Understanding and Enabling Nutrition and Agriculture Linkages: Development and Implementation of Home-Grown School Feeding in Nepal

(Thesis submitted for the degree of PhD)

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ABSTRACT

Providing nutritionally balanced diets through ecologically sustainable and equitable food systems is the most profound challenge facing us today. The current state of food and nutrition security is in many ways is a legacy of the green revolution and neoliberal market based political economy. Technocratic and market- based approaches have contributed to creating a highly homogenised food system at the expense of diversity, ecological sustainability and nutrition quality. The origin of agriculture around 10000 years ago and the processes of domestication provide useful insights on the key drivers of food production that influence policy and programmes even today. More importantly there is compelling evidence which shows how the transition to agriculture adversely impacted human health in a wide range of contexts.

The study is an action research project primarily based on design, implementation and evaluation of 'Home Grown School Feeding' in eight districts across the three main agroecological zones of Nepal. It provides important policy and programmatic evidence on enabling decentralized food systems which are nutritionally and ecologically sensitive, as part of a government led universal food-based safety net project. Based on action research inquiry process, the thesis develops concepts and theories through the different chapters to contribute to our understanding of food systems and programme design. The intervention creates an effective platform for food system mediation through different pathways. Evidence on intervention governance through 'food sovereignty' lens demonstrates how HSGF interventions can also promote equity in food systems in terms of policies, funds and knowledge.

COVID-19 pandemic control measures have contributed to undermining food and nutrition security, with the poorest being hit the hardest and young children potentially facing life-long consequences. Overall evidence from the thesis including the recent covid crisis highlights the importance of resilient and context sensitive food production and it is an emphatic reminder of the need to have integrated public health-nutrition-ecology approach to food systems.

STATEMENT OF ORIGINALITY

I declare that the contents of this thesis are my own work except where otherwise acknowledged and referenced.

Samrat Singh

14 July 2022

COPYRIGHT DECLARATION

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I am deeply indebted to Prof Sir Gordon Conway, principal supervisor and Dr Lesley Drake, co-supervisor.

Prof Conway had not been supervising for quite some time to focus on his research and writing but he happily agreed to take make an exception and take me on as a student. In many ways this thesis is inspired by his vast body of work on food and agriculture. Prof Gordon was always available for a friendly chat over which we discussed the thesis amongst other things. He shared with me many of his precious field notes and monographs from the early 1970s onwards. These notes guided my fundamental approach to the intervention design and analysis. I shall forever be deeply indebted for his support, guidance, and mentorship.

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A substantial part of research and writing for this thesis was done in the Wellcome Trust Library, London. I am thankful to the trust and library staff for creating an excellent forum for research which is open to all. I believe that outside the formal university settings, such platforms are vital for fostering curiosity and discovery.

Developing the appropriate context and approach for this thesis in terms of a core idea was a long and often tedious process. I must acknowledge two books which were excellent teachers and gave me the foundational thought for this work; 'Affluence without Abundance' by James Suzman and 'Black Rice' by Judith Carney.

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Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AEZ	Agroecological zone
AMDR	Acceptable Macronutrient Distribution Range
ANPF	All Nepal Peasants' Federation
BCC	Behaviour Change Communication
DHS	Demographic and Health Survey
EAR	Estimated Average Requirement
EER	Estimated Energy Requirement
FAOSTAT	Food and Agriculture Organization of the United Nations
FCT	Food Composition Table
FGD	Focus Group Discussion
FSF	Future Smart Foods
FTC	Fixed Transaction Cost
GIAHS	Globally Important Agriculture Heritage Systems
GoN	Government of Nepal
HGSF	Home Grown School Feeding
HH	Household
ICL	Imperial College London
LEH	Linear enamel hypoplasia
LVC	La Via Campesina
MASL	Meters Above Sea Level
MDD	Minimum Dietary Diversity
MFAD	Modified Functional Attribute Diversity
MNR	Micronutrient rich
MoH	Ministry of Health
MPT	Meal Planning Tool
NARC	National Agriculture Research Council
NPR	Nepalese Rupee
NSFE	Non-Staple Food Energy
NSMP	National School Meals Programme
NUS	Neglected and Underutilized Species
PAL	Physical Activity Levels
PCD	Partnership for Child Development

RDA	Recommended Daily Allowance
SMC	School Management Committee
SMFB	School meal food basket
THFB	Typical Household Food Basket
USDA	United States Department of Agriculture
WFP	World Food Programme

INTRODUCTION

BACKGROUND

The word 'food' conjures up thousands of different images for different people across the world. A variety of perfectly shaped fruits, watery lentil soup, endless fields of wheat, a meal in a restaurant, a piece of old hard bread or a boat load of shiny fish. More importantly it has very different associations for different people. For some it is associated with flavours and satiation and for millions of others it is associated by its lack, with hunger and disease. It is telling that in large parts of the world dependent on subsistence farming, the time between planting and harvest is called the 'hunger season'. Besides hunger as we commonly understand it, more than 2 billion people worldwide suffer from hidden hunger due to nutrient deficiencies because of poor diets (IFPRI, 2014). 3.1 million child deaths occur each year due to undernutrition (Black ,2013).

Given that it defines our very existence, understanding food and hunger both in scientific and policy terms has been a key agenda for governments, international agencies and research centres. The solutions to food and nutrition security have evolved over time. Major food security interventions such as the green revolution were driven by a focus on productivity and technocratic approaches to increase edible biomass (Patel, 2104; Wald-Hill, 2016). As a response to the monlolithic post world war-2 hunger narrative and the Malthusian crisis of global shortages, nutrition gradually gained prominence. Micronutrient issues first entered nutrition discourse in the late 1950's with the introduction of iodine in salt to address iodine deficiency disorders (Allen,2005). In the 1980s, as empirical research highlighted the scale and impact of micronutrient deficiencies on human health, especially children, the following decade saw an international acknowledgement of the importance of micronutrients, with the 1990 World Summit for Children and the 1991 Montreal conference on 'ending hidden hunger' (Allen,2005).

In the post-colonial period when international agencies and donor countries created the framework of global problems and solutions, understanding of hunger including hidden hunger and its solutions came to be driven by an almost exclusive pathological approach of deficiency and disease. The solutions evolved along two axis which are often viewed as separate issues. One relates to the production of greater edible biomass through increases in agriculture productivity and the other relates to the nutrient composition of food. Together and separately these solutions led to the displacement of the cultural, ecological, social and geographical components of food by the logic of nutritionism and productivity (Hayes-Conroy,2014). Whilst these productivity driven approaches, most significantly the green revolution made substantial contributions in alleviating global hunger, together they also led to significant ecological inefficiencies and social inequities (Pingali, 2012).

The quest for food is as old as our time on earth and to a large extent the ecological and food security challenges of today are in part the legacy of agriculture itself. Agriculture distorts natural cycles and, in the process, it creates a complex web of relationships between humans and our habitat. The rationale for distorting natural cycles has always been to maximize food available for human consumption. The degree of these aspects i.e. ecological disassociation and habitat distortion evolved in non-linear patterns over thousands of years in different parts of the world and for all these years it was largely contained within the limits of natural cycle. The advent of the modern world system around four hundred years ago and the industrial revolution around two hundred years ago rapidly and comprehensively transformed the process and purpose of food getting, creating hitherto unseen ecological changes and defining human-habitat relationships as external to natural life cycles.

As the world faces critical challenges in providing food that nourishes people and protects the planet, a fundamental shift is required in the way we approach food. Over two decades ago, in his influential book, Conway called for another revolution, a *Doubly Green Revolution*, a revolution which replicates the success of the green revolution in diverse locations whilst being environmentally friendly, sustainable and equitable (Conway,1999). This thesis builds on the fundamental idea of his work, the need to reimagine and realign our food systems. Given the complexity of ideas associated with the green revolution, it can perhaps be problematic to use the phrase for new initiatives which in part seek to address the maladies of green revolution. Debates on phraseology aside, the scale and scope of new initiatives must match the enormity and urgency of the challenges facing us today, a substantial and comprehensive shift in food systems is needed, a revolution of sorts.

CONTRIBUTION OF THIS RESEARCH

A key contribution of this study is that through the different chapters, it provides much needed policy and programme relevant evidence on developing an efficient and sustainable food system intervention for universal coverage. The study is part of wider government led programme i.e. Nepal School Feeding Programme and thus uniquely positioned to generate quality evidence with high relevance for researchers, policy makers and funding agencies. This thesis contributes to our understanding of the linkages between agriculture, diets, ecology and nutrition. It provides critical insights on implementation and governance of a food system intervention as part of a national programme

The thesis also contributes to our conceptual understanding of agriculture and nutrition by developing theories and concepts related to evolution of agriculture and nutrition, food sovereignty and local food systems.

The findings of the thesis provide evidence on how a Home Grown School Feeding (HGSF) project can be developed as a platform to enable nutrition and ecologically sensitive agriculture. Globally there is great potential to design similar school feeding programmes tailored to local contexts.388 million children, receive school meals every day in at least 161 countries from all income levels (WFP, 2020). Annual global investments in school feeding are estimated to be between US$41 billion and US$43 billion (WFP, 2020). HGSF is now being recognized as an important platform to enhance local food systems. UN agencies such as WFP and FAO and regional development agencies such as AUDA (African Union Development Agency) have identified HGSF as a key programmatic component. It is well recognized that HGSF can promote dietary diversification and improve market access for smallholder farmers (Drake et al.,2017). More recently there is increasing recognition of the of role HGSF can play in developing food system related climate change adaptation strategies such as promoting climate smart foods (WFP, 2020).

APPROACH AND METHODS

The principal purpose of this thesis is to identify processes and elements for implementing a decentralized food-based safety net intervention and in this context explore and develop theoretical concepts on food system-public health interventions. The study seeks to respond to the following research questions:

1.What was the impact of the agricultural transition as a method of acquiring food on human health?

2.How does current agriculture output in intervention areas in Nepal measure in terms of fulfilling dietary needs?

3. What are key factors influencing agriculture and food production choices in intervention areas?

4. What are the main conceptual and operational components to design and implement a food-based safety net intervention embedded in a government programme?

5. How does the HGSF intervention engage local food systems?

6. How does the intervention operationalize the concept of food sovereignty in Nepal?

7. How can the intervention methods and output be applied as a tool to analyse impact of food shocks on diets in a particular context?

To respond to these research questions, the thesis applies an action research (AR) approach with the development of theory and application of data in cyclical steps with programme design and implementation (HGSF Nepal) as the central quasi-experimental component. The research process was guided by political ecology studies in terms of exploring and analysing issues.

Action research integrates action and research where the evidence generated through research informs actions in iterative cycles which are usually characterized by spiral or cyclical steps of planning, acting, observing, and evaluating the result of action (Acosta & Goltz, 2014). Through this process which can be sequential or continuous, action research can generate a set of theories, concepts or hypothesis (Caswell & Johnson, 2006). It emphasises knowledge produced in the context of application through a scientific appreciation of evidence. In some ways action research provides a balance between empiricism and the *speculative excesses of social theory uninformed by data* (Peters & Robison, 1984). Over the years different methodological interpretations have evolved within the action research framework (Caswell & Johnson, 2006). Before describing the AR application in this thesis, it is important to understand its origins and key features.

Contemporary AR origins are often traced back to the experimental work of Kurt Lewin on social psychology and organizational behaviour in the 1930's (Peters & Robison, 1984). The theoretical foundations of AR predate Lewis's work, in the pragmatist philosophical movement that originated with Charles Pierce and was further developed in the early 20th century by William James and John Dewey (Barton, Stephens & Haslett, 2009). Dewey along with his associate Mead, a social psychologist developed AR theories in the context of improving people's social and democratic participation in society and to establish social equality and social justice (Boog, 2003). Around ten years later, Lewin coined the term action research 'a comparative research on the conditions and effects or various forms of social action, and research leading to social action' (Boog, 2003). Lewin's early body of work consisted of quasi-experimental tests to show that the application of democratic participation leads to greater improvements in productivity and order compared to autocratic coercion (Aldelman, 1993).

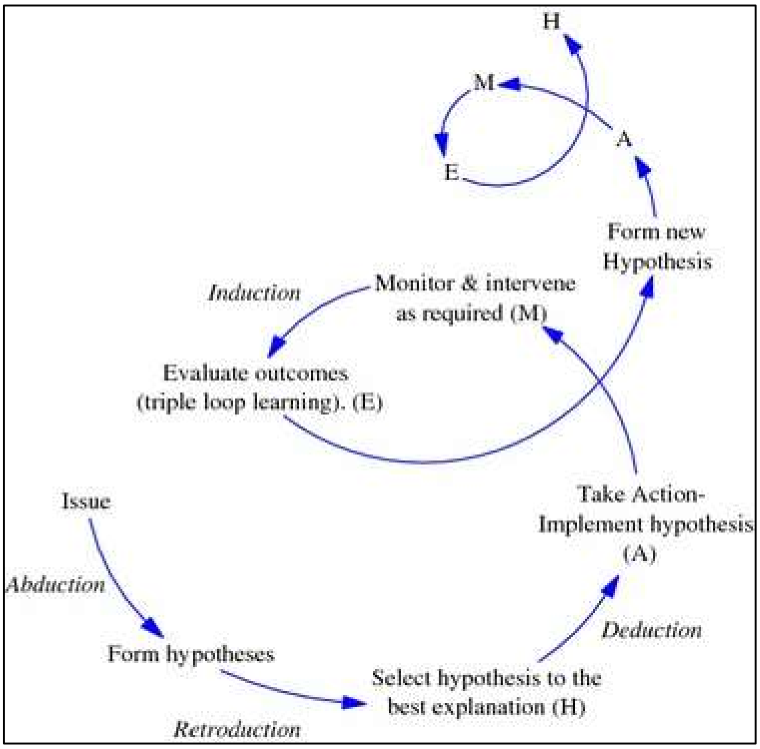
Lewin emphasised on formulating hypothesis as part of an interpretive methodology in a quasi-experimental framework (Adelman, 1993). In Lewin's conception the 'experiment' should not be too onerous, it should be naturalistic yet interventive (Adelman, 1993). The fundamental tenet of AR was studying things by changing them in 'natural' situations (Adelman, 1993; Caswell & Johnson, 2006). In later years, pioneering AR work was undertaken to develop group experiments at Centre for Group Dynamics in Massachusetts Institute of Technology, which was established by Lewin in 1945 and work on sensitivity training to combat radical and religious prejudice and racism with Ronald Lippitt at the National Training Laboratories in Connecticut (Adelman, 1993). AR was extensively applied and developed in subsequent decades in social policy interventions on health, education and housing, most of the early work being in US and UK (Boog, 2003; Caswell & Johnson, 2006; Acosta & Goltz, 2014). Action research approaches have been used in agricultural research and development since the 1970s and more recently for the study of food systems and value chains (Guzmán et al. 2013; Graef et al., 2014; Swords 2019; Braun, Bitsch & Haring, 2021).

Over the years, AR has evolved to include a range of methodological strategies and approaches; action learning; action science; developmental action inquiry; co-operative inquiry, participatory action research etc (Caswell & Jonhson, 2006). The common core element of AR across interpretations is an emphasis on theory development and enabling real world change. Some key features of AR include the following (Boog, 2003; Caswell & Jonhson, 2006; Barton, Stephens & Haslett, 2009).

1. Context specific i.e. the research is framed within specific social, ecological or cultural contexts.
2. Applies cycles of research, experiential learning and action.
3. Evaluation applies some form of single, double, and triple loop learning.
4. The research process is participatory.
5. Logic of inquiry can include abductive, deductive, and inductive modes of inference.
6. Monitoring processes that inform actions.
7. It is emergent and responsive.

The emphasis on specific features can depend on the nature of research inquiry and programmatic considerations. In contemporary AR, the logic of inquiry also varies in terms of its constituent elements. Here I present Peirce's inferential logic which can be said to represent a more original conception of AR given the contribution of Pierce to its theoretical foundations (Niiniluoto, 2006; Barton, Stephens & Haslett, 2009). The inferential logic includes three modes of inference; abduction, deduction, and induction which form the basis of most forms of AR (Barton, Stephens & Haslett, 2009; Kennedy & Thornberg, 2018). Abduction refers to the ability of a researcher to move back and forth between experiencing, reflecting, and theorizing to notice new patterns (Kennedy & Thornberg, 2018). It goes beyond data and pre-existing knowledge by creating new concepts or modifying existing concepts. Deduction begins with a theory and examines data to interrogate the validity of the theory. In qualitative research it can also include analysing data in a given theoretical framework (Kennedy & Thornberg, 2018). Induction refers to inferences based on interaction with data i.e. patterns or theories emerge from the data (Kennedy & Thornberg, 2018). The inquiry process as proposed by Pierce is illustrated in the Figure 1, below (Barton, Stephens & Haslett, 2009). Here 'retroduction' refers to the process of testing and refining hypotheses and their final selection.

FIGURE-1: ACTION RESEARCH INQUIRY PROCESS



(*Source: Barton, Stephens & Haslett, 2009*)

Given the purpose of the project and the nature of the research, the study draws in the context with interactions between the intervention, context of application and research. Therefore, Action Research was determined to be the most appropriate methodological framework for this thesis (Barton, Stephens & Haslett, 2009). AR approach in this thesis applies a form of the triadic logic described above. Some key features of AR as applied in this study are summarized below and a chapter-wise summary of the approach is provided in Table 1:

- Context specific- This element is inherent in the project design and thus flows through all research processes. It is contextualized in terms geography, culture, ecology and political economy.
- Participatory- This element was limited to the activities of the experiment which were participatory at the community and government level. Whilst knowledge was co-created with participants through these activities, research and data analysis was undertaken by the researcher with ultimate control over the research and design process.
- Logic of inquiry- It applies the triadic logic including elements of abduction, induction, deduction through the different chapters as summarized in Table 1.

- Experiment- The central experiment or intervention is naturalistic that it builds on current programmes and is embedded in local food systems and governance.
- Actions i.e. project design are informed by evidence generated through surveys and monitoring on a continuing basis.
- Learning context- Triple loop learning is implicitly applied through examination of context and systems especially food and governance systems.
- Emergent and responsive- The research reported in this thesis evolved over a three period through design, implementation and evaluation phases in a recursive process.
- Pluralistic perspectives- the study was undertaken through the actual design and intervention of the project, the analysis and findings are informed by a wide range of perspectives.

TABLE 1: SUMMARY OF MAIN APPROACH AND DATA APPLICATION BY CHAPTER

CHAPTER	DESCRIPTION/OBJECTIVE	APPROACH	DATA
1	Exploring the evolution of agriculture and its implications on human health.	Generating broader concepts and hypothesis through induction and abduction.	Secondary evidence. Literature review
2	Nutrition output and production diversity	Analysing current farm output in a specific context and drawing inferences to inform project design. Applies induction and abduction	Primary evidence - Household survey, Focus Group, Discussions.
3	Programme theory and intervention description	Constructing a HGSF programme theory based on prior understanding and interrogating the theory through evidence evaluation. Applies abduction and deduction	Literature review, FGDs, Key Informant Interviews
4	Describing main project activities	Translating theory into practice	Literature review, expert inputs, community participation

5	Intervention supply chain analysis and food system mediation	Abstracting concept/ frameworks. Applies abduction and induction.	Primary data analysis
6	Intervention and food sovereignty.	Further theory development and evaluating intervention in a theoretical framework. Applies abduction and deduction.	Field observation notes, Project monitoring, Document review
7	Applying the intervention output i.e. school meal to model effects of covid-19 pandemic on food commodity prices and nutrition security	Comparative observational study design analysing events before and during the pandemic. Applies induction	Modelling data Price data

Within the action research methodology, the research process in terms of exploring and framing issues and aspects of project design ideas, is inspired from political ecology studies, in particular Judith Carney's 'Black Rice' (2001), a seminal work on the African Origins of rice cultivation in the Americas, 'Changing Fortunes' (1996) by Zimmerer on biodiversity in the Peruvian Andes and James Suzman's 'Affluence without Abundance'(2017). The study also benefits from political ecology work on food and agriculture (Chambers & Conway, 1991; Blaikie, 1994; Brown, 1998; Perkins, 1998; Offen, 2004; Finnis, 2007; Moseley, 2017). Political ecology brings together elements of ecology and political economy to understand ecosystem productivity and its control as a function of political economic structures at different scales with agriculture and food systems as a central concern (Andersen, 2012; Galt, 2013; Bryant, 2015). Given its multi-disciplinary foundations and critical engagement with processes of knowledge, governance, history, technology and politics; political ecology provides a useful analytical framework to answer research questions posed in this thesis (Bryant, 2015).

In the initial exploratory stages of the study and intervention, a key challenge was identifying a framework which helps provide a wider and more holistic perspective to guide the research and action. In my experience of over 10 years working on operational and technical assistance projects, such projects are often driven by immediate programmatic contexts and closely defined indicators, which in part is a function of the nature of such projects in terms managing timelines, budgets and deliverables. With the support of the donor agencies, government and other stakeholders, I made a deliberate attempt to try and incorporate a wider learning process in the project implementation. Two specific learnings from political ecology studies guided and enabled this learning and research process. One is the importance of ecological, cultural, political and economic factors separately and together in shaping food systems and in turn individual and collective choices on food production and diets (Perkins, 1998; Finnis, 2007; Moseley, 2017). Second relates to understanding the processes by which governance, power and scale interconnect (Blaikie, 1994; Bryant, 2015, Chandra et al., 2017). These learnings form a common thread throughout all the chapters, building from the food system study in chapter-2, programme theory and actions in chapters 3 & 4, food system mediation in chapter-5 and food sovereignty in chapter-6.

THESIS OUTLINE

The thesis is divided into six main chapters, besides the introduction and conclusion section. Whilst all chapters are part of a continuous narrative, each chapter is drafted such that it forms an independent manuscript.

Chapter-1, 'Agriculture as a Food Acquisition System and Dietary Strategy: Development and Impact' analyses the impact of agriculture transition on human health and food security. It examines agriculture origins, transition and domestication in the overarching framework of analysing agriculture as a dietary strategy. It explores the issue of agriculture and human health from a bioarchaeological-evolutionary perspective and suggests key interactive pathways between health and agriculture. Finally, it proposes a conceptual framework to analyse the health impacts of transitioning to an agrarian system.

Building on the theme and overall findings of the first chapter, chapter-2, 'Understanding Nutrition Output and Production Diversity of Contemporary Small Farm Agriculture in Nepal: Case Study of Two Districts' undertakes an empirical investigation into the diet quality and food diversity of the most widespread contemporary agriculture system i.e. small farm agriculture. This investigation is conducted through primary surveys in two intervention districts of Nepal. The chapter estimates the status of agrobiodiversity and the extent to which farm output fulfils the food requirements of a household for a nutritious diet. It also explores the recent transition arc in terms production patterns and finally it seeks to understand the drivers and constraints of small farm food production.

Chapter-3, 'Intervention Theory and Development', develops the HGSF programme theory, describes the intervention and presents key evidence and presents a further analyses of the theory.

Chapter-4- 'Intervention Design and Implementation Activities' describes key project activities including a discussion on the processes that guided certain design elements.

Chapter-5, ‘Food System Mediation: Processes and Evidence from Nepal Home Grown School Feeding’ analyses the operationalized food commodity baskets to further evolve the programme theory with a particular focus on the element of local food system mediation. The food basket is examined as a function of the intervention design and activities to generate a generalized conceptual model’,

Chapter 6, ‘Food Sovereignty in Policy and Practice: A Critical Analysis of Home Grown School Feeding Implementation’. This chapter examines the implementation of the intervention through the lens of ‘food sovereignty’. It provides operational evidence on the processes and issues of translating food sovereignty into practice, through a study of the intervention. The analysis explores the translation of food sovereignty in practice as a technological and political process across issues of scale, governance and power.

Chapter 7, ‘Estimating the Potential Effects of COVID-19 Pandemic on Food Commodity Prices and Nutrition Security in Nepal’ applies intervention output i.e. school meal to model effects of covid-19 pandemic on food commodity prices and nutrition security. It analyses changes in food commodity prices and estimate the potential effects of food price change on nutrition security in Nepal in the context of COVID- 19 contagion control measures.

ROLE OF THE INVESTIGATOR/AUTHOR

All chapters are drafted in their entirety by the author. The research design and survey instruments for all studies and surveys described in the thesis were developed by the author. All data analysis was led and undertaken by Samrat Singh.

Samrat Singh is the project lead of Nepal HGSF project and responsible for all aspects of project design and management. Over the project period, Samrat undertook ten missions to Nepal for project implementation, studies and surveys. A project office was set up in Kathmandu, it consisted of Deepak Gautam, Laxman Acharaya and Rahita Pichai. Each intervention district had a district coordinator. Specific contributions for two chapters are mentioned

Chapter-2.

Samrat Singh designed the study and the survey instruments. SS led the training session for enumerators and supervisors and led pre-testing of survey instruments. SS also participated in one round of data collection. He undertook all the analysis and drafted the paper. Research Assistance was provided by Krystal Lau for data management and statistical analysis. Data collection surveys were conducted by NARMA Consultancy Pvt Ltd, Kathmandu under supervision of Samrat Singh.

Chapter-7

Samrat Singh designed the study, undertook final analysis and drafted the paper in its entirety. Sara Nourozi constructed the typical household food baskets, Laxman Acharya managed price data collection and assisted in computing cost comparisons for school meals and Sridhar Thapa undertook a quality check for data collection and assisted in in costing typical household food baskets.

SCOPE AND LIMITATION

In terms of assessing the impact of the HGSF intervention, this thesis is limited to evaluating the implementation processes, governance, design elements and content of the supply chains. It does not examine the impact of the intervention in terms of farmer incomes or production patterns. The rationale for excluding farm level impacts was because the intervention does not include any direct farm support in terms of inputs, training etc. Therefore, it is not credible to expect significant farm level changes attributable to the intervention, especially over a short period of effective intervention, less than two years. Furthermore, the objective of this specific HGSF intervention is to create a viable platform to promote nutrition and ecologically sensitive food systems and not to enhance farmer incomes or production levels, which is the objective of other programmes. Studying the potential effects of the intervention on child health through anthropometrics or biomarkers for micronutrients was also outside the scope of the study. This is an important issue which needs to be better understood.

RESEARCH ETHICS

All data collection including Focus Group Discussions, Key Informant Interviews and other consultations were undertaken as part of the technical assistance project with the Government of Nepal and UN World Food Programme, Nepal. All activities including research protocols were presented to a Government of Nepal project committee and approved by the relevant government department. Therefore, no separate ethics approval was required for specific project activities.

Standard research ethics were followed for all research and programme elements. Participants were made aware of the purpose of any consultation/data collection in the local language and informed that participation is entirely voluntary. Data collection was undertaken only after each participant individually consented. A list was circulated for signatures but in most cases the participants expressed a preference for verbal confirmation. The phone number of the field coordinator was provided to all participants for any follow up. All data was anonymized during coding. For consultations with government offices, the informants were made aware of the context and purpose of the consultations. The observations from these consultations were anonymized during analysis.

Letters from Centre for Education and Human Research Department (CHRD), Government of Nepal. The letter is in Nepali language is Annex-1. It confirms and approves all the programme and research work by our project team. The second page of the letter has signatures of other government and research partners who signed off on the work plan.

Household survey food production data which is used in Chapter-2 was collected by NARMA Consulting Ltd. After due diligence, their research committee also determined that separate approval was needed for these surveys. Letter from the Managing Director confirming the same is in Annex-2.

CHAPTER-1

AGRICULTURE AS A FOOD ACQUISTION SYSTEM AND DIETARY STRATEGY: DEVELOPMENT AND IMPACT

1.1 INTRODUCTION

Reap as you sow is an oft quoted metaphor reflecting human wisdom on actions and consequences. Its literal meaning reflects the source of this fundamental understanding of change effected through human agency i.e. agriculture.

The processes of food acquisition have defined the shape of human societies for millennia. The way we get our food defines our political, cultural, social and economic structures and it determines our fundamental relationship with the planet we inhabit. Whilst the story of food is increasingly obscured by long and complex supply chains, it is more important today than ever before. Our societies continue to be the products of how we eat, and what we eat, to sustain the human organism. At its core, the process of sustenance involves the capture of solar energy as it circulates to the earth through photosynthesis and associated biochemical processes. Agriculture has been the means of getting food only for the last 10,000 years of the 200,000 years history of the modern human (Larson et al., 2014); for more than ninety five percent of the time humans have inhabited earth, we fulfilled our food needs through other means.

One of the most critical existential challenges facing humankind today is providing nutritious and ecologically sustainable food to current and future generations (Willett et al., 2019). Food insecurity and malnutrition is responsible for millions of fatalities and lost life chances across the world (Black et al., 2013; Arndt et al.,2016). In 2019, an estimated two billion people in the world did not have regular access to safe, nutritious and sufficient food (FAO et al., 2020). According to recent global estimates 21.3 percent (144.0 million) of children under 5 years of age were stunted, 6.9 percent (47.0 million) wasted and 5.6 percent (38.3 million) overweight (FAO et al., 2020). Globally stunting rates have been decreasing over the past several decades. Prevalence in the last two decades (2000-2020) has reduced from 33.1% to 22.0%, and from 203.6 million to 149.2 million in terms of number of children (UNICEF/WHO/WB Joint Child Malnutrition Estimates, 2021). Global trends mask significant regional disparities, for example, in Africa the total number of children experiencing stunting has increased by ∼13.1 million since 1990 on account of substantial population growth (Vaivada et al.,2020).

To better understand the critical challenges related to nutrition, it is important that we look back through time to understand the relationship between modes of food acquisition, more specifically the transition to agriculture, and human health. Even today there is no single monolithic food acquisition system, across the world, communities use a wide variety of different practices to fulfill their food needs (Bellwood, 2005). More importantly our food acquisition strategies are ever changing in response to our changing needs and the environment. As we develop interventions and policies to influence these changes to be healthy and sustainable, it is essential that we understand the continuum of human food acquisition, which is the primary concern of this chapter.

Given the very large canvas of this subject and its many disciplinary perspectives, it is important to emphasize the focus and scope of this chapter. This chapter is focussed on understanding the relationship between the transition to agriculture and human health and developing a conceptual framework capturing the main components and interactions as a function of the foods consumed. It does not examine political-economic structures, behavioural pattens, socio-ecological systems and social norms in different communities which can have implications on food acquisition strategies (Kelly 2013; Kennett & Winterhalder 2006; Chiaravalloti & Dyble 2018). Another area, beyond the scope of this chapter with implications on diets and health relates to developments in cooking, processing and storage of food (Graff & Rodriguez-Algeria, 2012; Dunne et al., 2016, Chazan, 2017).

This paper examines agriculture origins, transition and domestication within the framework of analysing agriculture as a dietary strategy and proposes a simple model to understand these complex issues. It explores the issue of agriculture and human health from a bioarchaeological-evolutionary perspective and suggests key interactive pathways between health and agriculture. Finally, it proposes a conceptual framework to understand the health impacts of transitioning to an agrarian system.

This paper is divided into six main sections. The first section describes the evidence on agriculture origins and transition, it then introduces a model for the transition of food acquisition system. The next section presents a summary of specific foods as a function of agricultural selection and domestication. The third section analyses key aspects of domestication with specific reference to nutrition. The fourth section looks at the impact of agriculture transition on human health and reviews evidence from multiple disciplines. In the next section, this paper maps evidence-based pathways between agriculture and diets. The final section develops a conceptual framework to understand and evaluate agriculture as a food acquisition system and dietary strategy through a historical lens.

1.2 AGRICULTURE ORIGINS AND TRANSITION

By various estimates, agriculture began around 10000 to 12000 years ago in different parts of the world (Diamond, 2002). The agriculture revolution did not just change the way we acquire food, it led to the most dramatic changes in the history of man and defines almost every aspect of the human race today. Childe (1936), refers to this revolution as 'Neolithic revolution' and defines it as that which instigated a series of changes in human societies towards sedentism, larger populations, food production based on domesticated plants and animals, transformed cosmologies and the dawn of new malleable technologies such as ceramics and textiles.

The geographical origin of agriculture and the process of dissemination of crops has been a major area of study which has seen significant progress with advancements in archaeo-botany, linguistics, phytogeography, archaeology and genetics (Piperno, 2011). 'Centre of origin' and 'diversity of crop plants' are key concepts relating to the origin of agriculture. They relate to the patterns of distribution and build-up in regions and habitats, consequent to use and domestication by man in areas representing independent agricultural systems and separated by major geographical barriers. Various terms have been used to designate these 'geobotanical' diversity patterns in crop plants viz. *primary and secondary centres of diversity, gene centres, mega-gene centres, cradles of agriculture, hearths of agriculture, mega-centres* and *regions* (Darlington, 1956; Harlan, 1971; Zeven & Zhukovsky 1982, Diamond, 2002). As can be expected there are multiple interpretations of 'cradles of agriculture' or 'centers of origin' which have been widely discussed and explored over the past decades (Sauer, 1952; Darlington, 1956; Vavilov, 1987; Zeder, 2009).

Research into both the process and spatiotemporal origins of agriculture has accelerated significantly over the past decade through archaeological research, advances in DNA/RNA sequencing technology, and methods used to recover and formally identify changes in interactions among plants and animals leading to domestication. Contemporary studies help create a more precise and compelling story of the nature and context of the origin of agriculture, and pathways of dispersal (Larson, 2011; Zhao, 2011; Zeder, 2011; Lee, 2011; Crawford, 2011; Piperno, 2011; Larson et al., 2014; Khoury et al., 2016). Most recently, a five year project (2013-2018), *Comparative Pathways to Agriculture Project* (ComAg), produced the first global synthesis of the convergent evolution of domesticated plants and early agricultural systems based primarily on empirical archaeobotanical data. The findings estimate that plants were domesticated in around 20 different areas around the world. The ComAg project maps 20 sites with precise locations within regions, which are mentioned below (Fuller et al., 2014; Fuller et al., 2015).

1. North America
2. Mesoamerica
3. Northern Lowland South America

4. Northwestern Lowland South America
5. Central/Southern Andes
6. Southwestern Amazonia
7. West African Savannah/Sahel
8. West African tropical forest
9. Sudanic Savannah
10. Ethiopian plateau
11. Fertile Crescent
12. Savannahs of Western India
13. South India
14. Ganges and eastern Indian plains
15. Chinese loess plateau
16. Western Yunnan/Eastern Tibet
17. Lower-Middle Yangtze
18. Lingnan (tropical south China)
19. Japanese islands
20. New Guinea

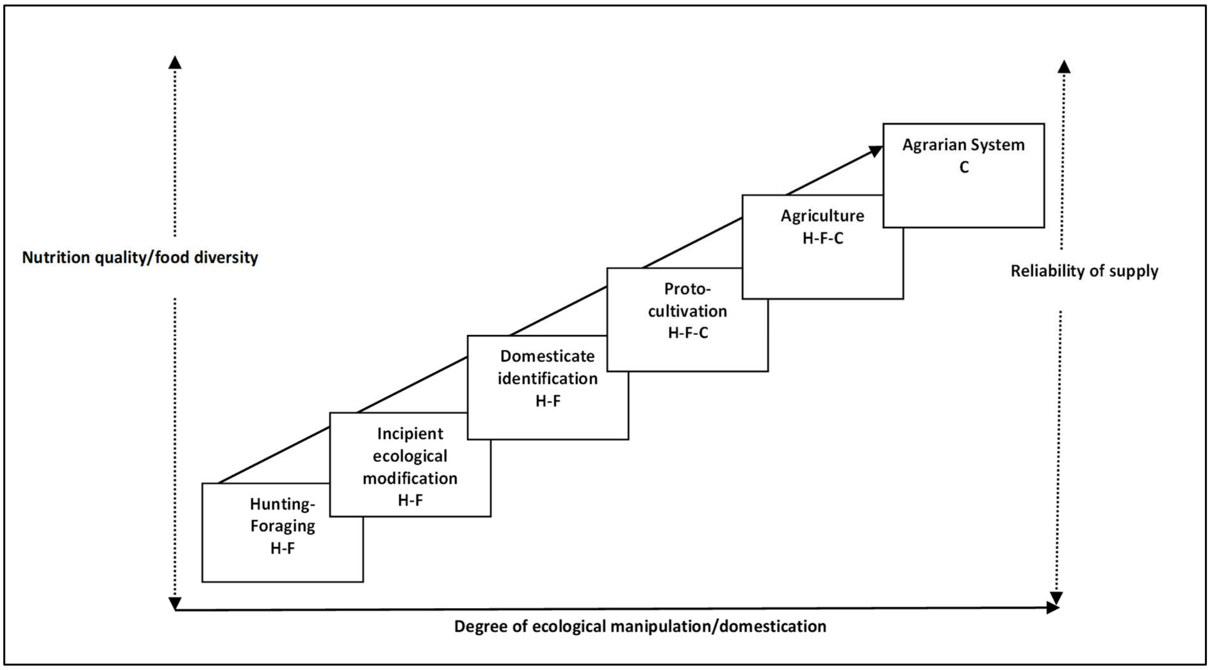
Over hundreds of years, many causes may have led hunter-gatherers to become farmers, such as climate change, population stress and overhunting (Diamond, 2002 ;Pryor, 2003; Weisdorf, 2005; Bellwood, 2005; Dow, 2017). Although the terms 'agriculture revolution' or 'Neolithic revolution' are often used to describe the adoption of agriculture as the principal form of food acquisition, it is widely accepted that the transition from hunting and gathering to agriculture was a gradual incremental process with highly variable trajectories in different parts of the world. The velocity of these evolutionary trajectories was determined by a range of co-deterministic factors such as demographic movements, ecological changes, development of tools and local ecology. This transition has been put forth in conceptual models by Ford and Harris (Harris, 2012) where the dichotomy between hunter-gatherer and farmer is blurred and the emphasis is on the range of activities that define interrelationship between exploitation of 'wild' and 'domesticated' plants.

These frameworks acknowledge that human-food interaction is a continuously changing process as human intervention leads to ecological modification. In his accounts of the transition from hunting–gathering to agriculture, Childe contrasted “food producing” with the “food gatherers” of earlier times and defined the boundary between them in terms of humans gaining control over their own food supply (Gepts et al., 2012). Whilst the methods of food acquisition have always been shaped by geography, ecology and people, the objective remains unaltered since humans came into being and that is to acquire a supply of all nutrients needed to fulfil the diverse needs of the human body.

The conceptual models mentioned above divided agriculture transition in three linear stages, (i) *Pre-Agricultural stage,* (ii) *proto-agricultural stage* and (iii) *the field agricultural stage.* The above categorization whilst useful, is mostly limited to a production perspective. Building on these models (Harris, 2012), I represent the food acquisition system as changing over time, across six overlapping components, as illustrated in figure 2. The models suggest the continuously increasing degree of ecological manipulation and domestication which is represented along the x axis. Two other variables of interest are (i) Nutrition quality/ food diversity and (ii) Reliability of supply are indicated on the y-1 axis and y-2 axis respectively. The direction of change in these variables is left undetermined in this model and is discussed in the remainder of this chapter.

