Accommodating diverse actors and practices in the climate-development nexus:

The case of Kenya's dairy sector

Vera Vernooij

Propositions

1. The focus on climate change mitigation undermines the capacity to accommodate diversity
(this thesis).

2. Binary and categorical thinking hampers including adaptive skills in finding solutions
(this thesis).

3. Social sciences are kept alive by the structure-agency debate.

4. *Ceteris paribus* only has value in science.

5. Proclaiming the need for radical change paralyses societies.

6. Living offline has become a nostalgic luxury of the past.

Propositions belonging to the thesis, entitled

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The case of Kenya's dairy sector

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Accommodating diverse actors and practices in the climate-development nexus

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Accommodating diverse actors and practices in the climate-development nexus

The case of Kenya's dairy sector

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Chapter 1

General introduction

1 General introduction

1.1 The societal challenge: Achieving triple wins for livestock sectors

The agricultural sector is of instrumental value for its contributions to food and nutrition security (FNS) and livelihoods in sub-Saharan Africa. In the future, the sector continues to be important for making these contributions to the growing world population. The agricultural sector has also been prioritised for climate action, which typically has a transformative character aimed to move the sector towards enhancing sustainability (Lipper et al., 2014). Simplified, sustainability means to achieve human, ecological, and economic health and vitality in just and future-proof ways, summarised as achieving win-win-wins for people, planet, and profit (Mensah, 2019). Examples of sustainability initiatives that aim to achieve win-win-wins are Sustainable Intensification (SI) (Pretty, 1997), Low Emission Development Strategies (LEDS) (UNFCCC, 2008, in Clapp et al., 2010), and Climate Smart Agriculture (CSA) (FAO, 2010). These initiatives can provide essential technical answers to climate change adaptation and mitigation dilemmas. They connect climate action in the form of adaptation and/or mitigation to interventions aiming to produce food more efficiently and responsibly, often formulated as agricultural intensification pathways. Agricultural intensification means to increase the agricultural output per unit of input (Pretty, 2018).

Livestock sectors in East Africa are particularly centre stage in agricultural sustainability initiatives because for people, planet and profit in livestock sectors, there are concerns and opportunities (Herrero et al., 2013; Gerber et al., 2013). The need for climate change mitigation is a response to the global warming potential of the Greenhouse Gas (GHG) emissions attributed to livestock sectors. Climate change mitigation means to reduce the release of GHG emissions into the atmosphere. Livestock account for 65% of global agricultural GHG emissions (Tubiello et al., 2014). Specifically for dairy, Sub-Saharan Africa has the highest emissions per product in the world at 7.5 kg CO_2-equivalent per produced kg of Fat-Protein Corrected Milk (Gerber et al., 2011). In East Africa, over 85% of the dairy cattle population resides in Kenya (Thorpe et al., 2000). In Kenya, methane constitutes an estimated 96% of the dairy sector's GHG emissions profile, mainly influenced by the type of animals, quality and quantity of feed, and environmental conditions (Kwamboka et al., 2022).

Simultaneously to contributing GHG emissions, dairy sectors in the East Africa are also vulnerable to climate change (Thornton & Herrero, 2008). The concerns for people and profit are related to the effects of climate change on livestock keepers in predominantly rainfed agricultural systems. In Kenya, dairy cattle populations constitute 25% of the total livestock population (Mbae et al., 2020), and are kept by an estimated 1.3 million households (Wangu et al., 2021). Smallholder producers, owning one to three dairy cows account for about 80% of the milk produced in Kenya, making dairy cattle an important livelihood asset for many rural residents (Makoni et al., 2013). Key climate risks for Kenya's dairy sector are higher (mean) temperatures, delayed seasonal onset, droughts, heavy rain, and floods, which can result in an increased likelihood to reduced fodder growing seasons, production, and quality, feed shortage, inadequate water supply and milk supply, and increasing costs of production (Mbae et al., 2020). This makes climate adaptation urgent for dairy keepers. Climate change adaptation means to alter practices to enhance the resilience of the sector to climate change (Rojas Downing et al., 2017).

In addition to the urge to address these environmental and social concerns, and the need for both climate change mitigation and adaptation, Kenya's dairy sector is expected to continue to contribute to both FNS and income security (Bateki et al., 2023). It is estimated that the dairy sector in Kenya contributes 4% to total GDP and 14% to agricultural GDP (Behnke & Muthami, 2010). To meet Kenya's growing national milk demand in 2050, the sector needs to grow with 175% compared to 2010, mainly due to population growth and urbanisation (FAO, 2017).

A complex challenge for Kenya's dairy sector is how to match realising human development and addressing climate change. From a climate change perspective, GHG emissions from dairy production systems should be reduced via sector transformations. Yet from a human development perspective, the dairy sector is expected to continue to offer valuable nutrients and increasingly meeting animal product demand, and dairy is part of people's cultural identities and livelihoods, providing an income (Herrero et al., 2013).

This thesis research is situated in a dynamic time (2017-2024). Global efforts to address climate change meet human development ambitions in the aftermath of the Paris Climate Accords (2016), during the first Food Systems Summit (2021), and underway to meeting the Sustainable Development Goals deadline (2030). The contents and relevance of this thesis should be situated in this time, not taking an evaluative stand on an intervention, but an exploratory view and approach on how to bridge climate change and human development ambitions.

1.2 Problem statement

Kenya's dairy sector is the focus of LEDS (Khatri-Chhetri et al., 2020) and Nationally Appropriate Mitigation Actions (NAMA) (Wilkes et al., 2019), which emphasise climate change mitigation. The triple-wins envisioned for Kenya's dairy sector include increased agricultural outputs leading to enhanced food availability, FNS, higher incomes from dairy product sales, and reduced GHG emissions per unit of product. This rationale starts with dairy intensification and is closely linked to commercialisation. Socioeconomic wellbeing is a key concern in dairy intensification strategies (Clay et al., 2020). While the technical potential to mitigate emissions in Kenya's dairy sector is increasingly recognised (Bosire et al., 2016; Brandt et al., 2020), effectively integrating technical options with socio-economic benefits for people targeted by climate action is less clear (Rasmussen et al., 2018; Ellis & Tschakert, 2019). Achieving this integration requires further translation to various sector actors and their contextualised practices (Kihoro, 2022).

Two main risks in current initiatives are 1) the exclusion of sector actors due to misalignment with their needs, priorities, practices, and capabilities, and 2) the creation of negative unwanted externalities because of intensification and commercialisation. Studies in Kenya report that dairy intensification can result in natural resource depletion, specifically the availability of water for drinking and use on the farm (Agutu et al., 2018). Additionally, increasing milk sales could increase the volumes of rejected milk, creating household health risks (*ibid.*). Increasing commercialisation likely intensifies men’s control over benefits from production (Tavenner et al., 2019). These risks simultaneously threaten the aims of LEDS.

Further defined for Kenya’s dairy sector, the risks involve three interconnected concerns. Firstly, mitigation-oriented initiatives may not resonate with smallholder dairy keepers’ priorities. Smallholders are typically motivated by sustaining their livelihoods. Paradoxically, their livelihoods are under pressure due to climate change. In addition to incomes and FNS, dairy provides manure for crops and are a means to save and store money and manage risks in the absence of banks and insurance policies (Hererro et al., 2013). Other value chain actors, such as those organising milk collection, transportation, processing, packaging, are also likely motivated by how the sector contributes to their livelihoods as opposed to how to mitigate climate change. The emphasis on mitigation, therefore, risks remaining a high-level ambition without clear implementation strategies that align with the priorities of dairy sector actors.

The second concern is that the climate change mitigation approach in Kenya's dairy sector adopts a one-size-fits-all technical model, potentially not aligning with diverse smallholder farming practices. This approach mirrors sustainable intensification efforts (Pretty et al., 2012), emphasising predefined technical practices for increased production. Farmers are categorised as adopters or non-adopters of these practices (Glover et al., 2016), and the action perspective following from that stresses the need to incentivise the non-adopters (Maindi et al., 2020). Mitigating GHG emissions from dairy production involves improving feed quality, managing manure, and enhancing animal husbandry (Ericksen & Crane, 2018). However, dairy management varies from extensive to intensive systems (Odero-Waitituh, 2017), including differences in feeding and manure management practices (Owino et al., 2020a; Ndung'u, 2021). This diversity stems from a mix of agro-ecological, socio-cultural, economic, and institutional conditions, embedding practices in their regions (Descheemaeker et al., 2016). To achieve triple-wins, the dairy mitigation agenda must move beyond a uniform technical approach to accommodate these embedded dairy practices.

The third concern is that the climate action's mitigation focus may lead to an exclusive pathway (Leach et al., 2007) of market formalization—legally registering and regulating economic activity (Habib-Mintz, 2009). The climate mitigation agenda involves organising and incentivising smallholder farmers through training and access to inputs via formal marketing channels, aiming to boost commercialisation. For food quality and safety, the preferred commercial route for milk and dairy products is through formal channels, which are considered capable of supplying food to growing urban centres. Literature supports a link between dairy intensification and market participation (van der Lee et al., 2020). However, in Kenya, 70% of marketed milk does not reach formalised markets (Rademaker et al., 2016). Emphasising market formalization therefore risks excluding producers from informal markets, which offer livelihood opportunities, and easier access for producers and low-income consumers (Alonso et al., 2018).

In summary, this thesis aims to address concerns about the disconnect between proposed climate actions and the priorities and practices of involved actors. These concerns share a binary conceptualisation, which categorises smallholders as either adopters or non-adopters of intensification practices and distinguishes between formal or informal milk markets. A binary perspective is inclined to treat some categories as superior to others. However, the social world does not consist of distinct and binary categories. Therefore, proposed climate actions may not align well with the complex social realities they are meant to address. Consequently, in this thesis, I advocate for capturing and accommodating the diversity of situated and embedded actors and practices as a response to these concerns.

1.3 Conceptual approach to the problem statement

The main approach to the problem statement is to explore how diverse actors and practices can become an integral part of intervention strategies at the climate-development nexus. This involves moving beyond categorical thinking. The thesis therefore examines how diverse actors, and their situated practices can be captured and accommodated in sustainability transitions. I here present the theories and concepts that inspire this thesis' approach, which I summarise as capturing actors and accommodating their practices.

The conceptual approach is broadly inspired by pathways to sustainability approaches and literature about inclusive development. Pathways to sustainability approaches offer a systemic perspective to sustainability transitions as a continuously changing process. It understands reality as a complex system encompassing a variety of dimensions including the social, technological, and ecological and it warrants for single pathways that become dominant (Leach et al., 2007). The need for capturing and accommodating diversity is further inspired by literature about inclusive development. The notion of inclusive development emphasises social and environmental aspects of development in response to trade-offs in sustainable development that tend to favour economic growth (Gupta et al., 2015). It explicitly encompasses social, ecological, and relational inclusiveness (Gupta & Pouw, 2017a; 2017b).

In my own words, pathways to sustainability and inclusive development literature invite to be wary of emphasising single dimensions in change processes, such as economic or technical dimensions, as well as single pathways towards sustainability. A single dimensional lens likely increases the risks of exclusion and negative externalities as introduced in section 1.2. I respond by capturing socio-economic inclusion as a continuous and adaptive process rather than as a definitive outcome (Gupta et al., 2015), to complement the technical emphasis in the emerging dominant pathway. This inspires me to explore how diverse actors and practices are currently accommodated in practice.

1.3.1 Capturing diversity

The problem statement calls for a need to make socio-economic diversity a more explicit part of predominantly technical agricultural intervention strategies in the climate-development nexus. Specifically, the livelihood strategies literature and typology development approaches help to move beyond binary categorical sense-making of socio-economic diversity. Making more refined diversity visible is what I call 'capturing diversity'.

First, at smallholder household level, dairy is part of livelihoods in distinct ways. Early livelihoods theory distinguished between intensification, diversification, and migration as strategies (Scoones, 2009). Climate change mitigation agendas emphasise intensification as a livelihood strategy, but households can employ more than one strategy at the same time, creating multiplex livelihood strategies (Bryceson, 2002). Scoones (2015: preface) explains how livelihood strategies emerge: “The dynamics of change in rural settings emerge from the particularities of place and people in interaction with wider processes of structural change, both constraining and opening up opportunities for different groups. Patterns of social differentiation – across class, gender, age, ethnicity and so on – emerge. Such processes result in diverse paths of accumulation, and so in turn different livelihoods.” For effectively supporting sustainability interventions in the climate-development nexus in Kenya’s dairy sector, it is therefore important to capture the diverse roles dairy has in multiplex livelihoods.

Second, there is a need to move beyond one-size-fits-all technical approaches and instead enable actor disaggregated technological support. A step towards that is to capture the variety of dairy farmers and their agricultural practices. For this purpose, typology development approaches are helpful, which allow for typifying farmer households, and evaluate correlations with farming practices and performance (Schoneveld et al., 2019). For example, a positive correlation between the education level of the household head and the adoption of certain climate smart agricultural practices can be observed (Okello et al., 2021). LEDS aim to stimulate the uptake of improved forage species, practice concentrate feeding, produce silage from maize, practice manure storage, install biodigesters, reduce the animal disease burden, and practice artificial insemination (AI) to improve breeds and genetics (Ericksen & Crane, 2018). Representative typification of who farmers are, and what they do in terms of dairy farming can therefore support the aims of LEDS, capture the variety of dairy farming practices, and deepen our understanding of smallholder dairy farmers as adopters or non-adopters of LEDS practices.

The first part of the conceptual approach is hereby to *capture* various dimensions of socio-economic diversity, specifically investigating the role of dairy in livelihoods, and the variety of situated technical dairy practices.

1.3.2 Accommodating diversity

After making visible diversity of actors and their practices, I explore how diversity can be accommodated in practice. An exclusive emphasis on capturing diversity risks a rather static outlook. Therefore, I expand my scope to accommodating diversity, which insinuates a process from one state to another. Helpful literature and concepts that incorporate a processual element focus on agriculture as performance and adopt a practice approach.

Agriculture as performance is eminently suitable for studying agriculture as a process. Where the capturing approach allows for a typification of actors and practices, it is unable to apprehend the complexity of socio-technical change in smallholder agriculture (Glover et al., 2019). Agriculture as performance adds a time and agency element and studies the skilful use of tools, techniques, and knowledge in situated actions (Richards, 1989). It thereby highlights human capacities to achieve practical ends, and know-how to make things work (Jansen & Vellema, 2011). An agriculture as performance lens resonates particularly well with analysing unfolding responses to climate change and climatic variability (Crane et al., 2011). Agriculture as performance therefore helps to move beyond capturing and understand processes that accommodate a range of actors and practices.

Another approach that draws attention to performance of practices is inspired by theories of practice (Nicolini, 2011; 2012). The theory of practice elaborates how combinations of practices constitute webs of practices, which create and sustain evolving institutions. Therefore, studying practices is a way to understand social organization and order, and offers guidance for studying how diverse actors and their practices are accommodated (Jones & Murphy, 2011). The approach offers particularly relevant insights into food provisioning in the economic middle between production and consumption (Legun & Bell, 2016). It further helps to elaborate how webs of practices are situated, and how market institutions can sustain themselves in dynamic contexts (Schoonhoven-Speijer, 2021). The approach therefore helps to move beyond static capturing of actors and practices and to study how embedded agricultural and commercial practices are accommodated.

The second part of the conceptual approach is to *accommodate* diverse dimensions of socio-economic diversity in practice, specifically investigating situated farming and commercial practices. Table 1.1 presents an overview of the connected problem statement, literature, and approach of this thesis.

Table 1.1: Overview of the connected problem statement, literature, and approach of this thesis.

Problem statement, three main concerns	**Helpful literature and concepts to address the concerns**	**Approach: capturing and accommodating in the empirical chapters**
1. Disconnect with smallholder livelihoods, potential negative externalities	Livelihood strategies	Capturing diverse livelihood strategies (Ch. 2)
2. One-size-fits-all technical approach, disconnect with smallholder practices	Typology development, Agriculture as performance	Capturing smallholder heterogeneity (Ch. 3), Accommodating situated farming practices through time (Ch. 4)
3. Exclusive formalisation pathway, disconnect with commercial practices	Practice approach	Accommodating embedded commercial practices (Ch. 5)

1.4 Research objectives and questions

The originality of the thesis lies in moving beyond categorical thinking. It contributes to making a refined capturing of diversity meaningful for the accommodation of diverse actors and practices in Kenya's dairy sector – a timely case. The thesis is innovative in combining established literatures and mixing research techniques for capturing diversity, building on upcoming theories and conceptualizations that offer space to accommodate diverse actors and practices.

The overall research question of this thesis is as follows:

> What conditions and processes likely accommodate a diversity of actors and practices in climate-development initiatives in Kenya's dairy sector?

In addition to answering the research question, this thesis also aims to make contributions to a conceptual understanding of accommodating diversity, a methodological perspective on the entangled process of capturing and accommodating, and the design of transformative agendas. The objectives of this thesis therefore are:

1. To conceptually understand directions for accommodating diverse actors and practices;
2. To offer an integrative methodological perspective on capturing and accommodating diverse dairy sector actors and practices;
3. To inform the design of transformative agendas that address human development and climate change ambitions in Kenya's dairy sector.

1.5 Research design

This section presents descriptions of the study sites, selection of cases and respondents, and briefly summarises the data collection and analysis methods. The latter are elaborated in the empirical chapters.

1.5.1 Multi-dimensional and processual approach

Following from the conceptual approach of the thesis, the research design employs a multi-dimensional and processual approach. A multi-dimensional approach entails the capturing of more than one dimension, specifically of dairy in diverse livelihood strategies, types of dairy smallholders, and technical dairy practices in diverse regions. This is complemented with a processual approach, which adds a non-static understanding to the captured actors and practices in aiming to understand how they are accommodated in practice.

1.5.2 Description of the study sites

The first empirical chapter (Chapter 2) draws on data from both Tanzania and Kenya for a first regional impression of the role of dairy in diverse livelihoods before further zooming into Kenya. The focus of this study are three research areas in Kenya: Nandi, Bomet and Murang'a county. In Tanzania, Mvomero, Mufindi, Njombe and Rungwe district were included in four different regions (figure 1.1). The study sites were selected for their presence and potential for win-wins for people and planet because of importance of dairy production, agro-ecological diversity, and relevance to regional and national policy and development priorities.

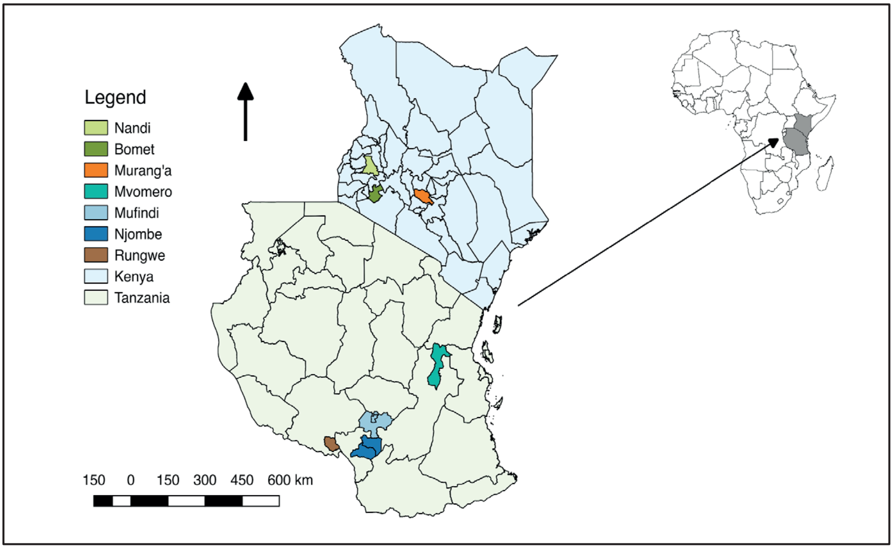

Figure 1.1: Study sites.

1.5.3 Selection of cases and respondents

Representative household sampling was done for the survey used in Chapter 2 and 3. Key informants were selected based on a combination of snowball sampling and mapping of relevant dairy sector actors. Participants for data collection for Chapter 4 are nested in the sample for the survey and selected based on a set of diverse characteristics. Participants for Chapter 5 were included using snowball sampling via the main dairy sector actors (gatekeepers) in the area until the network was satisfied.

1.5.4 Data collection and analysis

I employed a mixed-methods approach, with predominantly quantitative methods for data collection and analysis in Chapters 2 and 3, and qualitative methods in Chapters 4 and 5. To allow for representative capturing of smallholder heterogeneity in terms of their livelihood strategies, socio-economic characteristics, and farming practices, I specifically employed econometric modelling with survey data as the dominant method for data collection and analysis in Chapters 2 and 3. To allow for a detailed understanding of how actors and practices are accommodated in practice, I shift to an ethnographic lens in the second half of the thesis and deep-dive into case studies for Chapters 4 and 5. I do so via employing predominantly qualitative methods, namely life history interviews, participant observations and informal conversations, and followed iterative data analysis principles. Key informant interviews were used in the interpretation of the results in all Chapters (table 1.2).

Table 1.2: Overview of employed methods per empirical chapter.

Chapter	Topic	Methods for data collection					
		Survey	**Participatory workshops**	**Key informant interviews**	**Life history interviews**	**Participant observation**	**Informal conversations**
2	Capturing diverse livelihood strategies	X	X	X			
3	Capturing smallholder heterogeneity	X	X	X			
4	Accommodating situated farming practices			X	X	X	X
5	Accommodating embedded commercial practices			X		X	X

1.6 Thesis outline

Each empirical chapter addresses the capturing and accommodating of diverse actors and their practices.

Chapter 1 provides the general introduction to the problem and introduces the conceptual approach or capturing and accommodating. It further introduces the research objectives, the main research question, research design and methodological choices taken during the study.

Chapter 2 draws on data from Tanzania and Kenya and captures the roles of dairy in multiple livelihood strategies. It specifically explores whether dairy intensification threatens livelihood diversification, dietary diversity, and wealth. It examines how dairy is accommodated in diverse livelihood portfolios and identifies the potential for win-win-win as well as the risks for unwanted externalities because of dairy intensification strategies.

Chapter 3 zooms in to household dairy practices in three counties in Kenya, investigating in detail who farmers with cows are, and what dairy farming practices they employ. A household typology is presented, and dairy farming practices are further investigated per household type, and at county level. It informs a search for alignment of this diversity with LED dairy practices across the combined household and regional dimensions.

Chapter 4 adds a time and agency element to understanding cattle feeding practices in sub-optimal conditions in one county in Kenya. The findings inform the support of a shift towards accommodating the adaptive capacities of smallholders in climate ambitions, thereby balancing climate change mitigation and adaptation approaches.

Chapter 5 explores how diverse commercial practices of milk collectors, ranging from formal to "informal", are accommodated in a milk catchment area. This chapter analyses dynamics in an area where accommodating diversity seems to be possible and productive. It questions the need for formalisation to achieve intensification and commercialisation objectives.

Chapter 6 brings the main findings of this thesis together and identifies lessons that can be drawn from the combined learnings of the empirical chapters. These are then translated to implications for theory, methodology, and development practice.

Figure 1.2 below shows the chronological order of the chapters from top to bottom, and briefly explains the main topic of the chapters. All chapters provide valuable insights for both capturing and accommodating, however with a different emphasis. Moving from the first to the last empirical Chapters (2-5), the focus of the research graduates from an emphasis on capturing diverse actors and their practices, to understanding their accommodation in practice. The relation between capturing and accommodating is discussed in the final synthesis chapter.

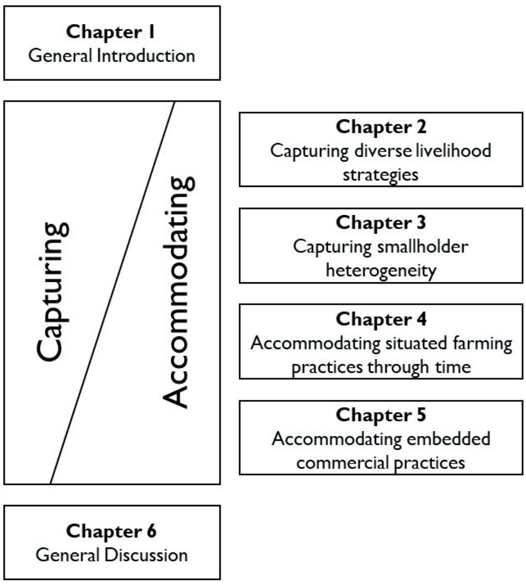

Figure 1.2: Schematic overview of the chapters of this thesis.

Chapter 2

Does dairy intensification threaten livelihood diversity in East Africa?

Publication status

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2 Does dairy intensification threaten livelihood diversity in East Africa?

2.1 Abstract

Sustainably intensifying smallholder agriculture is a way to reduce global greenhouse gas emissions and increase food production on existing croplands. In theory, sustainable intensification can reduce emissions per unit of production, and improve rural income and food security. However, evidence is lacking about whether intensification truly benefits people and the environment. Because intensification demands more labor and capital, rural livelihoods potentially become more specialized, possibly reducing dietary diversity and wealth accumulation. We examined the relationship between dairy intensification, livelihood diversity, dietary diversity, and well-being in Kenya and Tanzania. We find, albeit with some caveats, that dairy intensification enhances livelihood diversity, nutritional diversity, and wealth. These findings suggest that for dairy, intensification and diversification may be complementary livelihood strategies.

