Representation (Narrative)	'Outcomes' Representation (Conceptual framework visualisation)	'Feedbacks' Representation (Narrative)	'Feedbacks' Outcomes Representation (Conceptual framework visualisation)
		give rise to drivers through feedbacks.		natural system and nested human and food systems. Outcomes are in three dimensions:		
Zurek et al., 2018. Metrics, Models and Foresight for European SUStainable Food and Nutrition, (SUSFANS)	Indirect and direct drivers and EU policy goals. Drivers influence the different food system actors and their activities.	Drivers are explicitly labelled as direct and indirect. Direct drivers are detailed by supply chain actors, and indirect actors are in the broad categories of economic development, population dynamics, etc.	Nutrition and diet, environmental and economic outcomes together with social equity dimensions. Outcomes arise from actors and activities, with a subsequent arrow to the 'status' of the system.	Captured as a goal, which is to influence the performance of the EU food system.	Feedbacks not explicitly defined or discussed in detail, but are mentioned as interactions and feedback loops between the food system components.	Arrows between indirect drivers (context), policy goals, status of the EU food system, and the EU food system.

Cocoa vs. Food Crops: Smallholders' Seasonal Food Access and Extension Support for Climate Adaptation in the Central Region of Ghana

Laura Picot, **Genia Hill**, Bernice Sarpong, Alexander Obeng, Felix K. Mensah, Kelvin Adjei, Richard Adjei, Yadvinder Malhi, and Constance L. McDermott

Abstract: The food security implications of the production of cocoa compared to food crops and the phenomenon of the lean season amongst smallholder farmers have been well-researched. Yet, the literature has yet to consider how climate change affects these dynamics. This study addresses this gap by comparing the contributions of cocoa and food crops to food access during extreme and variable weather. It then compares government extension support for households' climate adaptation of these crops. Our data draw on the case of smallholder cocoa farmers in Ghana's Central Region and comprise a survey of 250 households, 16 focus group discussions, and 82 semi-structured interviews with smallholders, market sellers, and government officials. We find that food crops are essential for households' food access during the cocoa lean season and when cocoa yields are reduced by climate change-related extreme or erratic weather events. However, food crop yields are themselves negatively affected by climate change impacts. Furthermore, many farmers lack climate adaptation strategies or support for food crops as government extension services focus instead on export-driven cocoa. We argue that to promote households' food stability, more smallholder extension support for food crop production and climate adaptation is urgently needed.