The symbols ‘H’,’F’ and ‘C’ indicate hunting, foraging and cultivation respectively as elements of each system component. Early systems consisted primarily of hunting and gathering, subsequent systems consisted of hunting, foraging and cultivation as complimentary elements and finally the agrarian system consisted primarily of cultivation (Smith,2001; Bellwood,2005). Even today there are many communities around the world where hunting, foraging and cultivation are practiced together (Kennett & Winterhalder, 2006). The chronological line across these six components represents thousands of years between each component.

FIGURE 2: FOOD ACQUISTION SYSTEM CHANGES OVER TIME



Hunting-foraging was the method of food acquisition for the longest time (Kennett & Winterhalder, 2006). The second system included minimal ecological modification in the wild (such as digging or aerating the soil with pre-agricultural tools) and hunting-foraging remained the exclusive method of acquiring food (Smith, 2001; Harris, 2012). The next system involved identification of some potential domesticates based on observed growth patterns in the wild but hunting and foraging continued to be primary method of getting food (Bellwood,2005; Barker,2006). Specific potential domesticates were then incrementally cultivated, replicating the observed requirements of the wild progenitors, in proto-cultivation (Harris,2012). This is the first system which involved hunting, foraging and cultivation together as methods of getting food. The next system was agriculture with a variety of domesticates with specific traits, grown in modified ecologies (Smith,2001). In large parts of the world, food acquisition was still complimented by hunting and foraging to varying degrees (Bellwood,2005). This system also marked the conceptual birth of a central food element in diets i.e. staples (Kennett & Winterhalder,2006). Finally, we have the agrarian system which includes all forms of farming from small, terraced rice fields to large scale monocultures, in this system, cultivation is the exclusive method of getting food.

1.3 DOMESTICATION AND FOOD DIVERSITY

Agriculture is a multi-episode process that begins with gathering from the wild and ends with the cultivation of plants that have undergone the full suite of genetic and phenotypic changes that characterise the domesticated crop (Pringle, 1998). It is important to highlight the distinction between domestication and agriculture as a system of food acquisition. There is substantial evidence to conclude that domestication itself was a long process that occurred over hundreds of years (Diamond, 2002; Piperno, 2011; Smykal et al., 2018). Agriculture as an ecologically and nutritionally integrated system of food acquisition based on the convergence of different domesticates, evolved episodically thousands of years after domestication. This development of agriculture as a productive system of food acquisition varied across different geographies and chronologies.

Recent evidence suggests that the periods between domestication and the establishment of a productive food system lasted for around 6000 years in Mexico and New Guinea Highlands, 4000 years in eastern North America, and at least 3000 years in Southwest Asia (Harris, 2012). A study of this evolution in different regions shows that gradually, across food groups, the spectrum from which agroecosystems produced food narrowed over time (Smykal et al., 2018). Many of these systems would be complimented by hunting and foraging with different combinations of cultivated foods. There would have been significant differences in providing a nutritionally optimum diet, across these systems.

Most centers of domestication include a combination of protein (legume) and starch (cereal or root) staple crops (Gepts,2012). Evidence suggests that these early agricultural centers were dependent on one to three crops and communities here ate significantly less meat than their hunter-gatherer predecessors (Armelagos et al., 1991; Papathanasiou, 2005; Eshed et al., 2010). Cereals including barley, wheat, and millet, as well as rice and maize were the subsistence foods (Latham, 2013). The diversity of food production in early agriculture was governed by several considerations, the most important ones being the ease with which a commodity meets the criteria of a domesticate and efficiency in terms of consumable biomass produced to satiate hunger, primarily calorific hunger.

It is estimated that there are 1,000–2,500 semi and fully domesticated plant species from about 160 taxonomic families, most important being are Poaceae, Fabaceae, and Brassicaceae (Smykal et al., 2018). Humans rely on a relatively small fraction of species diversity for food, only about 150 species of plants have entered world commerce, and 103 species account for 90% of the supply of food plants by weight, calories, protein, and fat for most of the world's countries (Smykal et al., 2018). The reliance on a very narrow set of foods occurred mostly in the 20th century and the process of homogenization at a global level continues till today (Khoury et al., 2014). Thus, the forager to farmer trajectory is essentially one of increasing geographic reliance on fewer species (Cordain, 1999). The table below presents a list of main staple crops of early agriculture.

TABLE 2: MAIN INDIGENOUS STAPLE FOOD CROPS AND DOMESTIC HERD ANIMALS OF TEN MAJOR WORLD REGIONS OF EARLY AGRICULTURE (adapted from *Harris, 2012*)

MAJOR REGION	**MAIN INDIGENOUS STAPLE FOOD CROPS AND DOMESTICATED HERD ANIMALS**					
	Roots/Tubers	Cereals	Pulses	Other forbs	Tree crops	Herd Animals
SW Asia		Barley Einkorn Emmer Bread wheat	Lentil Pea Chickpea		Olive Fig Date Palm	Goat Sheep Pig Cattle
China		Rice Proso Millet Foxtail Millet	Soybean			Pig Water Buffalo
S Asia		Rice Browntop millet Bristly foxtail millet	Ming bean Horsegram Pigeon pea			Zebu Cattle Water buffalo
New Guinea	Taro Yam			Sugarcane	Banana Pandanus	
-Northern Africa: Sahel zone -Northern Africa: Forest Zone	 Guinea yams	Sorghum Pearl millet Finger millet	Cowpea Groundnuts (two species)		Shea butter tree Oil Palm	
Meso-america		Maize Teosinte	Common bean Lima bean Runner bean Tepary bean	Pepo squash Chili pepper	Avocado	
Eastern North America				Marsh elder Goosefoot Pepo squash Sunflower		
Central Andes	Potato Anu Oca Ullucu		Common bean Lima bean	Quinoa Canihua		Llama Alpaca

Northern lowland South America	Manioc Sweet potato Yam Cocoyam Arrowroot Leren			Peanut	Cashew Peach palm	

1.4 PLANT DOMESTICATION: PROCESSESS AND DRIVERS

Domestication is an incremental selection process in plant evolution associated with changes in the DNA regulating agronomically important traits. The onset of domestication is followed by gradual increases in the frequency of a set of desirable traits (Larson et al., 2014; Ainsworth & Tenaillon, 2016), and the end point is the cultivated populations adapted to both human and ecological needs (Ainsworth & Tenaillon, 2016). This process involves a combination of deliberate human intervention and natural selection, hypothesised by Darwin as conscious and unconscious selection (Meyet et al., 2012). It has also been suggested that in the process of domestication, humans were imitating nature; Anderson and Wohlgemuth (2012) describe this process in their study of Indian Proto-Agriculture in California. While consuming geophytes and severing propagules to grow into new plants, animals act as predators and dispersers. In digging and replanting bublets and cormlets, native Indians stepped into the herbivore role and essentially simulated mammalian disturbance. The next steps in this process were a result of accumulation of knowledge about the particular species and the incremental application of human cognition. The activities in the domestication continuum would thus include aerating the soil, ensuring optimal density for replantation, deliberate separation of propagules etc (Anderson & Wohlgemuth, 2012).

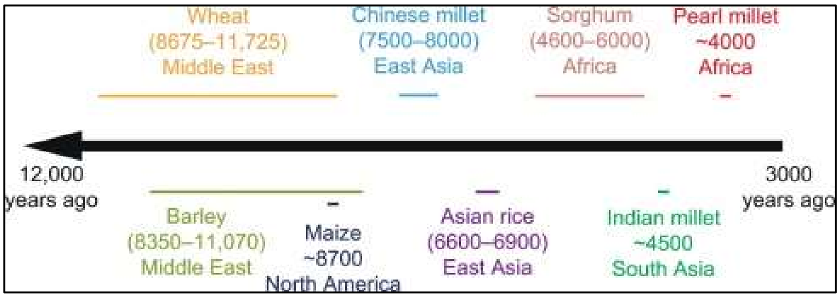
In plants, domestication is defined by a wide variety of traits that distinguish domesticates from their wild progenitor, collectively referred to as 'domestication syndrome' (Chen, 2015; Li & Olsen, 2016). Depending on the species, these traits include: a reduced ability to disperse seeds without human intervention, reduction in physical and chemical defences, reduction in unproductive side-shoots, reduction in seed dormancy, bigger seeds, more predictable and synchronous germination, and in some seed-propagated species, bigger and more inflorescences (Chen, 2015). For cereals, which were domesticated from wild grass species, domestication traits are associated with grain size, grain number, panicle size, grain quality, flowering time, plant architecture and seed shattering (Shomura et al., 2008; Vaughan et al., 2008; Brown, 2008). An important initial step in cereal domestication was to select plants that could retain ripe grains to allow effective field harvest, since wild grasses naturally shed mature grains. Further, this selection process may have been largely unconscious, because grains that did not fall as easily had a better chance of being harvested and planted in the following years (Diamond, 2002; Li, Zhou & Sang, 2006).

Domestication of many crops is also associated with an increase in size of the organs that are consumed to increase the amount of edible biomass. Thus, cultivated sorghum has much larger seed size than wild sorghum (Vaughan et al., 2008). The importance of gigantism in grain crop domestication has long been recognized, whereby domesticated plants are larger, fleshier, and more robust than their wild progenitors because seeds, leaves, stems, roots, and other organs are all enlarged (Kluwyer et al., 2017).

It is evident that the primary drivers of domestication traits, both conscious and unconscious, were yield (egs. propagule retention and indehiscent pods in legumes); edibility (reduction of chemical and physical defences) and cultivation (seed dormancy and loss of seed shattering in cereals). In the latter stages of domestication, determining factors would also perhaps include ease of storage and transportation (Chen, Gols & Benrey, 2015).

The overall domestication process took thousands of years. For example, a 2006 study (Tanno & Wilcox, 2006) showed that it took approximately 3,000 years for the tough rachis phenotype in wheat, an indicator of seed non-shattering and considered a key domestication trait, to predominate in the archaeological record in the Near East (Purugganan, 2019). The emergence of non-shattering phenotypes in cereal crops was perhaps one of the most significant domesticate traits which enabled control of plant reproduction and the ability to harvest seeds for consumption. The figure below the shows the timeline and different geographies of the emergence of this trait in the most important cereals, for example in the case of millets, the non-shattering trait appears in pearl millet (*Pennisetum glaucum*), Indian millet (*Pennisetum typhoides*), and foxtail millet (*Setaria italica*) about 4000, 4500, and 7500–8000 YA (years ago) respectively (Li & Olsen, 2016).

FIG- 3: DOMESTICATION TIMELINE FOR KEY CEREALS



(Source: Li & Olsen, 2016)

It is important to note that the nutrient composition of plants does not seem to be a relevant factor as a domestication trait. On the contrary, studies have shown that the emergence of domesticated traits in modern cultivars had deleterious side-effects in terms of nutritional quality (Smykal et al., 2018). Recent studies show that wild populations of wheat and barley have much higher content of essential amino acids than that of the domesticated varieties (Heblestrup, 2016). Similarly, wild emmer wheat populations contained significantly higher micronutrients and minerals such as Zn, Fe, Cu, Mn, Mg, K, P and S, than the domesticated varieties (Heblestrup, 2016). A key finding of a study evaluating the carotenoids and tocopherols (anti-oxidants), in the ten most economically important grain legumes and their closest wild relatives, was that domestication of grain legumes was accompanied by a reduction in carotenoids contents, including molecules essential to human nutrition (Marin et al., 2014). Although much more work is needed to examine the issue of the specific relationship between some domestication traits and nutrition components in different foods, it would appear that domestication drivers such as yield, seed dormancy and palatability, impacted nutritional quality of domesticated foods (Marin et al., 2014; Hebelstrup, 2017; Smykal et al 2018).

1.5 AGRICULTURE TRANSISTION AND IMPACT ON HUMAN HEALTH

Agriculture marked a significant shift in food acquisition behaviour and dietary strategies. In general terms, the advent of primarily food producing societies was marked by a decline in human health. Cohen and Armelagos produced a pioneering work in 1984 (*Paleopathology at the Origins of Agriculture*) which drew on 21 case studies evaluating the health status during the transition from subsistence to primary food production and developed new methodologies to examine impact of agriculture transition at the population level. The main conclusion of the study is that there was declining health and increase in nutritional diseases as societies moved from hunting and foraging to agriculture.

There is now an impressive body of empirical and theoretical work, exploring the links between agriculture and human health. The disciplines of bio-archaeology, biological anthropology and paleopathology have provided seminal evidence and techniques towards improving our understanding of how agriculture transition impacted human health (Pihnasi & Stock, 2011). The empirical research mainly involves an analysis of human skeletal remains dated to after transition to agriculture, including teeth, looking for biological markers of diseases and physiological stress which are then linked to possible nutritional deficiencies or other factors. Stressful stimuli recorded in human skeletal remains include disease and parasite load, dietary deficiencies, and synergistic effects between the two indicators (Scrimshaw et al.,1968; Stephenson & Holland, 1987; Keita, 2003). Some common measures of examination are those relating to dental health (tooth size, antemortem tooth loss, caries, wear, and enamel hypoplasia); chronic health problems (e.g., anemia through cribraorbitalia, arthritis, osteoporosis); specific diseases and infections (e.g., tuberculosis, leprosy, trepenomal infection); non-specific markers (e.g., porotic hyperostosis, periosteal reactions, osteomyelitis) infections; and growth patterns (Palkovich, 1987; Larsen, 1991; Starling & Stock, 2007).

Mummert provides a comprehensive review of recent studies in relation to the effect of agriculture transition on stature and robusticity (Mummert, 2011). This analysis reviews recent studies across regions including India, China, the Mediterranean, Georgia, the Levant and Europe, that examine multiple stress indicators and specifically report stature and robusticity observations. The paper reports that a number of these studies suggest a cumulative decline in skeletal robusticity, stature, and adult size as a result of the transition from hunting and gathering to agricultural dependence. However, the potential causes of the decline are not always conclusive to suggest a definite pattern and include causes other than nutrition deficiencies such as lack of physical activity.

Similarly, some palaeopathological markers such as porotic hyperostosis can indicate nutritional deficiencies (Macadam, 1985; Palkovich, 1987). Iron deficiency anemia triggers the expansion of the blood-forming tissues to increase production of red blood cells. As a result, the compact bone of the outer surface of the flat bones of the human skull becomes more porous, a pathological condition called porotic hyperostosis (Palkovich, 1987). Studies show that in a range of contexts worldwide, there is an elevated frequency of porotic hyperostosis in agricultural settings (Lallo, Armelagos & Mensforth 1977; Larsen, 1991; Harrison,1995). The increase in porotic hyperostosis can be attributed to reduced availability of dietary iron or intestinal infections (Larsen, Shavit, & Griffin, 1991).

Bioarchaeological data also suggests that rates of caries and periodontal disease increased with the onset of agriculture (Larsen, Shavit, & Griffin, 1991; Ettinger, 1999). An important study relating to the Nile valley looks at non pathological dental indicators of stress and disease. Starling and Stock (2007) investigate the patterns of disease and dietary health over the course of the Neolithic in the Nile valley, using a commonly applied indicator of general physiological stress, LEH of the dentition. Linear enamel hypoplasia (LEH) is an enamel defect that records the effects of physiological stress on tooth formation and thus can be suggestive of nutritional stress or disease (Starling & Stock ,2007). The results showed that the earliest ‘’proto-agricultural’’ population had the highest levels of dental developmental interruptions. Again, this evidence is not conclusive as it can be caused by other factors besides dietary insufficiency, such as disease.

Overall, the range of evidence clearly lends support to the proposition suggested over three decades ago in *Paleopathology at the Origins of Agriculture,* that there was declining health and nutritional diseases as societies moved from hunting and foraging to agriculture. The nutrition deficiencies and decline in human health can be attributed to many interrelated factors, directly or indirectly brought about by agriculture, such as population pressures, sedentism, infectious diseases (Kent, 1986; Diamond, 2002). Whilst all these are valid factors, our concern in this paper is limited to understanding the impact of agriculture on human health.

In exploring the hypothesis that during the agriculture transition, in most contexts, declining health and disease was primarily a function of nutrient deficiencies caused by poor intake, two lines of evidence are useful, along with the bioarchaeological and palaeopathological studies summarized above. One relates to the shift in the food commodity basket and its potential consequences, and second relates to the study of contemporary hunters and gatherers, as a reference for the evolution of human nutrition (Marlowe, 2005; Kelly, 2013).

Many studies have been carried out on the diets and health status of contemporary hunter-forager communities (Crittenden & Schnorr, 2017). These studies include investigations on anthropometrics, oral health and nutrition deficiencies in foraging populations before and after nutrition transitions. The studies suggest that post transition, sample populations suffered from a range of micronutrient deficiencies folate, iron, and vitamins A, E, and B12 compared to pre-transition population (Metz, Hart & Harpending, 1971; Kamien et al., 1974; Davis, Smith, & Curnow, 1975; Cassidy, 1980; O'Dea K et al.,1997). In a review of 51 studies examining human populations from differing chronologies, as they made the transition from hunter-gatherers to farmers, Cohen (1987) concluded that there was an overall decline in both the quality and quantity of life.

Comprehensive data among subtropical foragers is available for the Kung (San), the Aka and BaAka of the Central African Republic, the Efe of the Democratic Republic of the Congo, and Australian Aboriginals (Crittenden & Schnorr, 2017). Crittenden provides an excellent analytical summary of findings of different studies related to these forager communities. In the pre transition phase, levels of iron, zinc, copper, folate, and B12 were within target ranges, fifteen years post transition, high rates of iron deficiency anemia were reported (Fernandes-Costa et al., 1984). Other studies conducted among the Aka and BaAka of the Central African Republic found similar results. In a direct comparison of rates of iron deficiency anemia, 15.6% of BaAka women showed low hemoglobin values in the mid-1980s before transition to village lifestyle (Pennetti et al., 1986), compared to 63% post transition (Remis & Jost Robinson,2014). In another study, comparing malnutrition levels between neighbouring foraging and non-foraging communities, the findings indicated that Efe foragers in transition showed fewer clinical signs of malnutrition when compared with the Lese who relied on horticulture (Dietz et al., 1989).

Whilst all the studies mentioned above provide useful evidence of the association between agriculture transition and declining health in different comparative frameworks, it is important to exercise caution while attributing causality. Indicators for nutrient deficiencies such as haemoglobin status are multifactorial and can be influenced by infectious chronic diseases and other conditions.

1.6 AGRICULTURE AS A DIETARY STRATEGY-PATHWAYS AND EVIDENCE

Based on the evidence summarized above, it is reasonable to conclude, with some caveats, that for a variety of reasons, human health suffered with the advent of agriculture. Even allowing for factors of disease and sedentism, the fact that agriculture by its very nature substantially reduced the diversity of foods consumed, indicates that poor health was, to large extent, a function of defective intake. I deliberately use the word 'defective' here since nutrient deficiency and disease were not simply a function of adequacy in terms of quantity but also of food sources, combinations and consumption patterns. Humans require at least 50 known nutrients, in adequate amounts, consistently, to live healthy and productive lives (Welch, 2005; Lanham-New et al., 2019). These nutrients need to be obtained through a diverse range of food commodities depending on local ecology. Besides, diversity, the consumption pattern must also ensure that the correct combination of foods is consumed to ensure biological access and absorption of nutrients. Here I propose that the interaction between agriculture as a food system and health, for both historical and contemporary studies should be evaluated across four interrelated categories:

(1) Adequacy of nutrient intake

(2) Sources of nutrient intake

(3) Combinations of foods

(4) Seasonality and reliability of supply

The overwhelming dominance of cereals, seeds and legumes in agricultural diets has had significant deleterious consequences on nutrition status of humans. These commodities were the primary targets of domestication and gradually came to dominate our food system. These foods by themselves are deficient in micronutrients but also influence nutrition through another critical pathway. Cereals, seeds and grains contain high amount of phytates (Lindberg, 2009). Dietary presence of phytate can forms insoluble complexes mainly with cations such as calcium (Ca), magnesium (Mg), zinc (Zn), copper (Cu), and iron (Fe), thereby limiting the bioavailability of these minerals (Lindberg, 2009, Kumar & Sinha, 2011). Phytates, which are found in most plant foods including cereals, can reduce iron absorption by up to 80% (Papathanasiou, 2005). There are also studies showing that phytate can form complexes with proteins, ultimately resulting in decreased protein solubility, enzymatic activity, and proteolytic digestibility (Kumar & Sinha, 2011).

Goitrogens are naturally occurring substances that can interfere with the function of the thyroid gland (Chandra, 2010). One group of such substances are flavonoids in beans, which can suppress the synthesis of thyroid hormones by inhibiting the enzyme thyroxine peroxidase (Doerge & Sheehan, 2002; Chandra, 2010). Many staple foods that were domesticated during the Neolithic period and later (millet, maize, soy, cassava, sweet potatoes, lima beans, turnips, cabbage, cauliflower, rapeseed, mustard, onion, garlic, bamboo shoots, and palm tree fruit) contain a variety of such goitrogens (Gaitan, 1990; Doerge & Sheehan, 2002).

Some other major antinutrients include amylase inhibitors in beans, which prevent the action of enzymes that break the glycosidic bonds of starches and other complex carbohydrates, preventing the release of simple sugars and absorption by the body; protease inhibitors, found in legumes, cereals and other foods inhibit trypsin, pepsin, and other proteases in the gut, preventing digestion and absorption of proteins and amino acids; oxalic acid and oxalates, which are present in many plants, particularly members of the spinach family, bind calcium to prevent its absorption (Astley & Finglas, 2016). The following table lists the main antinutrients and dietary sources.

The link between antinutrients, reduced bioavailability and nutrient deficiencies is corroborated by bioarchaeological evidence and contemporary population studies. Prevalence of anemia and porotic hyperostosis is known to have increased dramatically in the Americas, due to the low amount of iron provided in a maize-based diet (Eshed et al., 2010). Similarly, poor nutrition is likely to have impacted Eastern Chinese populations who relied primarily on niacin-deficient cereals like millet, buckwheat, rice, and maize (Pechenkina et al., 2007). Egyptian populations likely suffered from similar deficiencies as their reliance on wheat and millet increased significantly from the Early Dynastic Period to the Middle Kingdom (Zakrzewski, 2003). Contemporary epidemiological evidence indicates that a diet based on millet as staple food, such as that occurring in rural villages of Africa and Asia, plays a role in the genesis of endemic goitre in these areas. For instance, goitre was found to be more prevalent in rural villages of the Darfur Province in Sudan, where as much as 74% of dietary energy is derived from millet, than in an urban area, where millet provides only 37% of calories, even though the degree of iodine deficiency was similar in the two areas (Boncompagni E et al., 2018).

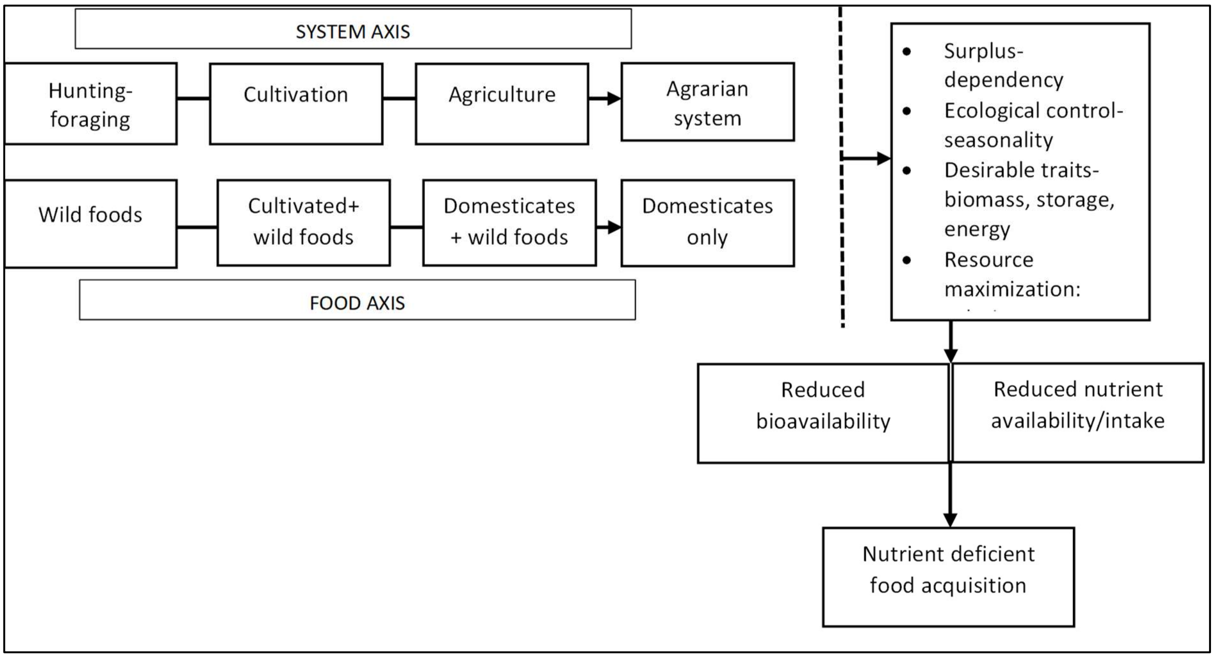
Another mechanism which impacts bioavailability and nutrient adequacy relates to food sources. This has important implications for our understanding of agriculture as a food system. Sources of different macro and micro-nutrients play an important role in nutrient adequacy. For example, the bioavailability of iron depends on several factors including the source. Dietary iron is found in two forms, haem iron and non-haem iron (Isabel et al 2018). Heme iron is the most readily absorbed form of iron: on average, people absorb between 25-30% of the heme iron they consume compared to 1-10% absorption for non-haem Iron (Skolmowska & Głąbska, 2019). Sources for haem iron include meat and other animal products and non-haem iron is found in plant foods and meat (Skolmowska & Głąbska, 2019). The absorption of non-haem iron can be improved by adding certain foods to the meal, for example, Vitamin C may be particularly effective, one study reported that adding just 63 mg of vitamin C to a meal rich in non-haem iron yielded a 2.9-fold increase in iron absorption (Fidler et al., 2004). In terms of nutrition transition, the issue of sources and combinations is important to understand the impact of decreased variety of food sources and nutrient bioavailability inhibitors and enhancers. This may be one of the factors in poor health status of post transition foraging populations and anaemia in early agricultural societies.

While it is obvious that agriculture would have been more productive in terms of food supply per unit of land (Bellwood, 2005), the issue of reliability is more complex. A widely stated proposition is that agriculture was found to be more reliable for food supply and this was one of the reasons for the transition (Bellwood, 2005; Barker,2006). However, there is evidence which suggests the contrary. A recent study presents evidence showing that hunter–gatherers have less famine than agriculturalists in terms of persistence, occurrence and recurrence (Berbesque et al, 2014). The study analysed famine and food shortages across different modes of subsistence, controlling for habitat quality (Berbesque et al, 2014). The function of a future wager in terms of harvest and storage as safety net is unique to agriculture. Although there is very limited direct evidence on storage, pre and post-harvest loss and surplus in early agricultural societies, it appears that through all times the health of agriculture communities would have suffered seriously on account of repeated and prolonged hunger seasons (Mummert, 2011). Droughts, harvests and other natural causes would have further exacerbated poor nutrition. Whilst hunting and foraging is also susceptible to the vagaries of nature, evidence suggests that based on highly evolved local knowledge and food acquisition strategies, hunting and foraging populations are able to cope with unfavourable conditions much better then agricultural populations (Hitchcock, 1988; Messner, 1988; Kelly, 1995).

1.7 PROPOSING A CONCEPTUAL FRAMEWORK

In this section, based on the evidence discussed above, I propose a conceptual framework to explore and evaluate the links between nutrition deficiency and disease, and the transition to an agrarian system as a dietary strategy. The framework is illustrated in the diagram below.

FIGURE 4 FOOD ACQUSITION SYSTEM EVOLUTION AND LINKAGES



The agriculture transition operated along two main axes, one is termed as the System Axis and the other can be termed as Food Axis as shown in the figure above.

The trajectory of the system axis with various intermediate and overlapping stages moved from hunting-foraging to an agrarian system, as a method of food acquisition The main constituent elements included ecological manipulation and control over growing patterns with the end goal of efficient and reliable food production. This generated a set of constraints and dependencies such as resource allocation, seasonality and climate. Over time, these constraints and dependencies further intensified the need for ecological manipulation and control and for generating surplus for storage. Resource allocation and efficiency became a defining criterion which translated into maximizing yields in terms of calories and proteins per unit area with main objective of minimizing hunger. The transition from initial cultivation to an agrarian system led to reduced availability of nutrients both in terms of diversity and quantity.

The food axis moved from wild foods to cultivated wild foods and finally to domesticates. The main constituent elements included selection of foods and desirable traits with the end point of growth cycle control and consumable biomass. This generated its own set of constraints and risks such as vulnerabilities to pests and disease, trade off in nutrient content and reduced diversity both within and across food groups. Over time, as storage became a key concern, it required the identification of foods best suited for storage, which would be a function of shelf life and energy supply. This gave rise to a dietary strategy which included a central element of staples which would provide year around energy supply and can be supplemented by other foods as needed. This dietary strategy led to a primary dependence on nutrient deficient cereals and created new food combinations which inhibited bioavailability of critical micronutrients. Overall the selection of certain foods, selection of traits a staple centred dietary strategy led to poor intake and lower bioavailability of consumed nutrients.

As the diagram above shows, the separate and cumulative effect of the two axes resulted in nutrient deficient food acquisition, as the objective of food getting shifted from sustenance to surplus. The overall loss of nutrition quality in diets was caused by individual domestication traits, selected commodities for domestication and resource allocation in an agrarian system.

In interpreting this framework, it is important to note that it theorizes one possible generalized scenario without controlling for context or habitats. For example, it suggests a decline in nutritional quality with the agrarian system based on a lower diversity of food sources and use of domesticates which may be less nutritious than wild counterparts. This may not hold true in certain specific ecological contexts with low hunting and foraging opportunities (Bellwood, 2005). Whist the framework can be tested and modified, its purpose is to help demonstrate key developments and components of food acquisition and potential impact on nutrition which can inform food system interventions.

1.8 CONCLUSION

Fulfilling food needs to survive and reproduce is the existential occupation of all living beings on earth. Irrespective of the place in the food web, acquiring sufficient nutrition is a constant struggle for all organisms. In a highly complex dance of interdependence, energy is constantly circulated and exchanged between all organic and inorganic matter. For millions of years, our human ancestors relied entirely on these natural processes and outputs to fulfil their food needs, and then 10000 years ago, agriculture enabled us to grow the food we need. Human agency and priorities replaced natural process and evolutionally senses, and redefined food and our relationship with food.

The transition to agriculture caused significant nutritional distress to human beings, which continues till today. The exclusive dependence on a narrow, deliberate food production system, made humans highly vulnerable to hunger and malnutrition. Through the different pathways discussed in this paper, agriculture transition was directly or indirectly the cause of nutritional deficiencies and diseases. As the risks of agriculture failures demanded a safety net in the form or surpluses, it defined the meaning of food, primarily as an energy source which can be stored and supplied to avoid hunger. To this end the focus was on production volume and resource maximization to the potential detriment of diversity and ecological sustainability.

Scientific advances continue to improve our understanding of the diverse and nuanced nutritional needs of the human body and associated biochemical interactions and processes. It can be assumed that our evolutionary dietary strategy, high contextualized to the local ecology was mostly adept at satisfying the nutritional requirements. It is interesting that 10000 years after the invention of agriculture, there is plethora of contemporary research and programme interventions on nutrition and ecologically sensitive agriculture. The history of agriculture has important lessons about the future of food. One, that favourable traits of foods must include nutrition, ecology and sustainability. Second, food production and consumption must respect and reflect local natural cycles in terms of seasons and diversity. And finally, the history of agriculture tells us that it is a human invention and therefore we must actively develop other new methods and systems of getting food. It follows that strategies of food getting are constantly changing, and that the agrarian system is not in any way suggested as an end point. New systems are already in the making and include elements of climate smart agriculture, laboratory grown foods, bio-fortification etc.

As a concluding note, as new systems develop, the future of food must not be defined by the question which in many ways led the agriculture revolution i.e. ‘Can we feed the world?’, it should be shaped by the question ‘How should we feed the world?’

CHAPTER-2

UNDERSTANDING NUTRITION OUTPUT AND PRODUCTION DIVERSITY OF CONTEMPORARY SMALL FARM AGRICULTURE IN NEPAL: A CASE STUDY OF TWO DISTRICTS

2.1 INTRODUCTION

As food systems are made vulnerable by climate change, depletion of natural resources, dietary changes and population stresses, promoting food diversity and nutritionally balanced farm output is critical to securing food and nutrition security and improving resilience of food production. To design and implement effective and relevant programmes and policies, it is important to understand the relationships between food production systems and public health outcomes. Studies show that the relationships and pathways between food production and nutrition outcomes are often complex and determined by specific food system contexts with varying implications at individual, household and community levels (Jones et al., 2014; Sibhatu et al., 2015). The nature and strength of these relationships depends on an interplay between different elements including gender, type of food, geography, market access and agroecology (Jones et al., 2014).

I discuss three interrelated strands of literature on production-consumption-nutrition linkages here. The first strand primarily consists of research analysing cross-sectional data from standardized global and national datasets and project data. This work looks at nutrition outcome as a function of dietary diversity and in this context locates the impact of production diversity on dietary diversity. The second strand is data analysis and modelling, examining nutrient output and production diversity by farm systems, based on farm acreage. The third strand of evidence relates to the impact of agriculture development programmes that seek to specifically promote production diversity. A summary of each of these strands of evidence is discussed below.

Evidence from recent studies shows positive relationships between production and dietary diversity (Jones et al., 2014; Malapit et al., 2015; Hiroven, 2016; Kisolly, 2020). A wider range of studies from Zambia, Kenya, Tanzania, Ethiopia and Nepal show a statistically significant positive association between household dietary diversity and production diversity; and individual dietary diversity (children aged 6–23 months) and production diversity (Kumar & Harris, 2018). Studies use multiple indicators for production diversity and dietary diversity (Verger, 2021) and in most cases the results are consistent for all indicators. A study by Remans looks at national level data on food supplies and finds that the diversity of foods produced is a strong predictor for the food supply diversity available for human consumption for low-income countries (Remans, 2014). The more profound linkages are found in subsistence farming systems and/or remote rural settings, which in most cases is a function of limited market access (Hiroven, 2016; Kisolly, 2020). This is turn can have important geographical implications in countries such as Nepal which as highly segmented and localized food systems (Shively & Sununtnasuk, 2015; Shivley, 2021). Whilst appreciating this evidence it is important to take note of some important limitations (Sibhatu & Quaim, 2018). One is that the associations and magnitude depend on the indicators and variables used. Second, there are a significant number of studies that show no or insignificant relationships and third, most studies use cross sectional data and identify associations which may not indicate causality. An important caveat to consider here is that whilst dietary diversity is an established nutrition indicator, by itself it does not necessarily lead to desired nutrition outcomes (Jones et al., 2014; Snapp & Fischer, 2015).

In the second strand, studies show that small farms play a vital role in their contribution to nutrition security especially in the poorest regions of the world. Besides food supply in terms of volume, small farms make a particularly important contribution in providing essential micronutrients (53–81%), which is a function of the level of small farm production diversity (Fanzo et al., 2013). In a pioneering study, Herrero and colleagues finds that farms smaller than 2 ha, produce more than 25% of the nutrients in South Asia, Southeast Asia, SSA and East Asia Pacific and have the highest level of agrobiodiversity (Herrero et al., 2017). Building on this work, data from a more recent study based on data from 55 countries confirms the findings on agrobiodiversity, it shows a negative relationship between farm size and crop species richness and finds that small farms produce more fruits, pulses, and roots and tubers (Riccardi et al., 2018).

The evidence on nutrition sensitive agriculture development programmes covers a wide range of interventions including home gardens, school/community gardens, integrated projects, food specific value chains, sensitization/behaviour change/training (Ruel et al., 2016). The quality of project evaluation evidence varies across studies with issues around sample size, duration and research design (Ruel et al., 2016). Notwithstanding these issues, reviews find evidence that agricultural development programs that promote production diversity, micronutrient-rich crops can improve the production and consumption of targeted commodities, sometimes through increase individual and household in dietary diversity (Ruel et al., 2016). Evidence on a wider set of NSA interventions finds that most interventions had positive effects on long-term outcomes regarding dietary practices (food consumption, dietary diversity, and nutrient intake) and diseases (Sharma et al., 2021).

This chapter seeks to contribute to the work by exploring issues based on primary data at the community and district level. The purpose of this study is to provide evidence on nutrient output, dietary needs, agrobiodiversity and drivers and constraints of agriculture, to inform the intervention design and implementation. The study is based on data from two phase-1 intervention districts representing distinct agroecological zones, 'terai' (plains) and 'mid-hills'. These two zones represent most of the agricultural production in Nepal (National Planning Commission, 2018).

The structure of the paper is as follows. Section 2 details the approach, methods and materials applied in the study. Methods and materials for each main topic are presented in detail. Section 3 describes the key results and findings for both qualitative and qualitative data. Finally, section-4 summarizes and analyses the main results and discusses their policy implications.

2.2 METHODS AND MATERIALS

The objective of this study is to understand food production in Nepal with a specific focus on nutrient output and dietary requirement. The findings of the study are applied to inform the intervention design and analysis. Both quantitative and qualitative data was collected and analysed in two rounds. Qualitative data was collected through farm household surveys to gather information on key aspects of food production. The quantitative data was collected in two separate survey rounds surveys to capture the effects of seasonality, in December 2018 (corresponding to the agricultural season of July to November), and in July 2019 (corresponding to the agricultural dry season of December to June). Qualitative data was collected through Focus Group Discussions (FGDs) to gather evidence on production patterns, food diversity and agriculture as a livelihood. I designed FGD guidelines iteratively for the two rounds. Based on the data analysis of the first round HH survey and FGDs, the guide for the round -2 FGD was designed to investigate specific issues on recently abandoned crops, new crops in production and related issues.

the study protocol and survey instruments based on detailed scoping surveys in each study district. The survey instruments were translated into Nepali language and pre-tested for relevance and appropriateness. The questionnaire was revised after pre-testing. Along with colleagues from NARMA consulting (the company contracted for data collection), I conducted three days orientation training for the enumerators and supervisor. Field testing was carried out in Sindhupalchowk district, and the survey instruments were finalized based on field testing.

The final survey team comprised of one supervisor and two enumerators for each district. Enumerators, along with the supervisor, were responsible for conducting the farmer survey. The questionnaire filled by the enumerators was cross-checked and edited in the field by the supervisor to avoid any discrepancies and data inconsistencies. The supervisors were provided with guidance notes to match key inputs such as farm size and production volume and also used the pre-tetsing survey round data as a reference.

This study was undertaken as part of school feeding technical assistance project to the Government of Nepal project by UN World Food Programme and Partnership for Child Development, Imperial College London. The research protocol and survey instruments were submitted to the Department of Education, Government of Nepal and duly approved. Standard research ethics were followed for all data collection. Participants were made aware of the purpose of the survey, use of the data and time the survey will take. It was emphasized that the survey is entirely voluntary, and they are free to withdraw their consent at any point. Prior verbal consent was taken from the respondents before starting the survey. Given the technical assistance project including the research has been approved by the government, no additional research ethics approval was deemed necessary. The same is confirmed by NARMA Consulting, the survey company, please see Annex-1. Approval letters from the Government of Nepal and signature of committee members approving the project is in Annex-2.