2.2 Introduction

The global development community increasingly prioritizes the reduction of greenhouse gas (GHG) emission intensities from agriculture, with special attention to livestock production systems (Herrero et al., 2016; Uwizeye et al., 2020). At the same time, raising the productivity of smallholder farmers who continue to struggle to make a living and achieve food security through agriculture remains high on the policy agenda (Gomez y Paloma et al., 2020). Low-emission development strategies (LEDS), generally understood as 'forward-looking national development plans or strategies that encompass low-emission and/or climate-resilient economic growth' (Clapp et al., 2010: 13), are viewed as a particularly promising avenue for reconciling these two priorities.

In East Africa, LEDS are increasingly being applied to dairy production for their potential to deliver win-win-win outcomes. By raising productivity through the dissemination of climate-smart production practices, national dairy output increases, emission intensities go down, and dairy farmers' incomes go up. Emission intensities are particularly high in the East African dairy sector because of poor animal feeding, manure management, herd management, and animal health practices and can be addressed by strengthening public extension and building a more dynamic service sector (Ericksen and Crane, 2018). Consequently, the sector has become a prime target for delivering on both national poverty reduction and climate change mitigation targets.

While there is evidence to suggest that emission intensities and productivity are typically inversely correlated (Havlík et al., 2014), whether LEDS-inspired intensification yields expected socio-economic gains is less clear. To intensify dairy may require the household to divert land, labor, and capital from other livelihood activities, which may threaten food security and livelihood resilience. East African dairy farmers generally produce dairy within diversified crop-livestock systems with a plethora of on- and off-farm activities contributing in unique and complementary ways to livelihoods (Acosta et al., 2021). These diversification strategies allow households to spread risk and produce for both consumptive and income-generating purposes (Waha et al., 2018). While safeguarding diversification received considerable attention from the development community in the past (Ellis, 2000; Macours and Premand, 2012; Megersa et al., 2014; Rider Smith et al., 2001), recent attention has been paid to GHG emissions, and the need to intensify production may well produce unwanted externalities (Tavenner et al., 2019).

By exploring the interaction between dairy intensification, livelihood diversification, and household well-being, this article speaks to this dilemma. While intensification can be interpreted in many ways (Pretty, 2018; Rockström et al., 2017) for dairy it generally means producing more milk per year per cow. Intensification can lead to specialization (Ellis, 2000; Iiyama et al., 2008), specialization being: '...the process of concentrating resources (land, labor, and capital) on producing a limited variety of goods.' (Abson, 2018: 301). Diversification strategies are typically motivated by risk reduction, utilization of idle resources, and social motivations (Hansson et al., 2013; Northcote and Alonso, 2011). Because specialization enhances farmer exposure to shocks, from a climate change adaptation perspective, diversification of crop and livestock production is generally preferred (Djurfeldt et al., 2018). Research has shown that to reduce poverty, emphasis should be placed on increasing returns to existing baskets of livelihood activities rather than encouraging households to disproportionately invest in one (Iiyama et al., 2008). However, encouraging households to produce more milk per cow may inadvertently undermine and divert resources away from other activities.

In this article, we explore whether dairy intensification drives specialization and consequently threatens household well-being. We hypothesize that dairy intensification leads to livelihood specialization, which in turn reduces dietary diversity and the ability to accumulate assets. We contend that because dairy intensification is so labor- and capital-intensive, considerable household human and financial capital gets locked up by dairy, thereby necessitating specialization. As households become more reliant on purchased inputs and the household cost burden subsequently goes up, we fear that the household's ability to acquire other instrumental livelihood assets is undermined. Moreover, because on-farm feed production is also land-extensive, households may well need to produce fewer food crops, thereby threatening household dietary diversity.

To test this hypothesis, we conducted 2250 semi-structured interviews with dairy households across seven study sites in Kenya and Tanzania. In this article, we use the data from these surveys to model the relationship between intensification and diversification and household well-being. Specifically, through a multinomial treatment effect model, we estimate the effects of three levels of intensification on livelihood diversity, nutritional security, and wealth. We opted for a model that can control for endogeneity since we can reasonably assume that assignment to specific intensification regimes is non-random.

2.3 Literature review

Studies about determinants of and motivations for diversification (e.g. Alobo Loison, 2015; Ellis, 2000) and intensification (e.g. Pretty et al., 2018; Rudel, 2020) infer that concentrating productive resources on certain farm activities (e.g. specializing or intensifying), the ability to diversify declines because the productive resources cannot be utilized for other activities if the concentration on certain farm activities is to be sustained. Some posit that diversification and intensification do not take place along distinct pathways, however. Rather, rural communities can be characterized by 'multiplex livelihoods' (Bryceson, 2002) and multifaceted livelihood pathways, which constitute "a complex *bricolage* or portfolio of activities" (Scoones, 2009: 172, italics in the original). This suggests that diversification and intensification are not necessarily conflicting strategies and can be mutually supportive - in contrast to early sustainable rural livelihoods literature depicting these as distinct livelihood strategies (Scoones, 1998).

Most empirical research on intensification and diversification still study these as separate strategies, with distinctive motivations and determinants (e.g. Boncinelli et al., 2017; Djurfeldt et al., 2021; Klasen et al., 2016; Smith et al., 2019, Clay et al., 2020). A small number do explore their interplay. A study about ecosystem outcomes and intensification processes shows how highly diversified systems can still be highly intensive (Rasmussen et al., 2018). They also show that higher input use such as fertilizers, irrigation, seeds, and labor might even encourage diversification when there are opportunities for polyculture. This applies to, for example, integrated fish and rice farming (Berg et al., 2012), integrated rice and fruit production (such as mango) (Rahman et al., 2016), and vegetable diversification (Agoramoorthy et al., 2012; Seck et al., 2005). Research on the intensification-diversification relationship is sparse for non-polycultural systems, with evidence to support recent views on their complementary functions largely missing. Even though intensification features highly on many policy agendas and can, theoretically, be risky to smallholder livelihoods, the lack of attention to the intensification-diversification interplay is concerning for praxis too.

In a similar vein, how diversification and specialization strategies compare concerning their poverty alleviation potential is also unclear. A literature review of rural livelihood diversification strategies in Sub-Saharan Africa provides mixed results. For instance, Alobo Loison (2015) suggests that due to asset constraints, the large majority of smallholders have not (yet) meaningfully benefitted from diversification, but this depends on context. De Roest et al. (2018) show that diversified farms are often as or more profitable than specialized farms, with specialization strategies often weakening economic resilience due to excessive exposure to market volatility.

Research on the outcome of intensification paints a rosier picture, with agricultural intensification often shown to positively impact household income (Rasmussen et al., 2018). Research from Northern Ghana shows how food security can improve as a result (Yahaya et al., 2018), but the authors point to the unique conditions in this area, limiting the findings in terms of their generalizability. Research from Rwanda suggests nutritional diversity may still be observed as a result of intensification (Del Prete et al., 2019). For dairy specifically, results are more mixed, with dairy intensification in Africa shown to have both positive and negative effects on income (Ahmed et al., 2000; Hoddinott et al., 2015). In a study specific to East Africa, Kebebe (2017) does find a generally positive effect of dairy intensification on both household income and nutritional diversity but shows that benefits are not evenly distributed, with marginalized producers less likely to benefit from intensification.

2.4 Materials and Methods

2.4.1 Study sites

This research was carried out in Kenya and Tanzania, where dairy is a leading agricultural sector and contributes to rural livelihoods. Across the two countries, over 80% of milk comes from smallholders, and more than half of rural households own cattle. Kenya's dairy subsector contributes 4% to the Gross Domestic Product (GDP), while Tanzania's dairy sector contributes 1.5% to GDP. In the region, Kenya has a high milk consumption at 110 litres per person per year, while Tanzanians consume 45 litres on average, well below the recommended 200 litres per year (Katjiuongua and Nelgen, 2014). Milk consumption is rising in both countries, and increased management practices can bridge supply gaps, especially among smallholders who often use low-input, low-output strategies.

Research activities were performed across seven sites capturing a wide array of agroecological, geographic, and market conditions, namely in three counties in Kenya and four districts in Tanzania (Figure 2.1). In Kenya, the study sites include Nandi, Bomet, and Murang'a counties. Nandi and Bomet are both located within the former Rift Valley Province and are dominated by semi-intensive livestock systems. While milk is mostly sold informally, several large processors source from these counties. The third county, Murang'a, is dominated by more intensive dairy systems. Located in the former Central Province, population pressure is comparatively high, and markets are more formalized. Tea is an important cash crop in the counties, and maize, beans and potatoes are common food crops.

In Tanzania, the study sites include the Mvomero district in the Morogoro region, Mufindi district in the Iringa region, Njombe district in the Njombe region, and Rungwe district in the Mbeya region. In Rungwe, smallholders produce dairy within intensive and semi-intensive systems, alongside crops such as bananas and maize, and dairy production is commercialized. Njombe is more intensive because of more than 30 years of dairy development interventions, which resulted in a well-established farmer cooperative and a milk processing plant. The main cash crop is tea, and food crops include maize and potatoes. Mufindi has semi-intensive systems but lacks a dynamic milk market and is more crop-oriented. Mvomero has a wide range of dairy systems, with pastoralists keeping cows within extensive systems and mixed crop farmers keeping their cattle under intensive or semi-intensive systems. Like Mufindi, there are no major processors collecting milk from this district.

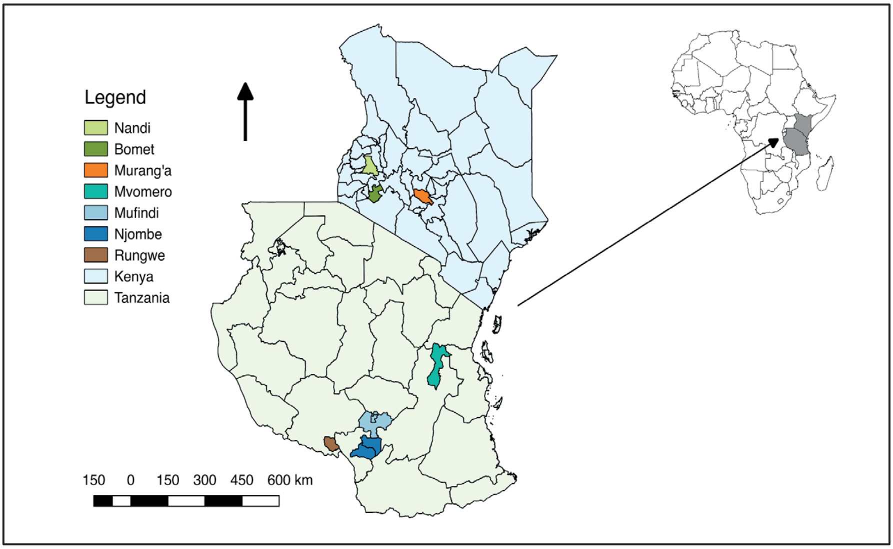

Figure 2.1: Study sites.

2.4.2 *Surveying activities*

Data were collected from 2250 households using a structured questionnaire. Households were sampled using a two-staged approach. First, a spatial cluster analysis was performed on each administrative unit to capture internal agroecological variabilities shaping dairy practices. Using spatially explicit rainfall, temperature, and elevation data, each unit was clustered into three zones representing different levels of agroecological suitability. 36 locations were randomly selected across the three clusters in every administrative unit, with several locations per cluster proportionate to the relative size of each cluster. Villages closest to each location were selected for inclusion in our surveying activities. Households were then randomly sampled in each village, based on sample frames constructed in collaboration with local authorities and leaders, with the number of farmers sampled per village informed by the relative size of each sample frame.

The administered questionnaire was loosely based on the Rural Household Multi-Indicator Survey (Hammond et al., 2017). Topics covered in the questionnaire relate to, amongst others: (1) household demographics; (2) household assets; (3) livelihood activities; (4) dairy and crop management practices; (5) milk marketing; (6) production output, revenues, and costs; and (7) household psycho-social attributes. Following data cleaning, 2069 households were retained for our analysis (978 in Kenya and 1091 in Tanzania). More information about the (spatial) sampling strategy and survey instrument can be found in Kihoro et al. (2021). In addition to the surveying activities, the authors also conducted validation workshops and extensive qualitative research in the study sites that support the interpretation of results (see e.g. Kihoro et al., 2021, others are forthcoming).

2.4.3 Analytical framework

We explored the relationship between household diversification and dairy intensification and related household welfare outcomes; specifically, wealth and dietary diversity. We do that by specifying a multinomial treatment effect model using the user-written *mtreatreg* package in STATA 15 that is estimated by maximum simulated likelihood. The two-stage model estimates the effect of endogenous multinomial treatments on continuous, count, and binary outcome variables. Such a model is considered appropriate for capturing multiple intensification levels while correcting for endogeneity problems. We assume that our multinomial treatment variable (intensification) is endogenous since allocation to a specific intensification regime is expected to be non-random.

In our model, the first stage consists of a multinomial selection equation that models household allocation to one of three intensification regimes, namely intensive, semi-intensive, or extensive. Regime allocation is determined by the adoption of two critical production practices: zero-grazing and keeping of improved dairy cows (see Table 2.1). These practices are widely considered reliable predictors of overall dairy production intensity (Herrero et al., 2016).

Table 2.1: Intensification regimes.

Category	Zero grazing	Improved cows	Number of observations	Proportion (%)
Intensive	1	1	885	42.77
Semi-intensive	0	1	794	38.38
Extensive	0	0	390	18.85

In the first stage, ui_{ij} represents the indirect utility function of household i for j^{th} intensification regime (j=0,1,2) and

$$ui_{ij} = x_i\alpha_j + \delta_j l_{ij} + \mu_{ij}$$

Equation 1

where x_i denotes exogenous co-variates with associated parameters α_j and μ_{ij}, the independent and identically distributed error terms. l_{ij} is the latent factor that incorporates unobserved characteristics for household i treatment choice and is assumed to be independent of μ_{ij}. Let p_j represent the observable variables for the intensification regimes, then the probability of treatment can be expressed as:

$$Pr(p_j|x_i l_i) = g(x_i'\alpha_1 + \delta_1 l_{i1}, x_i'\alpha_2 + \delta_2 l_{i2}, \ \dots \ , x_i'\alpha_j + \delta_j l_{ij})$$

Equation 2

where the vector g is assumed to follow a multinomial probability distribution with a mixed multinomial logit structure (Deb and Trivedi, 2006).

The second stage estimates the outcome equations for wealth, dietary diversity, and livelihood diversification. These equations can be expressed as:

$$e(y_i|\, p_i x_i l_i) = x_i'\beta + \sum_{j=1}^{j} \gamma_j\, p_{ij} + \sum_{j=1}^{j} \lambda_j\, l_{ij}$$

Equation 3

where y_i denotes the welfare outcome for household i and x_i a vector of exogenous co-variates with an associated vector of parameters β, while γ_j captures the treatment effect relative to the control group (extensive dairy farmers) and λ_j the factor-loading parameter associated with the latent factors.

A total of 500 simulations were performed to estimate the model. This follows Deb and Trivedi (2006) who note that models with endogenous regressors require 10 times more draws than the commonly recommended square root of n (√ 2069 = 46).

2.4.4 Variables

Outcomes were estimated using indices that proxy for livelihood diversification, nutritional diversity, and wealth. Livelihood diversification is captured by the commonly used Herfindahl–Hirschman Index (HHI) (Herfindahl, 1955), a measure of income concentration. To represent diversification, we calculated an inversed HHI (*InvHHI*) as follows:

$$InvHHI_i = 1 - \sum_{j=1}^{n} s_{ij}^2$$

Equation 4

where s_{ij} captures the share of total net income household i derives from income source j. Net income is derived from survey data and grouped into food crops, cash crops, livestock, dairy, forestry, formal employment, informal employment, commerce, and remittances. *InvHHI* ranges from 0 to 1, with a higher value representing greater livelihood diversification.

To capture nutritional diversity, we calculated Household Dietary Diversity Scores (HDDS) following the Food and Agriculture Organization of the United Nations (FAO, 2011). HDDS is a food consumption measure reflecting the diversity of foods households have access to and the nutritional quality of a household's diet. HDDS is derived from 12 standardized questions about the types of foods consumed by the household over the last 24 hours. This includes starchy staples, dark green leafy vegetables, other vitamin-rich fruits and vegetables, other fruits and vegetables, organ meat, meat and fish, eggs, legumes nuts and seeds, and milk and milk products. Values range from 0 to 12, with higher values indicating more diverse diets.

Finally, wealth was captured using an asset index, a non-income wealth indicator. An asset index is often preferred over household income and consumption expenditure because monetary wealth indicators tend to fluctuate over time and capture only one asset from which households derive well-being (Kakwani and Silber, 2008; Laderchi et al., 2003). Asset ownership is less affected by seasonal variations and better represents long-term well-being (Rakodi, 1999). We used the approach developed by Filmer and Pritchett (2001) to calculate an asset index for each household. This involved performing a Multiple Correspondence Analysis (MCA) on binary asset variables that, based on exploratory research activities were found to be locally relevant indicators of wealth. This includes ownership of an electric iron, refrigerator, mobile phone, mattress, sewing machine, stove, motorized vehicle, bicycle, DVD player, TV, radio, sofa, computer, chaffcutter, house, improved roofing material, brick or concrete wall, toilet, use of electricity, and use of modern cooking fuels. Following Filmer and Pritchett (2001), the factor scores of the first component, which captures the maximum variation between households, were subsequently used as weights to construct the wealth index as forth:

$$w = f_1\left(\frac{a_1-\bar{a}_1}{s_1}\right) + f_2\left(\frac{a_2-\bar{a}_2}{s_2}\right) + \cdots\ f_p\left(\frac{a_p-\bar{a}_p}{s_p}\right)$$

Equation 5

where $f = (f_1, f_2 \ldots f_p)$ is the vector of coefficients obtained from the MCA, and $\bar{a}$ and s are the mean and standard deviation across all households for asset a_k. The wealth score for household i is then $w_i = f'x_i$, where x_i is a vector of standardized variables $(a_k - \bar{a}_k/s_k)$. Scores were then normalized (0-1), with higher values representing greater household wealth.

To correct for endogeneity, we employed two binary instrumental variables (IV) that are assumed to be uncorrelated with the error term: use of radio, and discipline or innovativeness of the household head. The latter indicator was derived from psycho-social questions in the survey where household heads could characterize themselves across eight dimensions, ranking in the top three. Only those households where heads foremost characterized themselves as being either innovative or self-disciplined were assigned a positive value of 1.

Based on extensive qualitative research, we are confident that these instruments best meet the IV relevance assumption (e.g. the IV is correlated with intensification). In all the study areas, radio is a source of technical information on dairy management, with innovativeness and discipline typically required to invest or direct additional labor and capital in (new) practices. These IVs are expected to only affect outcomes indirectly (e.g. through intensification). Adherence to the IV monotonicity assumption is also assumed. Radio use will only have a unidirectional effect on intensification since radio broadcasts on dairy, given public policy, only promote intensification and are therefore unlikely to deter intensification. Information from radio could however be correlated to the provision of nutrition information, and the instrument was hence not used for the HDDS model. Additionally, while radio was used in developing the wealth index, its contribution to the overall asset index was insignificant as the majority (86%) of the households had a radio. In the absence of more profitable income-generating opportunities that provide the level of prestige and co-benefits (e.g., manure for crops) in the study areas, disciplined and innovative people are unlikely to purposefully avoid dairy intensification.

Descriptive statistics for the dependent and independent variables, disaggregated by treatment group, that were used to estimate our model are provided in Table 2.2.

Table 2.2: Descriptive statistics.

Regime	**Intensive**	**Semi-Intensive**	**Extensive**	**Total**
Variable	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Dependent				
Diversification	0.43 (0.22)	0.39 (0.22)	0.33 (0.47	0.39 (0.23)
Dietary diversity	7.53 (1.52)	7.14 (1.30)	6.54 (1.60)	7.19 (1.50)
Wealth	0.59 (0.13)	0.51 (0.15)	0.46 (0.15)	0.53 (0.15
Independent				
Age of Household head	53.64 (12.83)	52.40 (14.09)	49.98 (13.35)	52.47 (13.48)
Male household head	0.83 (0.38)	0.83 (0.38)	0.91 (0.29)	0.84 (0.36)
Household members	5.05 (2.04)	5.71 (2.21)	6.23 (2.72)	5.52 (2.29)
Dependency ratio	0.44 (0.24)	0.45 (0.23)	0.49 (0.22)	0.45 (0.24)
Indigenous to the area	0.80 (0.40)	0.84 (0.37)	0.87 (0.34)	0.83 (0.39)
Land size (in acres)	6.87 (11.06)	6.94 (10.99)	9.51 (11.32)	7.39 (11.12)
Group membership	0.57 (0.10)	0.54 (0.50)	0.20 (0.40)	0.49 (0.50)
Instruments				
Information from radio	0.11 (0.32)	0.12 (0.32)	0.04 (0.21)	0.102 (0.30)
Discipline or innovativeness	0.41 (0.52)	0.25 (0.46)	0.36 (0.51)	0.34 (0.50)

2.5 Results

2.5.1 Determinants of intensification

The results of the stage one selection equation are presented in Table 2.3. Results are generally consistent across the three models and demonstrate that the probability that households intensify is strongly shaped by household composition and lifecycle. Intensified households are generally older and smaller and have relatively few dependents. Such households tend to have more disposable income to invest in fixed and variable inputs and hired labor, while less burdened by childcare obligations. The effects of household composition and lifecycle are less pronounced for semi-intensifying, though lower dependency ratios do appear to enable a transition away from extensive production practices.

Household origin impacts the adoption of both intensive and semi-intensive practices, with migrant (e.g. non-indigenous) households more inclined to intensify. Less constrained by 'traditional' livestock management norms and with weaker access to common pool resources such as pasturelands, such households experience a greater desire and imperative to intensify. Group membership also positively influences (semi-)intensification. Because farmer groups often collectively buy inputs and sell milk, as well as facilitate horizontal learning, farmers generally gain greater confidence to adopt new practices.

Interestingly, land size positively predicts semi-intensification, but not intensification. Arguably, households with more land where cows can freely graze are less compelled to invest in zero-grazing structures, while households with less land that are necessarily reliant on feed and concentrate markets can benefit more from fully intensifying.

Finally, results also point to geographic determinants. For example, farmers in Murang'a (Kenya), Njombe, and Rungwe (Tanzania) are more inclined to fully intensify, compared to the base administrative unit (Mvomero, Tanzania). Those districts/countries have especially well-developed milk markets, which helps reduce marketing risks and ensures surplus can be absorbed. Under such conditions, intensification risks can be more effectively ameliorated. As can be observed, farmers in Mufindi are least inclined to intensify, largely because milk markets are underdeveloped, and household milk production largely serves subsistence purposes. Furthermore, in the Kenyan counties of Bomet and Nandi, semi-intensification is seemingly preferred. With readily available land and pastoral commons, few farmers in these counties are incentivized to invest in zero-grazing structures.

Both IVs are statistically significant, though discipline/innovativeness only at a 10% confidence interval.

Table 2.3: Intensification determinants.

Variables	InvHHI Intensifying	InvHHI Semi-intensifying	HDDS Intensifying	HDDS Semi-intensifying	Wealth index Intensifying	Wealth index Semi-intensifying
Age of household head	**0.079***	0.007	**0.086****	0.011	**0.094****	0.011
	(0.043)	(0.048)	(0.043)	(0.046)	(0.043)	(0.047)
Age squared	-0.001	0.000	**-0.001***	0.000	**-0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Male household head	-0.238	-0.284	-0.181	-0.219	-0.223	-0.263
	(0.278)	(0.285)	(0.269)	(0.280)	(0.284)	(0.283)
Household members	**-0.075***	-0.019	**-0.079****	-0.006	**-0.071***	-0.007
	(0.039)	(0.043)	(0.039)	(0.040)	(0.040)	(0.041)
Dependency ratio	**-0.010****	**-0.014*****	**-0.013*****	**-0.017*****	**-0.011****	**-0.016*****
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Indigenous to the area	**-1.420*****	**-1.623*****	**-1.498*****	**-1.662*****	**-1.428*****	**-1.623*****
	(0.296)	(0.298)	(0.287)	(0.293)	(0.291)	(0.300)
Land size	0.001	**0.028*****	0.003	**0.029*****	0.001	**0.029*****
	(0.008)	(0.007)	(0.009)	(0.008)	(0.009)	(0.008)
Group membership	**1.607*****	**1.250*****	**1.622*****	**1.220*****	**1.526*****	**1.204*****
	(0.203)	(0.212)	(0.200)	(0.214)	(0.205)	(0.212)
Information from radio	**1.705*****	**0.798****	**-1.066*****	0.351	**2.193*****	**0.866***
	(0.374)	(0.377)	(0.305)	(0.317)	(0.384)	(0.484)
Discipline/ innovativeness	**0.325***	**0.267***	**2.892*****	**1.815*****	**0.331***	**0.372***
	(0.177)	(0.187)	(0.311)	(0.371)	(0.176)	(0.198)
Mufindi	**-1.276*****	0.284	**2.411*****	0.323	**-1.144*****	0.311
	(0.321)	(0.329)	(0.293)	(0.407)	(0.315)	(0.321)
Rungwe	**2.925*****	**1.886*****	0.008	**5.427*****	**2.958*****	**1.882*****
	(0.314)	(0.366)	(0.492)	(0.403)	(0.309)	(0.374)
Njombe	**2.465*****	0.341	**-0.962***	**4.980*****	**2.622*****	0.398
	(0.297)	(0.396)	(0.558)	(0.397)	(0.296)	(0.402)
Bomet	0.027	**5.515*****	**3.294*****	**1.023****	0.102	**5.540*****
	(0.485)	(0.405)	(0.361)	(0.462)	(0.498)	(0.412)
Nandi	**-1.032***	**4.996*****	-1.311	-0.724	**-1.013***	**5.019*****
	(0.547)	(0.397)	(1.143)	(1.302)	(0.563)	(0.410)
Murang'a	**3.259*****	**1.196*****	**0.086****	0.011	**3.311*****	**1.128****
	(0.374)	(0.461)	(0.043)	(0.046)	(0.369)	(0.469)
Constant	-1.544	-0.763	**-0.001***	0.000	**-2.012***	-0.991
	(1.160)	(1.366)	(0.000)	(0.000)	(1.167)	(1.321)

The base category is the extensive producers. * = $p < 0.10$, ** = $p < 0.05$, *** = $p < 0.01$.

2.5.2 *Effects of intensification*

The second stage of our model estimates the effect of participation in different intensification regimes on the three outcome variables (Table 2.4). The results largely show significant positive effects of intensification across all three outcomes, especially for intensified households. Thereby discrediting much of our hypothesis, our results show that households within the intensification regime become more diversified and achieve greater dietary diversity and wealth. While households in the semi-intensification regime also achieve greater dietary diversity and wealth, albeit not to the same extent as intensified households, their livelihoods do appear to become more specialized. As can be observed, across the three models, effects are positively moderated by the household head being male (as opposed to female) and the amount of land owned, but negatively by dependency ratios (e.g. fewer dependents contribute positively to our outcomes).

Table 2.4: Intensification impacts.

Variables	**InvHHI**	**HDDS**	**Wealth index**
Intensive	**0.158*** **	**1.083*** **	**0.231*** **
	(0.022)	(0.154)	(0.01)
Semi-intensive	**-0.074*** **	**0.711*** **	**0.045*** **
	(0.022)	(0.217)	(0.02)
Age of household head	0.001	0.015	**0.003** **
	(0.003)	(0.016)	(0.001)
Age squared	-0.000	-0.000	**-0.000** **
	(0.000)	(0.000)	(0.000)
Male household head	**0.032* **	**0.179** **	**0.031*** **
	(0.017)	(0.083)	(0.009)
Household members	0.003	0.007	**0.005*** **
	(0.003)	(0.015)	(0.002)
Dependency ratio	**-0.000* **	**-0.003* **	**-0.001*** **
	(0.000)	(0.001)	(0.000)
Indigenous to the area	0.015	**-0.236*** **	**-0.029*** **
	(0.016)	(0.090)	(0.009)
Land size	**0.002*** **	**0.013*** **	**0.002*** **
	(0.000)	(0.004)	(0.000)
Group membership	**0.037*** **	-0.043	0.003
	(0.011)	(0.067)	(0.006)
Mufindi	**0.072** **	**1.007*** **	**0.125*** **
	(0.033)	(0.154)	(0.014)
Rungwe	-0.023	**0.531*** **	**-0.035** **
	(0.022)	(0.164)	(0.015)
Njombe	-0.001	**0.598*** **	0.018
	(0.024)	(0.160)	(0.016)
Bomet	**0.095*** **	**0.615*** **	0.027
	(0.026)	(0.209)	(0.028)
Nandi	**0.129*** **	**0.632*** **	**0.065** **
	(0.031)	(0.207)	(0.028)
Murang'a	**-0.070** **	**0.839*** **	**0.062*** **
	(0.028)	(0.166)	(0.017)
Constant	**0.217*** **	**5.596*** **	**0.276*** **
	(0.075)	(0.474)	(0.042)
Insigma	**-3.052*** **	**0.336*** **	**-2.441*** **
	(0.665)	(0.033)	(0.172)
λ intensive	**-0.065*** **	**-0.190* **	**-0.098*** **
	(0.015)	(0.115)	(0.018)
λ semi-intensive	**0.215*** **	-0.190	-0.018
	(0.013)	(0.191)	(0.024)
Sigma	0.01		0.04
	(-0.01)		(-0.01)
LR test Chi^2 (2)	**43.09*** **	6.12	**13.26*** **
N	2,048	2,069	2,069

Note LR= test of independence of equation. The base category is the extensive producers. * = p < 0.10, ** = p < 0.05, *** = p < 0.01.

For the intensification regime, the factor loadings for the latent factors *(λ intensive)* are statistically significant and negative in all three models. As proxies for unobserved covariates, this implies that unobserved factors that increase the likelihood of intensification reduce the outcome effect compared to random selection. In other words, the treatment and outcome are negatively correlated through unobservables, with households with below-average wealth and livelihood and nutritional diversity more likely to intensify. Because we consequently observe negative selection, without correcting for the non-random nature of intensification decisions, our results would have been downward-biased. In the case of semi-intensified households (*λ semi-intensive)*, negative selection is also observed about nutritional diversity though not statistically significant, and a positive correlation with income diversity, though no correlation can be established between wealth and the treatment. In contrast, the significant positive effect of the factor loading on diversification points to positive selection and risk of upward-bias results for semi-intensified households without correction.

To better illustrate effect size, we calculate the predicted value by the country for each model at means (e.g., co-variates are held constant), see Figure 2.2. This shows that a transition from extensive dairy production to intensive dairy production increases dietary diversity by slightly over 1 food group, and wealth and livelihood diversity by 16% and 21%, respectively. Differences in effect size between the two countries are nominal.

Figure 2.2: Average predicted values per country and production system.

The likelihood-ratio test for exogeneity of treatment is positive and significant across the income diversity and wealth models. This implies that the null hypothesis of exogeneity is rejected at a 1% level of significance for the diversification and wealth models but was not significant for the dietary diversity model. This confirms the presence of selection bias and the necessity of correcting for this in the income and wealth models through instrumental variables while the same was not necessary for the HDDs model, thereby justifying the used instruments.

2.6 Discussion

This study explored the link between dairy intensification, livelihood diversification, and household well-being in East Africa. It was hypothesized that intensification might lead to reduced diversification, impacting diets and wealth. However, our findings challenge this, showing that more intensive dairy systems lead to increased diversification, improved dietary diversity, and greater wealth compared to extensive systems. These results support the 'win-win-win' discourse in research and policy (Herrero et al., 2016; Uwizeye et al., 2020), emphasizing the potential for reduced emissions, agrobiodiversity preservation, and rural livelihood resilience through intensification. Additionally, our results suggest that contrary to earlier sustainable livelihoods literature (Scoones, 1998), intensification and diversification are not distinct livelihood strategies but in certain contexts may well be complementary and mutually reinforcing strategies.

Extensive qualitative research and validation workshops with respondents have unveiled a key motivation for more intensive dairy farmers: the interplay between crop cultivation and livestock rearing. This synergy is seen in the use of maize stovers as feed and dung as manure, enhancing nutrient recycling within households, corroborating findings by Acosta et al. (2021). Furthermore, intensive dairy farmers actively pursue diversification to bolster their income sources, especially during times of volatile milk prices, cattle losses, or surging input costs due to supply shortages. The inherently high-risk nature of dairy farming drives many households to seek alternative income streams and reinvest their dairy proceeds into different activities. However, semi-intensive farmers tend to be less diversified compared to their extensive and intensive counterparts initially. This is often due to the temporary reallocation of resources away from other livelihood activities as they intensify dairy production. Acquiring and maintaining improved cattle requires substantial human and financial investments, including savings for zero-grazing structures. As farmers achieve full intensification, they can effectively reinvest surpluses in a variety of income-generating ventures.

However, this reasoning likely applies to a sub-sample since in some of our study areas where land is relatively abundant many semi-intensive dairy farmers have no ambition to further intensify. This is despite semi-intensive households having the least diverse livelihood portfolios, and thereby can be considered the most specialized in dairy: dairy plays a central role in their livelihoods. Not wishing to further intensify can be because they have more land and can allow their cattle to graze, which is considered financially more interesting than having to invest in buying feed. This also warrants against assuming that households always wish to intensify, or that intensification is a binary: to intensify or not to intensify. Qualitative research disclosed that some households temporarily employ practices associated with dairy intensification in certain periods of the year. Understanding processes of combinations of livelihood strategies such as intensification and diversification over time is essential for further sense-making of our findings.

With findings showing that households with dairy-intensive systems have greater household dietary diversity and wealth, give reason to assume that diversification somehow contributed to this. Qualitative research revealed that more regular (almost daily) income associated with intensification-induced productivity gains allows households to plan their finances, asset investments, and food purchases better. This explains why dairy intensification, *ceteris paribus*, directly improves household well-being. But, indirectly, being able to manage manure more effectively because of zero grazing contributes to greater productivity and reduced input acquisition costs for cropping activities. Similarly, having a more regular income allows households to reinvest more income in a timelier manner into other activities, which in turn increases net economic surplus. In other words, dairy intensification contributes both directly and indirectly to household welfare. Our modelling approach is not equipped to measure the magnitude of the indirect (e.g., diversification-induced) effect, however. This, as well as the precise mechanics, could be an interesting area of future inquiry.

In addition to not being able to capture the magnitude of indirect effects, our study also does not speak to the effects of intensification on intra-household cost - and benefit distribution patterns. Even though intensified households on aggregate have more diverse diets and can accumulate more wealth, that does not mean that, for example, women in the household are necessarily better off. Keeping improved cattle is labor-intensive (Lenjiso, 2020). In our research areas, women play an important role in milking, cleaning, feeding, and marketing, which could imply that the female labor burden might also have increased disproportionately (Tavenner et al., 2019). Similarly, our modelling approach captures only aggregate effects and not distribution patterns within groups. As the findings from Kihoro et al. (2021) illustrate, not all (intensive) producers are the same, meaning that undoubtedly some benefit more than others from intensification. With our findings suggesting that farmers with more land (who are probably also more affluent) achieve better outcomes, intensification could produce some inclusivity challenges.

Furthermore, our HDDS measure has limitations: dietary diversity does not mean households are necessarily food secure throughout the year or necessarily meet their calorific and nutritional requirements. While the correlation between HDDS and other measures of food security is generally considered strong (Leroy et al., 2015), we do urge future research to consider other dimensions and indicators of food security. As such, while our research shows that intensification has the potential to produce win-win-win outcomes, limitations do suggest that some caution is warranted. Further research into intra-household effects and impact heterogeneity issues, including those related to conditions under which households make decisions, is needed to arrive at more definitive conclusions.

2.6.1 Policy implications

For policy targeting and LEDS design purposes, we do urge that the wider production systems in which dairy production is to be intensified be more explicitly considered, particularly for the majority of smallholders that are currently practicing semi-intensive and extensive dairy farming. This can for example be done by targeting systems where crops whose residues can function as (sufficiently nutritious) animal feed and where soils stand to particularly benefit from organic amendments, or by helping farmers that aspire to intensify dairy to fully exploit synergistic potentials. This requires geographically grounded approaches that account specifically for the pluriactive nature of rural livelihoods in low and middle-income countries.

We expect our results to be relevant to low and middle-income countries, where rural dairy-producing communities are typically accustomed to crop-livestock integration. However, in countries where commercial dairy markets are less developed, increasing milk production without having the markets needed to absorb more milk may instead produce greater milk losses and reduce farmers' ability to recover incurred costs. In such contexts, sector commercialization objectives need to feature explicitly in intensification strategies and associated policies. However, although some of the semi-intensive households have the resources to intensify, it might not make financial sense, or they prefer to prioritize other livelihood activities.

With intensification also featuring in climate - and poverty alleviation policy discourse for a wide diversity of agricultural activities, whether a virtuous relationship between intensification and diversification can be observed outside dairy (and how that can be maximized) is supremely relevant to increasing food production within planetary boundaries, while also safeguarding the environmental services generated through diversified (agroecological) smallholder production systems.

2.7 Conclusion

Sustainable development policy increasingly emphasizes sustainable agricultural intensification, particularly for livestock, including dairy in East Africa, due to their relatively high, reducible GHG emissions. This article examined whether intensification is pro-poor, as policymakers claim, and as LEDS assume, via exploring potential adverse impacts of dairy intensification on household well-being due to resource diversion. Contrary to our concerns, the results reveal that households with intensive dairy production are more diversified, better able to accumulate livelihood assets, and have more diversified diets, supporting recent policy initiatives focused on dairy intensification. Albeit with caveats, these results partly legitimize recent enviro-centric policy and LEDS innovations focused on intensifying dairy and suggest that a 'win-win-win' can under certain conditions for certain households be achieved. We do however find that semi-intensive households are less diversified than extensive and intensive farmers. In addition to the policy relevance, the study addresses a gap in agricultural development literature, emphasizing the intricate and potentially additive relationship between intensification and livelihood diversity in dairy and other sectors.

Chapter 3

From fix to fit: Connecting low-emission development with multi-level smallholder dairy practices in Kenya

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3 From fix to fit: Connecting low-emission development with multi-level smallholder dairy practices in Kenya

3.1 Abstract

Livestock production systems show high levels of greenhouse gas (GHG) emissions. Consequently, smallholder livestock production systems are targeted for realizing mitigation gains based on Low-Emission Development Strategies (LEDS), which promote the adoption of so-called best agricultural practices for mitigation gains, while also expecting to contribute to socio-economic development. However, the alignment between LEDS and the varied realities of smallholder farmers is not self-evident. This study, therefore, aims to connect LEDS and smallholder realities, specifically in Kenya's dairy sector. We do so by analysing variation of current dairy practices at household and regional levels and explaining this from household socio-economic characteristics and conditions in spatially bounded regions. To typify smallholder heterogeneity, we identified six clusters based on a multivariate analysis with data from 1009 households in three regions in Kenya. Next, the research aggregates household data to show variation in uptake of LEDS at the level of the three regions and uses qualitative data to contextualize the observed variation in uptake of Low-Emission Development (LED)-practices. After connecting household and regional level analysis of dairy practices, we identify starting points for LEDS design attuned to variation in smallholder dairy realities at multiple levels. This reframes the adoption problem, usually seen as the low uptake of ideal-typical and technical solutions (or 'fixes') and shifts the design focus to finding spaces that create a 'fit' between development goals and situated smallholder priorities and capabilities.

3.2 Introduction

In response to the global climate crisis, the environmental policy community is increasingly prioritizing the reduction of greenhouse gas (GHG) emission intensities (kg of CO_2-eq./kg of animal product) from livestock sectors (Mrówczyńska-Kamińska et al., 2021), which globally account for 65% of total GHG emissions from agriculture (Tubiello et al., 2014). In the Global South, most livestock production is performed by smallholders (Herrero et al., 2017). Therefore, smallholder livestock production systems are often identified as an opportunity for mitigation gains (Havlík et al., 2014; Herrero et al., 2016) along with potential for socio-economic development (Kihoro et al., 2021). The latter is foreseen through assumed increasing incomes from livestock such as milk sales because of adopting mitigating practices. The dual objectives of environmental and socio-economic development have led to the concept of Low-Emission Development Strategies (LEDS), generally understood as 'forward-looking national development plans or strategies that encompass low-emission and/or climate-resilient economic growth' (Clapp et al., 2010: 3). LEDS targeting dairy sectors in the Global South emphasize the uptake of practices to increase productivity while delivering high-quality protein with a lower per capita environmental footprint (Gerber et al., 2013).

The smallholder population is, however, very diverse, and successful LEDS uptake is contingent on donor and state ability to align LEDS with diverse local development conditions, capacities, and priorities (Kihoro et al., 2021; Yesuf et al., 2021). LEDS might have unintended effects and effectiveness problems because its success depends on largely on effective uptake of mitigation practices by livestock owners. In addition to threatening the success of climate change mitigation ambitions, limited sensitivity to the diverse realities in which these initiatives are embedded can have detrimental effects on social equity and inclusion (see for example Clay & King, 2019; Karlsson et al., 2017; Tavenner et al., 2019). To investigate the commensurability of LEDS and local diversity in the context of Kenya, this study aims to answer the question: 'What mechanisms and interactions determine the alignment between global and national LEDS and diverse smallholder priorities and capabilities?' This paves the way for discovering starting points for LEDS aligned with diverse smallholder practices and realities and to enhance the overall success of LEDS implementation.

This study specifically aims to inform LEDS design to align with diverse smallholder practices and realities for Kenya's dairy sector. In East Africa, dairy is typically part of a complex portfolio of livelihood activities of households in mixed crop-livestock farming systems (Scoones, 2009), which are often typified as low-input systems (Abraham & Pingali, 2020) and with considerable yield gaps (Henderson et al., 2016). The Kenyan government has identified the dairy sector for developing LEDS due to relatively high GHG emission intensities and clear technical pathways for gains, as well as socio-economic development needs (Bosire et al., 2016; Ericksen & Crane, 2018; van Dijk et al., 2015). LED-practices for dairy are effectively the same as dairy intensification practices, and focus on improving feeding, manure management, animal health and husbandry practices (Ericksen & Crane, 2018). The emphasis in many climate change policies and intervention strategies on pre-defined technological packages characterizes LEDS as having a top-down 'single-fix' design, which may result in sub-optimal adoption rates (Glover et al., 2016). This paper shifts focus to pathways that are responsive to smallholder and regional diversity in three counties in Kenya, which can inform the 'starting point' of LEDS that 'fit' diverse local and regional realities.

In the paper, we first present the context and explain our methods. The results section starts by analysing farm households and presenting a household typology. We also aggregate the household level data to the three counties. We then investigate what the farmers do by assessing how their current dairy practices align with advised LED dairy practices (Ericksen & Crane, 2018), both at household and at county level. For this purpose, the household typology is situated within the institutional environments that shape how households navigate and select practices. Nesting households within regions helps identify how LEDS can better account for geographic contexts. This integrative perspective adds to the growing body of research on smallholder dairy systems that are being targeted for climate change mitigation and adaptation initiatives.

3.3 Materials and Methods

3.3.1 Research areas

Our analysis draws on data from Murang'a, Nandi and Bomet counties in Kenya where dairy is one of the leading agricultural sectors contributing to rural livelihoods. Kenya's dairy subsector contributes 4% to national Gross Domestic Product (GDP), worth 100 billion Kenyan Shillings (KES), with a growth rate of 3 to 4% per year. The dairy subsector contributes 40% of the agricultural GDP. Milk consumption in Kenya is among the highest in Sub-Saharan Africa at an estimated 110 litres per person per year and is expected to grow to 220 litres per person per year in 2030. This translates into a projected annual production increase from 4.5 billion litres to 12.76 billion litres of milk in 2030. The average productivity level per cow per day is 5 litres (MoALF, 2010). Smallholder producers owning one to three cows contribute to about 80% of total milk production, and the sector is estimated to employ two million people directly or indirectly (TIAPD, 2021). Of all marketed milk, an estimated 15% is absorbed by commercial processors, with the remainder sold raw or processed through cottage industry. Kenya's three largest processors control about 85% of the formal market (Kimenju et al., 2017).

Kenya's livestock production systems are faced with major environmental problems. In Kenya, agriculture is the leading source of GHG emissions, contributing 63% of total emissions in 2019 (Climate Watch 2023). Of these agricultural emissions, 55% was estimated to be from enteric fermentation from livestock, and 37% due to manure left on pasture (USAID 2017). Livestock emissions are expected to increase in Kenya, mainly driven by a rising demand for meat and milk due to an increasing population, urbanization, and rising incomes. The Kenyan government is committed to reducing this impact: the livestock sector is central to Kenya's climate ambitions. Therefore, a Nationally Appropriate Mitigation Actions (NAMA) specific to livestock was developed that aims to cut emissions by 8.8 Mt CO_2-eq. over a 10-year period (Mbae et al., 2020).

The study sites (Table 3.1) were selected for their production potential, ecological significance and relevance to national dairy development priorities and policy processes. Murang'a is dominated by more intensified dairy systems. Located in the former Central Province near the capital Nairobi, population pressure is comparatively high and efforts to formalize milk markets are explicitly pursued by the county government (Murang'a county government, 2018). Milk from Murang'a that is not consumed locally is typically sold in Nairobi. While tea is an important cash crop, coffee, banana, and mango are also commonly cultivated in the county. The county has benefitted from significant public sector investment in dairy, resulting in a large farmer-owned milk cooling and marketing infrastructure competing with numerous commercial processors. Along with counties such as Kiambu, it is perceived as a dairy frontrunner due to high adoption of zero-grazing systems.

Table 3.1: Characteristics of the three counties.

Characteristics	Unit/description	Murang'a	Nandi	Bomet
Precipitation	Mm/year min-max	400-1600	1200-2000	1000-1400
Altitude	Meters above sea level	900-3300	1400-2300	1700-2500
Area	km^2	2,559	2,884	2,037
Population	Persons	1,128,177	1,022,380	891,168
Population density	Persons/km^2	441	354	437
Dairy cattle population	Number	239,750	223,943	297,439
Dairy system	Dominant dairy system	Intensive	Semi-intensive	Semi-intensive

Source: Extracted from Murang'a county government, 2018; Nandi county government, 2018; Bomet county government, 2018.

The other two sampled counties, Nandi and Bomet, are both located within the former Rift Valley Province and are united under the Lake Region Economic Bloc (LREB). In both counties, semi-intensive dairy systems dominate, expressing milk production per unit of land. Smaller pockets in Nandi North and Bomet West produce dairy more intensively. Tea is the main cash crop in both counties, with food crops such as maize, beans and potatoes cultivated by most households. At lower elevations in Nandi, sugarcane replaced tea as an important cash crop. Most of the milk produced in Nandi and Bomet is sold within the towns in the counties or large urban centres such as Eldoret and Kisumu. While most of the milk reaches consumers via intermediaries, large processors also source directly from these counties.

3.3.2 Research design

To find starting points for LEDS responsiveness to diversity, we aim to qualify the diversity of smallholder practices and realities at the household and regional levels. First, we characterize farmer households and farming system diversity by developing a data-driven typology (Alvarez et al., 2018; Schoneveld et al., 2019). This aligns with the work of other scholars who typify dairy smallholders in Kenya and the East African region by exploring variations in resource endowment and commercialization (low, moderate, and high) (Otieno et al., 2021) and gender of the household head and major income categories (Owino et al., 2020b). Other farm system typologies in Kenya find variations in livestock (not explicitly dairy) activities being part of distinct specialized and diversified (Musafiri et al., 2020) and conventional and organic farming systems

(Kamau et al., 2018). For a combined dataset of Kenya and Tanzania, dairy households are typified according to livelihood strategies, either specialized on dairy, diversified, or off farm oriented (Hawkins, 2021). For this study, we build on earlier work in Tanzania (Kihoro et al., 2021), where six distinct dairy farmer types were identified, ranging from marginalized to wealthier groups, with subsistence or commercial dairy orientations, and with dairy activities as specialization and as part of a more diversified livelihoods (both on – and off farm).

Second, complementary approaches to understanding and characterizing diverse smallholder realities, often for sustainable intensification efforts, adopt a regional perspective (Ollenburger et al., 2019). This responds to limitations of household and farm system typology studies that tend to treat farming systems and households in isolation, by instead focusing on embedding households and farm systems within specific historical contexts and broader institutional environments. This resonates with the observed need for context-sensitive institutional diagnostics to identify how to gear the institutional context towards desired socio-economic development goals (Schouten et al., 2018). Methodologically, this entails adding qualitative insights to statistical analyses (see e.g. Kihoro et al., 2021; Schoneveld et al., 2019). In this research, these suggestions are integrated, and current smallholder farming practices both from a farming household typology level and an administrative regional level, are explored.

3.3.3 Data Collection

The research followed a mixed-methods design. Firstly, we administered a structured questionnaire with 1050 households. This questionnaire was loosely based on the Rural Household Multi-Indicator Survey (RHOMIS) (Hammond et al., 2017) and covered topics such as household demographics, household assets, livelihood activities, dairy and crop management practices, milk marketing, production output, revenues and costs and household psycho-social attributes. Following data cleaning, 1009 households were retained for our analysis: 338 from Murang'a, 330 from Nandi, and 341 from Bomet.

A two-stage stratified random sampling technique was used to select households for the study. A more detailed description of the sampling strategy and survey instrument can be found in the study by Kihoro et al. (2021). First, a spatial cluster analysis was conducted to identify areas with similar agro-ecological characteristics within each county using rainfall, temperature, and elevation data. Following this, 36 locations were randomly selected across the agro-ecological zones (AEZs) in each county; the number of locations per zone were proportionate to the relative size of each zone in the counties. Villages closest to each location were selected for inclusion in the study.

Households were then randomly sampled in each village, based on sample frames constructed in collaboration with local authorities and leaders, consisting of all households with at least one cow or an in-calf heifer. The number of farmers sampled per village was then informed by the relative size of each sample frame. Figures 3.1 and 3.2 present the AEZs and sampled villages in the research sites. Compared to other semi-arid and arid regions in Kenya, these three counties are relatively similar in terms of agroecology, but with a transition area to semi-arid AEZs in the East of Murang'a.

To contextualize and improve interpretation of our quantitative analysis, qualitative data generation activities were performed. This involved interviews with key informants (n=46) in each county in 2018, and workshops in Nandi (n=2) and Bomet (n=2) in 2019 (see Yesuf et al., 2021). Topics included the history of the dairy sector in the counties, current dairy development initiatives, preferences, and priorities, and the role of the state and private sector.