SAMPLING STRATEGY

QUANTITATIVE SURVEY

The surveys were undertaken in two purposively selected districts i.e. Bardiya and Sindhupalchok. These two districts represent two distinct agroecologies i.e. 'terai' (Bardiya) and 'mid-hills' (Sindhupalchok). 'Terai' (plains) AEZ consists of lowland region (<1500 masl) south of the Himalayan foothills. The climate is mostly sub-tropical. 'Mid-hills' is centrally located extending from the southern slopes of the main Himalayan ranges with a varying width of 60 to 110 km running across the length of the country. The altitude range is significant (800–2400 masl) and the climate varies from warm to cool temperate. A stratified sampling method was used for the surveys. For each survey round, the sample consisted of 147 farmer households evenly divided between the two study districts. In each district four municipalities were purposively selected, thus a total of eight municipalities were selected in the two districts.

One cooperative (farmer/multipurpose/forest/savings cooperative) was purposively selected from each municipality (in Sindhupalchok, for one municipality two cooperatives were selected due to small size of cooperatives). To ensure gender balance in the sample, four out of the nine cooperatives selected were women cooperatives i.e. these cooperatives consist of only women as members. A fixed number of farmer households i.e. 18 HH for Bardiya and 15 HH for Sindhupalchok were randomly selected from each cooperative. The member's list of selected cooperatives was used as a sampling frame. Survey farmers household was replaced if they were unavailable during the survey period. A new sample was randomly drawn for each survey round, the households surveyed in round-1 were excluded from the sampling frame for round-2 to avoid repetition. In total, across both survey rounds, the sample size was 294 farmer HH, 144 farmer HH in Bardiya and 150 farmer HH in Sindhupalchok.

TABLE-3 SAMPLE SIZE BY DISTRICT AND SURVEY ROUND

District	No of farmer HH	No of municipalities	No of cooperatives
Survey-1 (December 2018)			
Bardiya	18x4=72	4	4
Sindupalchok	15x5=75	4	5
Total	147	8	9
Survey-2 (July 2019)			
Bardiya	18x4=72	4	4
Sindupalchok	15x5=75	4	5
Total	147	8	9
TOTAL (survey1+2)	294 (147x2)	8	9

QUALITATIVE SURVEY

Qualitative survey consisted of a series of FGDs in the two study districts, which were undertaken in the same time frame as the quantitative surveys. In total, 14 FGDs were undertaken with 168 participants representing a diversity of farmers and food traders. As far as possible gender balance was maintained in each focus group. Each FGD was conducted in a different municipality to maximize geographic coverage in the district. Most of the FGDs were conducted in the office of the local cooperative, community centre or a school building.

The first survey round consisted of five Focus group discussion (FGDs), two in Bardiya and three in Sindhupalchok with a total of 61 participants. FGD participants were selected from the cooperatives in each municipality. The FGDs were conducted in December 2018 which is the post-harvest season in Nepal. In this round, FGDs focused on production patterns, food diversity and challenges in agriculture. The selection of participants was defined by occupation such as farmer, food trader, input trader, farm worker etc. The second survey round consisted of nine FGDs, four in Bardiya and five in

Sindhupalchowk, with a total of 107 participants, with similar types of participants as in round-1. These FGDs were conducted in July 2019 which is the agricultural lean season in Nepal and focused on recently abandoned crops, new crops in production and associated issues.

DATA ANALYSIS

Quantitative data was coded and analysed in both excel and STATA to estimate nutrient output and compute diversity indices. FGD data was translated into English and all responses were collated and analysed by guiding questions and themes.

NUTRIENT OUTPUT ESTIMATION

The average nutrient output per household and then the total nutrient output was calculated for the district, by survey round and district. The sum of the nutrient output for all households in each survey round and district provided the total nutrient output. This was then divided by the number of households in each district and survey round to give the average nutrient output per household.

To estimate the volume of different nutrients supplied by our sample in the two districts, the average nutrient output per household and then the total nutrient output for the district by survey round and district was calculated. Both calculations were made using the plot size brackets. To determine the true production amount for each household, any pre and post-harvest losses were taken into consideration using production and losses data from the Food and Agriculture Organization of the United Nations (FAOSTAT). This included time series of the annual production and losses amounts in Nepal for each crop type of interest (cereals, fruits, pulses, starchy roots, and vegetables) from 2014 to 2017. We first calculated the average amount lost and produced for each crop type. The true production amount for each crop was then multiplied by their respective nutrient values. The sum of the nutrient output for all households in each survey round and district provided the total nutrient output. This was then divided by the number of households in each district and survey round to give the average nutrient output per household.

The nutrient output was calculated for vitamin A, zinc, iron, protein, and energy (measured in calories). Food volume data for each HH was converted to nutrient values based on 2017 Nepal Food Composition Table (FCT). For some crops that were not available in the Nepal FCT, the 2017 Indian FCT was used. Both calculations were made using the plot size brackets for different farm size categories. To determine the true nutrient amount available for actual consumption for each household, an approximation of pre-harvest loss and post-harvest losses were taken into consideration using production and losses data from the Food and Agriculture Organization of the United Nations (FAOSTAT). This included time series of the annual production and losses amounts in

Nepal for each crop type of interest (cereals, fruits, pulses, starchy roots, and vegetables) from 2014 to 2017, the most recent three year time period for which data was available.

ANNUAL HOUSEHOLD NUTRIENT REQUIREMENT

The annual HH nutrient requirement was calculated based on HH composition for the poorest wealth quintile, consisting of six members per HH (Singh et al., 2020). Nutrient reference intakes were used to calculate the daily nutritional recommended amounts for each household member. The average energy requirements were based on the age, weight, gender and level of physical activity for each household member. The energy requirements were based on estimated average requirement references sourced from the Joint FAO/WHO/UNI expert Consultation in 2001 (Gertlet et al.,2014, MoH, 2016). Safe level of protein intakes were estimated based on guidelines within the WHO/FAO/UNU Joint Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition (FAO et al., 2007). The recommended daily allowance (RDA) reference values were used for zinc, iron, vitamin C and calcium and the safe level of intake reference values for vitamin A were based on the FAO/WHO Guidelines on Vitamin and Mineral Requirements in Human Nutrition (FAO & WHO,2004). Low bioavailability reference values for zinc (15%) and iron (5%) were used given the Nepalese diet contains high levels of antinutrients and low amounts of animal-based food (FAO & WHO,2004). Fat was limited to contributing up to 30% of total energy requirements based on the acceptable macronutrient distribution range (AMDR) for fat of 15-30% (FAO & WHO,2008).

Table-4 summarizes the household composition and daily nutritional needs for each member and annual HH requirement

TABLE 4: ESTIMATED ENERGY REQUIREMENTS FOR REFERENCE HOUSEHOLD

Gender	Age	Energy (Kcal)	Protein (g)	Vit A-RAE (ug)	Iron (mg)	Zinc (mg)
M	2-3	1125	12	400	11.6	8.3
M	5-6	1475	16.2	450	12.6	9.6
F	13-14	2375	41	600	65.4	14.4
M	37	2570	46	600	27.4	17.1
F	28	2200	37	500	58.8	9.8
F	45-40	1950	35	500	58.2	9.8
Total HH RDA		11695	187.2	3050	234	69
Annual HH requirement		4268675	68328	1113250	85410	25185

PRODUCTION DIVERSITY INDICES

To gain an understanding on the diversity of crops grown in terms of nutritional content and production, and how attributes may differ between districts, we calculated three diversity indices: Modified Functional Attribute Diversity (MFAD) score, Simpson's index, and Non-Staple Food Energy (NSFE) score. The MFAD score is a measurement of food diversity by determining the nutritional distance between crops. The Simpson's index is a measure of richness (number of different crops) and evenness (distribution of cultivated area) of farms. The NSFE score is a measurement of the percentage of energy derived from food items that are not staples. The purpose and methods for each index are detailed in the findings section below.

2.3 RESULTS AND FINDINGS

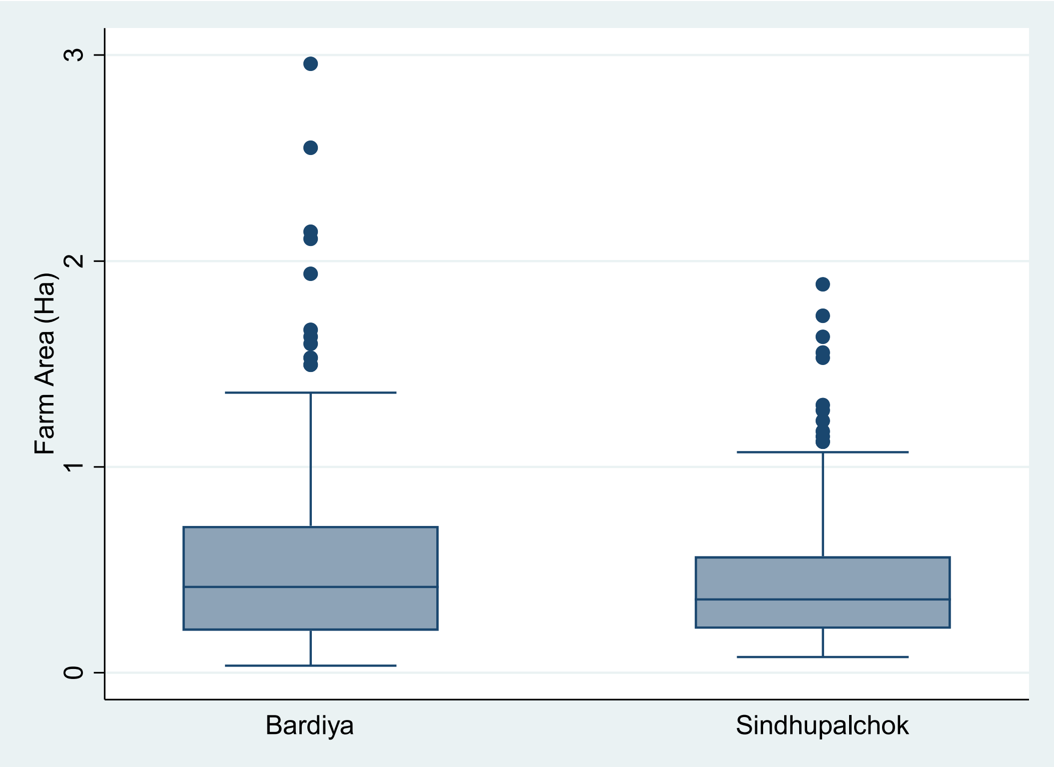
GENDER AND CASTE

In both survey rounds, of the total respondents surveyed, more than two-third were women. In survey-1, of the total respondent surveyed, the majority are from the higher castes such as *Brahmin/Chettri. Thakuri/Sanyasi* (47.6%) followed by an ethnic minority (46.9%) and lower caste/*dalit* (4.8%). While the respondent profile is dominated by 'higher' castes in Sindhupalchowk, it is dominated by an ethnic minority in the Terai, especially of *hill janajati* and *tharu* communities. In survey-2, of the total respondents surveyed, the majority are from *Brahmin/Chettri/Thakuri/Sanyasi* caste group (47.6%) followed by ethnic minority (39.5%) and *dalits* (10.98%).

FARM SIZE

Across the combined sample from both survey rounds, the average land holding in Bardiya is 0.28 ha and in Sindhupalchok it is 0.16 ha. Over 90% of total farm size in both districts is less than 0.5 ha. In Sindhupalchok, over 75% of farms on the combined sample are in 0-0.2 ha range. The box-plot showing farm size distribution for the two study districts is below in Figure-5.

FIG 5: FARM SIZE DISTRIBUTION BOX PLOT



PARCELS AND CULTIVATION

The total farm acreage consists of 313 unique land parcels across the combined sample of 144 farms. On average, each farm consists of 2.2 parcels and 3.4 parcels and in Bardiya and Sindhupalchok respectively. In the main growing season, almost 30% of farm area was left fallow in Sindhupalchok compared to 8% in Bardiya. During the lean season only 3.5% of land was left fallow in Sindhupalchok, compared to 12% in Bardiya. Table 4 presents the details of farm size distribution and cultivation by survey round and district.

TABLE 5: LAND CULTIVATION SUMMARY

	Parcels				
District	**Total**	**Cultivated**	**%age cultivated**	**%age cultivated**	**%fallow**
Season-1(Harvest season)					
Bardiya	196	180	91.8	92.2	7.8
Sindhupalchok	326	249	76.4	70.9	29.1
Season-2(Lean season)					

Bardiya	117	108	86.6	87.6	12.4
Sindhupalchok	179	174	92.3	96.6	3.4

PRODUCTION DIVERSITY

The analysis shows high nutritional functional diversity as represented by MFAD score in both districts, with small seasonal variations (~0.80). Simpsons index is higher in Sindhupalchok (0.60) compared to Bardiya (0.36) in season-1 and the reverse is found in season-2. Overall, the index is on the lower side which can be attributed to low level of evenness i.e. whilst there is diversity in terms of number of different crops, the relative abundance is low. The analysis also suggests that most energy is derived from staples as indicated by low NSFE scores, there is significant seasonality in Bardiya as NSFE increases from 5% in season-1 to 27% in season-2. Minimal NFSE seasonal variation in Sindhupalchok, from 11%-12%.

The table below presents indices for other countries as a reference. MFAD and NFSE scores are from a study by Remans et al. (2014). It is important to note that the variables used in this study are different, it includes seven key nutrients, carbohydrates, protein, vitamin A, vitamin C, iron, zinc, and folate whereas this study uses five nutrients. The food composition data is from FAO (INFOODS. Simpsons index could only be found for Malawi (Jones, 2014).

TABLE 6: PRODUCTION DIVERISTY INDEX SCORES BY COUNTRY

	MFAD**	NFSE**	Simpsons index
Bangladesh	52	17	-
India	67	35	-
Japan	82	55	-
Ghana	88	30	-
Italy	91	57	-
Kenya	70	42	-
Nepal	60	21	-
Malawi	-	-	0.39*

Source- **Remans et al 2014 supplement

*Jones 2014.

MFAD

The MFAD score is a measurement of food diversity by determining the nutritional distance between crops. The nutrients that were used to calculate these MFAD scores are vitamin A, zinc, iron, protein, and energy (measured in calories). The nutritional distance between two crops is calculated as an average dissimilarity among all the assessed nutrients. For each household, this nutritional distance was calculated between every crop grown. The nutrient content of crops was taken from the 2017 Nepal FCT. If crops could not be found the Nepal FCT, the 2017 Indian Food Composition Table was used. Each household was then assigned an MFAD score bounded between 0 and 1, where 0 represents the least nutritionally similar (least diverse) farm and 1 represents the most nutritionally dissimilar (most diverse) farm. The average MFAD score by survey round and by district is represented in Table 7 below. Overall MFAD scores suggest that on farm nutritional diversity is quite high in both districts and survey rounds.

TABLE 7: MFAD SCORES BY DISTRICT AND SURVEY ROUND

DISTRICT	**MFAD SCORE**	
	Round 1	**Round 2**
Bardiya	0.80	0.77
Sindhupalchowk	0.81	0.78

SIMPSON'S INDEX

The Simpson's index is a measure of richness (number of different crops) and evenness (distribution of cultivated area) of farms. The index which is primarily used in ecological literature to measure species diversity has been applied to measure crop diversity (Jones, 2014). It is calculated using the proportion of land each crop that is grown on the farm takes up and is bounded between 0 and 1, where 0 represents the least rich and least even farm and 1 represents the most rich and most even farm. The average Simpson's index (Table 8) by survey round and district are shown below. Simpson's indices were similar across survey rounds and districts, and they all had very low correlation with farm size except for Bardiya in round 1

TABLE 8: SIMPSON'S INDEX BY DISTRICT AND SURVEY ROUND

DISTRICT	**SIMPSON'S INDEX**	
District	**Round 1**	**Round 2**
Bardiya	0.36	0.57

Sindhupalchok	0.60	0.52

Non-Staples Food Energy (NFSE)

The NSFE score is a measurement of the percentage of energy derived from food items that are not staples. Staples are defined as cereals or grains/tubers (i.e. any of the following crops: Rice, Maize, Millet, Buck Wheat, Wheat, Pidalu, Sakharkhanda, Potato, and Radish). The average NSFE score by survey round and district is shown in Tables 9. NSFE scores are similar across rounds in Sindhupalchok but vary substantially between rounds for Bardiya with round 1 having a much lower score than round 2.

TABLE 9- NFSE SCORES BY DISTRICT AND SURVEY ROUND

DISTRICT	**NFSE SCORE**	
	Round 1	**Round 2**
Bardiya	5.23	26.74
Sindhupalchowk	10.77	12.08

NUTRIENT OUTPUT

Nutrient supply from own production as a percentage of household requirement.

Table 10 and 11 below summarize the net average supply (accounting for pre-harvest and post-harvest loss) of key nutrients per farm, by different farm size categories, as a percentage of annual recommended HH requirement for a typical notional HH. To assess annual supply against annual HH requirement, data from the two survey rounds, which account for the majority of the farm output in a year, was combined to provide annual average supply per farm HH by farm size category.

On average across farm sizes, the supply of all micronutrients in both districts is less than 100 % of a typical HH annual requirement, except for iron. Vit-A annual supply is the lowest at 14% in Bardiya and 22% in Sindhupalchok. Iron supply per farm in Bardiya is 36% of the annual HH requirement whereas in Sindhupalchok it is just over 100%. Energy supply is over 100% in Bardiya and around 90% in Sindhupalcok and protein supply is in surplus by a wide margin in both districts.

There are noticeable differences in nutrient supply by farm size categories; for example, in Bardiya energy supply varies from is 26%(0-0.2 ha) to 361% (1+ ha), zinc varies from 23% (0-0.2 ha) to 249% (1+ ha) and iron varies from 16%(0-0.2 ha) to 73% (1+ ha).

TABLE 10: BARDIYA DISTRICT- NUTRIENT SUPPLY FROM OWN PRODUCTION AS A %AGE OF HH REQUIREMENT BY FARM SIZE.

Nutrient	**Nutrient supply as %age of HH requirement**				
	0 - 0.2 ha	**0.2 - 0.5 ha**	**0.5 - 1 ha**	**1+ ha**	**Avg**
Energy	26.4	63.5	140.9	363.1	123.2
Protein	50.6	114.0	198.5	499.0	182.8
Vitamin A	5.3	11.9	14.9	28.8	13.9
Zinc	23.4	55.6	99.1	249.3	90.4
Iron	15.8	30.9	37.1	73.4	35.8

TABLE 11: SINDHUPALCHOK DISTRICT: NUTRIENT SUPPLY FROM OWN PRODUCTION AS A %AGE OF HH REQUIREMENT BY FARM SIZE.

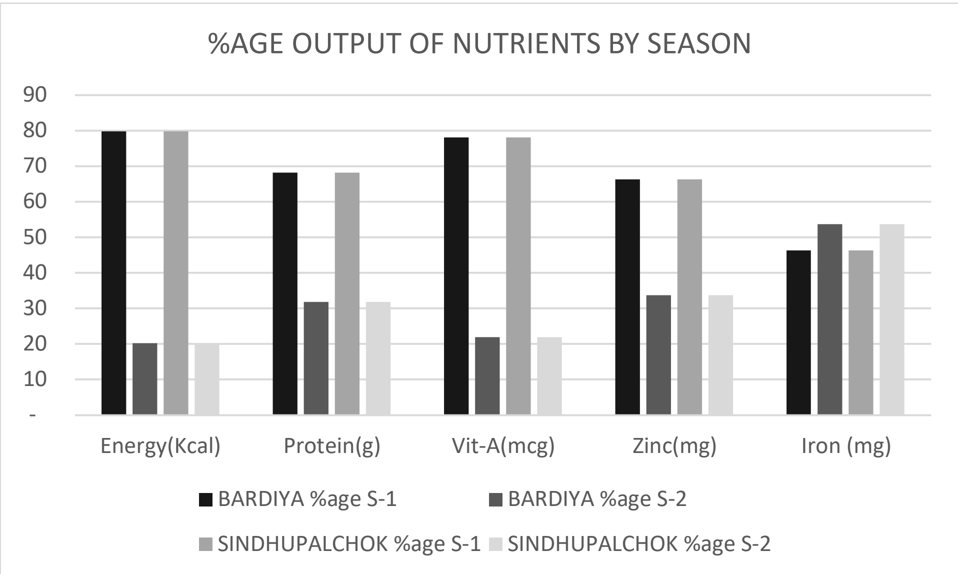
Nutrient	**Nutrient supply as %age of HH requirement**				
	0 - 0.2 ha	**0.2 - 0.5 ha**	**0.5 - 1 ha**	**1+ ha**	**Avg**
Energy	27.8	82.1	151.4	122.5	91.7
Protein	47.0	128.8	251.5	197.5	148.4
Vitamin A	19.4	12.6	41.4	24.5	21.9

Zinc	21.6	66.7	132.6	103.1	76.9
Iron	28.8	71.4	195.6	156.3	100.9

SEASONALITY OF NUTRIENT OUTPUT

The figure below shows the per farm annual nutrient output by agricultural seasons. The output for all nutrients, with the exception of iron in Bardiya is substantially concentrated in season-1 with energy output at over 75%, protein output at over 65%, zinc output at over 65% and Vit-A over 75% in season-1 in both districts. Iron is an exception in Bardiya, season-2 accounts for a greater proportion of annual output, the trend in Sindhupalchok is similar for other nutrients with season-1 accounting for over 85% of iron output.

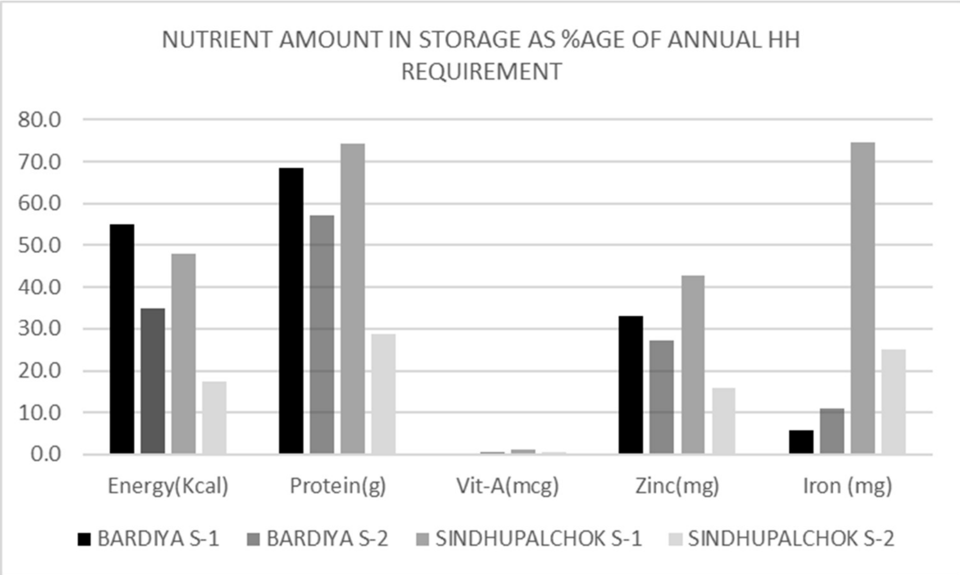
FIGURE 6: SEASONAL OUTPUT OF NUTRIENTS



NUTRIENT VALUE OF FOODS IN STORAGE

Figure 7 below summarizes the amount of food in storage per HH in nutrient values and as a percentage of annual HH requirement for harvest and lean season in both districts. Macronutrients such as proteins and calories represent highest stored values. The amount in season-2 is lower than season-1, by over 60% for both proteins and calories in Sindhupalchok, decrease is relatively less in Badriya. Amongst micronutrients, vitamin-A in storage is negligible in both districts, zinc in storage is in the range of 30%-85% depending on the season and district, iron in storage is very different between the two districts, in Bardiya, stored iron in season-1 is equal to 12% of annual HH requirement compared to 149% in Sindhupalchok. The inter-seasonal storage trends for iron are also inverse, in Bardiya, iron in storage in season-2 increases from 12 % to 22% of annual HH requirement and in Sindhupalchok, it decreases from 149% to 50% in season-2.

FIGURE 7: NUTRIENT OUTPUT IN STORAGE AS %AGE OF ANNUAL HH REQUIREMENT



QUALITATIVE SURVEY FINDINGS

STATE OF AGRICULTURE

Non-farm work is reported to be a far better financial option than cultivation. For example, in Bardiya on average farmers earn 30,000-35,000 NPR (250 USD) per year from non-agricultural work. Comparatively, by way of illustration, one farmer reported to have sold wheat for 36000 NPR cultivated on 10 katha (0.33 hectares) of land and made a profit of 11000 NPR in six months. It was reported that if the farmers do non-farm work for about 5 days every month, it is sufficient to feed whole family for a year. One farmer mentioned that the cost of ploughing by ox per day was NPR 1800, suggesting this was much higher than the returns.

Besides poor returns, lack of labour and climate change relates risks were highlighted as significant issues. Hence, many farmers often prefer to leave the land fallow, since the cost of farming exceeds the benefits. With the increasing cost of production most farmers in Sindhupalchok cultivate crops only in low land and have abandoned cultivation in up-land farm parcels, as much as 70-80% of agricultural land that was not used to grow rice was left fallow and almost 20% of the farm area is left permanently fallow, i.e. no crops are cultivated for the last two years. In Bardiya, the extent of permanent fallow land is almost negligible, at least one crop, i.e. paddy is cultivated in a year.

However, the tendency of leaving fallow land for wheat crops or another crop during the winter season was reported to be increasing.

FOOD AVAILABILTY FROM FARM PRODUCTION

Participants were asked to identify months for which their staple food production is enough for consumption by calendar months and crops. June, July and August constitute the hunger season. Majority of the farm households reported to be food self-sufficient for October-February period. This is the main harvest season for the major cereals such as maize and paddy. Likewise, they also consumed stored food during the period.

During the FGDs, the participants were asked to rank the months based on the availability of the vegetables for consumption from own farm production. Most of the participants cultivate seasonal vegetables for own self-consumption, and purchase of vegetables is virtually non-existent. In Bardiya, a wide range of vegetables is available throughout the year whereas in Sinduplachok, 2 periods (May-June and Sept-Oct) were reported with no vegetables and Jan-Feb, March-April, April-May and Aug-September were periods of one vegetable only.

PRODUCTION PATTERNS AND FOOD DIVERSITY

Majority of farmers reported that cultivation of local landraces is on a declining trend over the past 10 years. Cereal varieties such as millet, maize, buckwheat and rice, and legumes such as cowpea, soybean, peas, lentils and horse gram had declined in both districts. However, blackgram production was increasing where irrigation was available. Vegetable varieties of pumpkin, colocasia and bottle/ashgourd were also declining. The main reasons for the decline of local landraces are reported to be low productivity, late maturity, high production cost and high labour requirement.

The respondents were asked whether they were aware of any crops/foods that were grown by the previous generation and are not grown today. The objective was to get an understanding of the type and scale of foods that have gone out of production within one generation. In Sindhupalchok, participants reported 16 crops/landraces which were produced and consumed by the previous generation but are not used today. These mostly consist of varieties of rice and pulses. Similarly, in Bardiya district, the survey reported 42 foods/varieties including 17 varieties of rice, four varieties of maize, seven varieties of wheat and a wide range of medicinal plants. Most of the cereal varieties have been abandoned on account of low productivity, seed scarcity and vulnerability to pests and diseases. Almost all the medicinal plants have lost utility due to adoption of modern medicine.

The respondents were also asked about new food crops which were not produced earlier but are being cultivated currently. In Sindhupalchok district the survey identified eight new crops/varieties which include four varieties of rice and one variety of wheat. The main reasons for the adoption of new cereal varieties are productivity, size of grain and better taste. In Bardiya district, the survey identifies 19 new crops/varieties, which include nine varieties of rice, three varieties of maize and one type of wheat. Other new plants include green leafy vegetables and fruits. The reason for adopting the new rice varieties include early maturity, better taste, easy access to seeds and high productivity.

Food that was rarely consumed was mainly due to taste preferences, socio-cultural perceptions and labour needed to cultivate, process and cook. Additionally, limited production of certain commodities and lack of awareness regarding their nutritional properties were reported to be reasons for underconsumption. The increasing access to convenience foods was also reported to play a role in determining consumption habits. Women who are the main head of the households have many daily duties including meal preparation and prefer foods and meals which are quick to prepare. Therefore, foods that take a long time to cook are less frequently cooked, for example, *dhido*, a traditional nutritious meal requires continuous mixing of cereals like millet and buckwheat while cooking. Traditional cereals such as millet have been replaced by rice in most communities. It was reported that traditional cereals take more time and effort to cook compared to rice and people find the taste of rice more appealing. Proso millet, a traditional, highly nutritious and affordable grain, was reported to be less desirable due to taste and labour required for cultivation.

Socio-cultural perceptions of certain foods have negatively influenced the consumption of traditional and nutritious foods. For example, oats, barley, horsegram and yam are perceived as poor man's food and stinging nettle is considered *cheap food*. Stinging nettle was particularly avoided by people belonging to Brahmin community in some districts. Similarly, a focus group reported that Amaranthus and Bethe leaves were rarely consumed due to social reasons. There was also misinformation about some foods such as jackfruit and sweet potato, as being harmful to the digestive system.

2.4 DISCUSSION AND CONCLUSION

In examining the amount of nutrients produced by local agriculture in terms of dietary needs, the analysis finds deficient nutrient supply from local production for all nutrients and particularly for micronutrients, based on the target of annual requirements of one notional household. Average vitamin-A output per farm is the lowest in both districts meeting only 14%-22% of annual HH requirement. Bardiya shows high levels of iron deficiency at 36% supply compared to Sindhupalchok at over 100% supply. Energy and protein surplus are also very limited with the upper limit of around 180% for protein in Bardiya.

The deficient supply of nutrients would have a clear impact on local diets. The FGDs suggest that households supplement food production from local market mainly for meat, eggs and processed foods, while for other foods, reliance is primarily on own production. This is also supported by a study analysing national data from Nepal Living Standards Survey 2010/11, it reports that across Nepal, households are most reliant on self-production of milk, staples, vegetables, and pulses to meet HH dietary needs. In hills AEZ, an average household consumes 40% from their own production, 57% from purchased food, and 2% in-kind and in Terai AEZ figures are 43%, 54% and 3% respectively (National Planning Commission 2013).

I look at data on MNR deficiencies and food consumption practices from national surveys to correlate with the findings in this study. Results from the National Micronutrient Survey (MoH,2016) for population group of children 6-59 months is reported in the table-12 below. Iron deficiency at 23% is higher in Terai (Bardiya) compared to hills at 14.8% (Sindhupalchok), zinc deficiency prevalence is also substantial at over 20%. These findings correlate with the deficient output for these nutrients found in this study. However, vitamin-A deficiency prevalence as reported in the National Micronutrient Survey is moderately low whereas the vitamin-A farm output in this study is found to be highly deficient. I also look available consumption data, as per DHS consumption data for the 6-23 month age category, percentage of children who consumed foods rich in Vit-A in last 24 hrs is reported at 72% in hills and 57% in terai and iron consumption is reported at 43% and 31% for hills and Terai respectively. This aligns with our analysis which shows higher vit-A and iron output in Sindhupalchok compared to Bardiya.

TABLE 12: PREVALENCE OF MICRONUTREINT DEFICIENCY IN CHILDREN (6-59 months)

(National micronutrient survey, 2106)

Ecological region	Zinc	Vit-A	Iron
Terai	20.5%	7.3%	23%
Hills	24.9%	1.2%	14.8%

NOTE: DHS reports higher levels of iron deficiencies prevalence for Children Age 6-59 Months at 60% and 40% for Terai and Hills respectively.

The nutrient farm supply output analysis in this study in all probability underestimates the actual deficiencies that occur at many points in a year given the high degree of seasonality in farm nutrient output for most nutrients. This study shows that 60% to 75% of nutrient production is concentrated in the main agricultural season in both study districts. This is a function of highly seasonal rainfed agriculture in most parts of Nepal. Therefore, household and on-farm storage play a particularly important role in food consumption throughout the year. This study shows nutrients such as proteins, calories and zinc represent highest stored values as a percentage of annual HH requirement which is a function of the nature of foods i.e. foods with greater shelf life such as cereals and lentils. Vitamin-A in storage is negligible in both district and iron in storage is also generally quite low. In terms of resilience to production shocks, as a function of reliance on stored foods for consumption, micronutrients buffer is almost non-existent. Strong seasonality and low level of stored nutrients can have serious consequences on diet quality during lean seasons and production shocks.

However, it is important to note that farm nutrient output by itself does not directly translate to dietary nutrient availability. For example, iron and zinc in cereals have very low bioavailability compared with these nutrients in fruits and vegetables.

The loss of agrobiodiversity due to bias towards a few staples and overall reduction in production diversity is a major concern. To test this in the case of Nepal, this paper estimates the level of agrobiodiversity using nutrition sensitive metrics such as MFAD and NSFE. MFAD scores of 0.77-0.81 suggest a reasonably high nutrition functional diversity in comparison with national estimates for other countries (Remans et al.,2014). NFSE scores are very low and indicate that most of the energy is derived from cereals and tubers, and Simpsons index is also low in the 0.4 to 0.6 range. Overall, these findings show that while nutrition diversity of farms is strong, in terms of volume of production it is heavily biased towards protein and energy.

Qualitative surveys reveal a significant shift in production patterns over recent years with declining production of many varieties and landraces of cereals, legumes and vegetables. In Bardiya and Sindhupalchok, participants reported 42 and 16 crops respectively, which were produced and consumed by the previous generation but are not used today. Adoption of new varieties, eight in Sindhuplachok and 19 in Bardiya was also reported. There are many interrelated ecological, economic and behavioural reasons for the low production volumes and disappearance of certain foods, many of which are known to be nutrient rich.

The average farm size is very small, ranging from 0.16 to 0.28 ha in the study districts, the actual size of each parcel is even smaller as each farm consists of 2-3 separate land parcels. More critically a consistent finding from all FGDs was that overall agriculture has become an increasingly risky and financially unviable occupation. Farmers in many communities increasingly prefer to leave the land fallow and engage in other livelihood activities due to poor returns in farming. The absence of irrigation facilities, extension services, poor markets and other forms government support are major reasons for low levels of farming activity which adversely impacts agrobiodiversity. Besides medicinal plants, which have lost utility due to adoption of modern medicine, reasons for abandoning other foods include low productivity, late maturity, high production cost and high labour requirement.

Finally, there is the issue of demand which is guided by a range of issues such as taste, ease of preparation and socio-cultural perception. For example, traditional cereals such as millet have been replaced by rice in most communities as it easier to process and cook. Green vegetables rich in vitamin-A and other nutrients such as stinging nettle and bethe leaves are not consumed as they are considered poor man's food.

This study illustrates that there are many interrelated economic, ecological and behavioural components at play that fundamentally determine the nature of agriculture production. Policy interventions need to reflect the complex causality between agriculture, nutrition and agrobiodiversity. Multiple discreet interventions targeting specific issues such as diversified demand or increased production of neglected and underutilized species are bound to have limited overall impact, faced with severely limiting structural and ecological constraints. Given the increasingly disincentivized state of agriculture, basic investment and government support to agriculture in terms of extension services, storage, provision of inputs and output support is an indispensable prerequisite to create the enabling environment for a healthy food system. One of the most important contributions of this study is restating the obvious i.e. the urgent need for investment in agriculture ecosystem that supports small farmers.

The findings of this paper reflect the irony of a highly biodiverse agrarian country like Nepal suffering from high levels of malnutrition and nutrient deficient agriculture ecology. This is not unique to Nepal, many poor countries in the world share a similar fate. This has serious implications on food security and public health and perhaps calls into question the efficacy of national and international policies and programmes that seek to address food security. The challenges of supporting small farm agriculture in low-income countries with limited government capacity are profound. Funding and research must be directed to enable national and local governments to create mechanisms providing integrated support to agriculture. To improve nutrition and the resilience of food production especially in low-income countries with limited food import capacity, agriculture needs to be recognized in national and international governance priorities as a critical contributor to public health and ecological management.

CHAPTER-3

INTERVENTION THEORY AND DEVELOPMENT

3.1 INTRODUCTION

The project intervention i.e. Nepal Home Grown School Feeding was for a three year duration from January 2018 to December 2020 (some components extended to Dec 2021). It was funded by the United States Department of Agriculture (USDA) as part of the McGovern-Dole Food for Education Program 2018. The intervention was led by Partnership for Child Development (PCD), School of Public Health, Imperial College London in collaboration with UN World Food Programme (WFP) Nepal, Government of Nepal (GoN) and local municipal governments. The project team is based in London and Kathmandu. The team was headed is by the Project Lead (author) based in Imperial College London, under the overall supervision of Dr. Lesley Drake, Executive Director, PCD. The Kathmandu project office consists of a project manager (Dr Deepak Gautam), project coordinator (Laxman Achraya) and district coordinators in each of the eight intervention districts.

The intervention was a technical assistance project to design and implement a Nepal HGSF programme as part of government led national school feeding programme. An important component of the research methodology is the development of programme theory through deductive and inductive processes. The objective here is to develop a theoretical basis than effectively informs practice. Whilst this is a continuous exercise through the implementation process, at the initial stages some key project components such as intervention sites and key activities had to be determined. Whilst the broad purpose was established prior to commencement of the intervention at the grant application stage to USDA, the specific objectives evolved during the design phase. An important element of this intervention which needs to be emphasized is that it needs to be embedded in a currently operational national programme which requires the intervention to be closely aligned to government systems and objectives.

This chapter is structured according to the key research steps. It begins by describing the concept of HGSF and the associated programme theory which is the starting point of the intervention design. It then summarizes the stakeholder consultations which included a wide range of stakeholders including government departments, teachers, farmers and local government. The findings from these consultations contribute to the intervention objectives and intervention areas which are described subsequently. The combined evidence from stakeholder consultations, intervention sites and chapter-

2, is then applied to reexamine the programme theory. This is followed by the conclusion section which reflects on the implications of the theoretical and empirical perspectives on key project components.

3.2 HOME GROWN SCHOOL FEEDING

DEFINTION AND CONCEPT

There is no one definition of HGSF, broadly speaking it is a government led school feeding programme which seeks to rely on local agriculture production as against food aid or imported commodities (Singh & Fernandes, 2018). The definition of local and the mechanics of engagement are different for different country contexts, the overarching principle is to support market development for small holder farmers. Whilst the scope and content of HGSF can vary depending on the context and specific objectives, it can be defined as follows; "HGSF constitutes a school feeding model that is designed to provide children in schools with safe, diverse and nutritious food, sourced locally from smallholders" (FAO & WFP,2018).