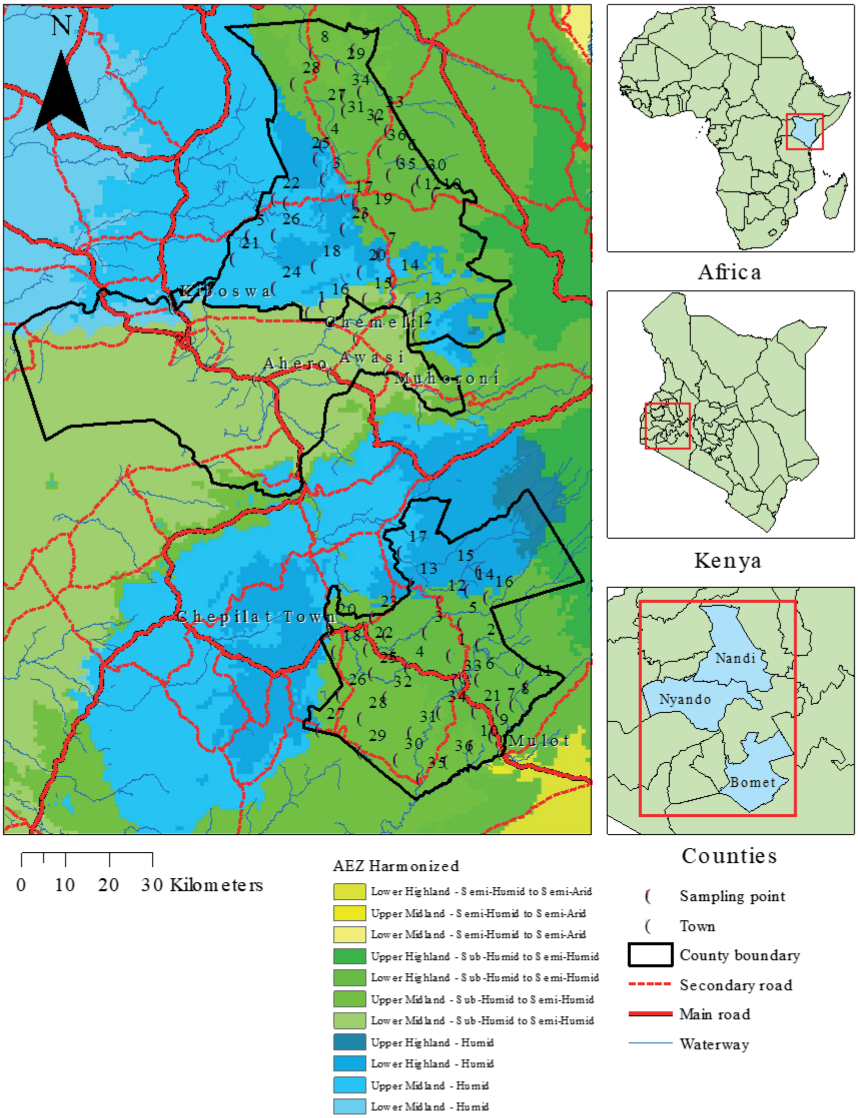

Figure 3.1: Agro-ecological zones and sampled villages in Nandi and Bomet.

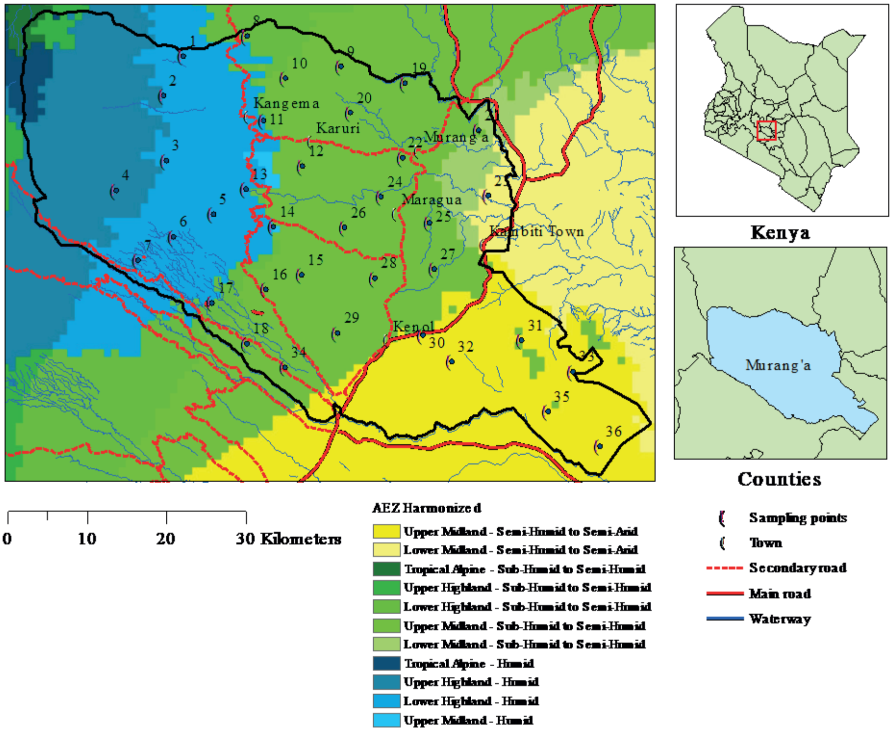

Figure 3.2: Agro-ecological zones and sampled villages in Murang'a.

3.3.4 *Data Analysis*

The next subsections present the methods used to analyse what types of farmers are located where, what different types of dairy practices these adopt, and implications for context sensitive LEDS.

3.3.4.1 Developing Farmer Typologies

To develop the farmer typology, we follow the clustering procedure employed by Schoneveld et al. (2019) that only uses socio-demographic data rather than also farm practice data as is often the case. This allows for an analytical separation between farming practices and the farmer; thereby facilitating the exploration of the relationship between what a farmer is and what a farmer does (*ibid.*).

Creating typologies involves classification, comparison, and explanation of defined elements (Alvarez et al., 2018). This allows for a synthesis of multiple elements into fewer elementary types or themes. Cluster analysis was employed using the DAISY package in R (3.5.1). DAISY uses Gower distance and partitioning around medoids

(PAM), where portioning creates clusters that have the greatest within-group similarity and high between-group dissimilarity. This approach is preferred to the commonly used k-means algorithm when using mixed type data. Because the ideal number of clusters is not pre-defined in this approach, silhouette width from PAM and dendrograms were used to identify the appropriate number of clusters (Mooi & Sarstedt, 2011). To preserve the underlying data structure, we did not perform a Principal Component Analysis (PCA).

Following expert consultation and validation workshops, 17 defining socio-economic variables were selected for the clustering (Table 3.2). These include demographic variables (Alvarez et al., 2018), and variables that represent livelihood activities and asset endowment, influencing the strategic orientation of households (Dorward et al., 2009; Tittonell, 2014). Livelihood activities were calculated as dummy variables representing whether a household was engaged in the activity or not (Schoneveld et al., 2019). Since we do this analysis to inform LEDS for dairy, income from dairy sales was weighted three times heavier than the other variables in the model. Analysis of variance (ANOVA) was employed to test for significant differences between clusters (for continuous variables) and chi-square tests were used for categorical variables (Kihoro et al., 2021; Michalscheck et al., 2018).

Table 3.2: Variables used to cluster producers.

Variable	Mean (SD)	Description	Proxy for
Age [years]	53.81 (14.47)	Age of the household head [years]	Demographic
Gender household head [% male]	79.58 (40.33)	Gender of the household head [1 = male, 0 = female]	Demographic
Education [ordered]	3.27 (1.16)	Highest completed education of household head. Ordinal with 6 levels [0 = no formal education, 1 = primary 1-4, 2 = primary 4-8, 3 = secondary 1-4, 4 = college, 5 = university]	Demographic
Ethnicity [% indigenous]	88.40 (32.03)	Dummy variable for indigenous to the area [1 = yes, 0 = no]	Demographic
Household size [number]	5.20 (2.18)	Household members [number]	Demographic
Land [acres]	3.82 (4.15)	Total land holding [acres]	Asset endowment
Assets [index]	0.53 (0.15)	Asset index [score]	Asset endowment
TLU [index]	3.45 (2.36)	Total livestock numbers expressed in Tropical Livestock Unit [score]	Asset endowment
Group Membership [%]	56.19 (49.64)	Dummy variable for group membership [1 = yes, 0 = no]	Asset endowment
Dairy [%]	80.67 (39.51)	Dummy variable for income dairy [1 = yes, 0 = no]	Livelihood activities
Other livestock [%]	47.47 (49.96)	Dummy variable for income other livestock [1 = yes, 0 = no]	Livelihood activities
Food crops [%]	53.12 (49.93)	Dummy variable for food crops revenue [1 = yes, 0 = no]	Livelihood activities
Cash crops [%]	62.93 (48.32)	Dummy variable for cash crops revenue [1 = yes, 0 = no]	Livelihood activities
Casual employment [%]	19.62 (39.73)	Dummy variable for casual income [1 = yes, 0 = no]	Livelihood activities
Formal employment [%]	19.33 (39.51)	Dummy variable for off-farm formal [1 = yes, 0 = no]	Livelihood activities
Business [%]	31.52 (46.48)	Dummy variable for off-farm business [1 = yes, 0 = no]	Livelihood activities
Other income [%]	20.02 (40.03)	Dummy variable for non-labour income (remittances, dividends, pension) [1 = yes, 0 = no]	Livelihood activities

Various clustering procedures produce different results (Alvarez et al. 2018). Factors not considered in this clustering exercise were the diversification strategies of households (Waha et al., 2018), intra-household dynamics (Michalscheck et al., 2018), and agroecological potential, although the agroecological conditions of the included study sites were quite similar and accounted for in the sampling of households. Finally, although the survey questions explicitly meant to incorporate what dairy practices households generally employ, their practices may vary throughout years and seasons, which is not reflected in modelling results.

3.3.4.2 LED Dairy Practices

Subsequently, we sought to determine whether different clusters of farmers are associated with different LED adoption rates. For this, LED-practices were grouped into (1) feeding, (2) animal health and husbandry, and (3) manure management (Table 3.3). Feeding and animal health and husbandry practices contribute to LED by reducing emission intensities. Improved manure management practices contribute to reducing absolute emissions (Ericksen & Crane, 2018). Using these variables, a composite indicator was created using factor analysis to express household uptake of all above mentioned variables, scaled from 0 and 1 (Nardo et al., 2005).

Table 3.3: Low-emission dairy practices at household level.

	Variable	Mean (SD)	Description
Feeding	Grow fodder [%]	77.50 (41.78)	Dummy variable for growing improved fodder
	Feed concentrates [%]	49.26 (50.02)	Dummy variable for feeding cattle concentrates
	Feed conservation [%]	11.10 (31.43)	Dummy variable for practicing feed conservation
	Fulltime water access [%]	34.79 (47.65)	Dummy variable for cows having fulltime access to water
	Zero grazing [%]	29.93 (45.82)	Dummy variable for practicing zero-grazing
Animal health and husbandry	Crossbred cows [%]	92.17 (26.88)	Proportion of crossbred as opposed to indigenous cattle
	Inseminate using AI [%]	42.12 (49.40)	Dummy variable for artificial insemination (AI)
	Spray at least every three months [%]	69.28 (46.16)	Dummy variable for spraying/dipping against ticks at least every three months
	Deworm at least every three months [%]	74.73 (43.48)	Dummy variable for deworming cattle at least every three months
Manure management	Collect and use manure [%]	70.37 (45.69)	Dummy variable for collecting and using manure on farm
	Use manure within 3 months [%]	42.72 (49.49)	Dummy variable for using manure on farm within 3 months after collecting
	Biodigester [%]	0.99 (9.91)	Dummy variables for having a functional biodigester

Between-cluster differences were subsequently analysed, descriptively. To uncover more structural dimensions shaping LED uptake, county differences were analysed. Different patterns emerge when analysing and contrasting uptake at the county and cluster level. Chi-square or ANOVA tests makes it possible to determine statistically significant differences between the uptake of the practices between the farmer clusters in the three counties. Findings are elaborated based on (regional) history of the dairy sector, socio-political conditions, and regional dairy development priorities and preferences in the counties (Yesuf et al. 2021). Finally, patterns resulting from the statistical analysis were contextualized based on additional survey data and qualitative data from key informant interviews and group discussions by the authors.

3.4 Results

This section assesses the (potential) alignment between ideal typical LED-practices and observed uptake. It investigates uptake through a demographic and socio-economic lens as well as a geographic/county-level lens. First, the results of cluster analysis present a household typology to typify who the smallholders are; we also know where they are located. We then explore what smallholders do in terms of current LED-practices, both at the household level and by aggregating the data to the county level. Different narratives emerge when examining the household dairy practice data at the household and county level. These different narratives are then combined and explained, leading to the identification of possible starting points for enhancing the alignment between LED-practices and diverse multilevel local realities.

3.4.1 Farmer Typology

The statistical cluster analysis points to a six-cluster solution, meaning six statistically distinct groups of households can be discerned. The household clusters are described below based (Table 3.4 and Figure 3.3).

Table 3.4: Characteristics of farmer clusters.

Variable	1	2	3	4	5	6	Chi/F-Statistic
Total cluster size [n]	166	105	245	90	287	116	
Total cluster size [%]	16.45	10.41	24.28	8.92	28.44	11.50	
Demographic							
Age [years]	49.15	53.56	57.86	57.02	53.94	49.32	10.93***
Gender household head [% male]	83.73	78.10	75.92	83.33	75.26	90.52	16.54***
Education [ordered]	3.56	2.78	2.98	3.12	3.13	4.38	36.88***
Ethnicity [% indigenous]	89.76	85.71	93.47	86.67	85.37	87.07	10.22*
Household size [number]	5.47	4.88	4.77	5.7	5.17	5.69	5.15***
Asset endowment							
Land [acres]	2.85	2.90	3.73	5.58	4.07	4.26	6.73***
Assets [index]	0.56	0.48	0.51	0.52	0.52	0.62	14.65***
TLU [index]	3.34	2.53	3.00	3.89	3.82	4.10	9.22***
Livelihood activities							
Group Membership [%]	78.92	24.76	17.55	67.78	74.56	79.31	295.01***
Dairy [%]	100	0	100	0	100	100	1000***
Other livestock [%]	27.11	27.62	19.18	63.33	78.05	66.38	256.14***
Food crops [%]	27.12	19.05	29.80	67.78	87.46	74.14	311.79***
Cash crops [%]	20.48	31.43	77.55	75.56	76.66	77.59	235.35***
Casual employment [%]	16.87	26.67	14.69	26.67	25.44	7.76	27.21***
Formal employment [%]	10.24	19.05	10.61	17.78	0	100	573.84***
Business [%]	77.71	25.71	11.43	32.22	27.53	22.41	218.15***
Other income [%]	16.87	20.95	20.00	24.44	21.60	16.38	3.60

*** significant at 1% level

* significant at 10% level

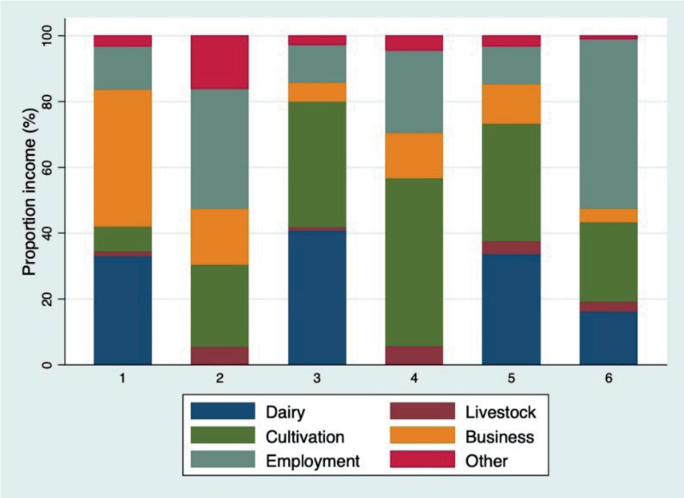

Figure 3.3: Relative importance of different livelihood sources.
Note: 'Cultivation' includes cash crops and food crops, 'Employment' includes formal and casual employment; 'Other' includes remittances, pensions, and dividends. X-axis represents the six clusters.

Cluster 1: Entrepreneurs
This group consists of comparatively young, educated, and affluent farm households, who have above-average incomes and assets. They have diverse sources of income, with most of them earning mainly from entrepreneurship or other off-farm activities. Dairy is important for their livelihoods, but they own less land than other groups and grow fewer food and cash crops. They are active in farmer groups that focus on dairy.

Cluster 2: Vulnerable Farmers (Subsistence)
This group consists of the most vulnerable farmers who have the smallest land size, the lowest livestock units, and the lowest wealth index scores. They have low levels of education and income diversification and rely strongly on casual employment. Dairy is not produced for sale, but for subsistence, due to labor and capital constraints. With comparatively few households involved in cultivation activities, they have little involvement in farmer groups and farm-based income activities. This group is the second smallest, representing about 10% of the total sample.

Cluster 3: Dairy-Oriented Farmers
This group earns more from dairy than from any other sources, but generally also grow cash crops and to a lesser extent food crops. Since households' focus lies on the tea-dairy combination, few are engaged in off farm activities. Farmers in this cluster are often older, less affluent and asset endowed than most. This group and the dairy farm specialists (cluster 5) make up more than half of the total sample.

Cluster 4: Non-Dairy Farm Specialists (Subsistence)

This group does not produce dairy for sale, but only for consumption. They are relatively wealthy and have more assets than most. They participate in diverse on-farm activities, partly because they own the largest average land size. They grow a variety of food and cash crops, which make up most of their income. Even though they have the resources to produce dairy, cropping activities are ostensibly preferred.

Cluster 5: Dairy Farm Specialists

Most in this group are active in across most farm activities, including dairying, which is a major source of income for them. They are similar to clusters 3 and 4, but more actively involved in farmer groups, other livestock activities and food crop cultivation. Despite being slightly less affluent and asset endowed than farmers in cluster 4, their on-farm diversification is similar. A variety of food and cash crops are grown by these farmers. None of them have formal employment. This is the largest cluster, representing more than a quarter of the total sample (28.4%), and more than three times larger than the smallest cluster (cluster 4).

Cluster 6: Formally Employed

This group has the highest wealth among dairy farmers, with incomes about three times higher than the median. Despite owning the largest number of cows, dairy production for sale is not their main income source, with all relying on formal employment, mainly in public service or education. Their livelihoods are diverse, with various crops supplementing their salaries. Household heads in this cluster are comparatively young and have high education levels.

3.4.2 Uptake of LED-Practices

Based on the composite indicator, uptake of LED-practices is highest among the formally employed (0.47), followed by entrepreneurs (0.42), dairy farm specialists (0.41), dairy-oriented farmers (0.39), non-dairy farm specialists (0.39), and vulnerable farmers (0.28). Uptake in the counties is highest in Murang’a (0.,48), followed by Nandi (0.39) and Bomet (0.30). Figures 3.4 and 3.5 show uptake per household cluster and county, respectively, for each LED practice.

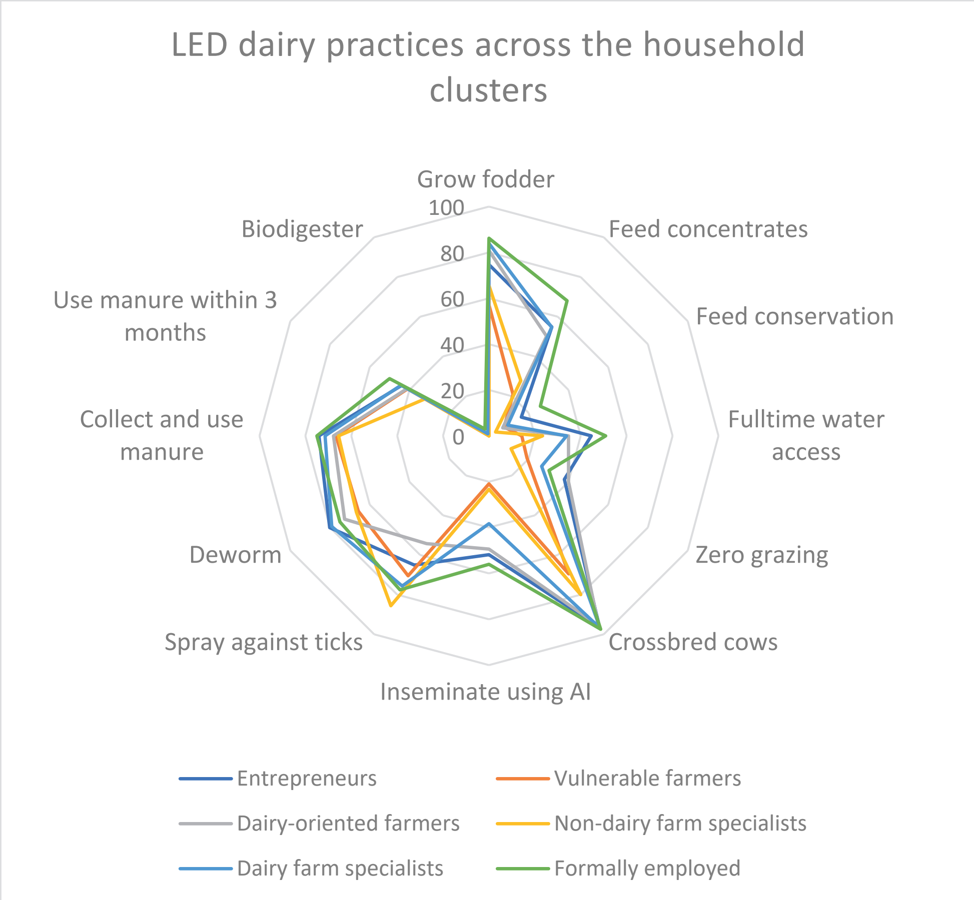

Figure 3.4: LED dairy practices across the household clusters. Y-axis: percentage (%) of total households.

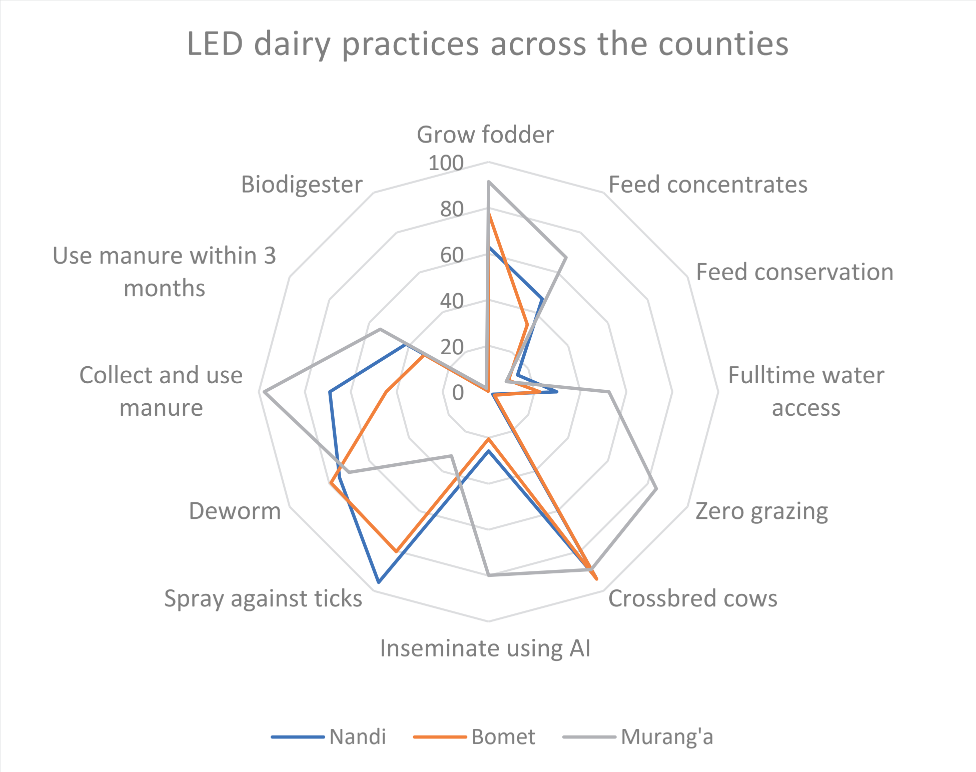

Figure 3.5: LED dairy practices across the counties. Y-axis: percentage (%) of total households.

Interestingly, the graph shape in Figure 3.4 does not drastically differ between clusters, suggesting a similar LED uptake practices, either relatively high uptake (e.g., crossbred cattle), or relatively low uptake (e.g., biodigesters). There are, however, slight uptake differences for most practices where similar clusters show slightly higher or lower uptake than others, with the most affluent farmers (e.g., entrepreneurs and formally employed) most intensified. As expected, farmers not engaged in milk marketing (e.g., vulnerable farmers and non-dairy farm specialists) adopt fewest LED-practices.

In contrast, the shape of county graphs (Figure 3.5) shows more variation in uptake of practices, particularly between Murang'a and the other two counties. Zero grazing systems are, for example, adopted by most sampled households in Murang'a but by nearly none in Nandi and Bomet. The uptake of zero-grazing has knock-on effects on other LED-practices; for example, there is more manure collection since cattle are confined, growing fodder since cattle do not graze, and fulltime access to water. Additionally, spraying against ticks is much less frequent in Murang'a compared to

Nandi and Bomet, presumably because cattle are not roaming freely, thus reducing the risk of ticks.

3.4.3 Multilevel Uptake of LED-Practices

This section explores the LED-practices of household clusters within each county, thereby combining findings about dairy practices at household cluster level and county level for a more comprehensive understanding of dairy practices uptake. Figure 3.6 shows the distribution of the household clusters across the counties.