There are no formalized criteria for a model to qualify as HGSF, generally HGSF model should include local food procurement, smallholder engagement, nutritious food, dietary diversity and regularity in meal provision (Singh & Fernandes, 2018). Most non- HGSF school feeding models usually have national centralized procurement which can include imported foods or a privatized model where school feeding is entirely outsourced to a private vendor. Mixed models are quite common where some foods such as fruits and vegetables are procured by schools locally and all other foods are supplied through centralized procurement and distribution system.

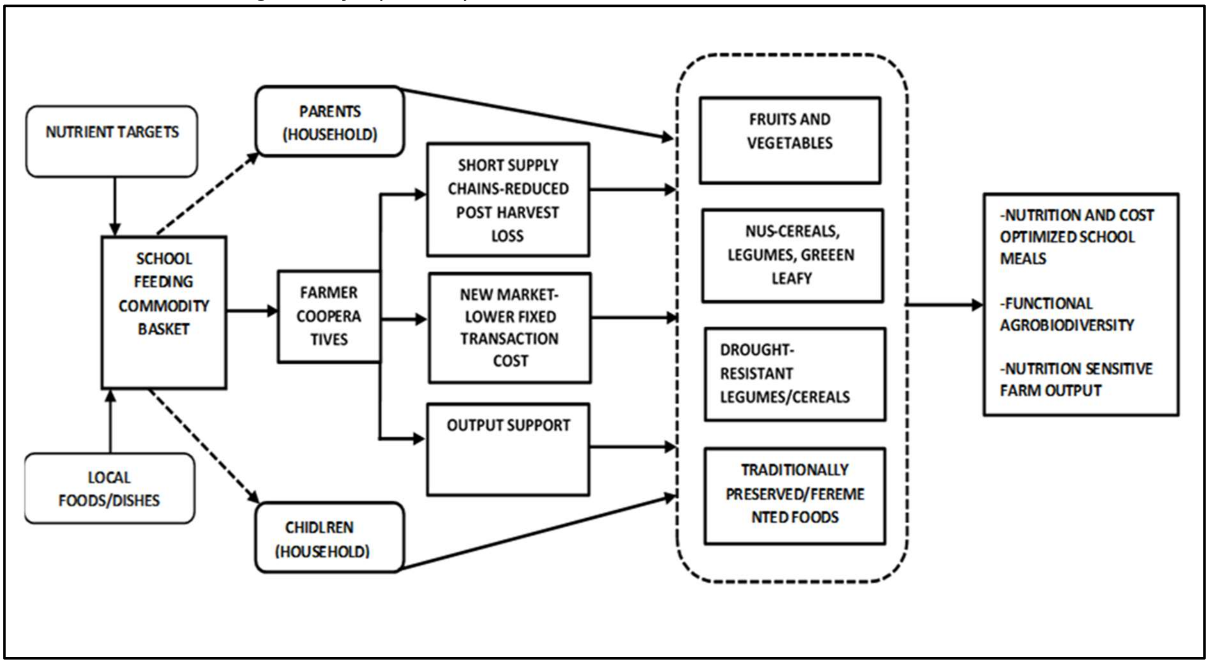
The concept of HGSF was initiated by NEPAD in 2003 and is now operational by some estimates in over 30 countries in Asia, Africa, and South America (Singh & Conway, 2021). Bill and Melinda Gates foundation was the first major donor to support HGSF and provided significant grants to develop and implement the concept in sub-Saharan Africa. In 2018, UN agencies and other partners came together for the first time to develop a joint framework for HGSF capacity strengthening efforts (FAO & WFP, 2018).

HGSF structured demand is explicitly shaped by considerations of geographic localization (proximity to school or national) and a diversified commodity basket based on menus. The menus are designed as per accepted nutrition requirements, based on local availability and agroecological suitability for production. It is well recognized that HGSF can promote dietary diversification and improve market access for smallholder farmers (Drake et al.,2017). More recently there is also increasing recognition of the of role HGSF in local food systems especially related climate change adaptation strategies such as promoting climate smart foods (WFP 2020).

3.3 PROGRAMME THEORY

The HGSF programme theory as described here was developed by the author based on experiences and evidence from HGSF and agriculture-nutrition projects in Ghana, Kenya, Nigeria and Uganda (Singh & Conway 2021). The theory was constructed based on a wider food system framework and simplified to reflect key inputs, components, pathways and outcomes described below.

FIGURE 8: HGSF PROGRAMME THEORY SCHEMATIC
Dotted arrows-knowledge transfer pathways



INPUT COMPONENTS

The main input component in the school feeding food basket which is the central driver of changes through different pathways. The food basket is determined based on established nutrition targets which includes both macronutrients and micronutrients and food diversity. These targets are sought to be achieved through the provision of a hot cooked meal of locally produced foods as per local dietary practices and tastes. The foods used are raw with minimal processing in some cases such as wheat flour or dried rice flakes.

MEDIATING COMPONENT

The key mediating element for food and markets is farmer cooperatives which provide the interface between local agriculture and the intervention. The school feeding commodity basket can influence the food system, primarily through the procurement and supply from the farmer cooperatives. Whilst the specific constitution of the cooperatives in terms of its membership and reach can vary, HGSF programmes aim to include cooperatives consisting of small holder farmers. Procurement agreements with farmer cooperatives are usually in the form of forward contracts.

PATHWAYS

As shown in Figure-8, three main pathways are enabled through the programme intervention, (1) Market pathways (2) Food pathways and (3) Knowledge pathways (in dotted lines). The pathways are not discrete elements separately leading to outcomes, they are integrated and mutually enabling as is shown on the description on each of these pathways below.

MARKET PATHWAYS

The forward contract modality between farmer cooperatives and proximate schools creates three distinct and interrelated market incentive linkages which are briefly described below.

(1) Short supply chains: Short supply chains reduce the need for storage which minimises the risk of post-harvest loss and storage costs (Conway et al., 2017). This is relevant for all foods but especially for perishable food such as fruits, vegetables, and green leafy vegetables. The length of supply chains is particularly vital for the food quality control in low-income countries where storage of vegetables, except roots and tubers, is very minimal and commercial processing is almost non-existent.

(2) Lower fixed transaction costs: The structured demand of school feeding though forward contracts lowers the fixed transaction cost (FTC) such as finding a buyer and price negotiation. The element of proportional transaction cost such as transport is included in the forward contract costing. Whilst both fixed and proportional transaction costs are equally important in market development, studies show that that FTC play a significant role in market decision making process (Key, Sadoulet & Janvry, 2000). This is particularly critical in the context of NUS where finding buyers and a fair selling price can be difficult as there is limited market for some NUS foods.

(3) Output support: The forward contract for school feeding provides output support for farmers through the cooperatives, with guaranteed pricing for fixed quantities across a diverse range of commodities.

FOOD PATHWAYS

The procurement system described above, which is based on HGSF menu, and targets food sourcing from women farmers, small farmers and local geographies, affects the farm output by directly and indirectly incentivizing certain foods and food groups. The nature of incentives can be both monetary and non-monetary. Non-monetary incentives relate to the idea at the community level, of preserving and promoting local food production and dietary heritage and providing local nutritious food to children through school feeding. The main foods which are affected by HGSF can be categorised in three categories. It is important to note that some foods in these categories can be overlapping, a fruit or vegetable can also be NUS.

1. Fruits and vegetables- This includes a range of seasonal foods in this food group including green leafy vegetables, the primary focus is foods rich in micro-nutrients.

2. Neglected and Underutilized Species- This includes orphan crops across food groups, specific to each agroecological zone. It also includes Future Smart Foods (FSF), FSF are a subset of NUS that are nutrition rich, climate resilient, economically viable and locally accessible (Li & Siddique 2018). Examples of FSF include buckwheat, taro, cowpea and chayote.

3. Fermented or preserved foods- This includes local foods preserved through traditional fermentation and preservation techniques such as Gari in West Africa, gari is traditionally fermented and dried cassava flour, and gundruk in Nepal, which is made by fermenting and drying leafy vegetables.

KNOWLEDGE TRANSFER PATHWAYS

Knowledge transfer pathways shown in the figure in dotted arrows, can lead to incorporation of certain foods in household consumption. The intervention includes specific components that can lead to knowledge transfer such as behaviour change communication at schools and community nutrition sensitization workshops. In addition, there can be due to increased awareness of the nutrition value of specific foods, through participation of parents in school feeding programme and through children. Parents, mostly farmers, participate in school feeding through school-based parent committees and, in some cases, are involved in supervision as well as design of school meals. Children are also known to influence dietary habits at home, based on their school meal experience (Master et al., 2018). This can eventually lead to incremental shifts in the cultural perception of certain nutritious foods which are undervalued.

MECHANISM AND OUTCOMES

The pathways mentioned above impact the farm output which is a function of two elements; the demand and the procurement strategy. The demand is determined by the school feeding menu which is designed to be nutritionally balanced and diverse with a focus on local micronutrient rich crops. The procurement strategy focusses on local small farms and more specifically on women small famers.

Both these components of the procurement strategy farmers contribute to the diversity of the commodity basket in the procurement strategy. Whilst there is wide variation across regions, overall women and small farmers led production contribute specifically to output of non-staple food groups such as fruits, vegetables, and legumes (Joshi et al., 2006; Malapit and Quisumbing, 2015).

Finally, the incentives for a diverse commodity basket through an institutionalised mechanism can lead to better agrobiodiversity and farm nutrition output. There is good evidence to suggest that production diversity is linked with dietary diversity both at the national and community levels in low-income countries (Remans et al., 2014). However, this does depend on the level of analysis and methodology and may not hold true in many cases. At the micro level, a number of variables comes into play such as agroecology, terrain, access to markets, proximity to market channels, proximity to international border, etc. These variables determine the type and level of engagement between local production and consumption.

3.4 THE INTERVENTION

The project i.e. Nepal HGSF is the first of its kind that aims to enable agriculture-nutrition-agrobiodiversity linkages through a multi-sectoral community driven HGSF model, integrated in a national government safety net programme. The project is integrated with National School Meals Programme (NSMP) of GoN which is coordinated by Centre for Education and Human Resource Development (CHRD) under the Ministry of Education. NSMP is a universal central government funded food-based safety net programme implemented by local governments in all 77 districts of the country as of 2020.

Besides the findings from consultations described later in this chapter and evidence from scoping studies and surveys, the project design builds on the substantial body of research and operational work on HGSF and agriculture-nutrition linkages in different parts of the world including Nepal. The intervention design also benefitted from personal experience of the author who has worked on agriculture-nutrition projects for over 10 years and guidance of the thesis supervisors, Prof Gordon Conway and Dr Lesley Drake, leading authorities on foods systems, school feeding and agriculture.

OBJECTIVES

The overarching purpose of the project is to improve food and nutrition security at the community level using school feeding as a platform. This is to be achieved by enabling nutritionally and ecologically sensitive production and consumption practices. The specific programme objectives of the intervention are as follows:

1. Improve health and nutrition of school children through school feeding.

2. Enable agriculture-nutrition-agrobiodiversity linkages in both policies and operations.
3. Improve production and consumption of local micro-nutrient rich and drought resilient crops/varieties.
4. Improve market access for small farmers through structured demand of school feeding supply chain.

INTERVENTION AREAS

Nepal consists of three distinct agroecological zones, (1) Terai-mostly plains with sub-tropical climate (2) Middle mountain-mountains in the range of 800-2400 masl, climate is warm and cool temperate and (3) High mountain-mountains above 2400 masl, climate is cool temperate and arctic. The total land area of the country is 147,181 km^2 of which 51,817 km^2 is covered by the Mountain region, 61,345 km^2 by the Hill region and 34,019 km^2 by the Terai region. Out of the total arable land in Nepal, Terai, Hill and mountain regions contain around 56%, 36% and 8% respectively (CBS, 2013). The intervention study districts cover these three major agro-ecological zones. Agroecological zones define the key aspects of seasonality of agriculture production and length of growing period which has direct implications on localized agricultural diversification. The implications vary significantly by food group leading to differential impact in terms of nutrient supply and food diversity.

Besides the wide geographical and ecological variations, stakeholder consultations highlighted the cultural/ethnic heterogeneity in different regions of Nepal which should be represented in the selection on the intervention areas. Nepal consists of more than a 100 ethnic groups and different caste hierarchies within and across the ethnic groups, the 2001 census categorizes these groups in 11 regional clusters (Ministry of Health, 2016). The high level of demographic heterogeneity has important implications on food production and consumption practices, creating prominent and entrenched cultural norms on food. The cultural component is recognized in national policy and legislation as a primary feature of food security and sovereignty. Sections 3(3E) of the primary food security legislation i.e. The Right to Food and Food Sovereignty Act, 2018 explicitly includes culturally acceptable food as one of three rights related to food security. In interviews with senior government functionaries across departments, it was one of the most prominent points of consideration in relation to intervention supply chains.

A total of eight district were selected for the intervention in a phased manner. Phase-1 in 2018 was in two districts, Bardiya and Sindhupalchok. Phase-1 districts were selected in consultation with GoN and UN WFP. These districts, representing two distinct regions had established local government buy-in due to earlier interventions and were most appropriate to serve as pioneer districts to assess the project design. In Year-2, the project was scaled up to four additional districts, Mahottari, Dhanusha, Nuwakot and Jumla, followed by another two districts (Baitadi and Dadeldhura) which were added in 2020. The districts were selected to be representative of Nepal's diversity in agroecology, geography, culture and economy in alignment with the operational criteria defined by GoN. The intervention was deliberately phased to ensure that findings from each phase can help improve the design for the subsequent scale up. The first phase was critical as it used to test and evaluate all project components.

The table below describes the diversity of the intervention district in terms of agroecological zone, food poverty, and nutrition status. Although this was not a principal criterion for selection, the different districts represent the ethnic diversity of the country to a significant extent (Bennett et al, 2006). The programme districts along with the intervention municipalities are highlighted in figure-9. Stunting prevalence and food poverty are indicated in figure-10. The prevalence of stunting is very high across the districts from the 36-45 % range in a few areas to 51-60% range in Jumla. Inter-district food poverty variation is relatively higher, from the second lowest range bracket (16-25%) to the highest range of 56-78%.

The selected districts cover all three major agroecological zones (AEZ) of Nepal, i.e., Terai, Mid-Hills, and High Mountains. 'Terai' (plains) AEZ consists of lowland region (<1500 masl) south of the Himalayan foothills. The climate is mostly sub-tropical. 'Mid-hills' is centrally located extending from the southern slopes of the main Himalayan ranges with a varying width of 60 to 110 km running across the length of the country. The altitude range is significant (800–2400 masl) and the climate varies from warm to cool temperate. 'High mountains' consists of the main Himalayan ranges (>2400 masl), climate varies from cool temperate to arctic.

TABLE 13: DESCRIPTION OF KEY INDICATORS OF INTERVENTION AREAS [1]

Code	**District**	**Agro-Ecology**	**Stunting Prevalence (%)**	**Food Poverty (%)**
D1	Bardiya	Terai	36-45	16-25 (3) and 26-35 (1)
D2	Sindhupalchok	Mid-hills	46-50 (3) and 36-45	16-25 (2) and 26-35 (2)
D3	Dhanusha	Terai	36-45	16-25
D4	Mahottari	Terai	36-45	16-25
D5	Nuwakot	Mid-hills	46-50	26-35
D6	Jumla	High hills	51-60	36-55
D7	Baitadi	Mid-hills	46-50	56-78
D8	Dadeldhura	High hills	46-50	36-55

[1] Also refer TABLE 2.20 in Nepal DHS Report 2017

FIG 9: MAP OF INTERVENTION AREAS (*VAM unit, WFP Nepal*)

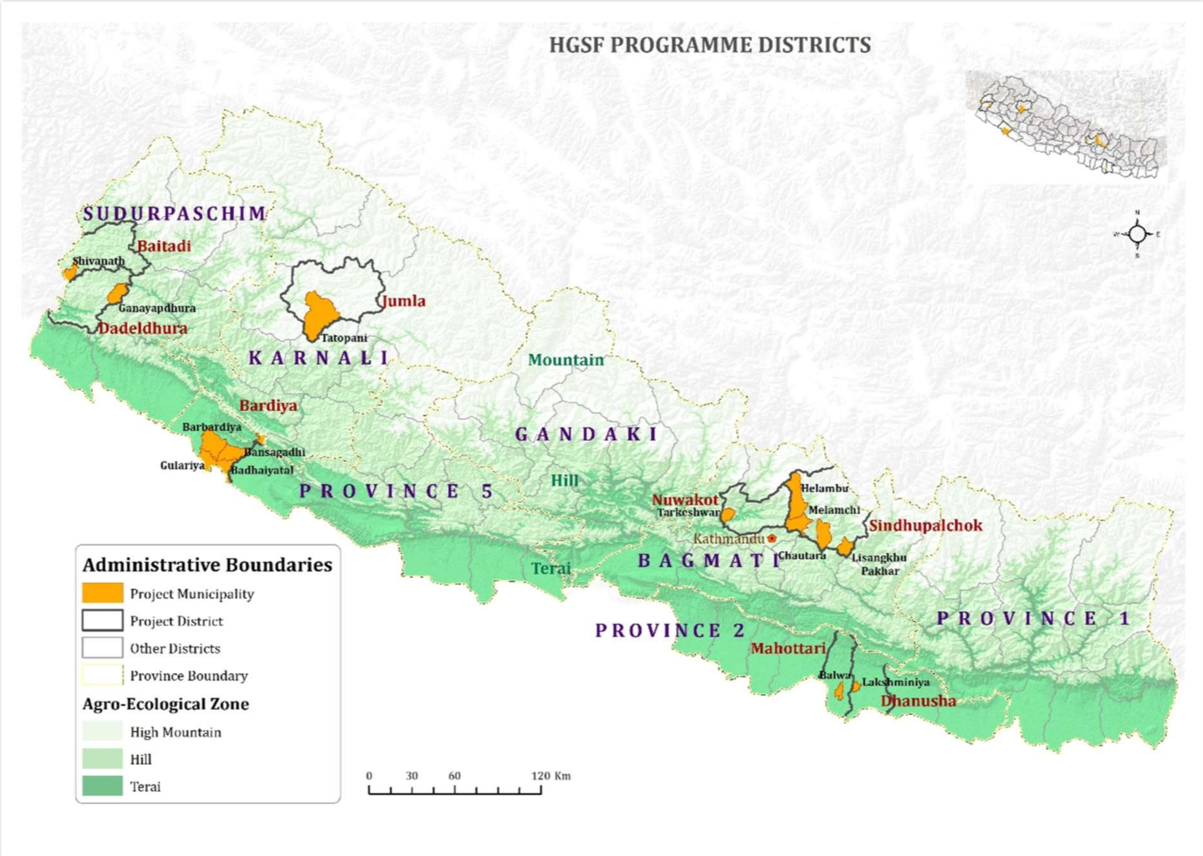
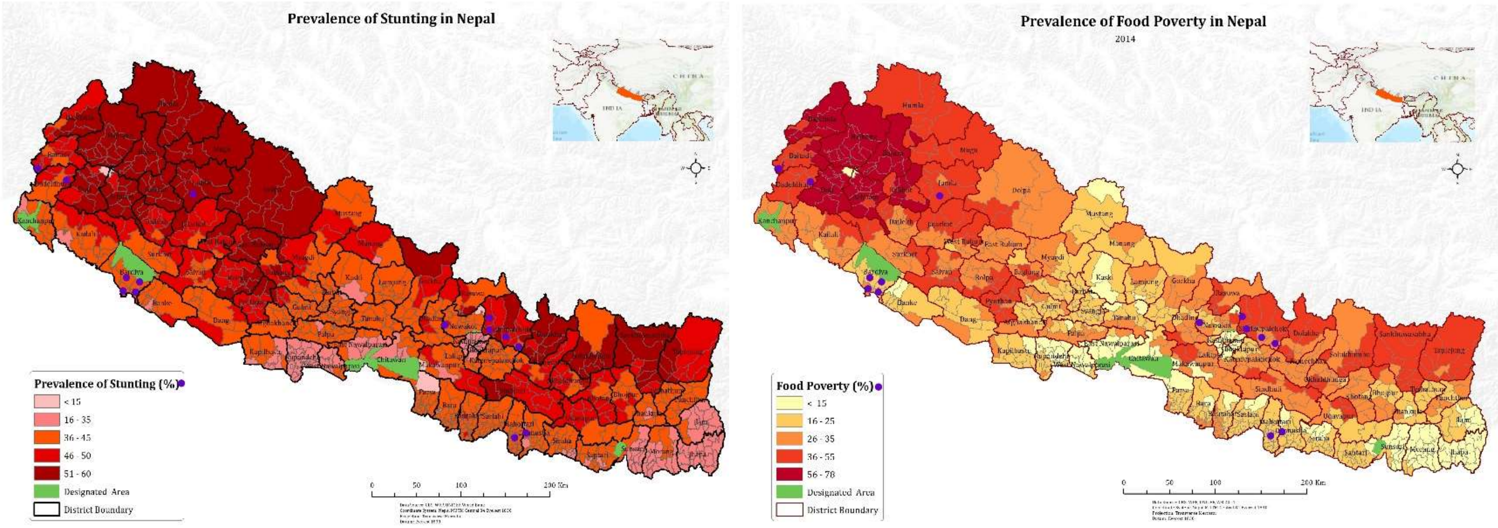


FIGURE 10: STUNTING AND FOOD POVERTY PREVALENCE MAP OF NEPAL (*VAM unit, WFP Nepal*)



After the stage of district selection, an approximation of a stratified random sampling technique was used to select schools. The intervention did not cover the entirety of selected districts. For phase-1 districts, four municipalities were purposively selected in each district. Schools were then selected from each of these municipalities. The project sought to cover around 25% of schools in each of the districts. Depending on the total number of schools per district, certain number of schools were randomly selected from each municipality. The process was adjusted in certain cases where randomisation was not feasible. The school selection process was modified for the remaining six districts to enhance operational efficiency. From each district, one municipality was purposively selected based on consultations with district administration and all schools in the selected municipality were selected for the intervention.

In total, the project was implemented in 202 schools across 14 municipalities of eight districts (highlighted in Map-1 above). The total number of students receiving school meals under this intervention is 23,595. The overall gender ratio is one female for every 1.14 males. The table below provides district wise details of intervention areas.

TABLE 14: DETAILS OF INTERVENTION DISTRICTS

S.NO.	DISTRICT	MUNICIPALITIES	NO OF SCHOOL	TOTAL NO OF STUDENTS	M/F	TOTAL WARDS
1	Sindhupalchok	Chautra, Melamchi,	29	2267	1196/1071	-

		Helambu, Lisankhupakher				
2	Bardiya	Barbardiya, Guleriya, Badiyatal, Bansgadi	14	2428	1267/1161	-
3	Dhanusha	Laxmania Rural Municipality	18	2720	1529/1191	7
4	Mahottari	Balewa Rural Municipality	22	5540	2963/2577	11
5	Nuwakot	Tarkeshwor Rural Municipality	34	1915	987/928	6
6	Jumla	Tatopani Rural Municipality	25	3391	1865/1526	8
7	Baitadi	Shiva Nath Rural Municipality	37	3171	1676/1495	6
8	Dadeldhura	Ganypdhura Rural Municipality	23	2163	1091/1072	5
TOTAL			202	23595	12574/11021	

3.5 STAKEHOLDER CONSULTATION AND PROJECT SENSITISATION

The design and implementation of the intervention was undertaken by the project team through a process of continuous engagement with all key stakeholders in the project design phase (Jan-March 2018) and throughout year-1 of implementation. Stakeholder here is defined as 'any person or organization related to the implementation of the intervention across its different components and the intended direct and indirect beneficiaries'. The purpose of the consultations was to design the project as responsive to local contexts and in alignment with government policies and programmes. Whilst the broad purpose of the intervention was determined at a prior stage of application to the funder, the specific objectives were formed during the project design.

All consultations were undertaken as part of the design phase of the HGSF technical assistance and research project with the Government of Nepal and UN WFP, which was approved by GoN. The detailed project design and work plan including the list of stakeholder consultations were approved by the Department of Education, GoN. In each district, the District Education Office, responsible for external projects approved the consultation exercise. No additional ethics approval was required. All participants were provided a detailed background and context and were made aware of the purpose of the consultations. Participants were informed that the participation is entirely voluntary, and no information used will be specifically attributed. In joint community meetings, all participants were individually asked for consent and a sheet was circulated for signatures.

I led the preparation of initial list of stakeholders with the PCD project team and UN WFP school feeding unit. Stakeholders were initially identified across seven categories; (i) Government of Nepal, (ii) Local government, (iii) Research organizations, (iv) Current agriculture/nutrition project leads, (v) Beneficiaries, (vi) relevant international organizations and (vii) community/operational actors. The list was expanded based on initial set of stakeholder interviews. Some categories were subsequently merged leaving four categories. I conducted a final review with the project team before closing the stakeholder engagement to ensure all key stakeholders were included.

I led all the consultations/interviews along with the project team. Some of these consultations with local governments, community members and children were also used for project sensitisation. Meetings were held with district line department officials such as district education officer and local government representatives such as mayor in their respective offices. Joint meetings were held in a designated school or community hall, separately for teachers, farmers, parents and other community members. Children were consulted in classrooms or preferably during school assembly to minimise disruption to teaching activities. The details of the main consultations and sensitization meetings are in table 16 below.

The consultations and interviews provided evidence and data on a wide range of topics. Interviews with government departments provided insights into relevant government policies and plans on health, agriculture, education and other related planning departments. The interviews also gave guidance on methods to integrate the intervention with the national school feeding programme. The intervention design requires national data on food prices, production patterns, NUS foods, public health which were identified and evaluated through these consultations. Detailed consultations were held with district government offices and local government covering a wide range of policy and operational issues. These consultations provided important inputs on the long-term feasibility of the intervention and political-economic drivers and constraints. The next set of consultations were with the critical beneficiaries and operational stakeholders contributed in examining the programme theory and developing specific project components/activities. Finally, international organizations implementing programmes relevant to the intervention were consulted to inform the design with their learnings.

The combined findings from these consultations were applied to determine the specific intervention objectives and intervention areas.

TABLE 15: CONSULTATION AND STAKEHOLDER MEETINGS

No.	**STAKEHOLDER/KEY INFORMANT**	**AGENDA/PURPOSE**
GOVERNMENT OF NEPAL – DEPARTMENT/OFFICE/RESEARCH AGENCY		
1	Ministry of Education, Science, and Technology	National policy and plans
2	Centre for Education and Human Resource Development	Operational/implementation issues
3	Food for Education Office	Technical and coordination issues
4	Department of Agriculture	National policy, plans and programmes
5	Agriculture Statistics Section	Data collection
6	Agrobiodiversity Section, Department of Agriculture	Policy and programmes and data collection
7	Centre for Crop Development and Agro-biodiversity Conservation	Policy and programmes and data collection
8	Ministry of Health and Population	National policy and plans
9	Department of Health Services	National survey data and protocols
10	National Nutrition and Food Security Secretariat, Nepal Planning Commission	National policy and plans
11	National Agriculture Research Council	Research activities
12	Department of Food Technology and Quality Control	Food composition table and food safety
DISTRICT GOVERNMENT OFFICES/LOCAL GOVERNMENT		
1	District Education Office	Situation analysis/project sensitization
2	District Agriculture Development Office	Data collection/local plans and programmes

3	Office of Mayor (Municipality)	Situation analysis/project sensitization
4	Office of Ward Chairperson	Situation analysis/project sensitization
COMMUNITY/BENEFICARIES/OPERATIONAL STAKEHOLDERS		
1	School teacher/head teacher	Situation analysis/project sensitization
2	Parents	Situation analysis/project sensitization
3	School children	Situation analysis/project sensitization
4	School meal cooks	Situation analysis/project sensitization
5	Farmers	Situation analysis/project sensitization
6	Agriculture traders	Situation analysis/project sensitization
7	Farmer/women/credit cooperatives	Situation analysis/project sensitization
INTERNATIONAL ORGANIZATIONS		
1	Bioversity International, Nepal	Research/programme activities
2	UN Food and Agriculture Organization, Nepal	Research/programme activities
3	World Food Programme, Nepal	Research/programme activities
4	UNICEF, Nepal	Research/programme activities
5	USAID Suaahara Project	Research/programme activities
6	Internatioal Food Policy Research Institute	Research/programme activities

3.6 REVISITING THE PROGRAMME THEORY

The HGSF programme theory described in the beginning of this chapter is analysed based on the findings from the stakeholder consultations and the study described in Chapter-2. Whilst the integrity of the theoretical pathways is not contradicted by the findings, evidentiary scrutiny of the programme theory interrogates some key assumptions which are discussed below.

The first assumption is around political drivers i.e. the stated outcomes are desired by the principal stakeholders. In the current intervention, relevant national government agencies were found highly supportive and embedded the intervention in the national programme. Similarly high levels of support were articulated at the community level, by parents and farmers. However, in many districts, especially in the Terai region, the idea of intervention was seen as an attempt at eroding the financial discretion on the application of funds by school authorities and local governments. Given the critical operational role of the local government and schools, this implied resistance appeared to be a fundamental constraint. Overall the assumption around political drivers holds true.

The second assumption relates to the nature of incentives. The length of supply chains is not an important issue in most of the intervention areas as the markets for most commodities are highly segmented and localized. The issue is even less relevant in mountain and hill districts as compared to the districts in terai. The burden of transaction costs borne by producers varies significantly by food group. Fixed costs related to finding buyers and price negotiation were not considered onerous as most farmers sold the surplus foods to the local cooperative or iterant traders. The element of output support through a forward contract based structured demand was recognized by farmers and communities as an important incentive because of high level of intra-annual price volatility and limited marketing options.

The third assumption relates to capacity of local agricultural production i.e. the presence of surplus farm output or available capacity/ability to increase or diversify output. Findings from the stakeholder consultations and chapter-2, indicate that current farm capacities are highly constrained by a number of factors including poor returns in agriculture, small farm size, fragmented holdings, low input support, lack of access to credit, limited human resources and poor infrastructure. In terms of acreage, substantial land is left fallow especially in hill and mountain districts. During consultations, farmers across districts emphatically voiced support for the intervention and its potential as food system change driver especially for particular food groups such as fruits and vegetables. Notwithstanding the structural constraints, most farmers reported that the intervention can address some constraints around economic viability and potentially incentivize farmers to utilize fallow land. Farmer consultations also highlighted the importance of some non-monetary incentives which were not considered a significant production driver in the theoretical model. Two such incentives were highlighted across districts; preserving and promoting local agricultural and dietary heritage and contributing to better health of children in the community by supplying to school feeding.

The fourth assumption pertains to the efficiency of the mediating component in terms of both reach and equity. According to the programme theory, a central mediating component is farmer cooperatives which provide the fundamental linkage to local agriculture. The theoretical assumption is that famer cooperatives can equitably and widely distribute the intended benefits to small farmers and more importantly farmers who are currently most disadvantaged in terms of market access. Feedback from discussions with farmers and cooperatives indicated that all members of the respective cooperatives would be able to participate in the supply chain. However, there were also suggestions that this is highly dependent on nature of the cooperative and local politics. In some districts, cooperatives are highly politicised and embedded in local power structures which raises issues around transparency of their functioning with implications on their integrity as mediating components to drive intended changes.

The fifth assumption relates to knowledge transfer i.e. the intervention through its implementation will generate knowledge around good dietary practices which will translate at the household both through children and parents. These knowledge transfer pathways to the household through parents and children were highlighted by the community as an important element of the project. For many community members this was based on past experiences of nutrition sensitization projects. Besides households, nutrition knowledge transfer to local governance structures at the district and community level was identified as a potentially important pathway which can influence local policy making and programmes.

In summary, the proposed assumptions on drivers, pathways and incentives hold true to varying degrees depending on the local context. To realize the intended outcomes, all these components need to engage synergistically. Any programme theory is based on a set of assumptions and is relevant in a given context, however it should account for leakages and imperfections of real-world application. The particular challenge for HGSF theory is inherent in the nature of the intervention i.e. it seeks to address issues on food production and diets at a micro level which brings into a play a number of localized contexts and associated variables. This issue is further compounded in countries such as Nepal with very large intra country variations. The lesson here is that the programme theory needs to be evaluated on a continuing basis through the intervention and more importantly assumptions should be tested with the purpose of informing the development of appropriate intervention practices.

3.7 CONCLUSION

This chapter demonstrates the critical foundational steps of the action research process for designing the intervention. It describes the HGSF programme theory which provides the principal conceptual basis for the intervention. The initial stage of design built on a series of stakeholder consultations and empirical findings from the study described in chapter-2. The intervention sites and methodology for implementation were guided, firstly by the need to ensure that the research outcomes capture different contexts to optimally inform national scale up of the intervention and secondly by operational considerations. Whilst the finally selected eight districts represented the main variations in terms of ecological, geographical, economic, and demographic variations, addition of two more districts from the eastern border with India and mountain AEZ would have added more credibility to the research.

The implementation of the intervention as part of a national programme required intensive engagement at multiple levels of government, ranging from policy engagement with the central ministries to discussion on cooks with municipal governments. More importantly, the programme theory and implementation strategy constantly evolved based on discussions with a range of stakeholders including children, farmers, and parents. The consultation findings helped explore important aspects on the validity of the programme theory. It revealed critical considerations that need should be reflected in the theoretical model. Whist this does not entail a revision of the theory as such, it provides important guidance in developing activities and concepts which are discussed in the next chapter and the remainder of the thesis.

CHAPTER- 4

INTERVENTION DESIGN AND IMPLEMENTATION ACTIVITIES

4.1 INTRODUCTION

The intervention activities were implemented building on the learning and analysis of the programme theory in the previous chapter and evidence from the stakeholder consultations. Activities were also guided by the personal experience of the author and other team members from agriculture-nutrition intervention in Nepal and other countries including Ghana, Nigeria, Uganda and Kenya.

The purpose of this chapter is to describe the key project activities including a discussion on the processes that guided certain design elements. The implementation, across activities attempted to incorporate community and government driven engagement and a non-prescriptive application of knowledge and technology. There was a clear recognition of the responsibility of this project as a proof of concept and the mandate to deliver operationally with impact on the ground at a certain scale. Whilst the processes were broadly standardized across the intervention areas, experiences and learnings were incorporated in the different activities on a continuing basis. The description of activities in this chapter presents this cumulative experience.

The chapter is divided into main sections. The first section summarizes the information technology element i.e. menu planning tool. The second section presents the development of key standards and references applied in the intervention. This is followed by section-3 on creating the meals and selecting food commodities. The next section (section-4) describes the procurement and supply system for delivering the commodities to the schools. Section-5 summarizes other supporting activities which were undertaken to improve overall project impact. This is followed by the final section which discusses the main findings.

4.2 MEAL PLANNING TOOL

Meal designing is aided by a software programme called 'Meal Planning Tool' (MPT). MPT is a software programme which was developed by PCD and was first piloted in Ghana in 2012 (Singh and Fernandes, 2016). It has been used by national school feeding programmes in Nigeria, Zanzibar and Kenya (AUDA-NEPAD, 2020). MPT is an easy to use computing tool which helps in quick calculation of prices, volume, and nutrient intake (Fernandes et al 2016). It can be used to design budgeted meals that meet a nutritional standard customised by the user. It calculates the macro and micronutrient contributions of each ingredient makes in a meal, the total nutrient composition of the meal and displays the target reference for each nutrient of interest. MPT analysis is based on country and region specific data which includes food composition table and food price data. It allows for customization in terms of selecting nutrients of interest, RDA targets, regional classification and age-group. The tool does not take into account issues of acceptability and taste which are addressed in the meal design process described in the next section.

MPT serves as a good meal budgeting tool. Market prices of each food item per 100gm can be inserted into the MPT. Costs contributions of each ingredient in the meal, each meal and menu set are automatically calculated. The tool creates menu sets (e.g. Weekly, monthly, seasonal) by selecting meals that have been designed within the MPT. This function displays a compiled list of the ingredients used for each meal and provides the total cost of the menu. Individual meals or menu sets can be exported to a excel or pdf document that provides a summary table the nutrient composition and costs of each ingredient and meal. To help visualise the nutrient composition of a meal, 'gingerbread men' graphics and bar charts are used to show the proportion of the target met for each nutrient in the meal designed. For illustration purposes, an excel format meal report as generated by the MPT for a meal in Bardiya district is shown in figure 11.

MPT is customized for each country with the relevant information, some of which included standards discussed in the next section. Access and user permissions to the data are restricted for each country based on requirements determined by the user government to ensure data protection.

FIGURE 11: MPT MEAL REPORT ILLUSTRATION

Region: Bardiya
Age range: 6-12
Nutrition target: 30 percent RDA

Nutritional summary (per child)

Nutritional details (per child)

Name	Weight	Total cost	Calcium	Energy	Fat	Iron	Niacin	Protein	Riboflavin	Thiamine	Vitamin A	Zinc
		रु	mg	kcal	g	mg	mg	g	mg	mg	mcg	mg
Potato boiled (without skin)	30	1.05	2.1	21.6	0.03	0.24	0.39	0.57	0.006	0.018	0	0
Bengal gram dal (chickpea)	50	6	28	186	2.8	2.65	1.2	10.4	0.09	0.24	0	1.825
Cauliflower (flower only)	30	0	3.453	12.3	0.72	0.255	0	0.225	0	0	0	0
Tomato red	30	1.05	4.5	6.3	0.03	0.21	0	0.39	0	0	127.2	0.036
Rice (raw) (Milled)	40	2.4	4	138	0.2	0.28	0.76	2.72	0.024	0.084	0	0.484
Total	**180**	**10.5**	**42.053**	**364.2**	**3.78**	**3.635**	**2.35**	**14.305**	**0.12**	**0.342**	**127.2**	**2.345**
			20%	**66%**	**25%**	**68%**	**65%**	**83%**	**44%**	**127%**	**85%**	**69%**

4.3 STANDARDS AND REFERENCES

Developing credible standards and references is critical for the quality of the intervention. They help ensure better compliance over time and are a determining factor in enabling effective scale up of the intervention. This section describes the processes and development of the following standards/references: (1) Nutrient targets and RDA, (2) Food Composition Table, (3) Micronutrient intake values and (4) Handy measures.

NUTRIENT TARGETS AND RDA

The nutrients included in the meal planning process include macronutrients: carbohydrates, protein, calcium and fat and macronutrients: niacin, thiamine, riboflavin, iodine, vit A, vit C, zinc, and iron. Whilst the nutrition targets for meal designing encompass all major macro and micro-nutrients, the focus nutrients can be country specific based on the public health status and policy priorities. Iron, vit A, and iodine are universally considered important as their deficiency, particularly amongst women and children, poses a significant public health burden (Allen et al., 2006). Other important mirconutrients from a public health perspective include zinc, folate, vit B12 and other B vitamins, vit C, vit D, calcium, selenium and fluoride (Allen et al.,2006). Based on the findings of the Nepal national micro-nutrient survey 2017, vit A, zinc and iron were identified as focus micronutrients for this intervention.

This intervention used RDA or dietary reference values as published in the report of the joint FAO/WHO/UNU 2001 expert consultation, for all nutrients as the reference for nutrition intake targets (FAO, 2001). RDA represents the amount of a nutrient that ensures the needs of nearly all the population (97.5%). RDA is derived from Estimated Average Requirement (EAR) which is the daily intake value of a nutrient estimated to meet the nutrient requirement of half the healthy individuals in a life stage and gender group (Institute of Medicine, 1998). RDA values vary by age group and gender for adolescents and adults. Children eligible for school meals are those in grade levels 1-5, typically aged 5-9. However, there are likely to be some students over the age of 9 years in grade 5 because some children start and drop out of school at different times. This suggests that some students over the age of 9 will receive school meals. In guiding the design of meals to meet the nutrient requirements of children within these grade levels, age-appropriate RDAs need to be selected. There are two different nutrient RDA values set for age groups 4-6 and 7-9 years. However, it would not be practical or feasible to design, cook, and distribute meals for two different age group meal standards. Therefore for this intervention only one set of RDAs based on the age group 7-9 has been selected for all children within grades 1-5. This higher age group was selected (7-9 years), to ensure all children’s nutritional needs will be covered by the meals.

The intervention sets the RDA target per school meal at 30% for all nutrients, for all districts in the country. A *Nepal Nutrition Technical Working Group* of prominent country experts was constituted as part of this intervention, to deliberate on nutrition issues including RDA targets. The working group concluded that a uniform 30% RDA target is currently optimal for Nepal, given budgetary and operational constraints. During deliberations of the nutrition technical working group, the issue of having higher RDA targets for districts with higher food insecurity was discussed. However, the consensus was that whilst it is desirable in terms of nutrition security, it may lead to operational challenges on account of budgetary and political issues. Similarly, higher RDA target for some micronutrients was also discussed and it was decided that this can be considered at a later stage once the intervention has become completely operational and universalized.

FOOD COMPOSITION TABLE

Food composition table or database is a data repository which details the nutritionally relevant chemical constituents of listed food commodities, most tables contain all major macro and micronutrients including specific reference to the chemical forms to assess bioavailability and conversion (Elmadfa and Meyer, 2014). FCTs primarily include information on raw commodities and can also include a limited range of processed or cooked foods. Most current food composition databases are prepared by a combination of direct methods such as laboratory analysis of food samples and indirect methods which rely on published literature and other reports. It is ideal to have national FCT for each country as many foods and varieties are country specific and the actual nutrient composition can be substantially affected by local agroecological and farming conditions. However, since many countries do not have the resources to develop national FCTs, regional FCTs have been developed with support from FAO, such as *West African Food Composition Table.*

FCT is a critical reference material for any nutrition related policy, analysis, and programme. Thus, the quality and accuracy of a FCT should be scrutinised for use in any intervention. There are some major initiatives working towards improving the quality and standardizing FCTs across regions and countries such as the FAO coordinated International Network of Food Data Systems (INFOODS) which is a worldwide network of food composition experts aiming to improve the quality, availability, reliability, and use of food composition data. Comprehensive FCTs are required to effectively provide scientific guidance for nutrition interventions. There is wide variation in the number of commodities and composition details across FCTs. For example, the Indian FCT, 2017 provides nutritional values for 528 food items, New Zealand, FCT 2018 contains data for 38 components for 1,187 foods, and the USDA Food Composition Database (https://ndb.nal.usda.gov) of the Agricultural Research Service's Nutrient

Data Lab contains 9,000 food items from USDA's National Nutrient Database for Standard Reference with composition information for up to 150 components.

For this intervention, the food nutrient data for all commodities is derived from the Nepalese Food Composition Table 2017, issued by the Department for Food Technology and Quality Control, GoN. Several macro and micronutrients values are included in the FCT for over 567 food items. Macronutrients include energy, carbohydrate, protein, crude fat, and crude fibre. Micronutrients include vitamin C, vitamin A, β-carotene, niacin, phosphorus, riboflavin, thiamine, calcium, and iron. The food items are divided into 18 categories including 'cooked foods', 'weaning foods prepared locally' and 'wild edible food plants'. While applying the FCT for meal planning, it was found that there are no values for zinc which is a nutrient of public health significance in Nepal. Also, occasionally some nutrient values were randomly missing for some commodities and some other commodities were missing as such. To address the issue of zinc values and other missing information, data was borrowed from India and Bangladesh FCTs based on the assumption that neighbouring countries would have similar food compositions. According to the methodology stated in the FCT document, 'samples of each food commodity were purchased from various markets of different areas of Nepal and they were mixed manually to create a composite sample'. This sampling strategy can mitigate to a certain extent the variability related to soil type and geography, which is more pronounced in countries like Nepal with very distinct ecological belts ranging from the lowlands of Terai to the mountains of Himalayan range.

In the context of understanding the RDA targets for these interventions, reliance on FCT is prone to certain errors. Some of the main issues are mentioned below:

a. The nutrient values are based on standardized national food composition table, mostly for raw ingredients. The actual nutrient availability can vary by methods of processing and cooking.

b. Nutrient quality of foods is dependent on soil type which can be highly variable across geographies.

c. Food nutrient quality is also impacted by farming practices, weather and storage.

d. The nutrient composition of meat products can vary greatly depending on the proportion of lean meat to fat tissue. The ratio between the two tissue types also affects levels of most other nutrients.

DETERMINING NUTRIENT INTAKE VALUES

There are significant differences between the quantity of nutrients ingested through food consumption and the amount absorbed by the body and used for bodily functions. The amount finally absorbed and used by the body as a proportion of the ingested nutrient is essentially the bioavailability of the specific nutrient (Hunt, 2003). Bioavailability includes the effect of a sequence of metabolic events on nutrient utilization, such as digestion, organ uptake and release, enzymatic transformation, secretion and excretion. It is determined by a host of different dietary and host specific physiological factors, such as the form of the nutrient, presence or absence of enhancers or inhibitors, metabolism, gut microflora, endocrine effects and infections (Fairweather-Tait and Southon, 2003). Many of these factors are determined by dietary patterns and the condition of the host population (Gibson, 2007). Therefore, understanding bioavailability for different foods, contexts, nutrients and populations is critical to provide functionally optimal nutrition guidance. The bioavailability of macronutrients, i.e. carbohydrates, proteins, and fats, is usually high with more than 90% of the amount ingested being absorbed and utilized in the human body. Micronutrients such as vitamins and minerals, and bioactive phytochemicals such as flavonoids, carotenoids, can vary widely in the extent to which they are absorbed and utilized after ingestion.

For zinc and iron, the issue of bioavailability was taken into consideration in determining RDA values, based on the standard Nepalese diet. It is understood that the lower the bioavailability of nutrients, the higher the RDA is, based on bioavailability factors. This is especially the case for zinc and iron requirements. For Vitamin-A, appropriate conversion factors were applied. These issues are discussed in some detail below.

There are four different iron RDAs for iron, defined using bioavailability adjustment factors. These factors are 10%, 12% and 15%, depending on the food components of the common local diet. In Nepal, the typical diet contains high levels of cereal and pulses which contain high levels of phytates and non-heme iron (non-animal protein) and a high consumption of tea. Furthermore, in Nepal there is low dietary diversity which includes low consumption of fruits and vegetables rich in vitamin C to enhance non-heme iron absorption (Ministry of Health, 2017). There is no specific data from Nepal on the bioavailability of iron in meals, but we can draw upon research from countries with similar dietary patterns to estimate its bioavailability. Data from India suggests there is a low bioavailability of iron in millet-based diets, 3.4% - 4.0% for wheat-based diets and 8.3% - 10.3% for rice-based diets (Rao et al., 1983). Furthermore, for developing countries, it has been advised to use bioavailability figures of 5% and 10% (WHO-FAO, 2004). Based on the above and FAO recommendations, the bioavailability of iron in the diet in Nepal can be considered as low (5%) and therefore the iron RNI for children 7-10 years of age in Nepal was set at 17.8mg per day.

Zinc bioavailability is also dependent on the overall composition of the diet and the presence of the promoters or inhibitors of zinc absorption (Sandstorm & Lonnerdal, 1989). Zinc absorption is reduced by the presence of phytates, presence of ions that compete for absorption (e.g. iron) and through consuming a vegetarian cereal-tuber based diet (high in phytate). These factors combined with the overall concentration of zinc in the diet majorly influence the efficiency of zinc absorption (Sandstorm & Lonnerdal, 1989). From experimental zinc absorption studies of single meals or total diets, three categories of diets have been established; high, moderate, and low zinc bioavailability (WHO-FAO, 2004). Fractional absorption figures have been applied for each category to meet the requirements for absorbed zinc as 50%, 30% and 15%, respectively. The habitual diet in Nepal is vegetarian, contains high levels of cereals, pulses and grains (*dal-bhat*) with large proportions of phytate and therefore meets the criteria for a diet low in bioavailable zinc (15% fractional absorption). Therefore, the highest RDA set of 11.2mg per day for children 7-9 years of age would need to be met to ensure that all children maintain adequate zinc intakes.

Vitamin A is a generic term used for a group of structurally related chemical compounds known as retinoids. Vitamin A activity in the diet derives from two sources: preformed vitamin A as retinyl esters or retinoids and provitamin A carotenoids, such as β-carotene, α-carotene, and β-cryptoxanthin (Institute of Medicine, 2001). The Nepal FCT has specified vitamin A relevant values as "carotene" (µg) levels in the FCT which refers to β-carotene. This is the main source of dietary intake of vitamin A and is a precursor of vitamin A which is usually expressed as retinol equivalent (RE). To calculate the vitamin A equivalent of β-carotene, a conversion factor must be applied. The appropriate conversion factor to use is an ongoing discussion and is based on two main factors (Haskell, 2012). The first is based on diet and food related factors, including food processing techniques, the amount and concentration of β-carotene, the amount of fat, fibre and vitamin A in the diet. The second is the human characteristics of the population, including health, nutrition, and genetics. Therefore, the conversion factor of vitamin A to β-carotene is likely to be context specific. FAO suggests the conversion factors from usual mixed vegetable diets of 14:1 for β-carotene and 28:1 for other provitamin carotenoids based the typical diet in Holland (WHO-FAO, 2004). Based on review of different factors and recommended conversion scales, the final conversion rates used for meal planning purposes in Nepal based on the food composition table is 1 RE is equivalent to 12 µg of all trans β-carotene, and 24 µg of α -carotene, β-cryptoxanthin and other provitamin A carotenoids.

Whilst the meal planning tool analyses a wide range of nutrients, in designing the meals, specific nutrients were selected for particular focus in terms of achieving the target 30% RDA, based on public health considerations. The final RDA values used for school meal design, based on the discussion in the previous section are summarized in the table below.

TABLE 16: FINAL INTERVENTION RDA VALUES FOR KEY NUTRIENTS

S. NO	NUTRIENT	INTERVENTION RDA
1	Energy (kcal)	1850
2	Fat (g)	30
3	Protein (g)	29.5
4	Calcium (g)	600
5	Iron (mg)	19.25
6	Zinc (mg)	11.2
7	Vitamin A -serum retinol (µg)	500

HANDY MEASURES

To translate quantities in menus into cooking portions for raw ingredients and serving portions for cooked food, a set of calibrated 'handy measures' were developed to help programme staff accurately visualize appropriate portion sizes and prepare meals accordingly. These 'handy measures' are bowls or spoons which reflect the converted metric quantities. The handy measure for Nepal were calibrated with buckets, jugs and ladles for appropriate quantification. The measures are used to measure raw ingredients before cooking and for serving correct portion size during meal distribution. Single ladle was calibrated to serve porridge, bean and vegetables as per the portion size prescribed by the menu. A market survey was conducted with the community (four women were identified including cooks, parents, farmer and teachers) to explore and identify suitable handy measures which are readily available in the local market. The survey group visited 3-4 shops in the local market selling steel and cooking wares. A set of ladles, jugs and bowls were identified and purchased for testing in the workshop. The handy measures were finalized in the local community centre in each municipality in participatory workshops. I led the market survey and participatory workshops in the phase-1 districts.

Cooks were trained in the use of these handy measures. Plate samples for each day were created using these measures and were pictorially represented to give a sense of the correct portion sizes in terms of the actual contents on a plate. Handy measures charts were prepared for each district in English and Nepali. As an illustration, sample handy measure charts from Jumla (left) and Mohatarri (right) are shown below.

FIGURE 12: HANDY MEASURE CHARTS

4.4 FOOD SELECTION AND MENU DESIGN

The method of developing school meals is critical in determining the strength of local agriculture interface and the quality of dietary intake. The different elements of the school feeding commodity basket guide the nature and extent of agriculture diversity linkages of HGSF. To meet the dietary targets of different nutrients and ensure a composite diet for maximum nutrition efficiency, a multi-stage process was undertaken. To ensure Minimum Dietary Diversity (MDD), at least four distinct food groups are reflected in each meal. In terms of individual foods, the selection is framed along three criteria (a) Micronutrient rich crops, (b) Neglected and Underutilized Species, and (c) Climate resilient varieties. Seasonal substitutions are undertaken for specific foods as appropriate. In terms of micronutrients, specific focus is on iron, vit A and zinc, reflecting the nature of micronutrient deficiencies in the country.

The menus were designed in participatory workshops using the meal planning tool. The author led the workshops in the first two districts, i.e. Bardiya and Sindhupalchok, supported by the project team, in August 2018. Workshops in another four districts were conducted in August 2019 and were led by project staff with inputs from the author. The workshop participants consisted of school management committee (SMC) members, head teachers, heads of local government, farmer cooperative members, and officers of the District Education Office. The total number of participants ranged from 64 in Bardiya District to 110 in Nuwakot District.

The participants were given a short primer on nutrition with a focus on food groups and the role of different macro and micro-nutrients. This was followed by group session with 3 to 5 groups. Each group was balanced in terms of gender and interest group, and was supported by a facilitator to develop 1 or 2 meal sets i.e. 6 meals for each school day of the week. In total across districts, 134 individual meals were designed through this process. The table below provides details on workshop participants and the meals for each district.

TABLE 17: MEAL DESIGNING WORKSHOPS

S. N	**DISTRICT**	**NO OF MEALS CREATED**	**PARTICIPANTS MALE/FEMALE**		**TOTAL PARTICIPANTS**
1	Mahottari	24	66	7	73
2	Dhanusha	24	68	24	92
3	Nuwakot	38	84	26	110
4	Jumla	48	66	15	81
5	Bardiya	30	44	20	64
6	Sindhupalchok	48	58	18	76
	Total	134	284	72	496

All the meals were then reviewed by the project team in the MPT for nutrition content and cost. These meals were used to create six costed meals per district for each school day of the week, this constituted a 'meal set'. Each meal set was further calibrated and validated by field coordinators, before finalization. In the last stage the meal sets for each district were reviewed by the author and finalized for implementation.

For all main food commodities in each intervention district, price data was collected by project staff, at farm level, village market, local market, and central market. Prices of the commodities were also collected and validated from Agriculture Knowledge Office where available and District Chamber of Commerce and Industry (DCCI) of each district. These prices were then validated during menu planning workshops. Based on three data sources, a median price was calculated for each commodity which served as the reference price for MPT.

By way of illustration, a summary of one school meal designed in Jumla District is presented in the table below. Jumla lies in the high mountain region of Nepal, over 800 Km above sea level, north west of the capital Kathmandu. In the table below, ingredients by weight are in the first two columns, the amount of main nutrients are described against each ingredient. The last row presents the percentage of the target nutrient quality achieved for each specific nutrient, the target nutrient quality for Nepal is 30% RDA. This meal achieves or exceeds the target for almost all nutrients especially vit A, zinc and iron.

The cereal staple in this meal is Naked Barley (*Hordeum vulgare* var. *nudum*). Naked barley is one of the oldest cultivated grains and a source of complex carbohydrates (Gabrovská et al., 2002). It is a neglected underutilized species (NUS) mountain crop and one of the eight mandate crops of a UNEP project on mountain crop genetic diversity[2].The primary vitamin-A contributor in this meal is Lamb's quarters (Chenopodium album), known in Nepal as *Bethe leaves*, contributing 120 mcg of the vital nutrient to this meal. Chenopodium album is an underutilized plant which grows as a weed in farms, known to be drought resistant and highly nutritious (Poonia and Upadhayay, 2015). The leaves are rich in essential amino acids and contain calcium and vitamin-A in significant amounts (Poonia and Upadhayay, 2015). Another NUS included in this meal is Horsegram red (Macrotyloma uniflorum) which is an underutilized legume crop and a good example of nutritious yet culturally undervalued food. It is primarily cultivated by poor and marginal farmers in India and Nepal and is considered *poor man's food* (Aditya et al., 2019). Horse gram is rich in iron and other macro and micro-nutrients and is known to have high stress tolerance (Aditya *et al*., 2019).

TABLE 18: HGSF MEAL FOR JUMLA DISTRICT

Ingredient	Weight (g)	Total cost	Calcium	Niacin	Riboflavin	Thiamine	Vitamin C	Energy	Fat	Protein	Vitamin A	Zinc	Iron
		NPR	mg	mg	mg	mg	mg	kcal	g	g	mcg	mg	mg
Naked barley, white (uwa)	80	4	20	0	0	0	0	276.8	1.28	10.08	0	1.2	3.28
Onion stalks (green)	10	0.7	5	0.03	0.003	0	1.7	4.1	0.02	0.09	4.95	0.09	0.74
Coriander leaves	5	0.25	9.2	0.04	0.003	0.0025	6.75	2.2	0.03	0.16	28.825	0.03	0.07
Taro tubers, raw	20	1.7	6.03	0.01	0.006	0.012	0.366	74.4	0.034	0.66	0	0.08	0.13

[2] Integrating Traditional Crop Genetic Diversity into Technology: Using a Biodiversity Portfolio Approach to Buffer against Unpredictable Environmental Change in the Nepal Himalayas

Sunflower oil	2	0.32	0	0	0	0	0	18	2	0	0	0	0
Peas (dry)	50	2	37.5	1.7	0.09	0.235	0	159.5	0.95	9.85	0	1.55	3.52
Bethe leaves	25	1.5	37.5	0.15	0.03	0.0025	8.75	7.5	0.1	0.925	120	0.24	1.05
Horse gram, red	10	0.8	0	0	0	0	0	32.2	0.085	2.11	0	0.27	0
Total	**202**	**11.27**	**115.23**	**1.93**	**0.14**	**0.25**	**17.56**	**574.7**	**4.49**	**23.88**	**153.77**	**3.48**	**8.80**
			55%	**53%**	**52%**	**93%**	**177%**	**103%**	**32%**	**140%**	**102%**	**103%**	**164%**

(Source: National HGSF Project, Nepal)

4.5 PROCUREMENT AND SUPPLY CHAIN

I designed a cluster based forward contract commodity supply system, including templates for forward contract, cooperative selection methodology, and supply monitoring mechanism. A forward contract is a contractual instrument in which the terms of sale including price and quantity are pre-determined for a specified period in the future (Wang et al., 2014). The benefit of this instrument is that it addresses the risk of price changes for both parties. It provides a predictable and secured market for the farmer and reliable supply for the buyer (Wang et al., 2014).

I mapped supply clusters for a group of schools based on geographical proximity and local government jurisdiction at the ward level. Based on the finalized menus and the total number of children eligible to receive school meals, a commodity demand schedule was created by the project team for one school year for each cluster. This schedule served as the basis of the forward supply contracts with cooperatives.

A procurement committee was constituted by the project team in each district for selecting cooperatives. The committee consists of heads of local government, school representative, and the District Education Officer. Applications were called from all major cooperatives in the district. The applications were evaluated based on the capacities of the following criteria: (a) financial capacity (b) transaction costs and (c) storage infrastructure. Overall preference was given based on two additional criteria; (i) Cooperatives which are primarily farmer cooperatives, and (ii) women led cooperatives. The type of cooperative varied, it included agriculture cooperative, savings and credit cooperative, multi-purpose cooperative, and women’s cooperative.

The demand schedule and a template of the forward contracts was sent to the selected cooperatives. Detailed consultations and negotiations were held with each cooperative, following which contracts were finalized. The reference price was the base price for contract negotiations with the cooperatives.

The school and student cluster size for each cooperative varies substantially across districts and municipalities in terms of the number of schools and the number of students. It ranges from 180 students (Thulopakhar Agriculture Cooperative, Sindhupalchok district) to 3391 students (Panchaswor Multipurpose Cooperative, Jumla District). Jumla is a unique case, since a single cooperative supplies all the 25 intervention schools in the district. In cases where schools are dispersed and enrolment numbers are low, one cooperative supplies to many small schools. For example, in Sindhupalchok district, Bansbari Community Agriculture Cooperative, supplies to 9 schools with a total of 590 students. The size of the cooperative also varies substantially within and across districts and can range from 100 members (Bhairab Agriculture Cooperaive, Dhanusha) to 2700 members (Panchaswor Multipurpose Cooperative, Jumla).

The table below provides details of selected cooperatives and school clusters for each intervention district.

TABLE 19: DETAILS OF COOPERATIVES AND SUPPLIES BY DISTRICT

NO.	NAME OF COOP	TYPE	NO OF MEMBERS	SCHOOLS/STUDENTS COVERED	MUNICIPALITY
	BARDIYA District				
1	Aantar nivar agriculture coop	Woman/ Multi-purpose	NA	4/691	Barbardiya
2	Sunaulo Women Development Multi- purpose coop	Woman Saving and credit	1035	3/755	Gulriya
3	Lalima Women Saving and credit coop	Woman/ Multi-purpose	714	3/434	Basgadi
4	Milan Agriculture multi- purpose coop	Agri coop	330	4/591	Badhaiyatal
	SINDHUPALCHOK District				
1	Shree Aalopalo Agrasar Coop	Multipurpose	7/581	581	Chautara Sangachowk Gadhi

2	Gaule Community Forest Coop	Community forest	3/213	213	Chautara Sangachowk Gadhi
3	Thulopakhar Agriculture Coop	Agri	4/180	180	Lisankhupakhar Rural
4	Shree Jay Bageshwori Women Development Saving and Credit	Savings and credit	6/350	350	Helambhu Rural Municipality
5	Bansbari Community Agriculture	Agri	9/590	590	Melamchi Municipality
	MAHOTTARI District				
1	Sana Kisan Agriculture Coop-Bachauri	Agri, savings & credit	2634	7/2275	Balwa Municipality
2	Sana Kisan Agriculture Coop-Paraul	Agri, savings & credit	450	5/1211	Balwa Municipality
3	Om Janjati Upavoktta Coop	Agric/Mutipurpose	172	10/2554	Balwa Municipality
	DHANUSHA District				
1	Bhairab Agriculture Coop	Agri	100	6/1136	Laxminiya Bazar (Dhanusha)
2	Women Small Farmer Agriculture Coop	Women	500	6/816	Laxminiya Bazar (Dhanusha)

3	Laxminiya Mai Agriculture Coop	Agri	1687	6/1061	Laxminiya Bazar (Dhanusha)
	NUWAKOT District				
1	Shree Taruka Women Small Farmer Agriculture Coop	Women	689	10/647	Tarkeshwor Rural Municipality
2	Community Saving and Credit Coop	Savings & Credit	221	6/249	Tarkeshwor Rural Municipality
3	Nageshwori Agriculture Coop	Agri	312	18/997	Tarkeshwor Rural Municipality
	JUMLA District				
1	Panchaswor Multipurpose coop	Multipurpose	2700	25/3391	Tatopani Rural Muincipality

4.6 OTHER SUPPORTING ACTVITIES

The supporting activities include Behaviour Change Communication and cooks training. For the purposes of this intervention, the scale and scope of these activities was constrained by operational and funding issues and therefore the discussion below is limited to summarizing the main content of these activities.

BEHAVIOUR CHANGE COMMUNICAION (BCC)

A BCC component was included in the intervention to address issues of food hygiene and safety, hand washing, food consumption diversity, food preparation and storage, and the link between farm and table in terms of raw foods and cooked dishes. BCC material covering all these themes was designed in the form of posters and charts. As an illustration, the posters below show the raw commodities and the cooked dishes explaining the health benefits of the ingredients (left poster) and the concept food diversity (right). The material was tested through community FGDs in four districts. Based on the inputs from the FGDs, changes were made to some aspects of the presentation before finalisation and dissemination. A major change based on testing was to develop region specific posters which show raw and cooked commodities to make it more relatable. A set of BCC posters was distributed to all schools for display in classrooms and common areas.

FIGURE 13: BCC POSTERS

TRAINING OF COOKS

Training of cooks was undertaken in each of the intervention districts by district coordinators and other project staff. Besides cooks, all local level stakeholders participated in the training. The training in each district was conducted over two days. The main topics included health/nutrition; Water, Sanitation and Hygiene (WASH), handy measure use, food waste reduction, food storage, food safety and management and serving method. A food preparation demonstration session was also undertaken. In total for 6 districts, around 250 participants were trained. Based on feedback from the training activities, posters were designed illustrating key messages on food hygiene and cooking (Figure 14). The posters were disseminated to all intervention schools and displayed in the kitchen.

FIGURE 14: COOK TRAINING POSTER

4.7 DISCUSSION AND CONCLUSION

This chapter demonstrates how programme theory is translated into practice through specific activities and provides some useful lessons for implementing similar interventions. An important finding which applies across all activities relates to the importance of processes which can contribute to improving project sustainability and efficacy. For example, the processes related to food commodity price data collection included multiple sources and mechanisms. Price data was collected by project staff, at farm level, village market, local market, and central market. Prices of the commodities were also collected and validated from Agriculture Knowledge Office where available and District Chamber of Commerce and Industry (DCCI) of each district. These prices were then validated during menu planning workshops. The engagement at multiple levels ensured more credible price information for costing meals and forward contracts. Equally importantly it provided vital inputs on seasonality, local trade and market behaviour. Similarly participatory processes enabled specific activities to engage pathways which may not be explicitly recognized in project design. Anecdotal evidence suggests that the development of handy measures in the intervention through community participation reiterated the importance of portion sizes for nutrition and the encouraged the use of similar measures at home especially for children.

This chapter explains the importance of developing and identifying locally relevant and credible standards. These standards are based on data availability which can be particularly challenging in some cases. Accurate price data is critical to ensure budgetary efficiency and programme sustainability. The viability of forward contracts and consequently the supply pipeline depends on a fair and accurate assessment of prices, including seasonality. A comprehensive FCT is another key requirement, actual nutrient composition can depend on local agroecological and farming conditions and therefore relying on a generic or regional FCT can lead to incorrect nutrient estimation. Moreover, many local foods will only be included in a country specific FCT. In this intervention, the Nepal FCT was used, however as this chapter shows, other FCTs had to be relied upon for certain commodities. The development of nutrient targets through a technical committee provided for realistic target setting balancing feasibility and requirement.

In this intervention model, cooperatives serve as the key interface between local agriculture and school feeding and thus appropriate cooperative selection is critical to enable intended project pathways. To ensure fair selection process, this intervention set up a procurement committee as highlighted in this chapter. Given that cooperatives here form an important part of local politics, ensuring transparency in selection required particular emphasis. The intervention included detailed procurement guidelines with mandatory preferential criteria such as preference for women only cooperatives.

To ensure more meaningful and effective engagement, additional components such as training/extension services to farmers, capacity building of cooperatives, behaviour change modules should be included. Whilst these components were considered during the design phase, they were finally determined to be outside the scope of the current intervention for operational reasons. The need for the inclusion of these specific components and more deliberate multi-sectoral engagement in the scale up of this intervention was emphasized in discussions with relevant government departments.

Whist the focus of this chapter is on translating theory to practice and describing activities, the implementation of these activities generated useful evidence on a wide range of issues which informed project implementation on a continuing basis. An appreciation of this evidence guides the evolution and development of food system concepts which is the primary focus of subsequent chapters.

CHAPTER-5

FOOD SYSTEM MEDIATION: PROCESSES AND EVIDENCE FROM NEPAL HOME GROWN SCHOOL FEEDING

5.1 INTRODUCTION

The increasingly homogenized contemporary food systems have undermined the resilience of farming and the ability of agriculture to provide a balanced diet especially in the poorest regions of the world. (Pingali, 2015; Fanzo, 2017; Bioversity, 2017). Currently more than half of the global energy need is met by only four crops i.e. rice, potatoes, wheat, and maize, while around 300,000 edible plant species are available for food (Lachat et al., 2017). It is estimated that since 1900, 75% of plant genetic diversity has been lost as farmers worldwide have left their multiple local varieties and landraces for genetically uniform, high-yielding varieties (FAO, 1999). For example, in Nepal, only three crops, i.e. rice, wheat, and maize cover 83% of the total cultivated area (Joshi et al., 2020). The diversity of species is important for the sustainability of food systems besides being essential for balanced diets (Pingali, 2015; Lachat et al., 2017).

A specific objective of the intervention is to promote a diverse range of nutritionally and ecologically sensitive foods within local food systems. The HGSF programme theory and related analysis in chapter-3 provides a conceptual basis on how this may be achieved through an appropriately designed intervention which is described in chapter-4. Whilst the intervention included elements of behaviour change, knowledge transfer and output support, the principal element was the creation of food baskets and its potential benefit in engaging with local food system through cooperative led supply chains. Here I analyse the properties of the final operationalized food commodity baskets in terms of nutrition and the range of foods included. Based on these findings and building on the programme theory, I develop the framework and concept of 'food system mediation'. The proposed concept can hopefully be applied in research and practice of food related interventions and contribute to a more nuanced and grounded understanding of interventions and their influences in specific contexts.

The structure of this chapter is as follows. It begins with a description of the methods including a summary of the intervention and the data analysis. The next section presents the findings across key categories. The findings are applied in the following section which proposes and develops the framework and definition of food system mediation. The final section summarizes the key findings, discusses the implications of the food system mediation in practice and proposes an agenda for further research.

5.2 METHODS

INTERVENTION SUMMARY

The main objective of the project is to design and implement a HGSF programme as a platform to catalyse and enhance agriculture-nutrition-agrobiodiversity through localized community driven interventions as part of the Government of Nepal's National School Meals Programme (NSMP). The intervention (2018-2020) was undertaken in specific municipalities in six districts: Bardiya, Sindhupalchok, Mahottari, Dhanusha, Nuwakot and Jumla. The districts were purposively selected to be representative of Nepal's agroecological and socio-economic diversity.

There are two central components of the intervention, (i) Developing menus for school feeding in each intervention district and (ii) creating forward-contract based supply modalities between schools and local cooperatives. Key intervention activities include developing a food system localization strategy, nutrition sensitization at the community and government level, mapping of Neglected Underutilized Species (NUS)/Micronutrient Rich (MNR) foods, identification of local cooperatives and forward contracts with local cooperatives for food supplies to schools.

A mapping of NUS/MNR foods was undertaken for inclusion in HGSF supply chain based on consultations with Biodiversity Section (Department of Agriculture), National Agricultural Research Council and Bioversity International, Nepal. Published proceedings of a national workshop on Conservation and Utilization of Agricultural Plant and Genetic Resources in Nepal, and a compilation on NUS, provided detailed guidance on the range of NUS commodities (NARC, 2017; Joshi et al., 2019). The NUS list was supplemented with inputs from the local community during participatory design workshops.

School meals were designed at the district level in community level workshops, using Meal Planning Tool (MPT), a linear programming software developed by Partnership for Child Development (PCD), Imperial College London (Singh & Fernandes, 2016). For each district, six separate meals were finalized for each day of the school week. Nutrient data for all commodities is derived from the Nepal Food Composition Table (FCT) 2017, issued by the Department for Food Technology and Quality Control, Government of Nepal. For nutrient requirement estimations, FAO/WHO guidelines and guidelines from India on Estimated Energy Requirement (EER), safe level of intake, acceptable macronutrient distribution range (AMDR), safe level of intake and Recommended Dietary Allowance (RDA), for the specific age group are used, as currently there are no Nepal specific nutrient reference values (Singh et al., 2020). The nutrient estimations are based the 7-9 years age group. The unit cost of each meal was kept below the per child per meal government budgetary allocation, 15 NPR (0.13 USD) for most districts and 20 NPR (0.17 USD) for some remote districts such as Jumla. The nutrition target for all nutrients was set at 30% RDA based on the recommendations on a national expert group on school feeding nutrition.

A forward-contract based commodity supply system was designed for supply of agricultural commodities to the schools. Supply clusters were mapped for a group of schools based on geographical proximity and local government jurisdiction at the ward level. Based on the finalized menus and the total number of children eligible to receive school meals, a commodity demand schedule was created per school year for each cluster. This schedule served as the basis of the forward supply contracts with cooperatives. These school meal supply chains have been operational in Baridya and Sindhupalchok since 2018 and in the remaining four study districts since 2019, barring covid related disruptions.

ANALYSIS

Data of 36 school meals (6 meals x 6 districts) disaggregated by ingredient and 19 forward contract demand schedules (total across 6 districts). The nutrient content of each meal was analysed using the MPT and the Nepal FCT, the nutrient values were then averaged for 6 meals in each district. The amount of nutrient supplied by HGSF by district, was computed as a percentage of RDA for different nutrients. The percentage RDA amounts were calculated for 6-9 years age group as per the intervention design. To examine the diversity of the intervention supply chains, the number of different commodities was calculated by food group by district, based on the demand schedules in the operationalized forward contracts.

Finally, the demand schedules were reviewed by commodity to identify relevant foods that can be indicative of specific food system elements. These foods were grouped into two main categories NUS-FSF and, fermented and preserved foods. The total volume supplied per child per commodity was calculated. To estimate the supply volume for the district, the amount was multiplied by the number

The intervention design and associated implementation processes were reviewed to identify key food system elements (eg. food processors, small farmers) that were potentially influenced by the procurement processes of the intervention. The next step coded the properties of each of the elements with respect to nutrition, health and agriculture. Further analysis excluded elements which had tenuous links with the intervention, for example, ‘trading/markets’ was excluded on this basis although it can be a critical food system element. The next step involved selecting elements with a set of significant mediating properties with a focus on food system sustainability. Here the author defines mediating property as a property which can lead to a change in the food system directly and by engaging other elements. The development of the concept was informed by field observations over a two year period through the design and implementation of the intervention from January 2018 to January 2020. Field observations notes were recorded by the author (project lead) during formal and informal interactions with project stakeholders and field visits. These notes were also complemented by field observations of project field staff. A simple framework was designed to demonstrate the concept of food system mediation through this intervention. This led to the next step of defining the concept and outlining some key principles. It is important to note that the application of these methodological steps is subjective and open to interpretation, for example determining what constitutes significant properties.

5.3 HGSF SUPPLY CHAIN FINDINGS

NUTRITION COMPOSITION

A menu set for each district consists of six different meals for six days of the week which are repeated every week, the unit of analysis for nutrient supply is one week. Table 21 summarizes the average daily nutrient content based on weekly HGSF meals. The figures in the table indicate the amount of nutrient supplied by HGSF by district, as a percentage of RDA for different nutrients. RDA amounts are based for 6-9 years age group as per the intervention design. The nutrition target for school meals as mentioned in the intervention summary is 30% RDA.

For macro nutrients, protein supply was found to above 50% RDA in all intervention districts and energy supply varies from 20% in Bardiya to 26% in Jumla. For micro-nutrients, zinc supply is similar across the intervention districts, in the 25%-28% range. There is substantial inter-district variation in iron supply, it varies from 25% in Sindhupalchok to 66% in Julma. Vitamin-A supply is in a relatively narrow range of 23%-32%, with the exception of Sindhupalchok which is 4.7%. Overall, these findings suggest that the intervention created nutritionally optimized food supply chains, based on the provision of one meal a day. The inter district variation can be a function of food availability, dietary habits and the quality of meal design process.

TABLE 20: AVERAGE DAILY NUTRIENT CONTENT (%AGE RDA) OF HGSF SUPPLY CHAIN BY DISTRICT

DISTRICT	Energy (kcal)	Protein	Zinc	Iron	Vit-A	Nutrition quality score

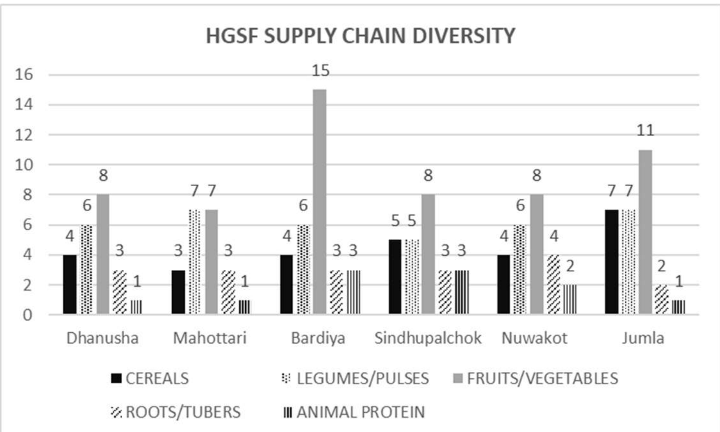
Dhanusha	23.6 %	65.0 %	26.8 %	51.5 %	25.6 %	37.08
Mahottari	23.9 %	66.7 %	28.3 %	47.8 %	23.1 %	36.11
Bardiya	20.3 %	52.2 %	23.4 %	31.8 %	26.3 %	27.38
Sindhupalchok	20.6 %	52.8 %	25.3 %	25.3 %	4.7 %	23.16
Nuwakot	25.3 %	73.4 %	25.3 %	43.1 %	31.8 %	37.42
Jumla	26.2 %	75.8 %	28.1 %	65.9 %	29.2 %	45.69

A nutrition quality score was calculated for each district. The actual weekly supply for each nutrient was calculated as a percentage of 100% RDA weekly supply as the 'nutrient score'. A weighted average was then calculated for all the nutrient scores for each district. Zinc, vit-A and iron were given two times the weight of energy and protein. This weighted average constitutes the meal quality score. There is significant variation in the meal score between districts, ranging from 45.69 in Jumla to 23.16 in Sindhupalchok. Other four districts are in a narrow range of 27 to 36.

FOOD DIVERSITY

The above analysis provides insights into the nutritional quality of diets in terms on specific nutrient values. To understand the diversity of food sources which contribute to the nutrient content, the inter food group and intra-food group diversity of supply chains was analysed by district. The analysis excluded foods used in small quantities as garnishing and seasoning. As can be seen in the figure 13, the intervention supply chains have high levels of diversity. All six study districts include at least one food from each food group. The intra-food group diversity is also significant across all districts, and food groups, except for animal proteins. The number of different cereals is in the range of 3-7, fruits and vegetables are in the range of 7 to 15 foods, legumes and pulses range is 5-8 foods and roots and tubers range is 2-3 foods.

FIGURE 13: HGSF SUPPLY CHAIN FOOD DIVERSITY



NUS-FSF FOODS

A review of the HGSF supply chains in each of intervention districts found that a total of 18 NUS commodities were included in the HGSF supply chains. By agroecological zones, seven commodities were found in terai (three districts), eight were found in hills (two districts) and ten were found in mountains (one district). Of the 18 NUS foods, nine foods are specifically identified as Future Smart Foods (FSF) in Nepal (Joshi et al., 2019).