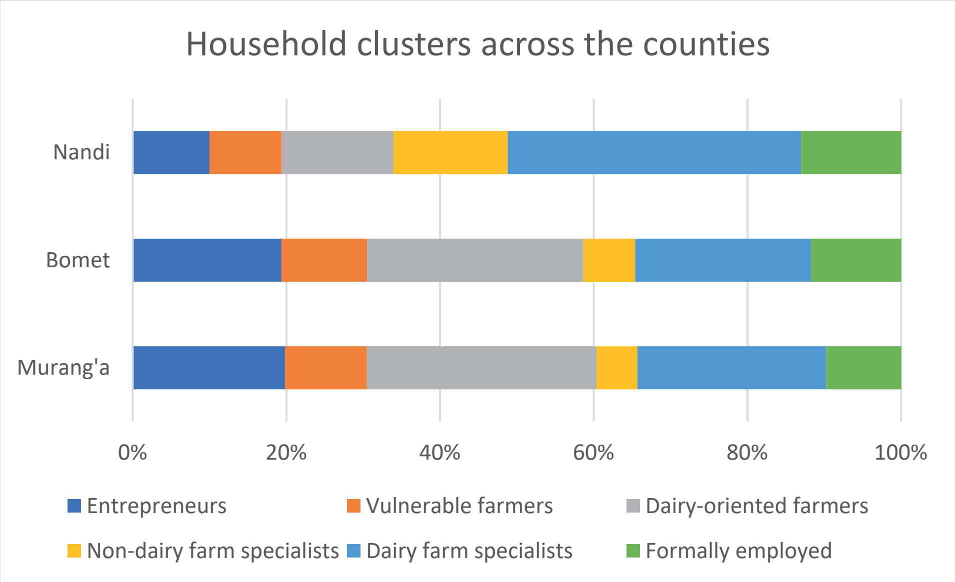

Figure 3.6: Household clusters across the counties.

From the previous section we might expect that household clusters with greatest LED dairy practice uptake are in Murang'a: the county with greatest LED dairy uptake. Figure 3.6 however indicates that we cannot assume this. Namely, the six household clusters are relatively equally distributed across the counties, especially between Bomet and Murang'a. In Nandi, we see a comparatively large number of non-dairy farm specialists and dairy farm specialists, and comparatively few dairy-oriented farmers and entrepreneurs. This reveals that despite overall higher uptake of LED-practices in Murang'a, when looking at who the farmers are, there are close to equally distinct household clusters to be identified compared to areas with lower overall uptake of LED-practices.

To further reveal what can be learned about the uptake of LED-practices, we integrate variation among household clusters in the three counties. Table 3.5 explores what smallholders do and shows the differences in uptake of LED-practices between the clusters within the counties.

Table 3.5: LED-practices among household clusters in the counties.

LED-practices	**Household clusters in Nandi**	**Household clusters in Bomet**	**Household clusters in Murang'a**
Grow fodder	1 5 6	3 4 5 6	3 5 6
Concentrates	1 5 6	5 6	1 3 5 6
Feed conservation	1 6	1 6	1 6
Fulltime water access	1 6	1 5 6	1 3 5 6
Zero-grazing			1 3 5 6
Crossbred cows	1 3 5 6	1 5 6	1 3 5 6
Artificial insemination	1 6	4 6	1 3 5 6
Spray against ticks		4 5 6	
Deworm	1 5 6		
Collect and use manure			
Manure use within 3 months			3 5 6
Biodigester			
Overall (CI)	1 5 6	1 5 6	1 3 5 6

	Highly significant difference (<0.01)
	Somewhat significant difference (<0.05)
	Weakly significant difference (<0.1)
	No significant difference

The colours show if there are statistically significant differences between the six clusters in the three counties. The numbers indicate the clusters that perform better than the expected value (mean). Numbers represent the clusters: 1=Entrepreneurs, 2=Vulnerable farmers, 3=Dairy-oriented farmers, 4=Non-dairy farm specialists, 5=Dairy farm specialists, and 6=Formally employed.

The dominance of the dark green colour in the table suggests that for most LED-practices there are highly significant differences in uptake between household clusters within counties. Red indicates that for some practices the uptake differences between the clusters is not significant within counties, suggesting more structural reasons for low uptake. Given that there are county differences for practices with red coloured cells, more structural reasons can differ per country. Additionally, some practices show rather consistent uptake among certain household clusters. This could still suggest structural reasons where some household clusters are willing and able to perform certain practices, in combination with household cluster specific priorities and capabilities such as resource endowment and market orientation. Particularly in

Murang'a, the entrepreneurs, dairy-oriented farmers, dairy farm specialists, and formally employed typically are clusters that consist of households that have adopted certain practices more than the average adoption of the total sample. For most practices in Nandi and Bomet, the entrepreneurs, dairy farm specialists, and formally employed have also adopted the practices above average. In Nandi and Bomet, with few exceptions, dairy-oriented farmers have however not adopted these practices above average, in contrast to Murang'a. Bomet is the only county where non-dairy farm specialists have above averagely adopted some of the LED dairy practices.

3.4.4 Explaining Variations in Uptake of LED-Practices

In designing better LEDS, reasons for LED-practice uptake variations must be uncovered. This requires contextualizing quantitative results through qualitative data. We start with regional conditions, followed by household clusters and LED dairy practices, thereby first zooming out to the regions, before zooming into households and practices. Bringing these levels together helps identify entry points for designing LEDS. LEDS that are tailored more to diversity of circumstances shaping household decisions. Because farmers in Murang'a adopt more LED-practices, this section compares Murang'a to Nandi and Bomet.

3.4.4.1 Regional Conditions

Except biodigesters and feed conservation, households in Murang'a practiced most LED-practices and are closest to the 'ideal prototype' of what smallholders with dairy cows are capable of. Three region-specific aspects for Murang'a explain this, namely (1) land size, (2) proximity to a large market, and (3) local political economy. Promoting LED within extensive and semi-intensive systems demands a different approach to LED in zero-grazing systems. Promoting zero-grazing for all is not the only pathway, especially in land abundant areas where free grazing remains viable. In Murang'a, the transition to zero-grazing was born out of necessity due to increasing land use competition and pressure. Because of declining land sizes, land fragmentation, and high land costs, zero grazing systems are the only option for many wishing to keep dairy cattle. Respondents in Murang'a only owned 2.26 acres of land, compared to 3.71 acres in Bomet and 4.97 acres in Nandi.

Murang'a is closest to the capital Nairobi, the main milk market of the country, which has attracted companies and encouraged local leaders to heavily invest in and support the dairy sector. Particularly heavy investments have been ongoing in formalizing milk markets via organizing milk suppliers in farmer cooperatives, and all farmer cooperatives in a union. A processing plant was opened to increase in-county processed milk and school milk programs were set up to guarantee a market for the milk that the union was collecting. Agricultural extension programs were intended to reaching majority of farmers in the county via the farmer cooperatives. The survey data showed that households in Murang'a sold significantly more (but not majority of the milk) to formally organized (farmer cooperatives) and large-scale commercial (processors) market outlets, compared to Nandi and Bomet where households sold significantly more directly to individual customers, middlemen. A combination of these location specific factors in Murang'a resulted in the dominance of zero-grazing systems and subsequently of a higher average uptake of LED-practices.

Future dairy development trajectories in Nandi and Bomet will most likely be influenced by similar land pressure largely due to the practice of subdividing land among children. Both county governments have similar dairy development ambitions in terms of formalizing the sector, and representatives of the counties went for 'benchmarking' trips to Murang'a to learn how they have organized the establishment of the union and a union-owned processing plant. Some of the largest and growing cities (and milk markets) besides Nairobi are not far, such as Kisumu and Eldoret.

These developments are taking place in a context of government decentralization (devolution) in Kenya, which was initiated in 2010, meaning that the decisions on how government funds are distributed are taken at regional levels (counties) as opposed to a national level. This has fuelled local political leadership ambitions to align with household ambitions to get/stay in the local government. Because the dairy sectors are significant in each of the three counties, there are also political reasons for (promises of) investments and efforts to formalize the dairy sector. It is, therefore, worthwhile to investigate how LEDS could position itself in relation to this political context.

3.4.4.2 Household Clusters

The dairy-oriented farmers are most specialized in dairy (closely followed by cash crop cultivation), yet in Nandi and Bomet, households in this cluster are practicing most LED-practices below average, as opposed to Murang'a. In Bomet, non-dairy farm specialists are even practicing above average for more practices than the dairy-oriented farmers. The main differences for the dairy-oriented farmers with Murang'a are in the uptake of feeding (incl. watering) and herd management practices. In Nandi and Bomet, cattle are in grazing systems, either free grazing, tethered or rotation grazing on their own -, government -, or rented land. Guaranteeing 24-hour access to water might not be a priority since the cattle keeps moving, and this would then bring extra work for organizing constant water supply. Investing in additional feeding is only possible if you are willing and have the means to invest.

It requires closer investigation to understand why non-dairy farm specialists in Bomet have above-average uptake of some LED-practices, over dairy-oriented farmers. It could be that other farm activities of the non-dairy farm specialists prove so versatile that they are able to invest in dairy, in combination with volatile or difficult access to milk markets in Bomet, leaving the dairy-oriented farmers unable to (re-)invest in dairy. It could also be that certain LED-practices for dairy benefit other farm activities.

Vulnerable farmers and non-dairy farm specialists do not sell milk and seemingly do not have the means or preference to invest in dairy, yet they have subsistence and perhaps other types of motivations (e.g. cultural) for keeping cattle. LEDS can presumably primarily become meaningful for these households with minimal investment requirements of the households, by supporting their subsistence needs, and by closer investigating additional motivations for dairy cattle keeping.

3.4.4.3 LED-Practices

Whether households are in a zero-grazing system, which is the case in Murang'a, or not has an impact on how other LED-practices can be organized. There is generally low uptake of biodigesters and feed conservation across counties and household clusters so structural barriers should first be addressed such as relatively high investment costs for future (not direct) benefits. For the other practices, there are significant differences in uptake between household clusters in the counties and LEDS should do specific targeting. Some practices have low, moderate, or high uptake for all household clusters in the counties, indicating structural reasons. For example, for animal health practices there are government programs that provide these or are heavily subsidized (e.g. generally high uptake of spraying and deworming, or AI).

For growing fodder, households need land, and growing fodder competes with growing food crops and using the land for grazing. Purchasing concentrates is generally not perceived to be necessary for the cattle's health but becomes important if you want to get more milk from your cattle. It is however relatively expensive compared to what a liter of milk is sold at the market, and for some households not a feasible investment. In addition, expert interviews and workshops in Nandi and Bomet (Yesuf et al., 2021) exposed a low preference for cultivating (more) feed, and limited preference for allocating more land to pasture, thereby retaining feed market dependability. Some smallholders in Bomet were voluntarily experimenting with collectively organizing their production assets differently, putting cattle in one plot and using the other plots to cultivate feeds. LEDS could fit by addressing structural issues in the feed markets and enhancing feed production that already takes place on current land without pushing to expand, while also supporting and further developing voluntary bottom-up efforts that take a slightly broader ('landscape') approach (such as communally organizing production assets) as opposed to considering the uptake of LEDS only at smallholder farm level.

Most non-subsistence households have improved breeds because of government investments already since the colonial days. In some areas local breeds are however preferred because they are perceived to withstand dry periods better. Practicing artificial insemination is then also not a priority, and a significant extra cost compared to often free insemination via using a bull. In addition, some households have had unsuccessful instances of AI which has resulted in distrust of AI. Manure management practices are very labor intensive in non-zero-grazing systems so any labor availability should be a focus point for LEDS in relation to manure management practices.

3.5 Discussion

This study argues for a shift away from problematizing the adoption of ideal-type and uniform LED-practices (or a 'fix') to finding spaces to create 'fit' between LED goals and diverse smallholder priorities and capabilities embedded in specific regional histories and conditions. This shift echoes other studies' search for solution spaces for agricultural development via fitting a variety of smallholder priorities with development goals (Kihoro et al., 2021; Ollenburger et al., 2019). For assessing the space for aligning LEDS and smallholder diversity, we first clustered the variety of farmers into 6 types. Next, we took a multilevel approach to complement this farmer typology. This allowed us to contextualize the modeling results and recognize that farmers navigate choices available within spatially bounded and dynamic non-static settings. This sets the stage for identifying a set of region and farmer-type specific starting points that capture or create fitting spaces for LEDS and can inform diverse dairy development pathways. Figure 3.7 epitomizes the starting points for creating fit of LEDS designs and dairy smallholder realities in the study sites in Kenya. This assessment makes fit contingent on three conditions: (1) the presence of zero-grazing systems; (2) the investment capacity of dairy farmers; and (3) the function of dairy in livelihood strategies.

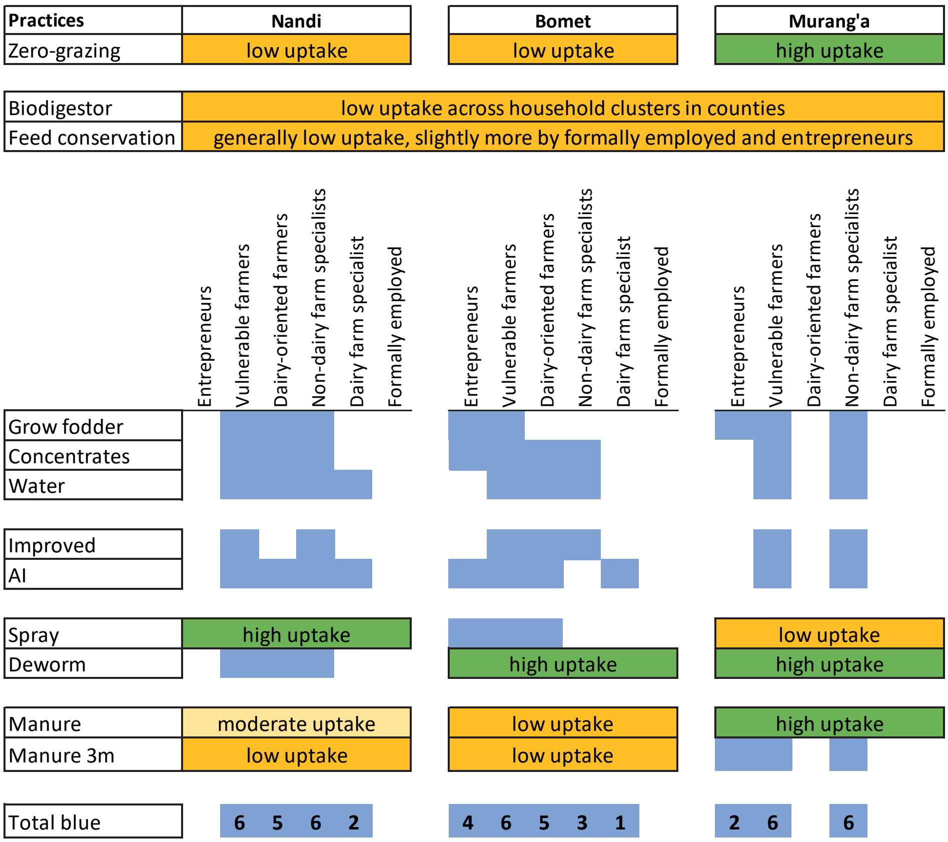

Figure 3.7: Visual overview of uptake of LED-practices per household cluster in the counties. Read from above to below. In blue is below average uptake, 'Total blue' below shows which household clusters have most below average uptake. Some practices in green, yellow, and orange have no differences in uptake between household clusters in the counties and indicate structural reasons for low/moderate/high uptake.

First, looking at the top of Figure 3.7, LED-practices for smallholders should be designed around whether households employ zero-grazing systems or not. Because main reasons for the prevalence of zero-grazing systems in Murang'a are greatly found in the institutional environment related to market infrastructure and effects of cultural practices of subdividing land, it will likely not make sense to push zero-grazing at smallholder level. Instead, other LED-practices should be designed around whether a household employs a zero-grazing system, and more regional institutional work should address the issues of market – and land availability. LEDS will likely not be as effective if they fixate on transforming producer practices, and therefore should include regional approaches that will support producers in having options to adjust their farming practices.

Second, low uptake of having a biodigester and practicing feed conservation across most households indicates that these practices require (labor, finance) investments that are unrealistic or are currently not worth the perceived benefits. The same holds for manure management practices in Nandi and Bomet (see detailed elaboration on technical and socio-economic constraints to improve manure management in Nandi by Owino et al., 2020a). Again, before fixating on smallholders' uptake of these practices, LEDS efforts could be on further elaborating more structural reasons for generally low uptake.

Third, moving down figure 3.7 and incorporating the household clusters in the counties, priorities of households regarding their dairy activities vary from wanting to meet subsistence needs to engaging in dairy as a commercial business activity. Therefore, LEDS should emphasize to find ways to connect to each household's (type) capabilities, preferences and needs (Mausch et al., 2021) both at smallholder level, but also via exploring how households with diverse capabilities, preferences and needs can complement each other at a regional level.

We see these starting points as signs of emerging 'fitting spaces' and from where distinct LEDS pathways responsive to diverse local realities can commence. This is in line with Sumberg (2005) who uses 'goodness-of-fit' to underscore the importance of understanding a technology in its context as a prerequisite for potential adoption. It also echoes the concept 'solution space', used by Ollenburger et al. (2019) to describe how top-down approaches can be grounded and aligned with local realities, and sustainable agriculture in general (Sumberg & Giller, 2022). Additionally, the term is inspired by the concept of institutional fit (Schouten et al., 2016; Ansari et al. 2010), which assesses potential for alignment between technical, cultural, and political characteristics of new practices and locally embedded ways to solve and manage problems (Vellema et al., 2020). By shifting from 'fix' to 'fit', we also step away from the language about the 'adoption' of technology (Obeng Adomaa, 2022; Glover, 2022; Glover et al., 2016). Adoption studies primarily center on the adoption of a fix and therefore simplify what happens during evolving processes of technological change. Instead, our results suggest that it is more productive to contextualise the adoption process, and be attentive to the emergence of starting points where different farming types can integrate and contribute to LEDS.

Identifying starting points and fitting spaces implies a careful diagnostic approach. This study started from situated practices at household level and embedded these into regional contexts. This is largely in line with the socio-ecological niche concept (Descheemaeker et al., 2019), which incorporates agro-ecological, socio-cultural, economic, and institutional dimensions at various levels to identify which agricultural improvement options fit best at diverse farmers, farming practices and systems. A possible next step is to advance and use an explicit institutional diagnostics approach to qualify the regional conditions for fitting (Schouten et al., 2018; Rodrik, 2010). Fitting to local realities also means incorporating LEDS to vertically align local and national strategies (Clapp et al., 2010) and horizontally align territorial governance modalities (Lamine, 2015) in the areas of climate change and development. Future research recommendations are to explore the institutional conditions for creating or reinforcing horizontal and vertical alignments of LEDS with the variation of and dynamics in the Kenyan dairy sector.

Chapter 4

Feeding cattle under suboptimal conditions in Kenya: From emphasizing technical (non-)adoption to stimulating adaptive performance

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4 Feeding cattle under suboptimal conditions in Kenya: From emphasising technical (non-)adoption to stimulating adaptive performance

4.1 Abstract

Predominantly focussing on mitigation in the climate-development interface risks silencing smallholder farmer adaptive capacities when 'performing' agriculture under suboptimal conditions. Mitigation implies alternating situated practices and therefore underscores the adoption problem when looking at technical change. We contrast climate change mitigation strategies with smallholders' dynamic, adaptive performance, highlighting agency and resourcefulness. We use an 'agriculture-as-performance' lens to investigate feeding practices through seasons and lifetimes in a sedentary agricultural system in Kenya. We aim to create conceptual space to examine how adaptive capacities are grounded in agricultural rhythms. Affordances emerging and disappearing in smallholder cow owners' immediate environment materialise in opportunities for actions over short and longer-term periods. Additionally, our findings present cattle feeding as a networked response anchored in practices of giving, sharing, and receiving. We conclude that, to align mitigation and adaptation, agriculture for development should shift from an exclusive focus on the adoption of predetermined optimal solutions and practices to an ex-ante appraisal and a diagnostic approach for catalysing or integrating situated adaptive performance through which farming households respond to action opportunities.

4.2 Introduction

Sustainably intensifying smallholder farming practices is central to initiatives at the climate-development interface in low and middle-income countries (Rockström et al., 2017). These initiatives bring together outlooks on climate change mitigation and adaptation. However, marrying perspectives is not easy: mitigation emphasis implies a transformation of current practices, which unintentionally silences smallholders' situated capacities to navigate and adapt to climate change conditions. Accordingly, evaluating climate change initiatives revolves around the language of technology adoption of mitigation-oriented agricultural intensification practices, often designed for and under optimal conditions (Kuyah et al., 2021; Makate et al., 2019; Mwangi & Kariuki, 2015).

This paradox is also manifested in climate change goals in East Africa, which strongly emphasise emissions in livestock sectors, including dairy (Ericksen & Crane, 2018; Khatri-Chhetri et al., 2020). Livestock provide nutrients, income, employment, and a safety net for the resource-poor (Herrero et al., 2013). In Kenya's dairy sector, climate change interventions aim to refashion livestock systems, focussing on intensification strategies based on feed quality and availability, manure management and animal husbandry (Ericksen & Crane, 2018, Paul et al., 2020). This reinforces focus on assessing barriers and incentives for diffusing designed and optimised intensification practices (Brandt et al., 2020; Hawkins et al., 2021, 2022; Bosire et al., 2016). In this paper, we utilise evolving, intertwined practices of cow owners navigating complex, changing conditions in drought-prone areas in Kenya to examine mitigation and adaptation in climate change interventions.

To shift from adoption to adaptation, we build on conceptual approaches critical of how technology diffusion frameworks portray complex processes constituting technological change (Glover et al., 2019, Glover et al., 2016). We consider agriculture as performance in the context of climate variability (Crane et al., 2011, Richards, 1989). This entails focussing on real-life practices embedded in dynamic livestock systems typically characterised by suboptimal and changing conditions visible in resource constraints, weather fluctuations and socio-economic vulnerabilities (Bosire et al., 2019; Wetende et al., 2018). Looking at agriculture as performance contests the notion that agricultural practices result from detailed execution of predefined designs. Instead, agriculture as performance draws attention to agriculture as the ability to perform a plan while simultaneously being able to respond, adjust and improvise according to changes affecting the plan. Conceptually, our study shifts from adoption to adaptation, drawing attention to smallholder agency and creative adaptive capacities to perform agriculture under suboptimal, changing conditions.

Empirically, we focus on the practice of providing feed to cows. Cows are essential to rural Kenyan households for monetary and non-monetary factors, including milk sale income, milk provision for children and social status (Ouma et al., 2003). Most dairy cattle in East Africa are kept in diversified crop-livestock systems and other on-farm and off-farm activities (Acosta et al., 2021). When a cow dies, part of the livelihood strategy disappears, potentially intensifying household vulnerability. In situations of climate change and/or and pressure, rural households anticipate the need to sustain self and cow survival; cow feed is essential to adaptation strategies (Ericksen & Crane, 2018). Our descriptive accounts, informed by technography (Jansen & Vellema, 2011), examine smallholder agency by documenting how cow owners integrate short and long-term perspectives to ensure cows are fed. Our integrative approach to agriculture as performance interweaves social and technical processes that can span '…time frames from the momentary to the life-time…' (Crane et al., 2011: 180). This opens space to explore what moving from adoption to adaptive performance means for programming agricultural research at the climate-development nexus. Consequently, we start from situated actions for an ex-ante appraisal of adaptive performance and refrain from focussing on intervention and the related adoption question.

Below, we elaborate our lens to adaptation and introduce our methods. The results section details long and short-term adaptive feed management strategies of five households. Finally, we discuss the implications of using an adaptation lens to ex ante programme agricultural research for development attuned to rural households navigating the rhythms of agriculture and livelihoods.

4.3 Conceptual framing of adaptive performance

This section outlines three conceptual implications of studying agriculture as adaptive performance: 1) integrating timespans entangled in evolving processes of socio-technical change; 2) identifying how cow owners recognise and use affordances emerging in practices and networks; and 3) considering agriculture as a constantly (re)configured repertoire of practices.

Studying agriculture as performance involves integrating time horizons for understanding socio-technical change. Conceptualising smallholder agricultural innovation as 'performance' was introduced by Richards (1989). Referring to tools, techniques, knowledge, and skills in situated actions, 'performance' highlights human capacities and know-how for practical ends (Jansen & Vellema, 2011). A performance lens resonates with analysing unfolding responses to climate change and climatic variability, because, as Crane et al. argue '…it highlights how adaptive processes and technologies, whether short or long term, are more than simple technical responses to biophysical conditions' (2011: 179). A performance lens understands agriculture as a result of human agency and social networks in historical and ecological contexts: smallholders have agency through practice.

We analyse how cow owners cope by mastering variable skills to attune practical daily activities to intrinsic properties of materials, things and beings associated with feeding animals. We build on ecological anthropologist Ingold's conceptualisation of affordances, anchored in Gibson's approach to perception and action. Ingold (2022) sees affordances as openings or hindrances, only present in situated actions, and made and remade (Glover, 2019). An affordance lens exposes how artefacts, materials or networks co-shape situated practices of keeping livestock. Tools or materials are not fixed but put into use. How depends not only on physical strength and soil quality but also cultural elements influencing and informing the day(s) or times the tool is (not) used. We relate this to how socio-economic positions condition access to additional information or collaborations that influence the use of tools and materials. For performance study, the concept of affordance (Glover, 2022; Smith, 2021) relates outcomes, such as consistent feeding, to opportunities for action in human and non-human surroundings anticipated by smallholders. Therefore, affordances and adaptive performance are coupled.

Third, we understand adaptive performance as a situated configuration of practices. Here, diverse affordances of similar tools or materials are visible in site or household specific configurations (Glover et al., 2017). To understand opportunities for action, we unravel household-level practices. Performance cannot be understood by looking at a single practice, such as feeding, in isolation. Rather, household-level decision-making creates connections among distinct practices. We approach performance as an empirical configuration of multiple practices, which changes over time, in line with seasonal or lifetime fluctuations. Our integrative perspective sees socio-technical practices as integral parts of a web of practices with short and longer-term orientations. A configurational perspective looks at what combinations work, and when, and searches for processes that (re)configure practices as adaptive responses to changing conditions.