FSF are a subset of NUS that are nutrition rich, climate resilient, economically viable and locally accessible (Li & Siddique, 2018). FSF are especially suitable to adapt to the ecological challenges associated with climate change (Acevedo et al, 2020). Millets are a good example of the features and potential of FSF. Minor millets include a range of different millets such as finger millet, foxtail millet, proso millet, kodo millet, little millet and barnyard millet. They are nutritious with high levels of macro and micro-nutrients and dietary diversity and offer significant resilience to climate on account of their tolerance to drought and, biotic and abiotic stresses and short maturing period etc. Furthermore, in terms of climate change mitigation, the low input requirements for millets also leads to a lower carbon footprint compared to other major staples that are input intensive in terms of fertilizer, pesticide and water requirements (Mal et al., 2010). Table 21 details the commodities by district and volume. The volume is based on the number of eligible beneficiary children for school meal in each district.

TABLE 21: NUS AND FSF FOODS IN HGSF SUPPLY CHAIN

No.	**AGRO-ECOLOGICAL ZONE**	**TERAI**			**HILL**		**MOUNTAIN**
		VOLUME (metric tons)					
	COMMODITY	Bardiya	Dhanusha	Mahottri	Sindhupalchok	Nuwakot	Jumla
1	Naked Barley-Hordeum vulgare var. nudum L.	0.0	0.0	0.0	0.0	0.0	63.4
2	Finger millet-Eleusine coracana	0.0	0.0	0.0	69.5	77.1	42.2
3	Marshi rice-Oryza sativa var. japonica	0.0	0.0	0.0	0.0	0.0	28.2
4	Buckwheat-Fagopyrum tataricum*	0.0	0.0	0.0	0.0	0.0	35.2
5	Horsegram Red-Macrotyloma uniflorum (Lam.) Verdc.*	0.0	0.0	0.0	0.0	0.0	7.0

6	Horsegram black-Macrotyloma uniflorum (Lam.) Verdc.*	0.0	0.0	0.0	417.2	0.0	0.0
7	Fava bean/Vicia faba*	0.0	0.0	0.0	0.0	11.0	0.0
8	Green amaranth/Green pigweed-Amaranthus gracilis Desf.*	48.7	62.8	0.0	0.0	0.0	21.1
9	Lambs quarter-Chenopodium album L.*	0.0	62.8	59.1	0.0	0.0	17.6
10	Chayote-Sechium edule (Jacq.) Sw.*	0.0	0.0	0.0	55.6	0.0	0.0
11	Himalayan nettle (powder)-Girardinia diversifolia (Link) Friis	0.0	0.0	0.0	27.8	0.0	1.4
12	Taro leaves (green)-Colocasia esculenta (L.) Schott	9.7	62.8	0.0	0.0	60.6	0.0
13	Taro leaves (dried)-Colocasia esculenta (L.) Schott	0.0	0.0	0.0	0.0	0.0	3.5
14	Pumpkin leaves-Cucurbita moschata Duchesne ex Poir	48.7	0.0	0.0	0.0	0.0	0.0
15	Bush okra leaves-Abelmoschus esculentus	0.0	78.6	73.9	0.0	0.0	0.0
16	Taro corm-Colocasia esculenta (L.) Schott *	0.0	0.0	0.0	0.0	93.6	42.2
17	Sweet potato-Ipomoea cairica (L) Sweet	14.6	78.6	59.1	0.0	33.0	0.0
18	Yam-Dioscorea alata L.*	0.0	0.0	118.2	0.0	33.0	0.0

*** Future smart food (FSF)**

Jumla district in the mountain AEZ has the highest number of NUS and FSF foods, followed by mid-hills and terai. This is a function of higher agrobiodiversity in Jumla and dietary practices which include a larger variety of foods as compared to mid-hills or terai. The analysis finds over 60 tons of naked barley in the HGSF supply chain in Jumla. Naked barley is one of the oldest cultivated grains and a source of complex carbohydrates (Gabrovská et al., 2002). It is a NUS mountain crop, and it is one of the eight mandate crops of a UNEP project on mountain crop genetic diversity[3]. Other cereals and pseudo cereals were also found in significant volumes in Jumla, such as buckwheat which contains over twice as much protein as standard varieties of rice or corn. Buckwheat is also well suited to higher altitude in terms of adaptation to different climatic variables and easily fits to different cropping patterns due to short duration (Pudasini & Gauchan, 2020). NUS foods can also consist of specific cultivars, for example, Jumla supplies consisted of over 20 tons of Marshi rice. Marshi rice is a local rice cultivar uniquely adapted to the extreme cold climate and geography of the region and grow at altitudes of up to 3050masl (Bajracharya, 2006). This rice variety is also known to have higher amount of protein, micronutrients and antioxidants as compared to popular native rice varieties grown in other hill and mountain regions of Nepal (Joshi et al., 2020).

Other NUS cereals and legumes in included finger millet and horsegram. Nuwakot and Sindhupalchok in the mid-hills included 77 tons and 70 tons of finger millet respectively, which is an excellent source of essential amino acids and calcium (Pudasini & Gauchan, 2020). Horesegram was found to be included in two districts i.e. Sindhupalchok (417 tons of horsegram black) and Jumla (7 tons of horsegram red). Horsegram red (Macrotyloma uniflorum), is an underutilized legume crop and a good example of nutritious food which is culturally undervalued. It is rich in iron and other macro and micro-nutrients and is known to have high stress tolerance (Aditya et al., 2019). It is primarily cultivated by poor and marginal farmers in India and Nepal and is considered poor man's food (Aditya et al., 2019).

Green amaranth, also known as pigweed is a source of essential amino acids, dietary fibre and minerals and is identified as FSF in Nepal (Joshi et al., 2019). It was found in significant quantities in the supply chains of both terai and mountain districts. Another underutilized plant which grows as a weed in farms, Lamb's quarter (Chenopodium album), was found in terai and mountain districts. The leaves of this plant are rich in essential amino acids and contain calcium and vitamin-A in significant amounts (Poonia & Upadhayay, 2015). Besides the foods described above, leaves of certain fruits and vegetables, rich in a wide range of proteins and essential vitamins and minerals, such taro, pumpkin, okra are included in large volumes in many of the intervention districts. Many of the crops included in the supply chain such as amaranth and finger millet are also known as 'Himalayan Superfoods' owing to their ecological and nutritive properties (Pudasini & Gauchan, 2020).

FERMENTED AND PRESERVED FOODS

This category refers to a range of traditionally preserved foods found in different parts world. These foods are found across food groups such as dairy, cereals, vegetables, legumes, roots, meat, fish.

[3] https://www.unep.org/resources/factsheet/integrating-traditional-crop-genetic-diversity-technology

Preserved foods are an important part of many local food cultures and a critical source of nutrients, especially in regions with challenging agroecological conditions. A recent study on the Himalayan region identifies over 200 varieties of community specific fermented foods which are consumed as staples diets or in the form of pickles (Tamang et al., 2021).

Some traditionally processed and preserved foods were included in the HGSF supply chain. These commodities include NUS-foods such as dried colcasia leaves, stinging nettle powder and gundruk, which is a mustard leaf based traditional fermented food. Besides these foods, dried beaten rice which is a staple, was also included in substantial volume in HGSF supply chain of all intervention districts. Table 22 details the commodities by district and volume. The volume is based on the number of eligible beneficiary children for school meal in each district.

TABLE 22: FERMENTED AND PRESERVED FOODS IN HGSF SUPPLY CHAIN

No.	**AGRO-ECOLOGICAL ZONE**	**TERAI**			**HILL**		**MOUNTAIN**
		VOLUME (kg)					
	COMMODITY	Bardiya	Dhanusha	Mahottri	Sindhupalchok	Nuwakot	Jumla
1	Taichin beaten rice	3000	0	0	3210	0.0	0
2	Rice flakes	0	13295	13642	0	2541	42.2
3	Stinging nettle powder	0	0	0	0	42	54
4	Colcasia leaves(dried)	0	0	0	0	0	135
5	Fermented mustard (Gundruk)	20	0	0	0	0	25

5.4 FOOD SYSTEM MEDIATION

DEVELOPING THE FRAMEWORK

Based on the analysis of the HGSF commodity baskets above and the intervention design, the intervention potentially engaged local food system across four key elements, each such element can be termed as ‘food system site’. This paper defines ‘food system site’ as a ‘food system component that represents a cohesive set of properties relevant to food production and consumption with direct or indirect implications on food security and public health.’

The four key sites engaged by this intervention are (1) small farms (2) women farmers (3) indigenous farming systems and (4) food heritage. Each of these sites are critical for food system sustainability with specific implications for nutrition and agrobiodiversity as discussed below.

The data in chapter 3 on two districts of Nepal shows that over 90% of total farm size in both districts is less than 0.5 ha, in Sindhupalchok district over 75% of farms were found to be less than 0.2 hectare. Given that nutritionally focussed school menus form the basis of the commodity demand, HGSF has the unique potential, as a national programme, to contribute towards creating sustainable linkages with small farmers. Most countries in Asia and Africa are dominated by small landholdings, as per one estimate, 85% of family farms in SSA are smallholdings, with a farm size of less than 2 hectares and in most cases less than 1 hectare (CIRAD, 2013; Rapsomanikis, 2015). In Nepal, small farm output constitutes approximately 70% of the national food production (Graeub, 2014). Besides food supply in terms of volume, small farms systems are reservoirs of agrobiodiversity, associated indigenous knowledge and primary supplies of essential micronutrients (Herrero et al.,2017).

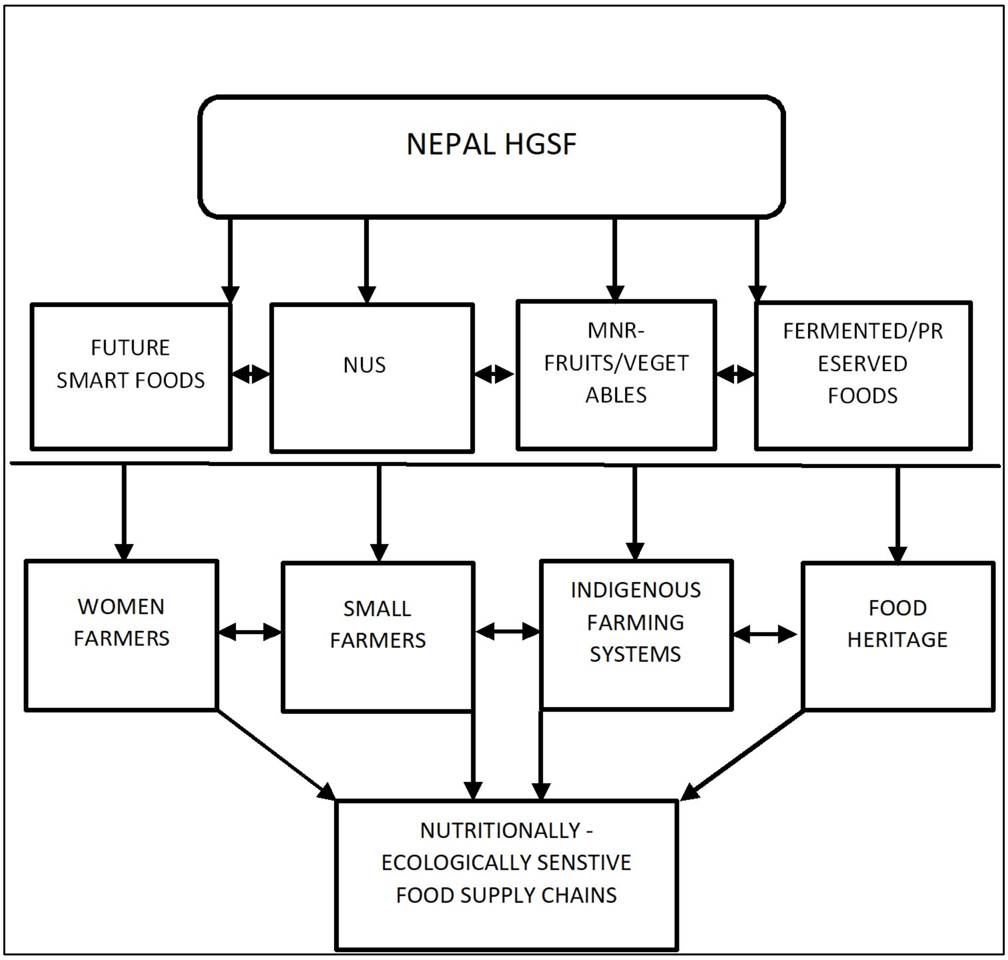
Whilst there is wide variation across regions, overall women and small farms led production contribute specifically to output of non-staple food groups such as fruits, vegetables, and legumes (FAO 2004, Joshi et al., 2006; Malapit & Quisumbing, 2015). In most contexts, women are the primary decision makers on household consumption diversity and tend to be more responsive to nutrition sensitive production incentives (Rukmani et al.,2019). There is evidence from Nepal which suggests that women farmers are critical to conserve agrobiodiversity and traditional farming knowledge, especially in relation to mountain agriculture (Pudasaini et al., 2020).

Indigenous or traditional farming practices and systems refers to a range of production systems and practices specific to particular geographic regions and applying methods developed over generations which are best suited to local ecologies and cultures (Saxena et al., 2016; Kurashima,Fortini & Ticktin., 2019). The definition here includes whole food systems such as high-mountain Andean agricultural systems and specific practices such as intercropping, crop rotation, cover cropping, traditional organic composting, integrated crop-animal farming (Saxena et al., 2016; Hamdani et al., 2021). Such systems are known to be more resilient to disturbances as they are contextualized to local landscapes and ecologies (Kurashima et al., 2019). FAOs Globally Important Agriculture Heritage Systems (GIAHS) programme provides examples of how agriculture systems promote diversity, local knowledge, culture and food traditions, ecological concepts that have been applied over centuries (https://www.fao.org/giahs/en/). Indigenous systems represent an important link with crops that are culturally accepted and well suited to local agroecological conditions and dietary practices (Kurashima et al., 2019). Many indigenous food systems are based on endemic food crops or farmer-saved varieties of major food staples, such as corn, rice, and wheat (Saxena et al., 2016). This high level of diversity and genetic variability makes these foods and production systems highly adaptive.

Food heritage can include many different components across production and consumption of food including farm practices, cooking methods, storage, preservation techniques, dishes and food combinations (Harmayani et al, 2019). It is often localized at different levels and can be specific to places, cultures and communities (Zocchi et al., 2021). Given its localized evolution over generations, preservation of food heritage components can potentially enhance the sustainability of food systems with specific implications on ecological sustainability and nutrition (Harmayani et al, 2019). For example, in resource poor communities, the application of traditional dietary practices and storage techniques which reflect local seasonality can promote food security. Besides specific practices, food heritage includes the cultural, historical and social properties of food across the supply chain and the ownership of associated communities over the means and methods of production and consumption (Almansouri el., 2021). Cultural preferences and practices are central to promoting and sustaining biodiversity in agroecosystems (Pant & Ramisch,2010). It follows that as a food system site, food heritage is critical for both food security and food sovereignty.

The sites and pathways are illustrated in the figure below.

FIGURE 15: NEPAL HGSF MARKET MEDIATION SITES AND PATHWAYS



The intervention engaged these four sites through multiple strategies and processes including procurement, meal design, commodity selection etc. The intervention was localized at district, sub-district(municipality/ward) and school level. Meal and supply chain designing was undertaken at municipality level in participatory community workshops at the sub districts (ward) level. Supply chains were localized between cooperatives and a cluster of schools within each municipality. The type of supply cooperative includes local agriculture cooperative, savings and credit cooperative and multi-purpose cooperative. Women led cooperatives were given priority for supplies, over 25% of cooperatives selected for supplies across the six intervention districts are women cooperatives.

The type of commodities included in the supply chains such as fruits and vegetables, and other NUS foods that are more likely to be produced by women farmers, small/subsistence farmers and in indigenous farming systems. For example, marshi rice in Jumla district is associated with specific indigenous farming system, unique to the Jumla valley. It is known to be the most cold tolerant rice landrace that can be grown in over 3000 m altitude (Joshi et al., 2020). Similarly, vegetable-based farming patterns are shown to improve the sustainability of upland farming in Nepal and benefit women and disadvantaged groups (Tiwari et al.,2011). The inclusion of traditional preserved foods such as gundruk (fermented mustard) interfaces with food heritage.

These four sites are overlapping, for example, indigenous farming systems are often managed by small farmers and there are common elements between food heritage and indigenous farming systems. Here they are identified separately to reflect their distinct functionality in enabling nutritionally and ecologically sensitive and sustainable food systems. Together the cumulative mediation process, with and between these sites as induced by the intervention leads to culturally, nutritionally and ecologically sensitive food supply chains.

DEFINITION AND PRINCIPLES

The analysis and development of this framework from this intervention leads to defining the concept of food system mediation. 'Food system mediation' derives from the substantial body of work on Alternate Food Network (AFN), AFN is an umbrella term that is understood to constitute all elements of a food system which is different from the default system; the default system being industrial, commercially oriented and generally disassociated (Murdoch et al., 2000). AFNs embody alternate properties such as embeddedness in local food culture, community based social and economic relations, quality of food production, ecological sustainability of the food supply chain and added value for the rural territory and farmers (Tregear, 2011; Barbera, 2014). Theoretically, different interpretative approaches have been proposed to characterize AFNs, framed around territoriality (Dematteis, 2007), functionality of agriculture (Barbera, 2014), producer-consumer relationships (Whatmore et al., 2003; Feagan, 2007; Smithers et al., 2008), participation in food provisioning (Hinrichs, 2003; Goodman, 2004) and rural development (van der Ploeg et al., 2000).

This paper defines 'food system mediation' as:

The engagement of relevant food system sites through mechanisms that optimize their interactions and functions to enable sustainability and food security.

The objective of food system mediation is to enhance social, ecological and public health efficiency in production-consumption relationships in both practice and policy. Depending on the local context and specific objectives, food system sites and the pathways can vary, however the principles of the framework should be broadly consistent. These principles include:

1. Community and local government engagement.
2. Recognition of cultural, ecological, economic and social characteristics of the intervention area.
3. Recognition of knowledge practices and application in non-hierarchical terms.
4. Political and economic viability embedded in project design.
5. Trade-offs and transaction costs of all interactions considered.

In applying these principles, food system mediation can be implemented through different mechanisms such as public procurement, behaviour change, input support, technology interventions, policy support etc. The food system sites and the nature of the interface with these sites is a function of the mechanisms applied. It can also include a range of specific outcomes within the overarching purpose of sustainability and food security.

5.5 DISCUSSION

This paper explores and analyses the intervention data on the final supply chains and applies the project experience to develop the concept of 'food system mediation'. The study shows that the intervention creates supply chains of significant nutritional content in terms of critical macro nutrients and micro-nutrients. In all the six study districts, energy content was in the range of 20%-26% RDA and protein content was found to be above 50% RDA. For micro-nutrients, vit-A was above 23% RDA in five of the six districts and zinc was above 25% RDA. The analysis found substantial inter-district variation in iron; 25%-66%. The analysis here finds that the intervention supply chains are substantially diverse for all study districts. For most food groups, the intervention supply chains included high levels of intra-food group variation. The number of different cereals is in the range of 3-7, fruits and vegetables is in the range of 7-15 foods, legumes and pulses range is 5-8 foods and roots and tubers range is 2-3 foods.

In terms of NUS-FSF foods, across the six study districts, the study found 18 NUS foods of which nine foods are specifically designated as Future Smart Foods. All the NUS food commodities are rich in essential minerals and micro-nutrients and well suited to the local ecological conditions. Many of the crops included in the supply chain such as amaranth and finger millet are also known as 'Himalayan Superfoods' owing to their ecological and nutritive properties (Pudasini & Gauchan, 2020). Except Jumla supply, which was found to include 10 NUS foods, the other five districts have 4-6 NUS foods. This is a function of higher agrobiodiversity in Jumla (mountain) and dietary practices which include a larger variety of foods, especially cereals and pseudo cereals, as compared to mid-hills or terai regions.

The number of fermented and preserved foods found is in the supply chains is very limited, although many such foods have been documented and mapped in the region(Tamang, 2021). This is partly a design limitation in the intervention which did not explicitly focus on preserved foods during the meal design process and partly a result of food preferences for children.

This intervention provides a useful illustration of enabling healthy and sustainable food systems, it is important to take note of some key demand side constraints. In the HGSF meal design process, local nutrient dense foods, rich in iron, vitamin A are included to the extent feasible. Whist this can be a main demand element in promoting quality production diversification, it is important to highlight that HGSF programmes provide one meal a day and aim to fulfil 30%-40% RDA for all nutrients depending on national nutrition guidelines, based on a specific per child per meal budgetary allocation. Enhanced food diversity including NUS-FSF foods in HGSF supply chains also have budgetary implications in terms of commodity costs and transaction costs for supply cooperatives. Given that in many low income countries, the school meal is the only proper meal of the day for the child, portion sizes and budgets must address calorific hunger and energy needs. It is important to recognize these trade-offs and develop appropriate mitigation strategies including supplementary funding, use of bio fortified foods etc.

A range of issues and processes ultimately determine the scale, efficacy and sustainability of food system mediation. Whilst it is well understood that agroecology is an important factor in food systems, this intervention highlights its profound importance in food system mediation strategies, especially in the context of subsistence agriculture and incomplete markets. The long lean season is of particular concern as production of protein and micronutrient rich foods is highly limited in most study districts.

It demonstrates the critical role of traditional knowledge and dietary heritage in challenging ecologies. Economic and ecological constraints have implications for food production diversification strategies. The limited ecological and economic resources can crowd out some NUS which often require longer growing periods, more labour and are also more vulnerable to pests and diseases. For example, proso millet, a traditional, highly nutritious and affordable grain, was reported to be less desirable due to taste and labour required for cultivation. However, the intervention clearly found that farmers across all study districts are interested in producing NUS and participating in a structured market such as HGSF. This reiterates the need for creating an enabling environment for food system mediation through support for agriculture in the form access to inputs, finance, technology and processing and storage infrastructure.

An important conclusion is that food system mediation with nutrition and ecological properties can be enabled in resource poor, small farm dominated agricultural economies, based on food system localization strategies. There are some inevitable trade-offs in balancing linkages across agriculture, nutrition and ecology, for example between farm yield and diversity. To ensure efficacy and sustainability of food system mediation processes, it is important to understand the nature of different incentives and disincentives in economic and non-economic terms through continuous engagement with all relevant stakeholders.

CHAPTER-6

FOOD SOVEREGNITY IN POLICY AND PRACTICE: ANALYSIS OF NEPAL HOME GROWN SCHOOL FEEDING

6.1 INTRODUCTION

Enabling nutrition sensitive, sustainable and equitable food systems is a central concern of contemporary food policy thinking. Over the years, a range of diverse voices from farmers, activists, scientists and policy makers have created a powerful if not always cohesive narrative of inclusive and sustainable food systems (Dekeyser et al., 2018; Godek , 2021). In part, this narrative seeks to redress the disruptions and inequities created by the neoliberal global food system (Clark, 2016). The dominance of productivity and production centred approach to food security has been challenged through alternate approaches to food governance, usually termed as alternate food networks (AFN) (Goodman et al., 2012). However, these approaches mostly took effect as discrete programmes and had limited influence on food policy at a national and global level.

A seminal concept and movement challenging the contemporary food system through principles of democratic and equitable food systems is *food sovereignty*. Over time it has come to bear a significant influence on policies, laws and programmes. As a concept, food sovereignty evolved as a deliberate alternative to food security, the dominant post World War-II food policy agenda and the subsequent market and trade-based solutions to hunger (Witman, 2016; Noll-Murdock, 2020). The definition of food security itself has changed from its origins in 1970s to 2001 (FAOs State of Food Insecurity, 2001), to include food security at different levels i.e. individual, household, national, regional and global levels (Agarwal, 2014). Conceptually food security is focussed on issues of access and application of distributive justice to eradicate hunger and whilst there are different interpretations, food security policies mostly came to be associated with technocratic approaches and reliance on market-based mechanisms (Wald-Hill, 2016). The adoption of such mechanisms which viewed hunger primarily in pathological terms disrupted local food systems with adverse impacts on ecology, dietary practices and production patterns (Pingali, 2015). Implementing food sovereignty can help realign food policies towards strengthening socially and ecologically equitable and sustainable food and nutrition security (Weiler et al., 2015, Zimmerer et al., 2020; Rosenzweig et al., 2020). Such approaches can also be tailored to address gender and health equities and enable better impact of other social and public health interventions (Jones, 2015; Weiler et al., 2015). As governments and international agencies invest in supporting sustainable food systems, principles of food sovereignty provide useful guidance for both policies and operations.

Whilst there is a substantial body of conceptual work on alternate food governance and on food sovereignty, evidence on how food sovereignty can be operationalized in national policies and programmes is scarce. This chapter aims to address this gap in evidence and also contribute to research methods for food system interventions. The two key objectives of this chapter are (i) to examine enabling elements or translating food sovereignty into practice in terms of both processes and context and (ii) to understand the HGSF intervention through a food sovereignty lens. In Nepal, food sovereignty is enshrined in the national constitution and in legislation, the HGSF intervention thus provides a valuable opportunity to understand some of the issues discussed above.

The structure of the paper is as follows. Section 2 describes the methodology for this study including a summary of the intervention. Section 3 analyses and describes the concept and definition of food sovereignty. Section 4 explores the location of food sovereignty in law and policy in Nepal. Section 5 examines the study intervention through the lens of food sovereignty to understand how food sovereignty is translated in practice through HGSF intervention. The next section examines the role and impact of governance systems. Section 7 analyses issues related to control and distribution of resources as function of food system across different intervention sites. Finally, the paper concludes with a discussion section on key findings and lessons for research and programmes.

6.2 METHODS AND MATERIALS

To evaluate the food sovereignty context and applicability of the intervention, I conducted a review of the intervention and the political-institutional context with a focus on governance structures, regulatory frameworks, institutions and constitutional mandate Data sources analysed for this study consist of: (a) Field observation notes by the author (project lead), covering a three year period (January 2018 to January 2021) on the design and implementation of the intervention. The notes include observations from formal and informal consultations and interviews with wide range of project stakeholders and beneficiaries conducted during 12 separate project missions to Nepal (b) Project monitoring stakeholder consultation; this included consultations with farmers, supply cooperatives, parents, staff from central government ministries and local government representatives in the study districts as part of project monitoring (c) Policy and legal documents from ministries of health, agriculture, education and national planning commission related to school feeding, food and nutrition security. (d) The constitution of Nepal and translated English text of Right to Food and Food Sovereignty Act.

The overall analytical framework for this study mainly derives from political ecology studies related to food policy, agriculture and environment (Zimmerer, 1997; Perkins, 1997; Finnis, 2007; Montobbio et al.,2010). I undertook the analysis in four sequential steps to explore the translation of food sovereignty in practice as a technological and political process across issues of scale, governance and power. The first step was examining the evolution of food sovereignty as a concept and identifying its key constituent elements. The second step was understanding the political and historical context of food sovereignty in Nepal and the legal and constitutional recognition and mandate. The final analysis investigated the operationalization of food sovereignty through the intervention in the framework of governance, capacity and resources.

INTERVENTION SUMMARY

The main objective of the project was to design and implement a HGSF programme as a platform to catalyse and enhance agriculture-nutrition-agrobiodiversity linkages through localized community driven interventions as part of the Government of Nepal's National School Meals Programme (NSMP). The intervention (2018-2020) was undertaken in specific municipalities in 6 districts; Bardiya, Sindhupalchok, Mahottari, Dhanusha, Nuwakot and Jumla. The districts were selected purposively to be representative of Nepal's agroecological and socio-economic diversity.

There are two central components of the intervention, (i) Developing menus for school feeding in each intervention districts and (ii) creating forward contract based supply modalities between schools and local cooperatives. Key intervention activities include developing a food system localization strategy, nutrition sensitization at the community and government level, mapping of Neglected Underutilized Species (NUS)/Micronutrient Rich (MNR) foods, identification of local cooperatives and forward contracts with local cooperatives for supplying school feeding.

I mapped NUS/MNR foods for inclusion in HGSF supply chain based on consultations with Biodiversity Section (Department of Agriculture), National Agricultural Research Council and Bioversity International, Nepal. Published proceedings of a government led national workshop on Conservation and Utilization of Agricultural Plant and Genetic Resources in Nepal, and a compilation on NUS, provided detailed guidance on the range of NUS commodities (Joshi et al., 2017; Joshi et al 2019). The NUS list was supplemented with inputs from the local community during meal development workshops.

School meals were designed at the district level in participatory workshops, using Meal Planning Tool (MPT), a linear programming software developed by Partnership for Child Development (PCD), Imperial College London. MPT is a linear programming software which was developed by PCD and was first piloted in Ghana in 2012 (Singh and Fernandes, 2016). MPT is an easy-to-use computing tool which helps in quick calculation of prices, volume, and nutrient intake (Fernandes et al 2016). It can be used to design budgeted meals that meet a nutritional standard customised by the user. It calculates the macro and micronutrient contributions of each ingredient makes in a meal, the total nutrient composition of the meal and displays the target reference for each nutrient of interest. MPT analysis is based on country and region specific data which includes a food composition table and food price data. It allows for customization in terms of selecting nutrients of interest, RDA targets, regional classification and age-group. For each district, six separate meals were finalized for each day of the school week. Nutrient data for all commodities is derived from the Nepal Food Composition Table (FCT), 2017. For nutrient requirement estimations, FAO/WHO guidelines and guidelines from India on Estimated Energy Requirement (EER), safe level of intake, acceptable macronutrient distribution range (AMDR), safe level of intake and Recommended Dietary Allowance (RDA), for the specific age group are used, as currently there are no Nepal specific nutrient reference values (Singh et al., 2020). The nutrient estimations are based the 7-9 years age group.

The researcher designed forward-contract based commodity supply system for supply of agricultural commodities to the schools and mapped supply clustres for a group of schools based on geographical proximity and local government jurisdiction at the ward level. Based on the finalized menus and the total number of children eligible to receive school meals, a commodity demand schedule was created per school year for each cluster. This schedule served as the basis of the forward supply contracts with cooperatives. These school meal supply chains have been operational in Baridya and Sindhupalchok since 2018 and in the remaining four study districts since 2019, barring covid related disruptions.

6.3 CONCEPT AND DEFINITION

The food sovereignty movement began as a farmer and peasant led repudiation of the capital intensive and productivity centred green revolution and globalized neoliberal agri-food networks (Weiler et al.,2014; Clark,2016). Its present form is primarily attributed to a politically transformative peasant movement, La Via Campesina (LVC) that began in South America in 1980s and is now a global coalition with national constituent farmer and peasant organizations around the world. Over the last two decades a significant body of work on food sovereignty; both academic and what might be termed as activist has evolved along several different disciplinary and ideological axes to create a compelling and increasingly influential narrative (Agarwal, 2014; Giunta, 2014; Zimmerer et al., 2020; Godek, 2021). At its conceptual core, it envisions democratic ownership of food resources and policies at different scales and the recognition of food as a public good (Patel, 2009; Gurcan, 2014). Whilst there are different interpretations and approaches, the primary objective of all food sovereignty movements is to create socially and ecologically equitable and healthy food systems (Borras & Mohamed, 2020; Zimmerer, 2020).

This definition and concept of food sovereignty developed over time, from the right of self-reliance of nations (1996), to the rights of people to define domestic production and trade (2002) to the current definition which was formalized in the Nyéléni Declaration of 2007 in Mali, *as the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems* (Gliessman et al., 2019). The founding principles of food sovereignty as articulated in Nyéléni Declaration of 2007 are stated in six pillars, summarized below.

1. Right to sufficient, healthy, and culturally appropriate food for all individuals and communities.
2. Rights of smallholder farmers as producers of food.
3. Enabling localised food systems.
4. Localized community governance of natural resources and associated rights.
5. Acknowledging and building traditional knowledge and skills on food production, ecological conservation etc.
6. Applying agroecological methods for food production to improve resilience and sustainability.

Different interpretative approaches can characterize food sovereignty, framed around territoriality (Tregear, 2011), functionality of agriculture (Barbera, 2014), producer-consumer relationships (Smithers et al., 2008), participation in food provisioning (Goodman & DuPuis, 2002; Hinrichs, 2003) and rural development (van der Ploeg et al., 2000). It is now widely acknowledged that food sovereignty interventions can also play an important role in addressing urgent ecological sustainability issues, more specifically on climate change mitigation and adaptation (Zimmerer et al., 2020).

The principles enumerated above have found explicit legal and constitutional recognition. 15 countries have specific laws to implement food sovereignty and it is included in the national constitution of seven countries namely Bolivia, Venezuela, Ecuador, Nicaragua, Mali, Senegal, and Nepal. Although food sovereignty principles are now increasingly well recognized in international mainstream food governance discourse, given its Latin American, farmer movement origins and Marxist views of the political economy and ecology, the concept appears to find greater institutional acceptance in left leaning political environments (Wald-Hill,2016).

6.4 LAW AND POLICY

Nepal is one of the few countries to institutionalize food sovereignty as a constitutional and legal right. The incorporation of food sovereignty in the national constitution can be best understood in the context of the recent political history of the country. A detailed study by Sharma & Daugbjerg (2020) provides key insights on this issue. The country transitioned to a democratic republic in 2008, after over two decades of armed resistance led by the Communist Party of Nepal. The vision of the new republic was enshrined in the national constitution which was finally promulgated in 2015. A significant player in the transition process was the National Peasants Coalition, a loose grouping of the three main leftist peasant organizations. This coalition included the All Nepal Peasants' Federation (ANPF), affiliated with the Communist Party of Nepal and a member of LVC. The different members of the coalition, most prominently ANPF advocated for the inclusion of food sovereignty in the new constitution. Thus, food sovereignty as a legal and constitutional right in Nepal is partly the result of communist ideological influence in the making of the new republic.

Article 36 of the Constitution of Nepal includes right to food sovereignty as a part of right to food. In furtherance of this constitutional mandate, 'Right to Food and Food Sovereignty Act' was enacted by the parliament of Nepal in 2018. The Act provides rights to farmers and citizens on food sovereignty and food security in the context of nutrition, biodiversity, localization, traditional foods and cultural acceptability.

S(2e) of the Act defines food sovereignty as consisting of the following four specific rights for farmers.

1. To participate in the process of formulation of policy relating to food.
2. To make choice of any occupation relating to food production or distribution system.
3. To make choice of agricultural land, labor, seeds, technology, tools.
4. To remain free from adverse impact of globalization or commercialization of agricultural business.

The Act frames the right to food for citizens within the food sovereignty framework and not simply limited to the right to be free from hunger or the right to have access to food. Section 3 of the Act includes the right to nutritious and quality foods and the right to culturally acceptable food, as part of the right to food.

Localization, agrobiodiversity and traditional foods which are important components of food sovereignty are emphasized as critical elements in the legislation. All food security programmes are mandated by Section-11 of the Act to give priority to local and traditional foods. Furthermore, the legislation mandates all tiers of government i.e. central, provincial and local governments to promote local agricultural crops and sustainable agricultural system based on biodiversity.

As is evident from the above discussion, food sovereignty is legislatively well entrenched as a set of rights with concomitant obligations on the State. Specifically in terms of implementing the national school feeding programme, section-11 of the Act which mandates priority for local and traditional food, read with the rights of farmers, the right to nutritious and culturally acceptable food and the promotion of sustainable agriculture systems, provides a clear mandate for a HGSF model. This is reflected to a certain extent in government planning and programme documents on school feeding such as Sector Development Plan (Ministry of Education) and the Multi-sector Nutrition Plan (National Planning Commission).

6.5 GOVERNANCE

The primary programmatic objectives of the intervention are (a) Improved dietary intake for children through school meals (b) Community sensitization on good nutrition and dietary practices (c) Output support to local farmers and (d) Promoting production and consumption of NUS and other ecologically suitable traditional foods. The intervention was designed to enable these multiple objectives through a localized community-based approach embedded in governance structures and political processes. The intervention through different programme elements operationalizes food sovereignty through the platform of a government led national food-based safety net programme.

The institutionalization of food sovereignty as an instrument of government policy brings to the fore the critical role of governance systems in devolving powers and decentralizing functions to enable food sovereignty at different scales (Dekeyser et al., 2018). Whilst food sovereignty is about the autonomy of communities and people to define and develop local food systems, national governance systems and regulations play a central role in enabling food sovereignty (Clark, 2016). These systems are further shaped by the political economic processes at different levels in the governance hierarchy. This section analyses the governance system and associated processes in how it relates to the implementation of the HGSF intervention.

Nepal is administratively divided into nine provinces and 77 districts, each district is further divided into urban and rural municipalities. Municipalities are governed by local governments which exercise jurisdiction over specific subjects such as education, agriculture and local development. The constitution of Nepal created local government structures at the municipal and sub-municipal level (ward) level and vested these local governments with significant governance powers. According to Schedule 8 of the national constitution, subjects, including farming, livestock, agriculture production management and local development programmes are specifically under the jurisdiction of local government i.e. municipal government headed by an elected mayor. This decentralized governance system whilst incipient, has enabled food system localization in terms of governance and political relevance. Food security and agriculture and in particular children's nutrition have become important issues in local government politics.

This intervention was uniquely positioned in terms of timelines as Nepal transitioned from a centralized governance structure to decentralized government through the design phase of the intervention in 2018. I conducted discussions on intervention design with both, the now erstwhile centralized offices and new local governments, providing some useful comparative insights. In consultations with district offices of agriculture, education and health, which are line offices of the Kathmandu based central government in the old system, the localization element of HGSF was seen primarily as an administrative concept limited to decentralization of power and resources. HGSF intervention was received as policy and technology validated by the central government and international expert agencies to be implemented through the state apparatus. In my subsequent consultations with the new local government offices a very different perspective was highlighted, HGSF components were viewed from a functional perspective with a recognition of the potential ecological, cultural, political and economic benefits.

The unit of localization for operational purposes was the municipality, in terms of linkages with local agriculture through cooperative forward contract and overall implementation of the project including management and funding. The mayor of each municipality and the ward chairpersons were identified as the principal political drivers of the intervention. Local government representatives were involved in the menu design process which establishes the commodities to be included in the HGSF supply chain. The mechanism to select cooperatives was also designed to be local government led, through a procurement committee. Whilst local governments were involved in all the processes, the selection of commodities was largely depoliticized through community sensitization about nutrition and orphan crops, community participation in menu design and the visible use of a technological solution, the meal planning tool.

Whilst direct engagement with local leaders was important, community participation was found to be a critical component for embedding the intervention in local politics. At the ward and municipal level, the relationship between the community i.e. the electorate and local government is very proximate. In all the intervention districts community participation was found to be an important factor in driving the political process. However, it is important to note that there were significant variations between districts. For example, in the mid hills and high mountain districts of Jumla and Sindhupalchok, local governments were found more community driven and responsive compared to the districts in the Terai region such as Dhansuha. Anecdotal evidence and other studies suggest that these differences can be attributed to the stark contrasts in demographic, socio-economic, ethnic/caste and gender factors (Malapit et al.,2014). Participation of women which is more prominent in the hill/mountain communities, appears to be a key differential in driving HGSF intervention as an important political agenda (Acharya et al.,2010).

6.6 DISTRIBUTION OF POWER AND RESOURCES

The translation of food sovereignty from a concept to a programmatic intervention entails regulation and distribution of power and resources across a range of key stakeholders. This is a cumulative function of governance systems and processes and the programme design. The process of food system democratization includes multiple sites, in hierarchical or nestled scales, such as farmer groups, national government, local governments, schools etc. Food sovereignty intervention seeks to enable equitable food systems by mediating resource control across these key sites. This section examines the distribution of power and issues of capacity in the implementation of the intervention. The findings are summarized in Table 23, across six key sites i.e. (1) Central government (2) Local government (3) Local community (4) Schools (5) Supply cooperatives and (6) Farmers.

TABLE 23: RESPONSIBILITES, RESOURCES AND CAPACITIES

SITE	ROLES/RESPONSIBILITIES	RESOURCE CONTROL	CAPACITIES/CONSTRAINTS
Central government	▪ Policy and regulations ▪ Programme strategy and guidelines ▪ Budget and fund flow ▪ Nutrition targets/standards	▪ Primary funds ▪ Technical knowledge ▪ Policies	▪ Budgetary limits ▪ Policy priorities ▪ Limited technical and administrative resources
Local government	▪ School feeding management ▪ Selection of supply cooperatives ▪ Provision of supplementary funding ▪ Community mobilization	▪ Supplementary funds ▪ Infrastructure	▪ Local politics ▪ Limited local revenues for supplementary funding ▪ Limited administrative resources
Local community	▪ Selection of food commodities ▪ Menu design ▪ Monitoring through school committees	▪ Nutrition ▪ Traditional/local knowledge ▪ Farm linkages ▪ Agrobiodiversity ▪ Food quality	▪ Food costs and availability ▪ Cultural and religious practices/taboos

Schools	▪ Monitoring of food supplies ▪ Contract management with supply cooperatives ▪ Food preparation and distribution	▪ Primary funds ▪ Food quality ▪ Nutrition ▪ Farm linkages	▪ Limited staff resources ▪ Limited kitchen and distribution facilities
Supply cooperatives	▪ Aggregation of commodities from local farmers or traders ▪ Food supplies to schools	▪ Farmer linkages	▪ Limited management capacity and resources ▪ High transaction costs ▪ Price volatility
Farmers	▪ Supply to cooperatives ▪ Food quality ▪ Food diversity	▪ Farm production	▪ Poor market access ▪ High production costs ▪ Climate risks ▪ Pre and post-harvest loss ▪ Poor agriculture extension services. ▪ Small land holdings

The role of the central government is principally that of a regulatory authority, responsible for national policies and guidelines across all intervention components. The regulations are framed based on technical inputs and governance priorities. In terms of resources, it controls funds as the core school feeding budget flows from the central government. It also controls technical and scientific knowledge, most technical expertise on nutrition, public health and agriculture is housed in various agencies that fully or partly operate under the central government. Technical assistance from international agencies is also routed through relevant central government departments. The main capacity issues include competing policy priorities and budgetary constraints.

Local governments at the municipal and sub-municipal level (ward) level are vested with significant governance powers, which is reflected in the wide range of critical responsibilities. Local governments exercise significant direct and indirect influence over all aspects of the intervention. However, resource control is limited to supplementary funds, local government can supplement central government allocation and provide capital grants to support kitchens, cooks etc. Local government institutions are very nascent in Nepal and currently have limited revenue sources and administrative capacity.

The local community is vested with the most significant operational role i.e. menu design and selection of food commodities. Whist this is undertaken according to the guidelines framed by the central government through participatory workshops, it is the local communities consisting of farmers, parents, traders etc, which determine the menus and food. The key resources controlled by the local community include nutrition, farm linkages through commodity selection of local foods and food quality through on-site monitoring. Local communities are often constrained by the cost and availability of foods and the prevalence of entrenched food taboos related to social or religious norms.

Schools are the actual site for delivery for the service and are responsible for food preparation and distribution and contract management with supply cooperatives. Ultimately schools control funds as money from the central government flows to the schools. As per law, role of local government for fund flow is only that of an intermediary. The supply contract is between schools and cooperatives, through which schools can exercise control over market linkages. Given that schools are responsible for cooking and serving food, which should be according to prescribed guidelines, they also control nutrition value of meals. In many cases depending on the district, schools suffer from severe capacity constraints such as absence of a proper kitchen or lack of resources to hire cooks.

The supply cooperatives control the important resource of farm level linkages as they are responsible for aggregation and supply of food commodities. To a large extent, the aggregation method determines if the food is actually local and the intervention is providing output support to small farmers. A wide variation was observed across the intervention districts, in terms of the administrative capacity of cooperatives. In some districts, there was a near complete absence of functional cooperatives or farmer groups. Additional critical capacity issues found across all districts relate to high transaction costs, which includes the cost of aggregation, storage and distribution, and intra-annual price volatility.

Finally, the role of individual farmers is to produce and supply food commodities and to that extent farmers exercise certain control the food quality, food diversity and nutrition. Depending on the agroecological zone and district, farmers suffer from a range of capacity issues such as high production costs, poor agriculture extension services, no irrigation and limited storage facilities.

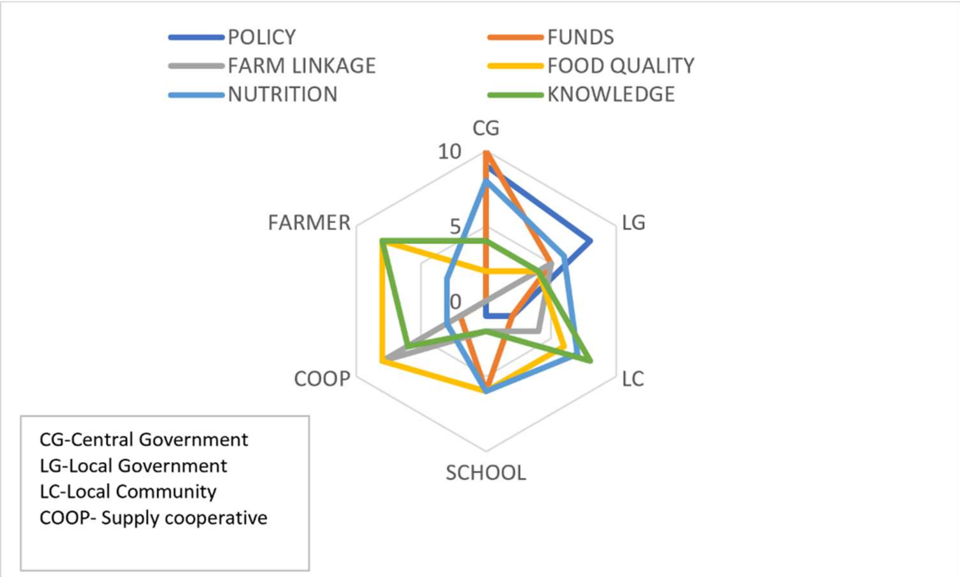
A key aspect of resource control with implications on HGSF localization is budget and fund flow. The programme is funded entirely by the central government on a per child per meal basis. The level of decentralization in terms of the use of funds is not aligned with the local government structures, as in effect funds are ultimately controlled and applied at the level of each individual school. According to current fiscal law, funds for school feeding are transferred directly from the federal government to the municipal government and the municipal government is legally bound to transfer the funds to schools under its jurisdiction. The intervention found that the current funding mechanism, limits the actual fiscal authority of local government.

This analysis finds that whilst the HGSF intervention includes many decentralization components, in effect significant resources are concentrated in a few sites such as central government and schools and on issues of policy and funds there is a significant vertical hierarchy flowing from the central government. Sites such as cooperatives and farmers which determine critical components such as farm linkages have limited explicit powers under the intervention and are highly constrained by a range of capacity issues. These sites are nestled in local government and local community and derive an element of control through participation in these other sites. Farmers ultimately control the quality and diversity of foods provided in the supply chains however they have negligible resource control under the intervention. It is the cooperatives and schools which determine the terms of engagement in terms of prices and supply schedule.

Building on the above analysis and consultations with key stakeholders, the six different sites were scored on a scale of 1-10 on the actual control exercised by these sites on six main intervention issues i.e. policy, funds, farm linkages, food quality, nutrition and knowledge (science based and indigenous). Control was assessed in both direct and indirect terms, for example, control on 'nutrition' can be direct by setting RDA targets and indirect through role in monitoring or meal design. The result is illustrated in the figure below.

The distribution of control demonstrates a disconnect between key aspects. Funds are primarily with central government with final control over disbursement with schools. Policy control is mostly with central government, although local governments have legal power on a range of issues. The critical issue of farm linkages is excessively controlled by a single site i.e. cooperatives. Nutrition is better distributed due the participatory processes although the minimum targets are set by the central government. Food quality is primarily a function of quality control and monitoring and therefore it is evenly distributed across multiple local sites. Knowledge refers to both scientific knowledge generated by research centres and indigenous knowledge. This intervention primarily relies on prescriptive knowledge generated by central agencies such as food composition tables and NUS mapping. Local knowledge on foods, diets, ecology and costs was included in the design process and this is reflected in the control score.

FIGURE 16: CONTROL MAPPING BY HGSF SITE



6.7 DISCUSSION AND CONCLUSION

This paper shows how a food-based safety net programme can operationalize food sovereignty across its different components. As the design components of the study intervention were limited to providing localized output support system for a diversified food basket, it does not directly interface at the farm level. However, the intervention engaged operational pathways on nutrition and agrobiodiversity, premised on catalytic processes related to farm level decision making and in the long run, incremental changes in wider dietary practices at the household level. A critical and relatively unique element of food sovereignty is recognizing the cultural and ecological aspects of food. The intervention enabled non-economic incentives which were recognized by farmers and the local community as important drivers for participating in the school feeding supply chain. These incentives built on traditional knowledge on food production and diets, ecological sustainability of neglected local foods and health benefits of consuming nutrient rich foods.

The analysis of the intervention provided two important insights into the nature of food sovereignty as an operational concept. One, is that the contours of food sovereignty are optimally defined by the political ecology of local communities. In consultations with central government, a frequently cited area of concern with regard to the implementation of food sovereignty was that it requires large scale investment in agriculture across the supply chain. Whilst this is true, at the community and local government level, the idea of food sovereignty was seen in terms of using local foods from local farms, irrespective of scale. The implementation of the intervention enabled by local communities, demonstrated that food self sufficiency at any scale; local, provincial or regional is not a prerequisite for food sovereignty. Second insight relates to the finding that food in the HGSF supply chain with its focus on nutrition, ecology and culture is viewed as a public good, which is a central element of the food sovereignty framework.

Although it is well understood that the ideological underpinnings of food sovereignty derive from Marxist ideology, the actual role of the state in implementing food sovereignty remains largely understudied. Translating food sovereignty principles into practice requires substantial government support and intervention. This study shows that it is critical for the State to play an active role across several key components such as creating decentralized governance structures, devolving powers to communities, investing in agriculture infrastructure, supporting science and technology developments, and enabling farmer-based organizations and other community cooperatives. Another important area for government intervention is in the regulatory sphere, to ensure that food and agriculture related regulations, ranging from agricultural land ownership to international trade policy, are aligned with the principles of food sovereignty.

A related aspect is governance system, it determines the degree and scope of localization, a key element of food sovereignty. In countries with high levels of ecological, cultural and ethnic heterogeneity, and predominantly traditional small farm agriculture systems, food and diet interventions need to highly localized and community driven, which can be challenging in centralized governance systems. In the intervention, localization was successfully undertaken at the municipal level and embedded in local politics, due to newly decentralized governance in Nepal. The content of localization includes enabling culturally, nutritionally and ecologically sensitive food supply chains based on local agriculture. All these objectives are based on specific constitutional and legal mandates as provided in the national constitution and the Right to Food and Food Sovereignty Act 2018.

The application of food sovereignty principles in developing and implementing agriculture-food security projects, locates food production and consumption issues such as dietary transitions and agrobiodiversity in the localized economic, political, social and ecological context. Community driven interventions optimally supported by government policy, scientific knowledge and technology can help redress the food and ecological injustices that pervade rural agrarian communities across large parts of the world (Finnis, 2007; Noll-Murdock, 2020). A key contribution of this paper is to highlight the role of rural agrarian communities as custodians of traditional knowledge on food and ecology and to ensure the development of these resources. Food governance systems and interventions need to incorporate community voices and agency and be informed by science and traditional knowledge in equal measure.

Food sovereignty interventions can also specifically target gender based and other social inequities through specific design components that focus on women and other marginalized groups. Programmes aimed at nutrition and ecological farming systems must give specific attention to women farmers and enable pathways for gender equity (Bhattarai, Beilin & Ford, 2015). In the HGSF intervention, this was achieved to some extent, directly through the inclusion of women cooperatives in the supply chain and meal design process, and to a more limited extent, through inclusion of non-staple food groups such as fruits, vegetables and legumes, as the contribution of women and small farmers to agricultural output is especially large for these food groups (Malapit & Quisumbing, 2015).

Finally, this study identifies areas of food sovereignty implementation which deserve further inquiry and research, such as the role of State, function of regulatory frameworks, capacities of farmer-based organizations, role of local governments and participation of indigenous communities. Whilst the intervention included participatory processes, community engagement across the implementation components must be more deliberate and detailed. It should inform the design elements of the intervention and not just the implementation. Indigenous knowledge on production and food consumption practices should be comprehensively mapped and included as a separate element of implementation. Finally, to ensure scalability and sustainability, food sovereignty interventions should be aligned with administrative structures and embedded in government led programmes.

Preface

This chapter was written in July 2020 as the first lockdowns to due to the Covid- 19 pandemic came into effect around the world. It applies the methods and outputs developed in the chapters above as an analytical tool to explore the potential impact of the lockdown on food security in Nepal and in that it demonstrates the wider application of some of the tools developed in this thesis. Given the time sensitive nature of the subject, after consultation with my supervisors the manuscript was submitted to Journal of Nutrition Sciences for publication. It was published in Oct 2020[4]. The study was designed by the author and the chapter was entirely written by the author. The published article includes three co-authors, their specific contributions are described in the thesis introduction.

CHAPTER-7

ESTIMATING THE POTENTIAL EFFECTS OF COVID-19 PANDEMIC ON FOOD COMMODITY PRICES AND NUTRITION SECURITY IN NEPAL

7.1 INTRODUCTION

The COVID-19 pandemic has caused a global public health crisis on an unprecedented scale, affecting nearly every country and community on the planet. As the disease continues to spread, we are beginning to get an initial glimpse of the destruction it leaves in its wake. The pandemic and contagion control measures have ravaged economies leading to millions of lost jobs and livelihoods. The need to divert community health and clinical resources, and social distancing requirement have led to the disruption of public health and safety net programmes. The most widely used contagion control instrument has been lock-downs and curfews, allowing for only very restricted movement of goods and people.

In Nepal, the national lock down commenced in the last week of March 2020. It included a ban on transport throughout the country and closure of schools, offices and markets. Whilst all sectors of the economy suffer due to such measures, the impact on agriculture and food availability can be particularly debilitating and profound. Countries such as Nepal, which are resource poor with fragile agricultural economies and underdeveloped supply chains are especially vulnerable. The cumulative impact of lost incomes, disrupted food supply, interrupted safety net programmes and reduced

[4] Singh, S., Nourozi, S., Acharya, L., & Thapa, S. (2020). Estimating the potential effects of COVID-19 pandemic on food commodity prices and nutrition security in Nepal. Journal of Nutritional Science, 9, E51. doi:10.1017/jns.2020.43

coverage of health interventions can lead to a critical food and nutrition crisis and increase in infant and maternal mortality (Akseer et al., 2020;Roberton et al.,2020) .

One of the most immediate drivers of food and nutrition insecurity is the increase in food prices. As a coping strategy, poor households replace micronutrient rich foods such as animal sourced foods, fruits and vegetables with cheaper energy dense foods to preserve caloric intake (Block et al.,2004;Klotz et al.,2008;Meerman & Aphane,2012) . The link between high food prices and food insecurity is well established (Klotz et al.,2008; Ivanic & Martin, 2008; Arndt et al.,2016) . Higher food prices are known to increase malnutrition in young children and mothers especially in low-income and mid-income countries (Arndt et al.,2016; Bhutta et al.,2009;Miller & Urdinola, 2010) . The consequences of malnutrition are especially severe for the youngest demography, affecting the development of cognitive abilities which can have significant long term and irreversible impacts on health (Victora et al.,2008; Hoddinott et al.,2008; Ampaabeng & Tan,2013). Studies have also shown that children who experience poor nutrition in-utero and at a very young age suffer from lifelong negative effects in the form of lost human capital, decreased productivity and lower earnings (Hoddinott et al.,2013;Gertler et al.,2014).

The pandemic and response measures are causing food and nutrition distress for millions of poor households around the world. As case numbers continue to rise and food production is disrupted, the possible final toll on the health and well-being of an entire generation presents a sobering picture. As is always the case, vulnerable populations in low income countries are likely to suffer the most. In order to better inform policy and catalyse responses, quantification of the potential impact of the pandemic on food and nutrition security in low income countries is required. Such analysis will also help contribute to further research on the medium and long-term impacts of the pandemic on food security and public health.

This paper investigates the impact of Covid-19 control measures on food prices and models the effect of food price changes on nutrition quality of diets. It specifically examines the effect of price changes on micronutrient intake. The study design includes three districts, enabling comparison between diverse agroecological zones and geographical contexts. The paper applies two different approaches to analyse the potential effect of food price increase on the nutritional quality of diets. School meal food basket (SMFB) provide a useful analytical platform to estimate the most realistic effect of price inflation on cost and diet quality based on local, balanced and diversified weekly diets. However, this does not tell us how the diets in the poorest households of the country will be impacted. In order to understand this aspect, the study constructed typical household food baskets (THFB) for the poorest quintile (quintile-1) for each district and analysed the cost and diet quality implications of food price changes for these baskets.

The structure of the paper is as follows. Section 2 details the approach, methods and materials applied in the study. Methods and materials for each main topic are presented in detail. Section3 describes the results, covering cost and diet quality estimates and analysis. Finally, section 4 summarizes and analyses the main results, discusses their implications and highlights some limitations of the study.

7.2 METHODOLOGY

This paper presents a comparative intra-country observational study design analysing events before and during the pandemic (after implementation of contagion control measures). The study design builds on the HGSF intervention and includes primary data collection, modelling and quantitative analysis. Meal Planning Tool (MPT), a linear programming software developed by Partnership for Child Development (PCD), Imperial College London, was used for nutrient estimations and costings. MPT was coded with relevant food and nutrition data for Nepal.

NUTRIENT REFERENCES

Nutrient data for all commodities is derived from the Nepal Food Composition Table (FCT), 2017, issued by the Department for Food Technology and Quality Control, Government of Nepal. Nepal FCT provided nutrient information for over 567 food items. It does not include zinc values, and occasionally some nutrient values were missing for some commodities and some commodities were missing as such. To address the issue of zinc values and other missing information, data was used from India and Bangladesh FCT's based on the assumption that neighbouring countries would have similar food compositions.

For nutrient requirement estimations, FAO/WHO guidelines and guidelines from India on Estimated Energy Requirement (EER), safe level of intake, acceptable macronutrient distribution range (AMDR), safe level of intake and Recommended Dietary Allowance (RDA), for the specific age group are used, as currently there are no Nepal specific nutrient reference values. Details on reference values for school meals and typical household are provided in the latter part of this section.

SITE SELECTION

Three districts of Nepal were purposively selected representing the main agroecological zones and geographical contexts Bardiya is in *Terai (plains)*, with an open land border with India, Sindhupalchok is in *mid-hills* with a restricted land border with China and Jumla is in the *high mountains*. There are also marked differences in the wealth distribution and food security of the study districts based on the different ecological zones, as can be observed from Table-24.

TABLE 24: WEALTH DISTRIBUTION AND HH FOOD INSECURITY OF STUDY DISTRICTS (DHS, 2016)

ECOLOGICAL ZONE/DISTRICT	WEALTH QUINTLE-%AGE POPULATION					HH FOOD INSECURITY- %AGE DISTRIBUTION	
	Q-1	Q-2	Q-3	Q-4	Q-5	MODERATE	SEVERE
Terai/ Baridya	5.7	19.1	28.9	26.4	19.9	28.9	13.8
Hills/ Sindhupalchok	31.0	20.5	11.2	22.6	22.6	24.4	10.0
Mountains/ Jumla	57.8	23.4	8.3	5.7	4.9	19.1	9.2

FOOD PRICE DATA AND REFERENCE PERIOD

The reference period for this analysis is aimed at capturing the potential initial effect of COVID-19 control measures on food prices and diet quality in Nepal. The national lock down in Nepal due to COVID-19, with a ban on movement of people and goods, commenced on 25 March 2020. In order to allow for some time lag, end May/early June 2020 was selected as the 'Post COVID 19' as reference point. To ensure comparability, the same time period in 2019 i.e. June 2019 was selected as the 'Pre COVID 19' reference point.

Phone surveys were undertaken to collect food commodity prices for this period from the three study districts. SMFB provided the list of commodities for price data collection. It consists of a wide range of commodities, around 26 food items on average in each district, from across food groups. Condiments, spices and commodities used in small amounts such as chilly and ginger were not included. Table-25 indicates the number of food commodities by food group for each district for which price data was collected.

TABLE 25: NO OF FOOD ITEMS IN FOOD COMMODITY SAMPLE BY FOOD GROUP/STUDY DISTRICT

DISTRICT	CEREALS	LEGUMES/ PULSES	FRUITS/ VEGETABLES	ROOTS/ TUBERS	ANIMAL PROTEIN	TOTAL
Baridya	4	6	15	3	3	31
Sindhupalchok	5	5	8	3	3	24
Jumla	7	7	11	2	1	23

Prices were collected from two different independent sources i.e. traders and farm cooperatives. Price data was verified from a third source i.e. the World Food Programme (WFP) Nepal's Vulnerability Analysis and Mapping (VAM) unit, by comparing data for some commodities for each district. The 'Pre COVID 19' prices were collected during school meal design workshops and market surveys during the HGSF intervention. Bardiya and Sindhupalchok base prices were collected in August 2018 and Jumla prices were collected in June 2019. For the purposes of this study, Bardiya and Sindhupalchok prices were inflation adjusted using inflation data from Nepal Central Bank, till June 2019 and validated with actual June 2019 prices for some commodities.

FOOD PRICE CHANGES

The food commodity data was coded separately for five food groups. Changes in prices for each district by food group were then analysed. Prices for 2019 and 2020 were averaged for each food group and calculated the change in prices over our reference period.

SCHOOL MEALS

The SMFBs represent culturally, locally and nutritionally optimised food baskets, developed by the local community and currently served as school meals. All school meals were designed at the district level, in participatory workshops based on menu development guidelines. The meals are based on local taste, culture, production and availability for each district. For each district, six separate meals were designed for each day of the school week. The six meals have been combined to comprise a SMFB for this analysis.

Recommended nutritional intakes for school meals were calculated based on FAO/WHO guidelines as endorsed by *Nepal School Meals Nutrition Technical Working Group*. Table 26 summarizes the nutrient reference values for school meals in Nepal.

TABLE 26: RECCOMENDED NUTRIENT INTAKE REFERENCE VALUES (DAILY) FOR SCHOOL MEALS

NUTRIENT	RECOMMENDED AMOUNT/WEEK	MEASURE	DETAILS
Energy (kcal)	11100	Estimated average requirement (EAR)[21]	Boys 7-10 =2100kcal Girls 7-10 1800 kcal
Fat (kcal)	369.6	Acceptable macronutrient distribution range (AMDR)[24]	Max 30% of calories from energy

Protein (g)	177	Safe level of intake[2]	Based on India's values, child weight = 25.1kg, Grams protein per kg = 1.17 Age= 7-9
Zinc (mg)	67.2	Recommended daily allowance (RDA)[22]	Low bioavailability, 15% Age=7-9 years
Vitamin A (µg)	3000	Safe level of intake	Age=7-9 years of age
Iron (mg)	106.8	Recommended daily allowance (RDA)[22]	Low bioavailability, 5% Age= 7-10 years
Calcium (mg)	4200	Recommended daily allowance (RDA)([22]	Range= 600mg-800mg

The unit cost of school meals (per child/ per meal/ per day) for the two points in time based on the food price data was calculated. As each set for each district consists of six different meals for six days of the week which are repeated every week, the unit of analysis for nutrient supply is one week. Prices for each actual daily meal vary depending on ingredients. The unit cost is thus derived from the average cost of the six meals.

In order to estimate the impact of increased prices on the nutrient intake, HGSF food baskets adjustment modelling for all school meals for the three districts was conducted. The objective of this modelling was to understand and estimate the net effect of price changes on nutrient intake. The basic idea was to adjust all daily meals for the three districts i.e. 18 meals, based on 2020 food prices, such that the total cost of each meal remains the same as the baseline reference cost in 2019. This required a reduction in quantity of each ingredient by a certain amount. Different methods for meal adjustment were considered. As HGSF meals were designed by the community with fixed proportions of different ingredients as per local culinary practices and therefore it is important to maintain the correct proportion of ingredients in a meal to preserve its integrity. Finally, the following method was applied which keeps each meal intact in terms of ingredients and proportions. The main computational steps for this method are as follows:

a. Calculate the ratio of the total meal cost 2019 (pre COVID 19) and 2020 (post COVID 19).
b. Apply this ratio to each ingredient
c. Apply this ratio to each nutrient value of the 2019 cost of meal.

Adjusted ingredient weight = original weight of ingredient x (2019 cost of meal ÷ 2020 cost of meal)

After all the 18 meals were adjusted, the nutrient composition of all the adjusted meals was calculated in terms of amount of each nutrient and as percentage of the RDA using the MPT. Total nutrient weekly supply was then calculated for each district based on the six district specific meals. These values (2020) were compared with the base reference values (2019).

TYPICAL HOUSEHOLD FOOD BASKET (THFB)

THFBs were developed specifically for each district and represent notional diets being consumed by the poorest quintile of population. Typical food baskets have their limitations in that they provide a restricted model of what households actually consume over a week or a month. Whilst the limitations remain, this chapter has attempted to develop credible THFBs based on multiple primary and secondary evidence.

A THFB was designed for a HH in the first wealth quintile (quintile-1) for each district. Quintile-1 and quintile-2 account for 31% and 22% of the rural population respectively (DHS 2016). The population of interest is quintile-1 and quintile-2 as these segments are most vulnerable to the effects of food price inflation on food and nutrition security. In Nepal, quintile-1 and quintile-2 spend 64.2 % and 62.4% of the total household budget on food respectively. THFB for both quintiles were designed but on further analysis only quintile-1 THFBs was included. The difference between the two baskets was insubstantial and therefore the quintile-2 THFBs were not included in the analysis.

Method of Household and THFB construction

The construction of the three THFB involved approximations of household composition, household food consumption and expenditure data. The household of 6 members for quintile-1 was determined based on national survey findings (CBS, 2017). These assumptions related to age and gender were made and validated from the analysis of primary and secondary data sources (Akhter, 2003; MoH,2016; CBS,2017; MoH 2017). The household profile was kept the same for all nutrient and cost assessments of the THFBs, by district.

Nutrient reference intakes were used to calculate the daily nutritional recommended amounts for each household member. The average energy requirements were based on the age, weight, gender and level of physical activity for each household member. Adult household members were assumed to have moderate physical activity levels (PAL), from 1.70 – 1.90, except for the older female who had sedentary levels of physical activity at 1.60. The weight of each family member was estimated using data collected from previous research (Sudo et al.,2006). The energy requirements were based on estimated average requirement references sourced from the Joint FAO/WHO/UNI expert Consultation in 2001 (Gertler, 2014; MoH, 2016). Safe level of protein intakes were estimated based on guidelines within the WHO/FAO/UNU Joint Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition (FAO-WHO,2004). The recommended daily allowance (RDA) reference values were used for zinc, iron, vitamin C and calcium and the safe level of intake reference values for vitamin A were based on the FAO/WHO Guidelines on Vitamin and Mineral Requirements in Human Nutrition (FAO-WHO,2004). Low bioavailability reference values for zinc (15%) and iron (5%) were used given the Nepalese diet contains high levels of antinutrients and low amounts of animal-based foods (FAO-WHO,2004). Fat was limited to contributing up to 30% of total energy requirements based on the acceptable macronutrient distribution range (AMDR) for fat of 15-30% (FAO-WHO, 2008). Table 27 summarizes the household composition and daily nutritional needs for each member.

TABLE 27: RECCOMENDED NUTRIENT INTAKE REFERENCE VALUES (WEEKLY) FOR EACH MEMBER OF THFB HOUSEHOLD

HOUSEHOLD MEMBER	AGE	PAL	ENERGY (Kcal)	PROTEIN (g)	FAT (Kcal)	VIT-A (μg)	IRON (mg)	ZINC (mg)	CALCIUM (mg)
Boy	2–3	1.45	1125	12	337.5	400	11.6	8.3	500
Boy	5–6	1.55	1475	16.2	442.5	450	12.6	9.6	600
Girl	13-14	1.75	2375	41	712.5	600	65.4	14.4	1300
Male adult	37	1.9	2570	46	771	600	27.4	17.1	1000
Female adult	28	1.9	2200	37	660	500	58.8	9.8	1000
Female adult	45-50	1.6	1950	35	585	500	58.2	9.8	1000
Total			**11695**	**187.2**	**3508.5**	**3050**	**234**	**69**	**5400**

THFBs were designed to reflect likely household consumption of foods over time by converting per capita food consumption (kg) into daily amounts. The THFB were constrained by food expenditure and consumption data for quintile-1. A broad range of foods were selected, including seasonally consumed foods. For example, it is likely that milk is not consumed daily in quintile-1, however it was included in the basket in small amounts relative to actual consumption over the year. Also, the inclusion of a variety of foods consumed at different times in the year, allowed to analyse the effect of more food price changes on the diet.

For each THFB, the total cost of the basket was calculated using food price data for pre and post Covid-19 period, i.e. 2019 and 2020.

Using additional evidence on food consumption behaviours and coping strategies for poor households, this assumption was quantified into proportionate reduction of different food items, to nullify the effect of increased total THFB cost over the reference period. The reduction weightage was applied uniformly to all districts.

The main computational steps are summarized below.

1. Total cost of the THFB using prices from our two reference points were calculated separately and a price difference *(D)* for each of these was obtained.
2. A weight *(W)* of food group expenditure reduction were established. This was 2.5 for fruits and dairy, 2 for vegetables, 1 for roots, tubers, pulses, legumes and nuts, 0.5 for cereals and grains, while sugar and oil quantities were not given a ratio i.e. not reduced.
3. Each weight *(W)* was applied to the total cost difference *(D),* to calculate the reduction in expenditure of each food item needed, to maintain the original daily budget for food.

The weight given to each food group was estimated based on evidence of food price sensitivity in the South Asian region and changes in food consumption for the quintile-1 due to food price increases. Food group price sensitivity, from highest to lowest were dairy, fruits, vegetables, beans/legumes, roots and tubers, then cereals and grains (Green et al.,2013; Muhammad et al.,2017). In the analysis here, no weight was given to oil and sugar, due to the assumption that reductions in caloric rich foods would be avoided where possible.

The cost reduction for each food item was calculated based on a formula, applying the weights mentioned above. The quantity for each food item was then adjusted as per the reduced costing. Finally, the nutrient composition of the meal based on reduced food quantities was calculated using the MPT and compared with the nutrient composition of the baseline (2019) THFB.

7.3 RESULTS

FOOD PRICE CHANGES

Figure 17 indicates the percentage change in price by food group for each district.

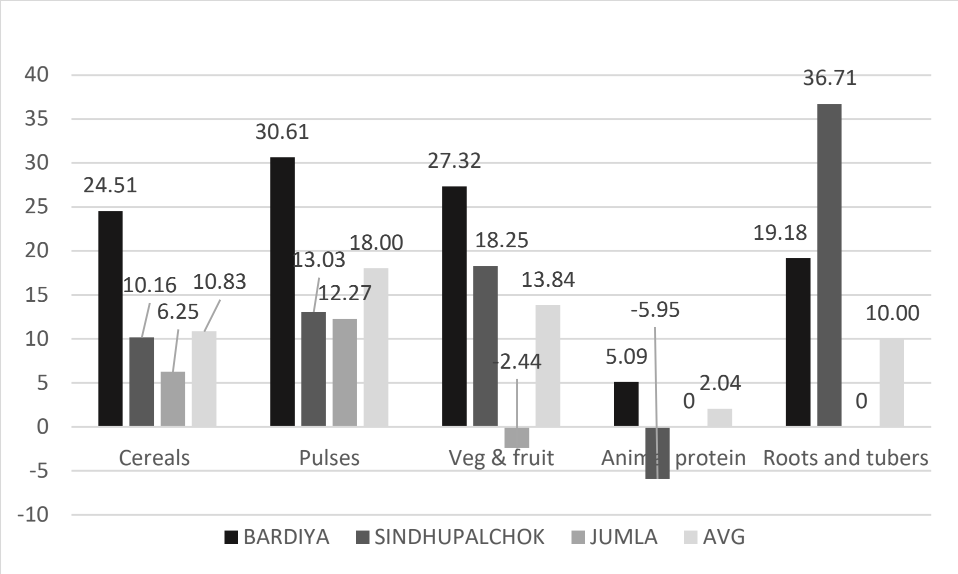


Figure 17: Percentage increase in food commodity prices between June 2019 (Pre-Covid19) and May/June 2020 (Post Covid19) by food group by study district.

On average, across the three districts, data shows a substantial increase in prices for almost all food groups. Pulses and vegetables & fruits show the highest average price rise at 18% and 14% respectively, followed by roots & tubers and cereals at around 10%. Animal proteins show a very marginal increase in prices at 2%.

Inter-district price variations by food groups

There is large inter-district variation in terms by food group. For example, in Sindhupalchok, cereal prices increased marginally by 6.2% whereas in Bardiya, cereal prices increased by 25%. For fruit & vegetables, prices rose substantially in Bardiya (27%) and Sindhupalchok (18%), on the other hand Jumla shows a decrease of 2.4%. For roots & tubers, the inter-district price increase range is very wide, from 0% in Jumla to 37% in Sindhuplachok.

The food group price changes mask significant intra-food group price variations. For example, in Bardiya, in the cereals food group, price of wheat flour and rice has marginally increased, whereas price of dry maize has increased from 52 Nepali Rupee (NPR)/Kg to 80 NPR/Kg. Similarly, in Jumla, the rise in cereal prices is primarily driven by a single commodity i.e. *marsi rice*.

SCHOOL MEALS

COST ANALYSIS

As can be seen in Table-28, the unit cost (child/meal) has shown a similar percentage increase in Sindhupalchok and Jumla of between 6-7%, whereas in Bardiya the increase is 10.5%.

TABLE 28: MEAL COST COMPARISON (SMFB)

DISTRICT	2019	2020	%AGE CHANGE
Bardiya	16.34	18.05	10.47
Sindhupalchok	13.74	14.68	6.84
Jumla	14.50	15.44	6.48

DIET QUALITY ANALYSIS

A summary for the three districts is presented in table 29. The column '%age change' refers to the relative change in quantity between the two points in time i.e. 2019 and 2020. '%RDA' is used here. '2019 RDA' and '2020 RDA' refers to percentage RDA in a weekly context to suggest the amount of nutrient supplies in a weekly cycle as a percentage of cumulative RDA for six days for each nutrient.

From the table below, whilst the percentage change in weekly RDA might not appear substantial in some cases, a small percentage change in RDA can reflect a significant reduction in the actual amount of nutrient supplied. For example, for Sindhupalchok, for vitamin-A, the RDA has reduced by less than one percentage point from 4.73% in 2019 to 4.48% in 2020, but the decrease in terms of the actual intake of vitamin-A is 5%.

TABLE 29: COMPARATIVE CHANGE IN NUTRIENT COMPOSITION(SMFB)

	SINDHUPALCHOK			BARDIYA			JUMLA		
NUTRIENT	**% CHANGE**	**2019 RDA**	**2020 RDA**	**% CHANGE**	**2019 RDA**	**2020 RDA**	**% CHANGE**	**2019 RDA**	**2020 RDA**
Calcium (mg)	-8.72	25.04	22.86	-14.49	24.61	21.04	-9.25	24.38	22.12
Energy(kcal)	-6.65	20.66	19.28	-12.42	20.37	17.84	-11.82	26.20	23.10
Fat(g)	-1.50	7.98	7.86	-6.15	9.64	9.05	-2.72	10.01	9.74
Protein(g)	-6.90	52.83	49.18	-15.19	52.28	44.34	-12.12	75.81	66.63
Vit-A(mcg)	-5.32	4.73	4.48	-11.80	26.35	23.24	-10.91	29.21	26.02
Zinc(mg)	-6.64	25.36	23.67	-9.89	23.47	21.15	-11.87	28.18	24.83
Iron(mg)	-7.47	25.83	23.91	-12.58	31.87	27.86	-8.08	65.90	60.57

Overall, nutrient intake is negatively impacted across all nutrients in the three districts as can be seen from Figure-18. On average, protein shows the highest decline at 11.5%, followed by energy at over 10%. All micronutrients show large declines ranging from 9.5% for zinc to 11% for vitamin A.

Figure 18: Average change (%) in nutrient quantities across study districts for school meal food basket between June 2019 (Pre-Covid19) and May/June 2020 (Post Covid19), due to food price inflation over the reference period. Units used: mg-milligram, mcg – microgram, g-gram, and kcal- kilocalorie.

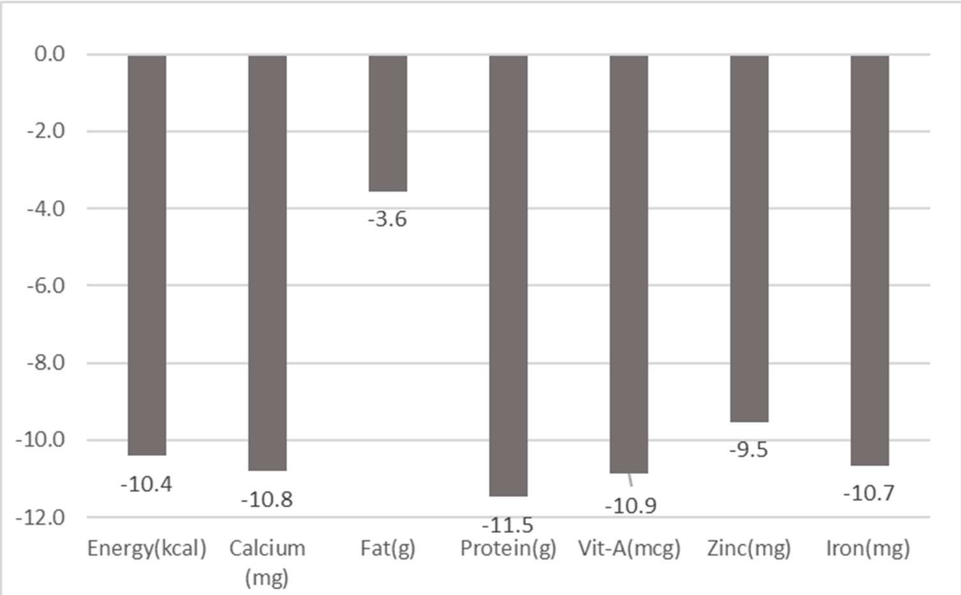
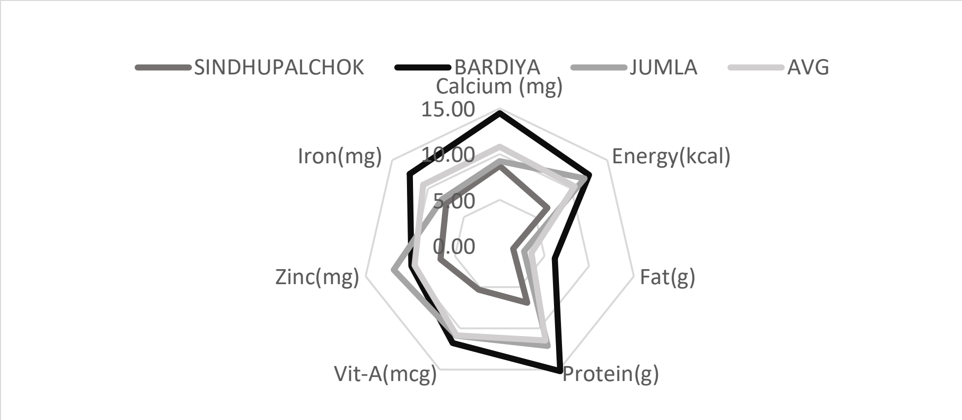


Figure 19 illustrates the relative changes for seven nutrients for each of the study districts. The decrease in nutrient levels during the reference period is the largest and substantially above average for Bardiya for all nutrients, except zinc. In Sindhupalchok, the decrease in nutrient levels during the reference period is the least. Jumla is close to the average for almost all nutrients. As can be observed from the figure, the general pattern in change in nutrient levels, proportionate to each other, is quite similar for all three districts.