4.4 Methods

4.4.1 The research area

This study was conducted in a sedentary agricultural area, Chepalungu subcounty in the south of Bomet county (Figure 4.1). In recent decades, the region has experienced climate zone characteristic shifts: temperature increases and changing precipitation patterns (Lawrence et al., 2023a), affecting climatic suitability of agropastoral farming systems (Lawrence et al., 2023b), and others. Typically, there are two rainy and two dry seasons throughout the year, starting with a dry period from January to mid-March, then rains until May, another drier period until October, and rains in November and December (Bomet county government, 2018). The area was further affected by the Maize Lethal Necrotic Disease (MLND), first reported in 2011, resulting in total yield losses (Kiruwa et al., 2016) for about ten years. Maize is the region's main staple crop and an important cattle feed ingredient. The changing climatic conditions and MLND generate suboptimal feeding conditions. Dairy is an important livelihood activity, predominantly kept in mixed crop-livestock systems (The county government of Bomet, 2022). In 2019, 124,306 households kept livestock; 60% of farmers can be classified as subsistence livestock and 40% as commercial (MoALF, 2019).

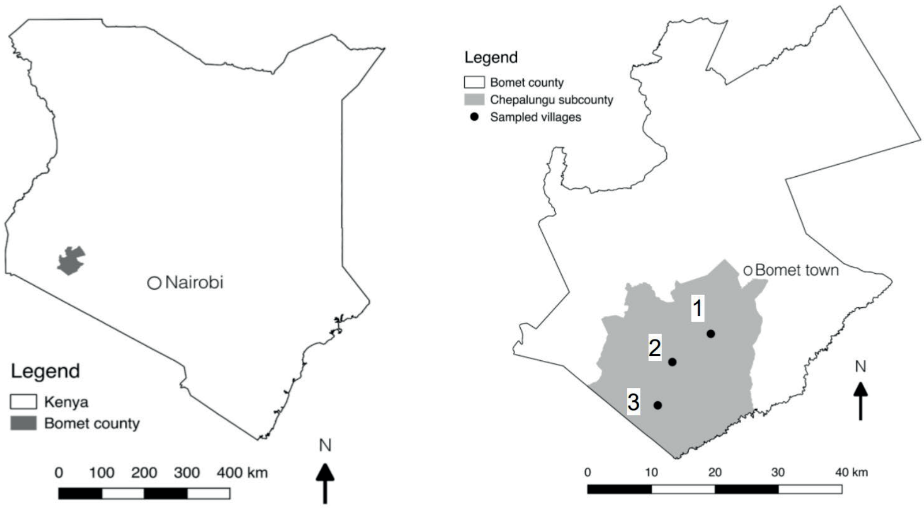

Figure 4.1: The research area in Kenya (left), drawing on data from households in 3 villages in Chepalungu Subcounty in Bomet county (right).

4.4.2 Data collection and analysis

Data collection focused on long and short-term changes in cattle feeding practices. Based on earlier survey work[1], five households with diverse cattle feeding practices were involved in documenting practices and assets (Table 4.1). All--Jackie, Loraine, John & Maria, Faith, Daniel & Gloria,[2] or three widowed women and two male-headed

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[1] Included households are a subsample that participated in an earlier conducted household survey about dairy farming in which 1,050 households participated in 3 Kenyan counties between October 2017 – May 2018: Nandi, Murang'a and Bomet (n=350 per county, remaining with n=341 for Bomet after data cleaning).

[2] Names changed for anonymity.

households--experienced prolonged dry periods (a dry season followed by a weak rainy season) and MLND. Data were collected between October – December 2019. Loraine and Faith resided in Village 1, Daniel & Gloria in Village 2, and Jackie and John & Maria in Village 3 (Figure 4.1).

Table 4.1: Mean and Standard Deviations (SD) of land and livestock ownership of households in Bomet county, Chepalungu subcounty, and the households included in this study.

Land and livestock ownership*	Plot size (acres) [SD]	Arable land (acres) [SD]	Number of cattle [SD]	Number of cows [SD]
Bomet County (n=341)	4,27 [4,67]	3,98 [4,36]	4,65 [2,94]	2,16 [1,35]
Chepalungu Subcounty (n=69)	3,96 [3,74]	3,49 [3,51]	4,86 [3,29]	2,32 [1,56]
Included households (n=5)	4,43 [5,26]	4,33 [5,04]	3,2 [1,79]	1 [0]

* Descriptive statistics from a household survey conducted by this chapters' first and last author (among others) in late 2017.

Life histories were the data collection starting point, specifically key life events (i.e., marriage or migration) and the accumulation and fluctuation in key dairy production assets, namely cows and land. Life histories commenced the year the respondent married their (late) spouses (Table 4.2). Next, interviews and participant observation in farm activities mapped configurations of feeding practices during the short rainy season from October – December 2019. Feeding practices during a recent severe dry season were recalled via interviews describing respondents' chosen year and season. Initial data collection and analysis took place iteratively; multiple visits allowed for intermittent analysis related to understanding the households' cattle feeding practices. Additionally, data interpretation was informed by 25 interviews with government officials, hay brokers, agro-vet stores, financial input providers and dairy cooperative societies in the research area (see De Koeijer 2020).

Table 4.2: Birth year and time period (years) covered during live history interviews.

Household life histories	Jackie	Lorraine	John & Maria	Faith	Daniel & Gloria
Birth year	1958	1985	1956 (John)	1972	1972 (Daniel)
*The time period (years) covered in live history interviews**	1977-2019	2001-2019	1980-2019	1989-2019	2005**-2019

* Year of marriage with (late) spouses was the starting point for the life history interviews.
** Daniel & Gloria got married in 2006. In 2005 Daniel purchased 1 cow and 0,9 acres of land, hence this is the start year for the life history interview.

4.5 Results

The results section presents adaptive responses over time and describes how households navigated access to dairy production assets. It next elaborates the configurations of practices in the wet season and during the (prolonged) dry season.

4.5.1 Navigating access to production assets

Access to land and cattle were key and shaped the longer-term conditions of cattle feeding practices. Life history interviews revealed links between key events (e.g., marriage and migration) to production assets. Network linkages proved important for households navigating access to production assets. Jackie reported initially having 10 acres of land upon marriage, while her father-in-law had not subdivided the land. This changed when he subdivided his land among his five sons and sold another five acres. John and Maria reported the opposite: due to subdivision, their share increased. Faith, Lorraine and, after her husband's death also Jackie, were able to rent additional agricultural plots when without sufficient access to land in (family) ownership. Life histories indicated fluctuation in the number of cows owned and access to (rented) land as conditions for feeding livestock. Increases in (rented) land and cows were primarily due to subdivision of land, purchasing cows and breeding cattle. Table 4.3 summarises reported reasons for reduced amounts of cows and (rented) land. Cow numbers decreased due to drought, disease, dowry payments, medical bills, school fees and migration. (Rented) land did not reduce, or it reduced due to subdivision and migration.

Relevant to feeding cattle is that, previously, households and/or their cattle migrated during (prolonged) dry periods, as reported by respondents from the 1990s and 2000s. During the early 1990s, Jackie stayed with family members near Mau Forest, where their single cow could graze. When Lorraine and her husband were unable to feed their cow during a dry season in 2006, they also moved the cow close to the Mau Forest where relatives cared for the animal. John and his brothers' cows temporarily migrated to communal land along the border with Kisii county as a response to severe drought in 1992. Faith and her husband wished to (permanently) migrate to '…a more productive area with a better climate', but they had no money or place to migrate to until, in 1995, a neighbour migrated elsewhere. Faith (temporarily) followed, shortly after her neighbour introduced her to the area. In recent years, temporary migration of cattle and households has been less common. John explains: 'You cannot migrate anymore. People only have land for their own cows.' For Lorraine, migration is not preferred: when the cow migrates, her children lack milk.

Table 4.3: Households' fluctuating production assets, and migration.

Households fluctuating production assets and migration	**Jackie**	**Lorraine**	**John & Maria**	**Faith**	**Daniel & Gloria**
Lowest to highest reported amount of cattle (number)	0-9	0-1	4-12	0-3	0-5
Reported events that reduced the number of cattle	Drought, disease, medical bills, school fees	Cow sold by (late) husband	Subdivision of cows by John's father, dowry	School fees	Moving his farm, selling all cattle and purchasing new
Lowest to highest reported amount of (owned/rented) land (acres)	1-10 (owned), 1-1,5 (rented)	0,2-1 (owned), 0,5-1 (rented)	4-15 (owned)	0,4-1,5 (owned), 0,6-1,1 (rented)	0,9-3 (owned)
Reported events that reduced size of (rented) land	Subdivision by in-laws	Rented land fluctuated	*Only increased, via purchasing*	Migration back home from another region	Moving his farm, selling all land and purchasing new
History of (cattle/household) migration	Yes (cattle + household)	Yes (cattle)	Yes (cattle)	Yes (only Faith)	No (but moved farm)

These stories show the importance of household networks. Similar narratives emerged regarding access to (rented) land and borrowed cows. Jackie rented from a relative but lost access in 2012. That same year, she rented from a friend's husband. During months with limited rainfall, the land was free. When there was rainfall and grass growth, the price could rise to 1,000 KES (9.87 USD in 2019) monthly. Lorraine and her late husband borrowed a cow from a friend after her husband had sold theirs. According to Lorraine, borrowing a cow is common for households with young children and no cows. They borrowed the cow for seven years, until Lorraine could purchase her own.

This section showed how households navigate access to production assets and which events cause fluctuations in production assets. Considering navigating access to production assets as prerequisite for being able to practice cattle feeding, the importance of networks is key. The next sections detail practice configurations for included households.

4

4.5.2 Cattle feeding practices in the wet season

This section presents cattle feeding practice configurations during the short rainy season (October-December in 2019). Households combined food crop residues, meal leftovers, fodder crops and other feed sources entering or leaving the farm via purchasing or trade, or for free (Table 4.4). Variable feeding practices suggest that each household realised different affordances.

In addition to grazing on a rented field, Jackie's cows fed on maize stalks, Napier grass, sweet potato vines, sorghum stems, family leftovers (e.g., potato peels, chewed sugarcane) even mineral salts from the agrovet. When rain became heavy, the grazing grass fed the cows sufficiently while additional feeding stopped.

During the wet season, Lorraine mainly fed her cows sugar cane, in addition to grazing on 0.2 acres. When dairy meal, a concentrate feed, ran out, she shifted to 0.5 kg of (typically only for human consumption) maize meal. Feed quantity and type depended on farming activities and household meals and included weeds, maize stalks, pumpkin leaves and leaves and trunks of banana trees. Lorraine received Boma Rhodes grass in return for helping another; she also received maize stalks and sweet potato vines from others. After harvesting maize, she replanted quickly because predicted heavy rains could spoil ripened maize and complicate planting. Thereafter, she fed the cow with maize stalks for a few weeks—a long period for a single feed ingredient.

John & Maria produced and stored hay from their Boma Rhodes grass, which they fed their cattle after finishing an earlier harvest's maize stalks. They added Napier grass and sweet potato vines for lactating cows. The pasture provided little grass at the beginning of the short rainy season. They only provided dairy meal and molasses to cows that just calved and gave much milk. After the rainfall peaked, grass grew faster, and cows required less feeding. They only gave Boma Rhodes hay to lactating cows. There were no crop residues to feed—the harvesting season was over.

Faith's cow grazed at her brother-in-law's pasture. At the beginning of the short rains, the cow was dry and had to calve in three months. The cow was fed with Napier grass (when no crops are harvested) or sweet potato vines, maize stalks, and other crop residues (when crops are harvested). She did not harvest sugar cane, saving it for calving, to boost milk production. Since the cow produced no milk at the time, she traded Napier grass with neighbours for milk. She had her tree nursery and utilised Calliandra tree leaves every fortnight. Additional feeding stopped as heavy rains commenced and Napier grass rose in moisture, reducing the benefits of feeds over pasture.

Daniel & Gloria fed five (four lactating) cows and three calves with purchased maize stalks because natural grass was unavailable to start the rainy season. Additionally, their cows grazed in the forest while calves remained at home. With maize stalks depleted, Daniel wished to purchase difficult-to-find Boma Rhodes hay and the cows continued grazing in the forest. Additionally, he cut Napier grass in the morning and fed it in the afternoon for moisture to evaporate. The natural pasture increased as the rainy season proceeded.

All households balanced pasture with additional feeding. In the wet season, they anticipated availability and used affordances of fodder, crop residues and other feed ingredients. Feeding cows involved quick and sometimes improvised decision-making attuned to cow reproductive cycles and rain prediction.

Table 4.4: Sources and types of cattle feed per household (rainy season, October-December 2019).

Cattle feed	**Feed source* (2019)**	**October**	**November**	**December**
Jackie	*Farm*	Maize stalks, pasture, fresh cut Napier, sweet potato vines, sorghum stems		Pasture
	Off farm	Mineral salts (purchased), pasture (friendly price)		
Lorraine	*Farm*	Pasture, sugar cane, maize stalks, pumpkin leaves, banana leaves and trunks, weeds		Maize stalks
	Off farm	Maize meal, mineral salts (purchased), Boma Rhodes (exchange)		Mineral salts (purchased)
John & Maria	*Farm*	Maize stalks, Boma Rhodes hay, Napier grass, sweet potato vines		Pasture, Boma Rhodes hay
	Off farm	*Nothing*		
Faith	*Farm*	Pasture, Napier grass, sweet potato vines, maize stalks, Calliandra tree leaves		Pasture
	Off farm	Mineral salts (purchased), pasture (free)		
Daniel & Gloria	*Farm*	Napier grass	Pasture, Napier grass	Pasture
	Off farm	Maize stalks, mineral salts (purchased), forest grazing (fee)		Mineral salts (purchased)

* In addition to feed sources from the farms, all households fed crop residues (when harvested and available), and meal leftovers.

4.5.3 Cattle feeding practices in a (prolonged) dry season

Cattle feeding practices represent situated performance. This section portrays emerging feeding practices in a recently experienced severe dry period in 2017 or 2018. For Jackie and Daniel & Gloria, a failing wet season followed a dry 2017. Table 5 summarises source and type of feed, resulting in diverse feeding configurations.

Jackie's cows grazed on rented pasture and were fed sorghum stems and a failed maize and bean intercrop harvest in the first months of 2017's dry season. After three months, natural grass and Napier grass were finished and dried out. From April, Jackie combined scarce free feed sources: tree leaves, Napier grass from her sisters and grass cut on the land of family and neighbours. During light, inconsistent rains in June, she planted 0.5 acres of maize and beans, but the crops failed, and she fed cattle with uprooted plants in August and September. Then, she had to purchase two bales of hay per two days, which was more than two litres of milk could cover. In September, she fed leaves and sugar cane stems. Proper rains started in late October.

Lorraine let her cows graze on a small pasture and fed sugar cane to start 2018's dry season. Soon, she had to source feed elsewhere—sugar cane and crop residues were insufficient. She cut native grass and tree leaves along neighbour and family fences, for free or a small fee; sometimes her cow grazed along the fences. Occasionally, she purchased hay from a broker. In March, she fed her cow with a previous harvest's dried maize stalks. She referred to health hazards of feeding cattle maize stalks infected by MLND and the extra importance to sufficiently dry stalks before feeding.

John & Maria initially fed their cattle with hay from their store and cut Napier grass in 2018's dry season. In April, they ran out of feed and used uprooted maize and beans planted in December, combined with tree leaves. Afterwards, they purchased dairy meal for lactating cows and molasses for all cows, in response to the milk production drop from 10-15 to 2 litres per day. John bought eight bales of Boma Rhodes hay during this period. Hay bale prices varied from 250 to 300 KES (2,47-2,96 USD in 2019), sometimes 600 KES (5,92 USD in 2019).

Faith initially grazed her three cows on the pasture of her brother-in-law in 2017's dry period. She cut grass from her land and added Napier grass. In February, Napier grass dried out, and she shifted to banana trunks, leaves and other harvested residues, complemented with harvested bean and sugar cane residues. In March, after selling one cow, she fed two with sugar cane and banana trunks. Later, she cut down maize plants, which yielded no grains due to MLND. When the maize was finished, she purchased stalks from her sister-in-law at half market price.

Daniel & Gloria let two cows graze on the home pasture and in the forest during the first months of 2017's dry season. In February, no pasture was left, and most Napier grass had dried out. Daniel fed dried uprooted maize and beans in March. Until September, Daniel bought Boma Rhodes hay from a friend, but this was insufficient.

He decided to additionally purchase and feed (possibly overpriced) sugar cane from his neighbour.

During (prolonged) dry seasons, feeding cows involved improvisation: where to get enough, affordably? All households resorted to sources of feed outside their farms: some purchased feed while others relied on sources freely (or at a lower price) available via social networks. Kosgei, a member of the same dairy group as John, discussed social networks in farming practices: 'We gather every two weeks, we move around from farm to farm where the host shares a certain subject on his farm…We are one, I share my chaff cutter, and some [group members] come when I am not here and pick some yellow maize… I also give [fodder] seeds to group members, my neighbours, and my casual workers, and I encourage them to do the same thing at home.' During the (prolonged) dry season, in some cases, keeping the cows alive was the priority, while others aimed to sustain milk production. The unpredictable, uncertain prolonged dry period resulted in households combining sources as adaptive responses to changing conditions.

Table 4.5: Sources and types of cattle feed per household.

Cattle feed*	*Feed source*	January	February	March	April	May	June	July	August	September	October
Jackie (2017)	*Farm*	Sorghum stems, failed maize & beans harvest, Napier grass			Tree leaves				Tree leaves, failed maize & beans harvest	Tree leaves, failed maize & beans harvest, sugar cane stems	
	Off farm	Pasture (rented land), mineral salts (purchased)			Napier grass, cut grass, tree leaves, Boma Rhodes grass (free), mineral salts (purchased)				Hay, mineral salts (purchased)		
Lorraine (2018)	*Farm*	Pasture, sugar cane		Maize stalks		Not reported					
	Off farm	Mineral salts (purchased)	Cut grass, tree leaves (free or at friendly price), hay, mineral salts (purchased)			Not reported					
John & Maria (2018)	*Farm*	Hay, Napier grass			Maize and beans, tree leaves		Not reported				
	Off farm	*Nothing*			Dairy meal, molasses, hay (purchased)		Not reported				
Faith (2017)	*Farm*	Cut grass, Napier grass	Banana trunk and leaves, beans, sugar cane	Banana trunk, sugar cane	Sugar cane, failed maize harvest		Not reported				
	Off farm	Pasture (free), mineral salts (purchased)		Mineral salts (purchased)		Maize stalks (friendly price), mineral salts (purchased	Not reported				
Daniel & Gloria (2017)	*Farm*	Pasture, Napier grass		Failed maize & beans harvest			*Nothing*				
	Off farm	Forest grazing (fee), mineral salts (purchased)		Boma Rhodes hay, sugar cane, mineral salts (purchased)							

* In addition to feed sources from the farms, all households feed (other) crop residues (when harvested and available), and meal leftovers. Reported for the dry season, January until April-May, either in 2017 or 2018, with two households experiencing a failed wet season until October 2017.

4.6 Discussion

This paper aims to offer conceptual space in the climate-development interface to balanced mitigation and adaptation interests. Mitigation-oriented strategies likely reinforce a focus on adopting predefined practices and consequently reduce space for adaptation. We countered by drawing attention to people's abilities to navigate dynamic and changing environments. Case examples analysed so-called 'suboptimal' cow feeding conditions: scarcity of resources, vulnerabilities intrinsic to livelihoods and longer-term disturbances related to drought and plant diseases. Our findings indicate that focus on a mitigation perspective on predesigned optimal practices, raising the technology adoption question, contrasts with the improvisational, changing, and adaptive performance exposing smallholder farmer household agencies expressed in performing agriculture, according to seasons and lifetimes and under uncertain conditions.

Creating space to integrate adaptive capacities into climate change policy and intervention research benefits from alternate conceptual lenses. First, our temporal lens exposes the coupling of short and long-term rhythms in the performance of smallholder farmer practices (Crane et al., 2011). Our descriptive accounts show how cow owners mobilise networks to ensure access to production assets in line with personal dynamics. Driven by seasonal fluctuations and during prolonged droughts, farmers cleverly mix available and affordable feed ingredients in their immediate environment, such as food waste, crop residues, weeds, even tree leaves and forage, in combination with external inputs. These specific affordances are only realised and visible in action. A temporal lens attends to fluctuating affordances in feeding practices and recognises cow owners, attuned to what is available and with an eye on the future.

Second, the results present configured feeding practices as networked responses. This makes the practice of feeding cows also social and intrinsic to communal experiences of fluctuations between scarcity and abundance. Consequently, the need to be part of a network of giving, sharing, and receiving is a salient feature of feeding cattle, linking short-term needs to long-term networked elements. Accordingly, we argue in favour of careful diagnosis of evolving feeding configurations and detect interventions that can integrate with or catalyse local practices over time (Habermann et al., 2022). Our study highlights a variety of affordances (Glover, 2022), emerging and disappearing in short and longer-term dimensions of feeding cattle, namely in relation to 1) material elements and characteristics of feeds, and 2) to the networks that people are a part of, making feeding practices networked responses. Situating adaptation in dynamic, evolving configurations of practices directs agricultural development research towards flexible diagnostics for the myriad affordances that arise between cattle feeders and material, cultural and socio-economic contexts. A prime focus on catalysing or refashioning situated configurations of practices can be the contribution of living lab initiatives for low emission development (Habermann & Zhang, 2022). This perspective on technical change starts from the contextualised agency of smallholders visible in actions through which they anticipate the possible and desirable.

4.7 Conclusion

The concern addressed is that, in the climate-development interface, a focus on mitigation silences smallholder farmer's situated agency and reduces space to marry mitigation and adaptation. The adoption lens implied by a mitigation focus centralises induced technical tools or packages framing farmers' agency in binary terms ('adopter', 'non-adopter'). This reinforces a once-in-a-moment measurement with limited attention to how practices evolve. We argue that agricultural research for development can offer space and potentially catalyse or add to contextualised practices via integrating multiple and consecutive solutions constructed by people under vulnerable or scarce conditions, thereby supporting rhythms and increasing affordances. Therefore, an ex-ante focus on adaptive performance may create opportunities for aligning interventions with affordances visible in webs of situated actions. This sets the stage for ex ante programming and design, based on careful diagnostics of what people do and why and how this works in changing temporal and material conditions. Therefore, we conclude by supporting a diagnostic instead of an interventionist approach to address climate change and human development challenges.

Chapter 5

Beyond the formal-informal dichotomy: Towards accommodating diverse milk-collection practices in the economic middle of Kenya's dairy sector

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5 Beyond the formal-informal dichotomy: Towards accommodating diverse milk-collection practices in the economic middle of Kenya's dairy sector

5.1 Abstract

The triangle of dairy intensification, commercialisation and market formalisation is promoted to address the challenges of food and nutrition security (FNS) and climate change. This article questions the need for formalisation to reach intensification and commercialisation objectives in Kenya. Moving beyond the binary perception of milk markets as either 'formal' or 'informal', we investigate a repertoire of milk-collection practices and address the following question: 'What enables diverse intermediary practices to ensure a consistent flow of milk from grass to glass?' Sampling, data collection and analysis were guided by a qualitative research design for an empirical exploration of the practices of owner-operated (N = 13) and corporate (N = 4) milk collectors. Iterative analysis of observations revealed three main themes constituting milk-collection practices: (1) buying milk, (2) managing milk (quantity and quality measurement) and (3) selling milk to the next buyer. These practices were enabled and sustained by the diverse options available for each aspect of milk collection, and by the capacity of collectors to accommodate variety in their practices. We invite scholars and practitioners to conduct deeper explorations of how to accommodate events in practice to enhance the success of ambitions relating to FNS and climate change through pathways of intensification and commercialisation.

5.2 Introduction

The entangled challenges of food and nutrition security (FNS) and climate change are increasingly directing policy and interventions towards a combination of intensification, commercialisation and market formalisation, with particular attention to reducing greenhouse gas (GHG) emissions from livestock (Clay, Garnett, & Lorimer, 2020; Clay & Yurco, 2020; Khatri-Chhetri, Wilkes, & Odhong, 2020). This development pathway is evident in Kenya, where market dynamics, governments and international NGOs are promoting a transformation through 'Low Emission Development Strategies' or LEDS (Khatri-Chhetri et al., 2020; Wilkes, Wassie, Vorlaufer, Odhong, & van Dijk, 2020). Kenya is not unique in this regard: similar developments are taking place throughout the East-African region (see e.g. Kihoro, Schoneveld, & Crane, 2021; Minten, Habte, Tamru, & Tesfaye, 2020).

The triangle of intensification, commercialisation and formalisation is gaining ground in national development policies specific to the dairy sector in Kenya (Blackmore, Guarin, Vorley, Alonso, & Grace, 2022). Policies and interventions aimed at reducing GHG emissions centre on intensification via promoting practices that increase milk yields per cow, which then reduces the emission intensities per liter of produced milk (Ericksen & Crane, 2018; Khatri-Chhetri et al., 2020). Commercialisation is the production of dairy for commercial rather than subsistence purposes. The formalisation of commercial transactions between milk producers, collectors and processors is presented as the most effective way of incentivising and enabling intensification. The underlying assumptions are that intensification practices can be promoted via the agricultural extension support of cooperatives and companies, and that formalisation creates a reliable market demand which incentivises producers to intensify. Formalisation implies a drastic transformation of current milk trade, which is largely operated by small enterprises (MALF, 2013). It is nevertheless important to consider whether formalisation is needed in order to achieve objectives relating to intensification and commercialisation in Kenya.