Figure 19: Percentage decrease in key nutrients by study district and average, for school meals food basket between June 2019 (Pre-Covid19) and May/June 2020 (Post Covid19). Scale (0.00-15.00) represents the magnitude of decrease. Units used: mg-milligram, mcg – microgram, g-gram, and kcal-kilocalorie.



Finally, the effect of a unit increase in cost i.e. 1 Nepalese rupee (1 NPR=0.008 USD) increase on the level of nutrient intake from our baseline cost of 2019 was calculated, findings are summarized in Table 30. The impact of 1 NPR cost increase is largest in Jumla, for most nutrients. It is useful to look at the range across districts, as representing the potential impact of a 1 rupee increase on diet quality in Nepal. A 1 NPR increase in SMFB cost results in a 5.66% -12.63% decrease in micronutrients and a 7%-12.57% decrease in energy content, across districts.

TABLE 30: PERCENTAGE EFFECT ON NUTRIENTS FOR 1 NPR INCREASE IN MEAL COST BY DISTRICT (SMFB)

NUTRIENT	SINDHUPALCHOK	BARDIYA	JUMLA
Calcium (mg)	-9.28	-8.47	-9.84
Energy(kcal)	-7.07	-7.26	-12.57
Fat(g)	-1.60	-3.59	-2.89
Protein(g)	-7.34	-8.88	-12.89
Vit-A(mcg)	-5.66	-6.90	-11.61
Zinc(mg)	-7.06	-5.78	-12.63
Iron(mg)	-7.95	-7.36	-8.59

TYPICAL HOUSEHOLD FOOD BASKET

COST ANALYSIS

Table-31 summarizes the total cost of food per day and the percentage increase over the reference period, for a household. The increase in cost varies from 7% in Jumla to around 11% in Bardiya and Sindhupalchok.

TABLE 31: COST COMPARISON OF THFB BY DISTRICT

DISTRICT	2019	2020	%AGE CHANGE
Bardiya	296.9	330.2	11.2
Sindhupalchok	266.0	295.0	10.9
Jumla	205.5	219.9	7

DIET QUALITY ANALYSIS

The results for the three districts are summarized in table 32 below. Column '%age change' refers to the relative change in quantity between the two time points. '2019 RDA' and '2020 RDA' refer to percentage RDA to indicate the amount of nutrient supplied per day as a percentage of cumulative RDA for six days for each nutrient.

Whilst percentage change shows the actual reduction in intake over the reference period, changes in proportion of the RDA targets that were met by the household for some nutrients are also quite substantial. For example, in Bardiya, for vitamin A, the intake as a percentage of household RDA has decreased from 86% to 55%. Similarly, in Jumla, iron shows almost a 10% decline in household intake. Whilst looking at the different districts, it is important to note from the figures in '2019 RDA' that there is considerable variation in the baseline diet quality of the THFBs. A comparatively higher percentage decrease for some nutrients over the reference period is simply indicative of greater impact of food inflation on the particular THFB and not its actual diet quality.

TABLE 32: COMPARATIVE CHANGE IN NUTRIENT COMPOSITION (THFB)

	SINDHUPALCHOK			BARDIYA			JUMLA		
NUTRIENT	2019 RDA	2020 RDA	% CHANGE	2019 RDA	2020 RDA	% CHANGE	2019 RDA	2020 RDA	% CHANGE
Calcium (mg)	69%	58%	-17	40%	28%	-35	40%	32%	-23
Energy(kcal)	101%	101%	0	107%	100%	-8	80%	75%	-9
Fat(g)	48%	46%	-4	51%	49%	-7	25%	21%	-13
Protein(g)	159%	148%	-7	169%	155%	-10	142%	126%	-16
Vit-A(mcg)	25%	18%	-27	86%	55%	-44	13%	7%	-69

Zinc(mg)	108%	98%	-9	89%	83%	-8	78%	72%	-11
Iron(mg)	47%	41%	-14	46%	38%	-19	41%	32%	-32

Figure-20 illustrates the average changes in nutrient levels across districts. In terms of macronutrients, the average reduction is relatively lower for energy and fat, compared to other macronutrients. This is partly a function of weighted reduction methods, used for THFB meal adjustment, which was lower for energy dense foods. For micronutrients, vitamin-A content reduces by the largest average amount at 37% followed by iron at 19%. Reduction in zinc is quite low due to the high zinc content in whole grain cereals in all the THFBs.

Figure 20: Average change (%) in nutrient quantities across study districts for typical household food basket between June 2019 (Pre-Covid19) and May/June 2020 (Post Covid19), due to food price inflation over the reference period. Units used: mg-milligram, mcg – microgram, g-gram, and kcal-kilocalorie.

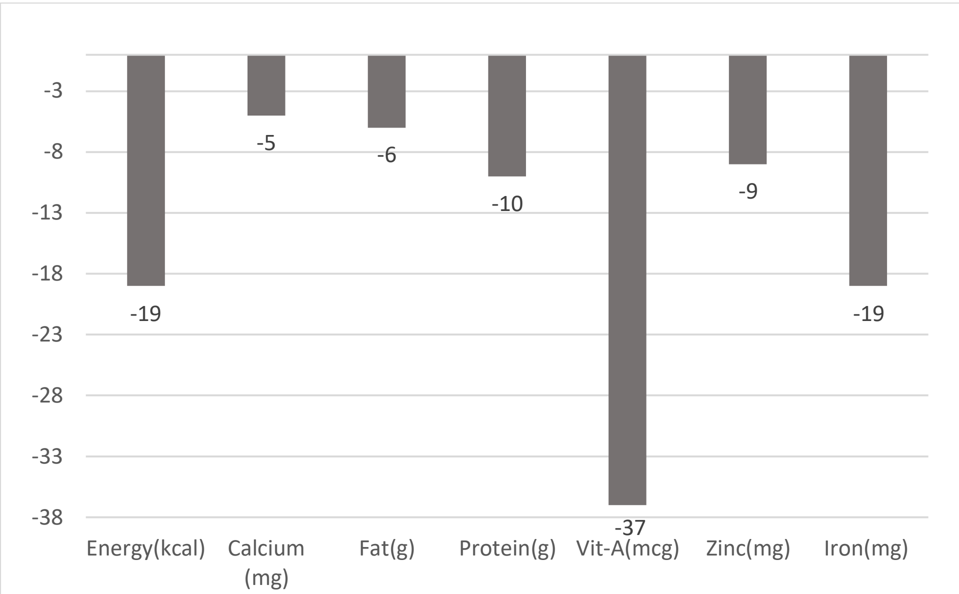
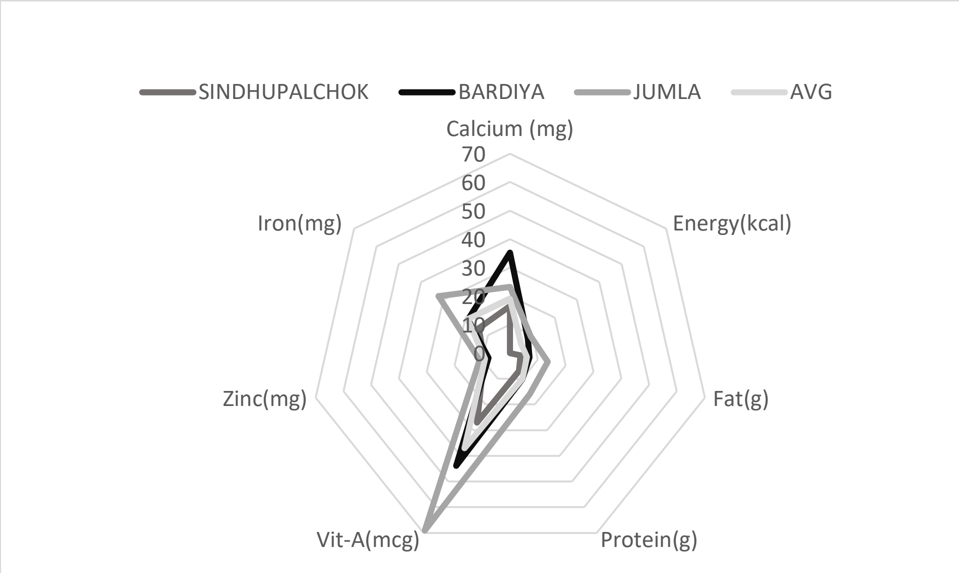


Figure 21 illustrates the relative changes for the seven nutrients for each of the study districts. Sindhupalchok and Jumla follow a similar pattern, although the magnitude of reduction in Jumla is substantially greater than the other two districts. Overall, Sindhupalchok shows the least reduction for all nutrients and is below average. Reductions in vitamin-A, iron and calcium appear most prominent for all districts.

Figure 21: Percentage decrease in key nutrients by study district and average, for typical household food basket between June 2019 (Pre-Covid19) and May/June 2020 (Post Covid19). Scale (0.00-15.00) represents the magnitude of decrease. Units used: mg-milligram, mcg – microgram, g-gram, and kcal-kilocalorie.



Finally, changes in nutrient intake (%) when a unit increase in cost i.e. 10 NPR, is applied to the baseline cost of 2019 was calculated. Findings are summarized in Table 10. 10 NPR was chosen as the unit for the THFBs, compared to 1 NPR for SMFBs to reflect the much larger budget scale of the THFBs. For every 10 NPR increase in cost of THFB, vitamin-A is reduced by 9%-48%, iron by 5%-22% and zinc by 3%-8%. The wide range represents substantial inter-district variation, Sindhupalchok showing substantially lower percentage reduction for all nutrients compared to other two districts.

TABLE 33: PERCENTAGE CHANGE OF NUTRIENTS FOR 10 NPR INCREASE IN MEAL COST BY DISTRICT(THFB)

NUTRIENT	SINDHUPALCHOK	BARDIYA	JUMLA
Calcium (mg)	-5.72	-31.54	-16.14
Energy(kcal)	0.00	-7.07	-6.41
Fat(g)	-1.30	-6.14	-9.33
Protein(g)	-2.44	-9.02	-11.05

Vit-A(mcg)	-9.34	-39.10	-47.79
Zinc(mg)	-3.23	-6.96	-7.65
Iron(mg)	-4.83	-16.82	-22.18

7.4 DISCUSSION

This study shows that food prices have increased substantially over the reference period across all food groups except animal proteins. The findings highlight substantial differences in price changes between the study districts. For example, in Bardiya prices for fruits and vegetables have increased by 27% whereas in Jumla the prices decreased by 2.4%. The inter-district difference in price inflation can be primarily attributed to the nature of agriculture markets and trade, with nationally and internationally integrated markets being more vulnerable to disruptions in transport. For example, Bardiya district is well integrated in national agriculture supply chain, due its location and topography. The closest major agriculture market is in Nepalgunj which is around 2 hours by road. By comparison Jumla district is located in the high mountain ranges of the Himalayas with an average elevation of 2250 metres. The closest major agricultural commodity market is in Surkhet which is around 11 hours travel by road. Agriculture markets in Jumla, especially for perishables like vegetables and fruits are mostly localised, and people depend on own production for household consumption.

As expected, increased food prices have resulted in cost increase for SMFB and THFB. For SMFB, percentage increase in Sindhupalchok and Jumla is between 6-7%, whereas in Bardiya the increase is 10.5%. For THFB, the increase in cost varies from 7% (450 NPR/month) in Jumla to around 11% (1000 NPR/month) in Bardiya and Sindhupalchok. This increase of 450 NPR and 1000 NPR represents around 6% and 13% of the monthly household food budget and around 4% and 8% of the overall HH consumption, respectively (authors calculation based on DHS 2016).

The estimations based on two different approaches developed in this chapter i.e. SMFB and THFB, are representative of two very distinct dietary strategies. SMFBs based nutrient analysis provides estimates for nutritionally balanced and diverse diets and THFB based analysis provides estimates for typical diets of poor households. The findings based on both approaches, clearly suggest that even a nominal increase in food basket cost can have marked negative implications on the diet quality of the meals, impacting the intake of both macro and micro-nutrients. A 1 NPR increase in the unit cost of SMFB, decreases micronutrient intake by 5.66% -12.63% and energy by 7%-13%. A 10 NPR increase in the unit cost of THFB, decreases micronutrient intake by 9%-69% and energy by 0%-9%. Whilst there are noticeable inter-district variations in the scale of impact, and between SMFB and THFB, the overall conclusion remains consistent.

The significant reduction in the intake of some micronutrients is of particular concern given the severity of the current deficiencies in zinc, iron and vitamin A, as highlighted in the national micronutrient survey (MoH, 2016). Deficiencies in these micronutrients constitute a serious public health crisis and can lead to poor growth, lower school performance, wide range of diseases, ailments, increased morbidity and mortality (Allen et al.,2006;Black et al.,2008;Swaminathan et al.,2013).

The change in consumption patterns to cope with increased prices will have the most serious impact on the diet quality of poor households. In terms of intra-household food allocation, women and children are likely to suffer disproportionately (Bhutta et al.,2009). This is especially detrimental during pregnancy, where even small changes in the micronutrient content of diets are associated with significant differences in foetal and infant growth (Block et al.,2004).

The analysis of this paper combined with the evidence from other studies, suggests that COVID-19 control measures are potentially contributing to undermining food and nutrition security, with the poorest being hit the hardest and young children potentially facing life-long consequences. The evidence emphasises the urgent need to address the impending food security related public health crisis by implementing mitigating and remedial strategies. As schools continue to remain closed, weekly take home rations should be explored with clear safety protocols. The school feeding platform can also be leveraged as a public distribution system by providing extra rations during this crisis. National food supply reserve agencies like the Food Management and Trading Company of Nepal can also play a vital role in providing support to food markets and supplies such as ensuring procurement after harvest and enabling aggregation.

The findings of this study also indicate the importance of resilient localized food systems. This is not to suggest that food supply chains should not be optimally integrated but where possible, local production systems need to be strengthened through deliberate input and output support interventions. Finally, the scale of the current crisis is an emphatic reminder of the need to have integrated public health-food system approach in response to such crisis. This can include rapid public procurement of agriculture commodities, distribution of micronutrient supplements and fortified foods, and targeted antenatal care.

This study looks at the situation two months post implementation of control measures. As the public health crisis is still unfolding, over the next few months, food prices can be volatile depending on issues of storage, international prices, disruption to summer planting season etc. It will be useful to conduct multiple small rapid surveys on food production and consumption over the next few months to capture the diverse effects of the pandemic on food and nutrition security on a continuing basis. This can provide useful evidence to inform decision making on contextually relevant food security interventions.

Some major limitations of this study need to be highlighted. First, seasonality in an important element in food production and consumption which could not be included in the research design. Second, the research design assumes that purchasing power is constant over our reference period. Due to reduced incomes and wages, the actual impact on diet quality, in all probability is more substantial than indicated by the findings and estimations of this paper. Notwithstanding the limitations, this paper provides useful insights on the magnitude and nature of the potential effects of COVID-19 pandemic on food prices and nutrition security. It also highlights the very critical and immediate need for sustained food and nutrition support as a priority, to ensure that the hard won public health gains of recent years are not entirely lost.

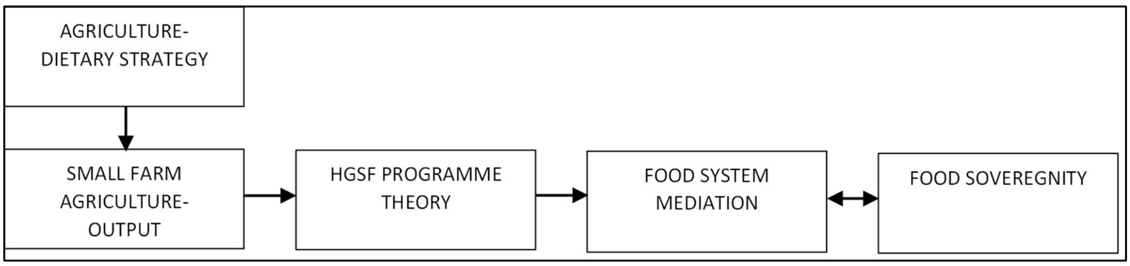
CONCLUSION

The primary goal of the thesis was to provide policy and programme relevant evidence on developing ecologically and nutritionally efficient and sustainable food system intervention for universal coverage and to contribute to concepts and methods on agriculture, nutrition and diets. The thesis provides evidence on how school feeding, the world's largest safety net programme operational in 161 countries, can be effectively leveraged to enable nutrition and ecologically sensitive food systems. It also develops concepts and theories on food systems which can contribute to our understanding of food system interventions and inform projects and policies.

THEORETICAL DEVELOPMENTS

The figure below illustrates the main theoretical and conceptual developments through the thesis. Chapter-1 develops a conceptual framework on the links between nutrition deficiency and disease, and the transition to an agrarian system as a dietary strategy. Some of the key issues identified are further explored through a case study of two intervention districts to provide evidence on small farm agriculture output. Next, the HGSF programme theory is described and reviewed to inform implementation. In chapter 5, the intervention evidence is explored and analysed to develop the concept of 'food system mediation'. The process of developing 'food system mediation' leads to the concept of food sovereignty, which is explored and framed in the context of the intervention in Chapter-6.

FIG 22: CONCEPTUAL DEVELOPMENT THROUGH THE THESIS



PROGRAMATTIC FINDINGS

NUTRITION

Nutrition sensitivity is measured in terms of nutrient content and food diversity of the HGSF supply chains. The findings show that protein supply is above 50% RDA in all intervention districts and energy supply is in the range of 20%-26%. In terms of micro-nutrients, zinc supply is similar across the intervention districts, in the 25%-28% range. There is substantial inter-district variation in iron supply, 25% - 66%. Vit A supply is in a relatively narrow range of 23%-32%, with the exception of one district. All six study districts include at least one food from each food group. The intra-food group diversity is significant across all districts, and food groups, except for animal proteins. The number of different cereals is in the range of 3-7, fruit and vegetable is in the range of 7 to 15 foods, legumes and pulses range is 5-8 foods and roots and tubers range is 2-3 foods. The findings suggest that the intervention created nutritionally optimized food supply chains, based on the provision of one meal a day. The inter district variation can be a function of food availability, dietary habits and the quality of meal design process which including sensitization workshops and final calibration of ingredients.

ECOLOGICAL SENSITIVITY

Ecological sensitivity here is measured in terms of promoting local agrobiodiversity and improving climate resilience through adoption NUS foods, future smart foods and preserved and fermented foods. Future Smart Foods (FSF) are defined as NUS that are nutrient dense, climate resilient, economically viable, and locally available or adaptable. Fermented foods refer to a range of traditionally preserved foods, these foods can improve climate resilience by creating household buffer stocks and reducing post-harvest loss. A review of the HGSF supply chains in each of intervention districts found that a total of 18 NUS commodities were included in the HGSF supply chain. By agroecological zones, 7 NUS commodities were found in terai (3 districts), 8 in hills (2 districts) and 10 in mountains (1 district). Supply chains included nine FSF as identified such as Chayote and Lamb's quarter. Some foods included in the supply chain such as amaranth and finger millet are also known as 'Himalayan Superfoods' owing to their ecological and nutritive properties. The supply chains were found to include a range of preserved and fermented foods dried colcasia leaves, stinging nettle powder, dried beaten rice and gundruk, which is a mustard leaf based traditional fermented food.

EQUITY

Equity is measured in terms of governance of the intervention, food supplies and food production. Traditional knowledge and local food culture on food production, diets and health was incorporated in meal and supply chain design process. The key operational elements of the project were localized at district, sub-district(municipality/ward) and school level, including menu design and selection of food commodities. The intervention mediated resource control across key stakeholders with a particular focus on local governments and communities with responsibilities on key issues such as nutrition, food procurement, costing and food quality.

To promote equity in food supplies, supply chains were decentralized through forward contracts with local cooperatives within each municipality. 19 supply cooperative and school clusters were created across the intervention districts, which included a range of cooperative types including agriculture cooperative, savings and credit cooperative and multi-purpose cooperative. The procurement protocols were designed to give preference to women farmers, over 25% of cooperatives selected for supplies are women only cooperatives. Gender equity was also promoted through the food basket, most of the NUS foods, especially fruits and vegetables were grown by women farmers.

CONDITIONS AND CAVEATS

The intervention found that the economic efficiencies of promoting MNR and some NUS foods was related to the level of decentralization. At the municipal level, supply cooperatives in many districts found it financially unviable to aggregate and supply perishables such as fruits and vegetables due to high transaction costs.

A consistent finding is that agriculture has become an increasingly risky and financially untenable occupation with poor returns to investment, compared to non-farm work including daily wage employment. The lack of agricultural support in the form of subsidies, extension services, irrigation and inputs in the face of more frequent climatic risks is adding to disincentives for agriculture. Farmers in many communities increasingly prefer to leave the land fallow and engage in other livelihood activities due to poor returns in farming. The absence of irrigation facilities, extension services, poor markets and other forms government support are major reasons for low levels of farming activity and agrobiodiversity

In Nepal, depending on the region, the lean season can last from anywhere between two to four months. During the lean period, stored commodities such as cereals, legumes and tubers are initially available. Given limited on and off farm stock capacities, as stocks dwindle, there are serious food deficits at the household level. Therefore, during the hunger season, the increasing costs of staples and the intensity of calorific hunger, can also undermine any food diversification strategies. The long lean season is of particular concern as production of protein and micro nutrient rich foods is highly limited in most study districts.

Whilst HGSF based food system localization provides a useful illustration of enabling healthy and sustainable food systems, it is important to take note of some key demand side constraints. In the HGSF meal design process, local nutrient dense foods, rich in iron, vitamin A are included to the extent feasible. Given that in many low-income countries, the school meal is the only proper meal of the day for the child, portion sizes and budgets must address calorific hunger and energy needs. It is important to recognize these trade-offs and develop appropriate mitigation strategies including supplementary funding.

A wide variation was observed across the intervention districts, in terms of the administrative capacity of cooperatives, in some districts, there was a near complete absence of functional cooperatives or farmer groups. Additional critical capacity issues found across all districts relate to high transaction costs, which includes the cost of aggregation, storage and distribution, and intra-annual price volatility.

DISCUSSION

The thesis demonstrates how agriculture-nutrition-agrobiodiversity linkages can be enabled through a multi-sectoral community driven HGSF model, integrated in a national government safety net programme. The intervention design enabled a community-based approach embedded in relevant governance structures and political processes at both the central government and municipal government level. The use of participatory methods though all project activities was aimed to generate and frame knowledge in a way that minimizes the distinction between external or scientific and indigenous knowledge, with its implied hierarchy. Nepal transitioned from a centralized governance structure to local government through the design phase of the intervention in 2018, which shaped the critical aspect of localization.

The thesis highlights the importance of the geographic and political contours of localization in a country such as Nepal with high levels of ecological, cultural and ethnic heterogeneity, and predominantly traditional small farm agriculture systems. In the intervention, localization was successfully undertaken at the municipal level and embedded in local politics, due to newly decentralized governance in Nepal. The content of localization enabled culturally, nutritionally and ecologically sensitive food supply chains based on local agriculture. This can be challenging in countries with centralized governance systems and would require development of suitable alternate modalities. The development and analysis of food system mediation provides insights on a range of issues and processes that ultimately determine the scale, efficacy and sustainability of food system localization and mediation.

The study also shows the importance of agroecology in agriculture-nutrition-ecology linkage interventions, especially in the context of subsistence agriculture and incomplete markets. It also demonstrates the critical role of traditional knowledge and dietary heritage in challenging ecologies. This includes the use traditionally preserved nutritious foods and fermentation techniques. The economic and ecological constraints faced by farmers can be a key constraint for food production diversification strategies. Dietary norms and food traditions can also substantially influence the promotion of nutrition and agrobiodiversity and can act as both drivers and constraints. The application of participatory methods in conjunction with knowledge sharing can help further embed nutritional and ecological values in local cultural contexts.

The relevance of food sovereignty as an operational concept that can be applied to national programmes to help address critical food security challenges provides useful insights on food system governance. The study provides evidence on a unique driver of food sovereignty i.e. the cultural and ecological aspects of food. The intervention enabled non-economic incentives which were recognized by farmers and local community as important incentives for participating in the school feeding supply chain. These incentives built on traditional knowledge on food production and diets, ecological sustainability of neglected local foods and the health benefits of consuming nutrient rich foods. A key contribution of this thesis is to highlight the role of rural agrarian communities as custodians of traditional knowledge on food and ecology and to ensure the development of these resources. Food governance systems and interventions need to incorporate community voices and agency and be informed by science and traditional knowledge in equal measure. Community driven interventions optimally supported by government policy, scientific knowledge and technology can help redress the food and ecological injustices. Programmes aimed at nutrition and ecological farming systems must give specific attention to women farmers and enable pathways for gender equity. In the HGSF intervention, this was achieved to some extent, directly through the inclusion of women cooperatives in the supply chain and meal design process, and to a more limited extent, through inclusion of non-staple food groups such as fruits, vegetables and legumes which are more likely to be women centric.

The last chapter was added as the Covid pandemic began causing serious disruptions to food supply chains and school feeding programme. As of Oct 2021, schools have been closed in Nepal for over 18 months. In order to capture some of the impact of these disruptions, the last chapter builds the on analysis of the previous chapters and the HGSF food basket. The findings suggest that COVID-19 control measures are potentially contributed to undermining food and nutrition security, with the poorest being hit the hardest. The evidence emphasises the urgent need to develop protocols to address food security related public health crisis.

The evolution of agriculture in terms of its impact on human health and nutrition in chapter-1 helps us to understand contemporary public health challenges. Nutritional deficiencies and ecological stresses are often attributed to green revolution or capitalist neoliberal trade/economic policies. Whilst such policies have contributed to the production of ‘hunger’ and ‘hidden hunger’, in many ways contemporary food systems are shaped by the original domestication drivers such as yield, inputs, palatability, energy supply etc. The overwhelming dominance of cereals, seeds and legumes in agricultural diets has had significant deleterious consequences on nutrition status of humans. This is further compounded by seasonality of agriculture which accounts for substantial nutritional distress in many parts of the world. Seasonality is also partly a legacy of domestication as synchronous growth cycles was a key domestication trait.

The thesis presents important new evidence on the state of nutrient output and food production. It demonstrates that nutrient supply from local production for all nutrients and particularly for micronutrients is highly deficient. This has direct implications on diets as on average over 40% of HH consumption was reported to be from own production, market purchase is limited to meat, eggs and processed foods. This issue is further exacerbated by highly seasonal rainfed agriculture in most parts of Nepal. 60% - 75% of nutrient production is concentrated in the main agricultural season in both study districts. These findings strongly indicate that in rural subsistence agriculture economies, hidden hunger is a function of deficient availability and not only access. Analysis on agrobiodiversity shows high levels nutrition diversity of farms is strong, in terms of volume of production it is heavily biased towards protein and energy.

Finally, this study shows that it is critical for the government to play an active role across several key components such as creating decentralized governance structures, devolving powers to communities, investing in agriculture infrastructure, supporting science and technology developments and enabling farmer-based organizations and other community cooperatives. Another important area for government intervention is in the regulatory sphere, to ensure that food and agriculture related regulations, ranging from agricultural land ownership to international trade policy, are aligned with the principles of food sovereignty.

The central message of this thesis is that to address the critical food challenges we face today, we need to comprehensively re-examine our relationship with the planet we inhabit including our primal connection with our habitat, which is through food. James Suzman in his seminal work on the bushmen of Kalhari tells us how hunter gatherers in one of the most hostile environments in the world have survived and prospered because of confidence in the providence of the environment or 'primitive affluence'. Hazda only went hunting and gathering when they needed to, didn't store food and in seasons when wild fruits are plenty didn't change behaviour to preserve food. Notwithstanding the great scientific and technological advances of the last 200 years, fundamentally, we continue depend on the generosity of the environment for our survival. Whilst the demands of the modern world are very different from the Hazda of Kalahari, they teach us a valuable lesson that the key to sustainable living lies in respect for our environment and equitable use of resources between people and planet.

POLICY AND PROGRAMME RECCOMENDATIONS

1. Develop multi-sectoral agriculture-public health-ecology national strategies and investment plans to systematically integrate food production, ecological sustainability and health, programmes and policies.
2. Develop an ecological audit system for agriculture and food policies to ensure that research, extension services, technologies and new varieties are appropriate for specific food systems, with a particular focus on climate change adaptation and mitigation.
3. Create a scientific protocol for mapping of NUS, FSF and fermented and preserved foods and establish national data repository.
4. Inclusion of specific policy and programme features to address gender equity and social equity (marginalized/indigenous communities) in food and nutrition interventions.
5. Building on the GIAHS initiative, create national level registries of unique agricultural systems.
6. Document traditional production methods, microbiology, and biochemistry of locally preserved and fermented foods.
7. Develop multi-sectoral platform at national and local level to develop robust environment-public health-agriculture linkages and generate evidence to inform policy and programmes.
8. Government support for agriculture in the form access to inputs, finance, technology and processing and storage infrastructure. Such support should be integrated with other agricultural interventions especially those related to agrobiodiversity and climate smart agriculture.
9. Specific programme and investment to improve capacity and reach of farmer-based organizations including establishing institutionalized linkages with agriculture credit facilities
10. Development of food based dietary guidelines and food composition tables with inclusion of Future Smart Foods and preserved and fermented foods in national dietary guidelines.

FURTHER RESEARCH

Based on the research for this thesis and operational experience of the project, four areas for further research were identified which are discussed below.

1. A long-term quasi experimental study in different ecological contexts to examine changes in agrobiodiversity, especially functional agrobiodiversity related to nutrition and climate change will provide valuable evidence for a wide range of food system related policies and programmes.

2. Further research on traditional farming systems including the role of indigenous and marginalized communities in food production. Whilst this issue was outside the scope of the thesis, it was found to be an important component which needs to be closely examined.
3. Given the disincentivized state of agriculture, there is need for research on production and transaction costs of specific food groups in small farm contexts to understand economic viability in terms of nutrient output and agrobiodiversity.
4. The key concepts on mediated markets and food sovereignty as proposed in this thesis need to be tested and developed further through purposively designed research projects in different country contexts.

Building on the findings of the thesis, two studies led by the author are currently in progress which will provide quantitative evidence on some of the important issues discussed in the thesis. The first study is being conducted in Nepal and Nigeria to assess the level of long-term compliance with prescribed HGSF menus and compare the nutritional quality across three arms, school feeding based on HGSF menus, school feeding based on non-HGSF menus and home food for consumption in school. The second study is designed to assess the transaction costs incurred by cooperatives for food aggregation and distribution, disaggregated by food groups.

As a final concluding note, it is important to emphasize that given the complexity of the challenges of feeding the world, no singular approach is unambiguously and inherently beneficial. Research and solutions should be developed through a community of farmers, scientists, parents, children, and governments in the service of alleviating hunger and creating a healthy planet. In an account of Indian mythology, Lord Krishna consumes a single grain of rice stuck at the side of an empty vessel and at that moment the entire planet is satiated. The lesson here is not about divine prowess, but the ultimate indivisibility of all beings and the universe. In more prosaic terms, food connects us all and the planet we inhabit. Whilst we may be fortunate enough not to feel its physiological pangs, we need to realize that hunger is collective, and we should all respond and act in our own ways to ensure food for all.

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Annex-1: Letters from CHRD, Government of Nepal

नेपाल सरकार

शिक्षा, विज्ञान तथा प्रविधि मन्त्रालय

शिक्षा तथा मानव स्रोत विकास केन्द्र

(विद्यालय शिक्षा [illegible] निर्धारण शाखा)

सानोठिमी, भक्तपुर

प.स.: २०७५/०७६

च.नं. १३५

मिति: २०७६/०१/१७

विषय: आवश्यक सहयोग गरि दिने बारे ।

श्री शिक्षा विकास तथा समन्वय ईकाई

जुम्ला

प्रस्तुत विषयमा यस केन्द्र र WFP नेपाल एवं Imperial college london, PCD संगको सहकार्यमा विद्यालय दिवाखाजा कार्यक्रमलाई प्रभावकारी ढंगले संचालन गर्न Cash model लागु भएका जिल्लाहरु मध्ये यस वर्ष ६ ओटा जिल्ला छनौट गर्ने क्रममा जुम्ला जिल्ला समेत रहेकोले त्यस जिल्लाको एउटा स्थानीय तहका सवै विद्यालयमा पाईलटिङ्ग कार्यक्रम संचालन गर्नु पर्ने हुँदा सोकार्यका लागि उपयुक्त स्थानीय तह छनौट गर्न खटिएको PCD को टीमलाई आवश्यक सहयोग गर्न हुन अनुरोध छ ।

२०७६/०१/१७

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शिक्षा विकास तथा समन्वय इकाइ
जुम्ला

प.सं. : ०७५।०७६
च.नं. १५३१

मिति: २०७६।०१।२०

विषय: आवश्यक सहयोग गरिदिने बारे ।

श्री तातोपानी गाउपालिकाको कार्यालय

जुम्ला ।

प्रस्तुत् विषयमा शिक्षा तथा मानव स्रोत विकास केन्द्र सानोठिमी, भक्तपुरको च.नं.१३५ को मिति २०७६।०१।१२ को प्राप्त पत्रानुसार शिक्षा तथा मानव स्रोत विकास केन्द्र र WFP नेपाल एवं Imperial college London, PCD संगको सहकार्यमा विद्यालय दिवाखाजा कार्यक्रमलाई प्रभावकारी ढंगले संचालन गर्न Cash Model लागु भएका जिल्लाहरु मध्ये यस वर्ष ६ वटा जिल्ला छनौट गर्ने क्रममा जुम्ला जिल्ला समेत रहेकाले यस जिल्लाबाट तहाँ गाउपालिकाका विद्यालयहरुमा पाइलटिङ कार्यक्रम संचालन गर्नपर्ने हुँदा सो कार्यको लागि तहाँ खटिएकाको PCD टिमलाई आवश्यक सहयोग गरिदिन हुन अनुरोध छ ।

१।२०

(मक्कर बहादुर भण्डारी)
इकाइ प्रमुख

बोधार्थ:

शिक्षा तथा मानव स्रोत विकास केन्द्र

सानोठिमी, भक्तपुर ।

आज मिति २०५८ चैत्र १३ गतेका दिन [illegible]
[illegible] प्रमुख प्रशासकीय अधिकृत श्री
अशोक प्रसाद दाहाल ज्यू को अध्यक्षतामा निम्न
[illegible] [illegible] [illegible] कार्यक्रमलाई [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] व्यक्तिहरूको उपस्थितिमा छलफल गरी
निर्णय गरियो ।

उपस्थिति –

१. अशोक प्रसाद दाहाल – प्र.जि.अ.
२. पद्मसिंह बिष्ट – शिक्षा तथा मानव विकास [illegible]
३. मनोज शाह – [illegible]
४. डा० दिपक कु. गौतम P.C.D.
५. लक्ष्मीकान्त आचार्य P.C.D.
६. मदन कुमार थापा जि.शि.अ.
७. चूडामणी प्रसाद [illegible] निरीक्षक
८. ललितराज [illegible]
९. अर्जुन प्र. सापकोटा
१०. शिव अधिकारी
चन्द्रनिधि घिमिरे [illegible] सचिव
11 राम प्र. अधिकारी
12 शिव प्र. अधिकारी – [illegible]
13 ध्रुव प्र. सापकोटा
14

प्रस्ताव नं. १ – विश्वखाद्यकार्यक्रमको वैज्ञानिक [illegible]
मा स्थानीय स्तर जस्तै व्यवस्था –

निर्णय नं. १ प्रस्ताव नं. १ माथि छलफल हुँदा यस
गाउँपालिकाको (WFP) X P.C.D को प्राविधिक सहयोग
मा आधारित गरि जाने कार्यक्रमहरू [illegible]
हुँदा आउँदो वर्षमा पनि यस पालिकाको प्रतिबद्धता
रहेको व्यहोरा जानकारी गराउँदै, कार्यक्रमको लागि
आवश्यक सम्पूर्ण सहयोग यस पालिकाको
रहेको प्रतिबद्धता गरियो ।

Annex-2: Letter from NARMA consuting in re research ethics approval for surveys

Regd. No.: 104845/053/054 PAN: 500148570

NARMA Consultancy Pvt. Ltd.

Centre for Natural Resource Analysis, Management, Training and Policy Research

SUBJECT- FOOD PRODUCTION SURVEYS FOR NEPAL HGSF PROJECT IN 2019.

NARMA Consultancy undertook quantitative and qualitative data collection surveys in 2019 in relation to the Nepal Home Grown School Feeding Project led by Partnership for Child Development (PCD) in collaboration with UN World Food Programme Nepal and Government of Nepal. The surveys were conducted as per research protocol presented by Samrat Singh, project lead.

The requirement for any ethical approval was discussed with the relevant authorities in Nepal. Given that the survey was part of a technical assistance project approved by the Government of Nepal, no specific ethical clearance was required for these surveys. The Department of Education, Government of Nepal was provided with the research protocol and provided the approval.

NARMA is a leading research organization and followed standard ethical protocols for the surveys, these were included in the training of enumerators and supervisors. For all surveys, the survey team field supervisor followed a consent checklist. All participants were clearly explained the following:

- The purpose of the survey.
- That the data will be used for research purposes.
- The time the survey will take.
- All data will be anonymized.

Survey was commenced after all participants provided their consent verbally. They were given a contact number of the district coordinator in case they wished to withdraw their consent at anytime.

Please contact me if any further information in required.

Best regards,

Birendra Bir Singh Basnyat

Managing Director

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