Strategies of formalisation are accompanied by risks. In 2015, an estimated 12% of all milk produced in Kenya, about 30% of all marketed milk, was processed in formal supply channels (Rademaker, Bebe, Lee, Kilelu, & Tonui, 2016), meaning that 70% of all marketed milk finds its ways via 'informal' channels. An emphasis on formalisation tends to ignore that informal markets often constitute a great share of markets, particularly in developing economies (Cerutti et al., 2018), where informal markets function as important links between small-scale farmers and low-income consumers (Leksmono, Young, Hooton, Muriuki, & Romney, 2006; Vorley, del Pozo-Vergnes, & Barnett, 2012). In many dairy sectors, the majority of both business actors and consumers are able to cope with, rely on and/or prefer to engage with informal institutional features of milk markets, as indicated by the perseverance of these features. This suggests that formalisation efforts might not reach the majority of people, and that they thus fail to achieve their initial objectives of enhancing FNS and realising reductions in GHG emissions. It would therefore seem more effective to explore contextualised solutions, rather than striving to realise ideal-type market organisations (Mangnus & Schoonhoven-Speijer, 2020).

To this end, the current study aims to offer a perspective that avoids the promotion of an exclusive sustainable-development pathway of formalisation. Our basic principle is understanding before intervening to transform. Addressing the issue from this perspective highlights the need for an institutional diagnostic question (Rodrik, Subramanian, & Trebbi, 2004; Schouten, Vink, & Vellema, 2018). Prior to proposing a transformative model, we consider why current trading practices and institutional arrangements in the economic middle are durable (Nicolini, 2011; Schoonhoven-Speijer & Vellema, 2020). Taking practices as the unit of analysis helps to depart from the binary view of markets as either 'formal' or 'informal'. We take an empirical route to answering the research question: 'What enables diverse intermediary practices to ensure a consistent flow of milk from grass to glass (farmer to consumer)?'

For a nuanced understanding of the contribution of real markets to FNS, the binary between 'formal' and 'informal' seems particularly problematic. Conceptually, there is general consensus about the meaning of 'formal' as legally registered, regulated and included in official statistics (Habib-Mintz, 2009). Formalisation is diverse and can be categorised into various forms at various levels (see e.g. Berkel & Tarp, 2022). The concept of 'informal' remains troublesome, however, as 'Describing people and their enterprises by what they are not has a built in assumption of their insignificance and that the other that they are not – formal – is superior' (Wegerif, 2020, p. 3). Moreover, thinking in binary terms reduces the options to extremes (Duncan & Bailey, 2017). Rather than opting for any specific type of market infrastructure, this article responds to calls for investigating real markets as configurations of various types of market channels along and within a continuum from formal to informal (Blackmore, Guarín, Alonso, Grace, & Vorley, 2020; White & Aylward, 2016).

Various scholars have studied informal food sectors (Wegerif, 2020; Wegerif & Hebinck, 2016; Wegerif & Martucci, 2019), including in the Kenyan dairy sector (Alonso, Muunda, Ahlberg, Blackmore, & Grace, 2018; Blackmore, Alonso, & Grace, 2015, Blackmore et al., 2020; Galiè, Njiru, Heckert, Myers, & Alonso, 2022; Tavenner, Crane, & Saxena, 2021). Formal and informal markets continue to receive attention, as do the linkages between them (Berkel & Tarp, 2022; Fafchamps, 2018; Meagher, 2013;

Mishra, 2022; Putzel, Kelly, Cerutti, & Artati, 2015). According to existing literature, strict formalisation policies entail the risk of adverse outcomes (Almeida, Paz, & Poole, 2022; Sen, Danquah, & Schotte, 2022), while actors operating within the informal middle are indispensable in food provisioning (Liverpool-Tasie et al., 2020; Mangnus & Vellema, 2019; Roba, Lelea, & Kaufmann, 2017; Schoonhoven-Speijer & Vellema, 2020; Soundararajan, Khan, & Tarba, 2018; Wegerif, 2020; Wegerif & Hebinck, 2016; Wegerif & Martucci, 2019).

Our study proceeds from the everyday practices of milk collectors in the economic middle of Kenya's dairy sector. Studies of FNS focus primarily on producers and consumers (Reardon, 2015; Veldhuizen et al., 2020). A stronger discussion engaged with the economic middle is becoming increasingly relevant, given the significant contributions of this segment to food provisioning (Legun & Bell, 2016). Activities in the economic middle include processing, storage and logistics, and they are estimated to account for 30–40% of all economic value added within food value chains in developing regions (Reardon, 2015). The diverse functions of intermediary actors have been categorised for the agri-food industry in innovation studies based on actor-network approaches (see e.g. Batterink, Wubben, Klerkx, & Omta, 2010; Kilelu, Klerkx, Leeuwis, & Hall, 2011; Winch & Courtney, 2007). Our study re-emphasizes the importance of intermediaries and complements actor approaches with a practice approach.

5.3 Methodology and methods

Our analytical approach is anchored within a methodological shift towards the examination of practices. A practice perspective is sensitive to everyday realities and an appropriate remedy for the tendency to describe the world in terms of irreducible dualisms (Nicolini, 2012), such as the formal-informal dichotomy. It can facilitate the exploration of how market institutions are ordered and reinforced (Mangnus & Vellema, 2019; Schoonhoven-Speijer & Vellema, 2020). As routinized and improvised social actions that reproduce economic space, practices are order-producing activities at the macro level (Jones & Murphy, 2011).

Following the methodological guidance proposed by Jones and Murphy (2011), we demarcate the boundaries for our analysis around the practices through which milk is transferred from the producer to the collector (A to B), and then transferred from the collector to another buyer/the consumer (B to C). Central in the practices are the flow of milk from producer towards consumers and the associated cash flow in the other direction (Figure 5.1). After zooming in on milk collection practices the analysis broadens to consider the various supply channels within a catchment area. A catchment area is typically a road network along which milk is collected. We conceptualize supply channels as various bundles of practices that together constitute a diversity of channels that in combination form the milk market within a catchment area.

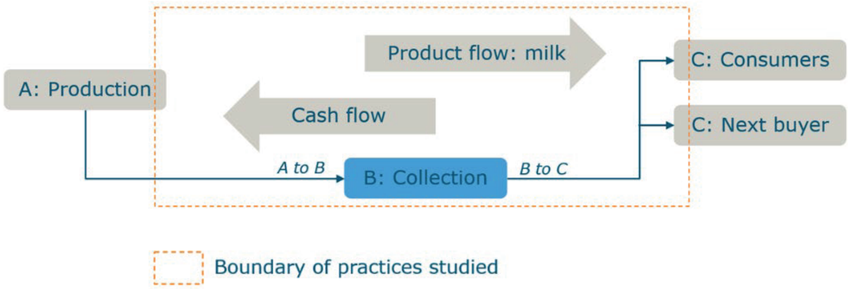

Figure 5.1: Visualisation of the boundaries for investigating practices of milk collection. This figure does not represent all supply chains and variety of practices that exist.

The terminology used to distinguish between supply channels – owner-operated and corporate (Wegerif, 2020) – are more nuanced than formal and informal. We also depart from the use of terminology that is often pejorative (e.g. middlemen, hawkers) to describe the actors operating in the economic middle. Owner-operated supply channels are typically characterised as being small-scale, embedded within their local communities and with low barriers to entry (Wegerif, 2020; Wegerif & Hebinck, 2016; Wegerif & Martucci, 2019). Corporate market channels generally handle larger volumes of milk, which – in Kenya – typically reaches consumers in processed form. Milk that flows through owner-operated market channels is often consumed raw. For owner-operated collectors (hereafter owner-operators), building on the categorisation of Alonso et al. (2018) we also use terminology that distinguishes between those collecting at small shops (shop collectors), from one point along a road (street collectors), and those collecting milk in different locations, typically moving about by motorbike (mobile collectors). Table 5.1 presents and overview of the data collection activities.

Table 5.1: Overview of the data collection activities.

Objective	Month – Year	Activities
Mapping of the dairy network and exploration of the political economy of dairy-development initiatives in Murang'a County. This informed the sampling of the research area and helped place further findings in its context.	Nov–Dec 2018	*Key informant interviews* with the main actors in the dairy sector in Murang'a County (N=12).
Scoping trip to the research area to discuss research plans with relevant actors and to explore options for a practice-oriented research design.	Aug 2019	Meetings with managers of the private and parastatal companies to discuss research plans; *joining a collector* (N=1) in his milk collection activities.
Data collection at the level of milk collectors (Round 1).	Early Sept 2019	Meetings with managers of the private and parastatal companies and their extension-services staff to discuss the research approach. *Start joining milk collectors* (N=4) in the network of the companies, with an extension staff member from one of the companies serving as a motorbike driver and interpreter, where necessary.
Data collection at level of milk collectors (Round 2) and filling in gaps.	Late Sept 2019	Meetings with managers of the private and parastatal companies and their extension-services staff to discuss progress and diversity in the types of milk collectors observed. In these meetings, the managers also elaborated on their own *milk-collection activities* (N=2), which we had observed along the way while joining other collectors. *Join milk collectors* (N=10). *Develop overview of key aspects of milk-collection practices and revisit most of the milk collectors* to clarify and confirm the data about these key aspects (see complementary material for the overview).

5

5.3.1 Research area

The selection of the research area was informed by semi-structured interviews with 12 key informants in the dairy sector in Murang'a County in 2018. A catchment area around a middle-sized town was selected (Figure 5.2), characterised by the presence of three diverse, formally governed corporate marketing channels and a thriving raw-milk market operating partly outside the scope of state regulations. The town is about 30 km from the Murang'a County capital and about 110 km from the national capital, Nairobi, both of which are important milk markets.

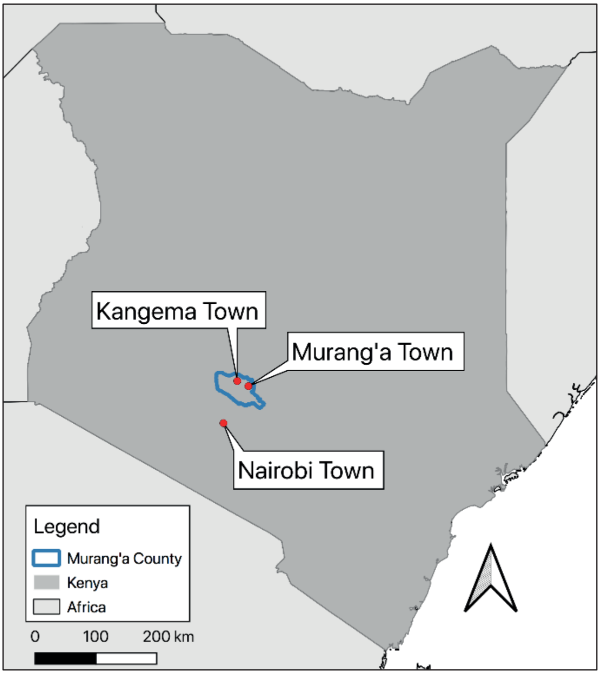

Figure 5.2: Research location: a milk catchment area around Kangema town in Murang'a County, Kenya.

Murang'a County has a diversified physical environment comprising three agro-ecological zones. In recent years, dairy production has been an emerging business across all altitudes (Asayehegn, Iglesias, Triomphe, Pédelahore, & Temple, 2017). The area is characterised by relatively intensive dairy systems, with the majority of smallholder producers operating in zero-grazing systems (TIAPD, 2021). Therefore, in contrast to other production systems in Kenya, milk is not as scarce in the dry seasons because the predominantly zero-grazing systems are less dependent on available grazing lands, although fluctuations in the production and availability of milk are experienced due to dry and wet seasons. Murang'a County has been subject to government interventions aimed at formalising the dairy sector (County Government of Murang'a, 2018).

5.3.2 *Sampling milk collectors*

We sampled 15 milk collectors for in-depth observations of their everyday business practices via a private and parastatal dairy company. These two companies are the most visible entry points to other dairy sector actors in the area. Proceeding from these companies, we used snowball sampling, purposefully requesting to observe as many diverse practices of milk collection as possible. Employees of the two companies who had been assigned to assist with the research also joined during the milk-collection observations, serving as drivers and interpreters where necessary. The data-collection activities were finalised when we had exhausted the network of the companies. We do not claim that our sample is representative of all milk-collection practices within the catchment area. A description of the sample is provided in Table 5.2.

Table 5.2: Description of the sample.

Collectors	**Corporate**			**Owner-operated**				
	Private company (N=1)	Parastatal company (N=1)	Suppliers' cooperative collectors (N=2)	Mobile collectors (N=2)	Both mobile and street collectors (N=3)	Mobile collectors for others (N=2)	Street collectors (N=3)	Shop collectors (N=3)
Name*			James, Robert	John, Patricia	William, David, Richard	Michael, Thomas	Jennifer, Elizabeth, Linda	Barbara, Jessica, Charles
Liters of milk collected per day	22,000 L/day	> 2,500 L/day	> 1,500 L/day	150–200 L/day	210–850 L/day	Included in number of owners	120–400 L/day	50–600 L/day
Daily distances covered	70 km	70 km	25 km	5–6 km	0–10 km	19–60 km	0 km	0 km
Activities	Collecting (along routes and fixed points) Transporting Cooling/bulking Processing Selling	Collecting (along routes and fixed points) Transporting Cooling/bulking Transporting Processing (somewhere else) Selling	Collecting (along routes and fixed points) Transporting Cooling/bulking Selling	Collecting (along routes and fixed points) Transporting Selling	Collecting (along routes and fixed points) Transporting Selling	Collecting (along routes and fixed points) Transporting Selling	Collecting (fixed points) Selling	Collecting (at a shop) Selling

* Names have been changed to protect respondents' identities.

5.3.3 Data collection and analysis

All collectors included in this study provided oral consent for the first author and an interpreter to join their milk-collection activities. We informed them about the objective of our study – to investigate how milk collection is organised – and made it explicit that we were working independently of the companies and from the regulatory authority. The research design allowed for various informal conversations by the first author with collectors, buyers and consumers where language allowed or with help of the interpreter. The collectors were already in the network of the companies and sometimes supplied there, making them both clients and competitors. A limitation of this study is that we can therefore not claim to have captured the variety of milk collection practices that exist. The first author was also regularly allowed to take pictures with verbal consent of the people in the pictures. All field notes and pictures were taken on a smartphone and transferred and processed on a computer the same day.

We identified three main aspects of the practice of milk collection within the catchment area through iterative data analysis of the observations, pictures, semi-structured interviews and informal conversations. These main aspects follow the flow of milk: (1) buying milk, (2) managing milk, and (3) selling milk. Specific aspects that constitute these practices that will be elaborated in the results section are establishing milk quality and quantity, organising buyers to sell milk to, establishing milk payments and prices, and competition.

The presentation of data in the following section it is intended to highlight our analytical process. The results section begins and ends with a detailed narration of the interactions between a milk collector named John and a milk supplier. In between, the three aspects of the practice of milk collection are elaborated by moving back and forth between the narrative descriptions and the analysis of the practices observed. The results section will continue to refer to John and other milk collectors to illustrate their practices.

5.4 Results: diverse milk-collection practices in the economic middle of Kenya's dairy sector

On a chilly morning in September 2019, John got up around 5:30 a.m. to start his daily milk-collection activities in Central Kenya's highlands. On his motorbike, he drove 3 km away from Kangema Town on an unpaved road to meet his first milk producer. She was waiting along the road in the dark at 6:05 a.m. with a few liters of milk in an aluminium can. John stopped and exchanged greetings, while he unpacked a funnel, sieve and plastic measuring cup from a bag hanging on the handlebars of his motorbike. He removed the small lid of a jerrycan on the back of his motorbike, put the funnel in the jerrycan and then inserted the sieve into the funnel. The supplier poured the milk into the plastic measuring cup held by John. After looking at the measuring cup, he poured the milk through the sieve and the funnel into the jerrycan. The supplier put down her aluminium can and handed him a piece of paper. After writing on it and handing it back to the supplier, John then wrote in a small notebook from inside his jacket. He put the funnel, sieve and measuring cup back into the bag on the handle bars, replaced the lid on the jerrycan, and left. He followed the road back towards Kangema Town to meet his next two suppliers and repeat the procedure four minutes later.

This narration of the interactions between a milk collector and his supplier illustrates key aspects of the practice of collecting milk from producers. These practices include the exchange of milk from the producer to the collector and measuring the quantity using the measuring cup. The amount of milk collected was registered on the collection card that the supplier kept in a small plastic bag and in John's notebook. Not everything was described, however, such as if the supplier was paid or if John performed any quality tests. These and other points are elaborated below.

5.4.1 Milk quantity measurements

Establishing the quantity of milk from the supplier is a central aspect of milk collection, as it determines the supplier's final payment. There were variations in how the quantity of milk was measured by the collectors. The companies and the suppliers' cooperative took measurements to one decimal place using scales that were located along their routes. Practices of measuring milk quantity using scales require a common trust in the correctness and objectivity of the scales, thus rendering the process of establishing the quantity of milk delivered a non-negotiable exercise. Owner-operators were less precise in how they established the amount of milk collected: they recorded only half or whole liters instead of recording amounts to one decimal place, as with the scales. In some cases, collectors asked producers how much milk they had delivered, roughly estimating whether these quantities were correct according to what they saw, but not using a measuring cup to confirm. Establishing the quantity of milk in this way requires some form of negotiation and agreement between the supplier and the collector, based on trust, previous interactions and knowing that there would be future interactions.

All moving and fixed-point collectors included in the sample recorded the volumes of milk they exchanged with suppliers. This consisted of noting the volumes of milk exchanged in liters on a so-called collection card for the supplier and in their own notebooks. The supplier's collecting card usually had a supplier number corresponding to a number in the collectors' records. The cards had space for recording volumes of milk for one month, and were distributed free of charge. All owner-operators indicated that their supplier numbers were relatively stable, although supplied milk volumes were varying depending on season and production cycle of the cows. There was more variety in the quantity-measurement practices within the owner-operated channels than there was within the corporate channels.

5.4.2 Milk quality measurements

Although payments were not based on quality with the collectors included in the sample, establishing the quality of milk remains an important aspect of the milk-collection practices for reasons of food safety. Focusing on quality-measurements practices, although John did not seem to perform any quality tests, he actually did. When the supplier poured milk from the aluminium can into John's measuring cup, he not only established the quantity of milk, but also looked at the milk and smelled it as a way of establishing the quality. Similarly for Richard, he explained after the suppliers left that he smelled the milk 'secretly, in order not to offend the supplier'. Some collectors who looked closely at the milk and smelled it to establish quality before pouring it into the other milk used the term 'organoleptic testing' to describe what they were doing. This means to establish milk (product) quality using senses of sight, smell and taste (Draaiyer et al., 2009). The collectors who performed this test were confident about their ability to distinguish good milk from bad milk, drawing on their years of experience as milk collectors, which varied from 3 to 20 years and on average was 10 years.

The companies did not regard organoleptic testing as very credible. As expressed by the manager of the parastatal company, 'You can't see antibiotics and aflatoxins or smell whether people have added water'. Despite their dissatisfaction with the organoleptic test as the only quality test performed, the companies independently reported that they rarely had milk-quality issues with collectors and noted that this is usually an issue with individual suppliers. The corporate collectors performed a variety of quality tests, including lactometer tests to measure milk density and the alcohol test to establish whether the milk is sour. These tests can be performed in a matter of seconds. The collectors of the suppliers' cooperative did not perform these tests during milk collection but at the chilling centre. The same was largely true for the private company, although the milk in some of the aluminium cans was randomly tested by the quality officers on each of the 24 trucks during milk collection. Additional tests that take more time (e.g. establishing levels of aflatoxins) were also performed by the labs of the companies.

These observations illustrate that the corporate supply channels performed more stringent quality tests. The various quality tests were valued differently between owner-operated – and corporate supply channels. Because the corporate collectors are the back-up markets for the owner-operators it is in the interest of all collectors to be able to guarantee the quality of their milk.

5.4.3 Selling the collected milk

John was registered with both companies and was allowed to sell his milk there, which he did. At the time of data collection he had sold milk to the private company that same month, and to the parastatal the month before. The parastatal company did not set any entry-level requirements for suppliers, but the milk price without registration is lower than the price after registration. The private company required collectors to register and to supply at least three days per month. Corporate collectors required suppliers to have a bank account, as payments were processed exclusively through the bank. There were no minimum milk-volume requirements for any of the collectors included in this study.

Focusing on the practices, we observed that all of the milk collected by owner-operators was sold the same day for example to schools, restaurants and other milk traders. The corporate collectors had cooling tanks and could store the milk for longer than a day. They also first processed the milk in their processing facilities (either in Kangema or one of their other locations) before selling it. The owner-operators included in the sample did not add value to the milk except on rare occasions that they had unsold milk left. This illustrates that the business models of owner-operated collectors consisted primarily of buying and selling milk, and not adding value. In contrast, the corporate collectors targeted a different consumer market: urban markets in which people consumed processed products such as yoghurt and packaged milk.

The owner-operators could get better prices (more on milk prices below) from other buyers than selling to the companies, including (1) direct sales to consumers, (2) schools, (3) food establishments, (4) Nairobi traders[3] and (5) other small dairy businesses within or close to Murang'a County. Milk prices that they received for their collected milk from these market outlets at the time of data collection varied between 33 and 50 KES (0.32-0.48 USD) per liter. Except for one cornershop collector, the owner-operators had at least two outlet markets, which could (but not always did)

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[3] Traders that purchase milk from collectors to sell in Nairobi. All included collectors in this study collect milk (at least partly) directly from milk producers. The collectors' buyers who do not collect milk directly from producers but are in the business of trading milk are labelled as traders.

include the companies, excluding sales to consumers. For example, David had nine buyers of milk (excluding the companies and consumers): four food establishments and schools, and a Nairobi trader. One major drawback of some market outlets was however that they were closed during parts of the week (e.g. Sundays) or year (e.g. schools are closed during holidays).

The market for afternoon milk was not as large as the market for morning milk. Of the owner-operators in this study, half collected in the afternoon and the others did not. In general, those who did collect milk in the afternoon/evening collected considerably less milk from less people. For example, William collected daily from 60 morning suppliers and 11 afternoon suppliers. The corporate collectors accepted milk at their coolers all day, albeit also from fewer suppliers in the afternoon than in the morning.

Broadening the focus to the various milk-supply channels, the practices of selling milk were strongly linked to the various business models that were in existence. Typically, the business models of the corporate channel centred on adding value through processing (thereby eliminating the necessity of selling the milk that has been collected each day) and generating income through the sale of processed dairy products to typically higher-end and urban consumers. Owner-operated channels typically did not have access to (cooled) storage facilities, which induced them to sell the collected milk each day. Thereby their business models revolved around collecting and selling raw milk as quickly as possible, with limited time of product ownership.

5.4.4 Establishing milk payments

John did not pay his suppliers for the milk that was exchanged on the morning of 12 September 2019. He also did not receive any payments for the milk that he sold to Nairobi traders later that morning, but he did receive cash payments from the three other milk buyers that he sold milk to (two food places and a shop). During the milk-collection activities, limited exchanges of cash were observed. The collectors included in the sample paid their suppliers according to the suppliers' preference. They mostly preferred to be paid monthly, none were paid daily in cash, and few were paid weekly and bi-weekly. The corporate collectors paid their suppliers monthly through bank accounts, without exception. Advance payments before the end of the month were not possible with the corporate collectors. Some fixed-point milk collectors with shops engaged in barter trade where suppliers delivered milk and took something from the shop (e.g. flour or sugar) in return without paying money for it.

Zooming in on the payment practices of collectors to suppliers, the few cash exchanges that were observed were primarily early payments (known locally as 'soft loans'). This service, which was offered only by owner-operators, allowed suppliers to request an advance of the final payment (in most cases, monthly). In general the amount that could be requested as an early payment should not exceed the value of the milk that had already been supplied for that month. Collectors who had working capital sometimes allowed suppliers to repay in two to four months. The amounts requested through early payments varied from 20 to 10,000 KES (0.18–96 USD). This system showed similarities to what is known as 'check-off' – a service offered by the corporate collectors, in which suppliers have access to inputs (e.g. feed and veterinary care), the costs of which were deducted from payments at the end of the month. The main difference is that owner-operators could provide cash while corporate collectors do not provide early cash payments, but only (early) access to inputs.

In addition to collector's payment practices to suppliers, there are payments between the collectors and their next buyers of the milk. Another exchange of cash was observed between Jennifer and Elizabeth and a new Nairobi trader to whom they sold half their collected milk. Since this trader was new, the collectors requested him to pay direct cash, as they feared that he would otherwise not show up again and take their milk for free. The other Nairobi traders who came to the area on a daily basis paid the owner-operators every two or four weeks. This suggests that cash payments indicated a lack of trust and relatively new relationships, with monthly payments thus indicating the durability of relationships and practices.

Broadening the focus to owner-operated supply channels, the variations in modes of payment for the different buyers to whom owner-operators sold their milk enabled these collectors to meet the daily costs of running their operations, while also saving enough to pay all their suppliers at the end of the month. With the exception of one corner-shop collector for whom the shop and not milk collection was the main source of income, all owner-operators received payments over different time periods (Table 5.3). Except for the direct sales to consumers which are not included in Table 5.3, most owner-operators in this study sold their milk to 1 to a maximum of 11 'bulk' buyers such as schools, the companies, or food places, with varying timing of payments.

Table 5.3: Number of buyers and frequency of payments from these buyers, per owner-operated milk collector.

Type of owner-operated collector	Buyers (no.)	Timing of payments*
Mobile collectors (N=2)	1	Biweekly
	2–4	Daily
	1	Daily
	2	Biweekly or monthly
Both mobile and street collectors (N=3)	1	Weekly
	2	Biweekly
	3–6	Monthly
	≥ 1**	Weekly
	≥ 1**	Daily
	≥ 1**	Monthly
	1–2	Weekly
	3–4	Monthly
Street collectors (N=3)	1	Biweekly or monthly
	2	Daily
	≥ 1**	Biweekly
	≥ 1**	Monthly
	1	Biweekly
	2	Monthly
Shop collectors (N=3)	1–2	Monthly
	3–4	Every 2 – 3 days
	5	Less than monthly
	1	Monthly
	2–4	Daily
	1	Monthly

* Payments from milk sales to individual consumers are not included.

** Exact number unknown, but at least 1 buyer.

5.4.5 Milk prices and competition

With regard to establishing milk prices to suppliers, owner-operators paid similar prices as the corporate collectors. This is because the companies were their back-up markets and they could not risk their other markets falling through and losing money. Prices for the parastatal company were set nationally each month. Price-setting by the private company was also done monthly, based on supply and demand. The owner-operators' prices to suppliers were based on oral agreements for the duration of a month. An overview of the prices paid to suppliers per liter of milk is provided in Table 5.4, along with the consumer prices per liter of raw milk.

Table 5.4: Raw milk prices at the time of data collection.

Kenya Shillings (KES)	Price paid to producers for 1L raw milk in KES [USD]	Price for 1L raw milk for consumers in KES [USD]
Private company (N=1)	32 [0.31]	Not applicable. no raw milk sales
Parastatal (N=1)	30* [0.29]	Not applicable. no raw milk sales
Suppliers' cooperative (N=1)	32 [0.31]	Not applicable. no raw milk sales
Mobile collectors (N=2)	32 [0.31]	40 [0.39]
	30 [0.29]	50 [0.48]
Both mobile and street collectors (N=3)	27–32** [0.26-0.31]	40 [0.39]
	32 [0.31]	50 [0.48]
	30 [0.29]	50 [0.48]
Street collectors (N=3)	30 [0.29]	50 [0.48]
	30 [0.29]	50 [0.48]
	30 [0.29]	40 [0.39]
Shop collectors (N=3)	32 [0.31]	50 [0.48]
	32 [0.31]	40 [0.39]
	32 [0.31]	45 [0.43]

* Final price depended on amounts supplied per agreement; if the amount supplied was more or less than agreed, the price was slightly lower. Although the costs of transportation and extension services are usually deducted as well, the majority of producers delivering to the parastatal in September 2019 received KES 30 (0.29 USD) per liter.

** William paid his morning suppliers KES 30 (0.29 USD) and his afternoon suppliers KES 27 (0.26 USD), due to differences between the morning and afternoon markets, with his primary afternoon market being the parastatal company.

Interestingly, broadening the focus to the various supply channels, the milk prices paid to producers hardly varied between channels. Some owner-operated collectors even paid slightly less than the companies did, contrary to other accounts of prices in raw-milk markets in Kenya in which owner-operated enterprises usually pay more than the companies (Blackmore et al., 2020). Jennifer indicated that producers were aware that they were offering 2 cents less than the private company, but people continued to sell milk to them, primarily because of the service of early payments, which was not available with the corporate collectors.

With regard to competition for milk in the area, an employee of the parastatal company shared a proverb in the local language, Kikuyu: '*Ngombe itiri cianinanira nyeki'* which is roughly translated to 'Cows can't finish each other's grass'. He used this proverb to describe that all actors will always get their share. He further noted that the main function of the parastatal is to ensure that a milk market is always available to producers. This seemingly productive co-existence despite competition for the same milk was further expressed by the private company who noted that they were in business to make a profit and grow, but that they mostly needed to meet a target amount of milk in order to supply their current markets, and the target amount was less than all the milk that was produced in the area. A related example of productive co-existence amongst owner-operated collectors was illustrated by Jennifer and Elizabeth sitting next to each other every morning, collecting milk. They paid the producers the same price, and they both had a business involving milk. They, along with other collectors on their route, also sought to make sure that new buyers would get their share of 'grass' when deciding to sell part of their milk to these new buyers to increase competition and negotiation power. Through these practices, they enabled other practices and, together, they constituted the milk markets around the Kangema area.

At 7:35 a.m. on the same day with which this section opened, John arrived at a junction south of Kangema Town to meet the Nairobi traders, to whom he sold 105 liters of milk. At the same junction, John also met Patricia and Linda, who sold some of their milk to the Nairobi traders, and on his way, John drove past one of William's collectors and the cooling plant of the parastatal company. After leaving the junction, John sold the remaining 30 and 15 liters to two roadside restaurants in town. He had already sold another 10 liters to a shop along the road to the junction. He estimated that he had sold 20 liters of milk directly to consumers, although he did not maintain records of this. He had now sold all the milk that he had collected that morning and, because he did not collect milk in the afternoon, his milk-collection activities for that day were finalised, leaving him with a profit of 980 KES (9.45 USD).

5.5 Discussion

The combined interests in FNS and the reduction of GHG emissions have been a driving force in policy and intervention in East African dairy sectors. This interest commonly translates into a pathway approach that combines the intensification of dairy farming with the commercialisation and formalisation of market infrastructures. We use an empirical study of the practices of milk collection to examine whether formalisation is productive in achieving ambitions pertaining to FNS and GHG emission reductions. We adopted an empirical approach to answer our diagnostic research question: 'What enables diverse intermediary practices to ensure a consistent flow of milk from grass to glass (supplier to consumer)?'

Iterative analysis of observations revealed three main themes constituting milk-collection practices: (1) buying milk from the producer, (2) managing milk (quantity and quality measurement) and (3) selling milk to the next buyer. These practices were enabled and sustained by the diverse options available regarding the aspects of milk collection and the capacity of collectors (particularly owner-operators) to accommodate such variety in their practices. Moreover, the collectors' practices enable and constitute different supply channels that serve and provide benefits to a variety of producers and consumers. At the catchment level, we conclude that the diversity of practices by actors operating along a continuum from 'formal' to 'informal' are productive in the sense that they successfully arrange the flow of milk from farms to consumers on a very frequent (daily or more) basis. This is highly valuable in terms of supporting rural livelihoods and availing nutritious food, and therefore for contributing to FNS.

Proceeding from practices of conduction in order to detect the institutional dimensions of daily transaction processes (Mangnus & Vellema, 2019; Schoonhoven-Speijer & Vellema, 2020), we demonstrate how suppliers know what to expect from milk collectors, given that sourcing milk is not a random, unorganized practice, but reflects institutional features that are recognized within rural communities. As a specialised task, the manner in which milk collection is organized relates to a set of unwritten rules linked to the timing and frequency of supply, the mode and timing of payments and acceptable quantities and quality controls. These aspects are enacted and reinforced in the everyday practices of buying and selling milk, in which collectors play a central role.

In the situated practices of milk collection, the collectors demonstrate skills in managing milk and associated cash flows in a flexible yet predictable manner. This sustains the flow of milk sourced from rural communities, as small-scale suppliers and remote buyers depend for their access to transaction on the performance of the skilled collectors in managing the middle of the milk chain. In addition, milk collectors are able to accommodate a variety of interests and supply practices. Given the diverse needs of producers and consumers, milk collectors need a variety of skills relating to various forms of interaction and transaction. At the level of milk collection in rural communities, therefore, there is no single way of governing the transactions, and the resulting degree of institutional variety within the catchment area is again reinforced and enacted in milk-collection practices. Institutional variety can support sustainability and inclusivity of the system.

Although formal and informal markets may exist theoretically, in practice, they are not as distinct as the concepts suggest. This is illustrated by the included owner-operators in this study who's milk partly ends up with companies ('formal') and individual consumers ('informal'), among others. Strategically, thinking in binary terms rather than looking at markets along a continuum from formal to informal reduces the options to extremes (Duncan & Bailey, 2017) – such as formalisation – thereby excluding options that may appear in between the extremes. It would therefore be much more effective to explore contextualised solutions, rather than striving to realise ideal-type market organisations (Mangnus & Schoonhoven-Speijer, 2020). Approaching the concepts as a continuum (Blackmore et al., 2020; White & Aylward, 2016) could enhance the likelihood of reducing what Blackmore et al. (2022) refer to as the 'regulation-reality' gap for Kenya's dairy sector. Instead of applying a 'state' perspective to economic activity in dichotomous terms of 'formal' and 'informal' terminology, we recommend adopting an actor and practice perspective when discussing economic activity. One way to do this could involve adopting a more precisely nuanced view of the types of actors observed (Alonso et al., 2018; Wegerif, 2020; Wegerif & Martucci, 2019) and examining the diverse functions that they perform and the productivity of these functions (Kilelu et al., 2011).

The formalisation of commercial transactions between milk producers, collectors and processors is often presented as the most effective way in which to incentivise and enable intensification. The underlying assumptions that we partly challenged are that intensification practices can be best promoted via the extension support of cooperatives and companies, that formalisation of transactions create reliable markets and foster commercialisation: all considered incentives for producers to intensify dairy. The results of this study suggest that the owner-operators, as much as the corporate collectors, do provide the reliable market demand and create incentives to intensify. Moreover, it appears having both 'informal' and 'formal' alongside each other creates a more diverse and sustainable system that gives more options and therefore better incentives for a wider range of producers.

It is important to note, however, that the intensification of production is not only a function of having access to markets. A subsequent step towards the realisation of intensification efforts could be to complement this practice-oriented study of milk-collection practices with an actor-oriented typology of intermediary functions in innovation, such as those focused on providing access to inputs and those distributing technology (Kilelu et al., 2011). Future studies could explore which functions are already being performed and could be supported in order to fit within the business models of collectors, and which functions would likely fit better with types of actors and institutions other than corporate and owner-operated milk collectors.

In this article, we avoid promoting an exclusive sustainable-development pathway (of formalisation) in favour of engaging with 'messier' (but often organised) realities of the provisioning and marketing of food. We invite scholars and practitioners to engage in deeper exploration of how what occurs in practice could be accommodated and improved for ambitions relating to FNS and the reduction of GHG emissions through pathways of intensification and commercialisation.

Chapter 6

General discussion

6 General discussion

6.1 Introduction

The thesis makes the case for coupling capturing and accommodating diverse and situated actors and practices. This creates room to explore and support the likely success of ambitions that combine human development and climate action, the so-called triple-win outcomes. All empirical chapters examine how diverse and situated actors and practices can be captured and accommodated, with an emphasis on 'capturing' in Chapters 2 and 3, and on 'accommodating' in Chapters 4 and 5. The individual chapters addressed specific knowledge gaps. Chapter 2 investigated the relation between dairy intensification practices and livelihoods, wealth, and household dietary diversity in Kenya and Tanzania. Chapter 3 identified different types of smallholder dairy farmers and dairy farming practices embedded in specific geographical locations in three counties in Kenya. Chapter 4 exposed the use of skills and know-how in adaptive cattle feeding practices of smallholder cow owners, over time and in sub-optimal and changing conditions in Bomet Country, Kenya. Chapter 5 documented the diversity of commercial practices of milk collectors, which is accommodated in a catchment area in Murang'a County, Kenya. This discussion chapter brings the learnings from the empirical chapters together in answering the main research question: *What conditions and processes likely accommodate a diversity of actors and practices in climate-development initiatives in Kenya's dairy sector?*

6.2 Main findings: Capturing and accommodating diversity

6.2.1 Capturing diversity

This thesis explored the realities of diverse actors and a wide range of practices that speak to the emerging sustainable development pathway of smallholder dairy intensification, which is often coupled with the integration of smallholders into formalised market arrangements. All chapters captured the diversity of actors and their practices and therefore move beyond bounded categories of intensification or diversification strategies, adopters or non-adopters of technical practices, and formal and informal marketing channels.

Chapter 2 found that under certain conditions, dairy intensification can be part of a diversified livelihood portfolio. This suggests that win-win-win for people, profit and planet can co-exist. Conditionally, dairy intensification can contribute to household wellbeing, and can be part of a multiplex livelihood portfolio that includes diversification strategies.

Chapter 3 then investigated classifications of socio-economic profiles of smallholder farmers that keep dairy. It answered the question who the farmers are, and what they do in terms of dairy farming practices. The chapter distinguished six household types and investigated their dairy farming practices both at household and regional levels. The chapter revealed patterns in dairy farming practices to which LEDS should attune for enhanced success. This entails being sensitive to both household and regional dimensions that influence the uptake of practices.

The analysis in Chapter 4 is based on temporal dynamics in the uptake of LED practices. The analysis informed a discussion on a shift towards accommodating situated adaptive capacities of smallholders in strategies with climate ambitions. The outlook in this chapter balanced climate change mitigation and adaptation approaches. It showed that households are not permanent adopters or non-adopters of certain technologies; rather, they employed networked adaptive capacities to feed their cattle through seasons, moving along with the rhythms of agriculture.

Chapter 5 portrayed an interconnected variety of milk collection practices on a formal-informal continuum, with the aim to move beyond a formal-informal dichotomy. The empirical study found a set of market channels, ranging from milk collected by large buyers looking for a consistent supply of milk, to owner-operated collectors embedded in local communities able to buy varying volumes. The diversity of commercial practices could co-exist in a single catchment area.

Together, the chapters empirically capture the diversity of livelihood strategies, production systems, household characteristics, and farming - and milk collection practices at cross-national level, regional level, milk catchment level, household level, and across time. The chapters relate the identified diversity to certain conditions. Chapter 2 found that win-win-wins for people, profit and planet are likely, but only for a subsample of the households. Our results suggest that where land is relatively abundant, semi-intensive dairy farmers might have no ambition to further intensify. Being able to graze the cattle is considered financially more interesting than having to invest in buying feed. Relevant conditions for our findings are therefore related to access to production assets, notably land, and input market dynamics, notably access to and prices of feed.

The results in Chapter 3 show the relevance of considering regional conditions in combination with socio-economic profiles for designing strategies for technology uptake. The results suggest that the (non-)uptake of zero-grazing and associated other feeding – and manure management practices is an emergent outcome of the historical element of land pressure and geographical element of proximity to major milk markets. This chapter adds access to and pricing at output markets to the relevant conditions found in Chapter 2.

The diversity of cow feeding practices presented in in Chapter 4 unfolded in sub-optimal conditions of (prolonged) dry seasons and a maize crop disease. The persistence of situated and sometimes improvised feeding practices contrasts with the dominantly presumed optimal and stable conditions for which intensification practices are designed. The chapter centralises household adaptive capabilities in responding to the environmental conditions of changing seasons, weather patterns, and shocks such as a plant disease affecting a major food and feed crop.

The findings in Chapter 5 were observed in a catchment area with specific conditions, such as the generally sufficient availability of milk, and the proximity of three formal marketing channels in combination with owner-operated milk collector businesses. A certain degree of competition and the co-existence of a multiplicity of market outlets in a spatially bounded catchment area appears to be conducive to sustaining a variety of commercial practices.

To conclude, the findings about capturing show that understanding the conditions under which diversity is observed are relevant for explaining the observed diversity. The next section elaborates how these conditions are key to learning how the diversity of actors and practices can be accommodated.

6.2.2 Accommodating diversity

All chapters explored the conditions under which a diversity of actors and practices can be accommodated. First, at the level of households, diversity for Kenya's dairy sector can be understood by looking at the integration of dairy and other livelihood activities, and particularly synergies between crop cultivation and livestock rearing. Chapter 2 further shows that, under certain conditions, dairy intensification can exist in a diversified livelihood portfolio. This suggests that diverse livelihood strategies can co-exist. The chapter cannot speak to causality, but the findings suggest that dairy intensification can be accommodated by a diversified livelihood strategy, and the other way around.

Chapter 3 contextualized household diversity in the specific dynamic and histories of regions. It makes a step towards exploring how to accommodate diversity that moves away from an exclusive household focus. Chapters 2 and 3 show that dairy is part a larger livelihood portfolio embedded in a specific agri-food system. Diversity in dairy is accommodated by other farm and off farm activities, for example for generating incomes to invest in dairy. Vice versa, dairy also accommodates a range of other farm and off farm activities, for example via providing manure and financial security. Both chapters show that dairy can have various priorities in the household, which influences how households can be incentivized to adjust their dairy practices.

Second, at practice level, the findings suggest that to successfully accommodate diversity it is relevant to look across time and spatial dimensions. In Chapter 3, the added value of the household and area levels allowed for examining perspectives for fitting induced dairy practices to diverse realities. In addition, the chapter touched on the time element at county level. It showed that the relative prevalence of zero-grazing systems in Murang'a is partly attributed to sever historical land pressures in relation to geographical proximity to the capital, than in Nandi and Bomet. Including multiple spatial levels and time horizons is valuable for finding solution or intervention spaces to accommodate diversity compared to research strategies centring on a single level, particularly the level of household priorities and capacities.

Chapter 4 discovered that cattle feeding is not a momentary practice but a continuous and networked response containing elements that are initiated during previous seasons and that can resonate through future seasons. Describing cattle feeding as a technical as opposed to a socio-technical practice blinds an investigation to what really constitutes the practice, and across which time spans, thereby potentially eliminating the accommodation of elements of the practice. Understanding and accommodating practices through time is increasingly relevant now that recurring and relatively stable patterns through time, such as seasons, are changing due to the consequences of climate change.

Chapter 5 showed how accommodating diverse milk collection practices in a single area appears to be possible and productive, questioning the need for formalisation to achieve intensification and commercialisation objectives. Further, the findings show how accommodation of diversity is already happening in practice and is not something that necessarily has to be externally 'introduced'.

The empirical chapters expose conditions that are conducive for accommodating diversity in practice. Moreover, the chapters highlight that the combination of, for example, milk collection practices in a catchment area adds to the capacity to accommodate diverse realties of smallholder cow owners, and potentially, make this part and parcel of interventions in the climate-development nexus. It is relevant to recognise and unravel the interdependencies between multiple dimensions, such as household-level decision making, evolving situated practices, and regional dynamics in catchment areas. Analysis also benefits from taking a processual angle that allows for detecting practices that proof to be able to accommodate diverse practices that evolve across time horizons, such as seasons or life spans.

6.3 Conceptual implications and reflections

An objective of this thesis was to explore conceptual directions that aid in going beyond only capturing diverse actors and practices, and help to find spaces that accommodate this diversity. The conceptual implications that I present and reflect on are first a further defining of what specifically needs accommodation, and second, an explicit coupling of capturing and accommodating.

6.3.1 Agrarian diversity, and agency embedded in performance

The focus of this thesis' shifted from capturing diverse smallholders and their dairy farming practices to studying what conditions or processes accommodate diverse actors and practices. Therefore, the question arose what precisely it is that needs accommodation in the context of agricultural sustainability transitions.

I propose to characterize the diversity of actors and practices explored in this thesis as "agrarian diversity." This term is chosen over "agricultural" diversity because the latter fails to encompass the observed range of actors and practices in this study. By utilizing the term "agrarian," attention is drawn to the 'agrarian question' in political economy (Kautsky, 1899; Watts, 1985; 2021). This question delves into how agricultural structures intersect with the quality of life and capital accumulation abilities of rural communities within different economic systems such as capitalism and socialism. In my perspective, the term "agricultural diversity" falls short in adequately capturing the social and economic relations that smallholder farmers maintain with other participants in the value chain, as it tends to focus on technical agronomic practices and farming systems. Furthermore, the concept of agrarian diversity aligns well with the captured diversity in this thesis, including the socio-economic characteristics of how smallholders organize dairy production, and how these aspects relate to livelihood strategies (Chapters 2 and 3). Additionally, agrarian diversity serves as a lens through which to examine the relations of production not only among producers (Chapter 4) but also involving milk collectors' businesses (Chapter 5).

Reflecting on what precisely it is that needs accommodation, the empirical findings suggest this is actors' agency embedded in the performance of agrarian practices. The applied concepts of affordances (Glover, 2022; Ingold, 2022), agriculture as performance (Richards, 1989), and (networked or webs of) practices (Nicolini, 2011; 2012) represent a conceptual shift that aided in moving attention from capturing towards accommodating. Agency is partly created from performances in practices, specifically by how actors use skills, techniques, and know-how for achieving practical ends (Jansen & Vellema, 2011). Examples of agency emerging from the performance of practices is visible in how the cow owner Faith (Chapter 4) drew on her network in the dry season to sustain feeding her cow. It can also be seen in the use of skills by milk collector John (Chapter 5) in converting milk quality tests to sustain his access to the producers' milk while also safeguarding that his milk will be bought by his next buyers without contestations over the quality. Coupling agency and performance emphasises that agency is produced in people's actions, and complements conceptual directions deducing agency as a property of actors. Mentioning of agency is meaningless without addressing structure, which I touch upon under 'Suggestions for further research' later in this chapter.

6.3.2 Coupling capturing and accommodating

The observed diversity touching on multiple temporal and spatial dimensions or levels is subject to certain conditions, which guides my search for a conceptual direction that advances our understanding of processes of accommodation of a diversity of actors and practices. An implication of this thesis for agrarian sustainability transitions is that capturing should be a secondary to the quest for finding room to accommodate agrarian diversity and actors' agency emerging from the performance of practices. Coupling capturing and accommodating means that the ways to capture diversity should be assessed on their effectiveness for finding ways and space to accommodate.

Lessons for ways and space to accommodate can be derived from the thesis. Emphasizing the element of agency that is (re)produced in practices, spaces for accommodation can likely be found in existing webs of practices. Chapter 2 suggest that for a subsample of the included households, dairy intensification accommodates other livelihood activities, or the other way around. The building and performance of livelihoods can be considered as webs of practices. At county level, Chapter 3 showed rather distinct dominant dairy production systems in Nandi and Bomet (semi-intensive, grazing) compared to Murang'a (zero-grazing), yet in terms of household types, distribution across the regions was close to equal. This shows that each contextualized region accommodates a great diversity of smallholder farmers, from vulnerable to more affluent. The findings of Chapter 4 show the networked elements of the practice of feeding cattle, which support various smallholder cattle feeders over time. In Chapter 5, we find how accommodation materialises in commercial practices in a catchment area. This became more manifest after zooming out from practices bounded to specific actors, to webs of practices. The combination of parallel or co-existing milk collection practices constitutes the web of practices that accommodates diversity, serving diverse producer, collector, and consumer needs and effectively moving milk from grass to glass.

Furthermore, the findings of this thesis invite to reflect on lessons regarding spaces that struggle to accommodate diversity. Instances of less accommodative spaces are evident in the semi-intensive farming systems in Chapter 2, where households specialized mostly in dairy displayed the least diversity in their livelihood portfolios. Chapter 3 indicates a limited capacity to meet the needs of vulnerable households across the included countries and dairy production systems. Chapter 4 suggests a connection between access to social networks and the ability to perform dairy cattle feeding in suboptimal conditions, and therefore limited space to accommodate practices might be related to communal access and organisation. In Chapter 5, corporate collectors are identified as providing less room to accommodate diversity due to inflexible practices in collection, quality and quantity establishment, and payment processes, in contrast to owner-operated collectors.

The concluding Figure 6.1 below epitomises the lessons drawn from this thesis for finding spaces to accommodate actor's agency embedded in the performance of agrarian practices. It couples capturing and accommodating, as it is expressed in the number of captured dimensions (y-axis, single or plural), and of an expression about the interaction between the captured dimensions (x-axis, from static to processual). Chapter 2 captured static practices at household level and aggregated these to the level of the county, adding a regional dimension to the household dynamics. The combination of a household and regional dimension, despite capturing static practices, suggested the ability to develop LEDS more embedded to smallholder intensification practices. Chapters 4 and 5 employed the processual concepts of agriculture and milk collection as performance, and affordances, allowing me to understand better how the diversity of unfolding practices through time are accommodated. To greater or lesser extend the empirical chapters touched for example on economic (Chapters 2, 3), socio-technical (Chapters 2, 3, 4), geographic (Chapters 3, 5), agro-ecological (Chapter 4), and institutional dimensions (Chapter 5). Figure 6.1 shows overlaps from capturing into finding space to accommodate when multiple dimensions are studied (e.g. socio-technical and agro-ecological), and when (single) dimensions are studied following a processual approach (e.g. daily milk collector practices).

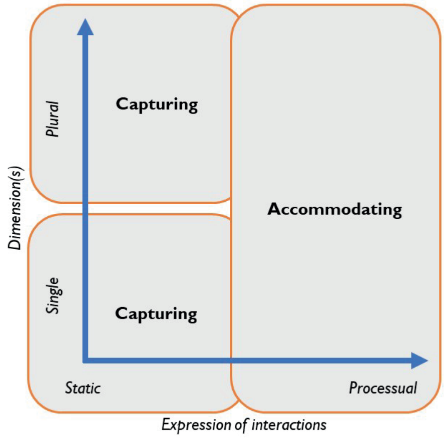

Figure 6.1: Directions for finding spaces to accommodate actor's agency in the performance of agrarian practices.

6.4 Methodological implications and reflections

Methodologically, the thesis aimed to offer an integrative perspective on capturing and accommodating diverse dairy sector actors and practices. I made several choices that aided in pushing beyond capturing diverse actors and practices, to finding spaces that accommodate them. This section reflects on my methodological and analytical choices and the methods used. Two methodological implications follow from a shift from capturing to finding spaces or processes that accommodate agrarian diversity, namely 1) purposefully combining methods for capturing and accommodating, and 2) ex-ante diagnostics research.

6

6.4.1 Purposefully combining methods for capturing and accommodating

The co-variational and multi-dimensional orientation in the research design and subsequent choice for quantitative methods allowed for representative capturing the diversity of dairy smallholder livelihood strategies (Chapter 2), socio-economic profiles of dairy smallholders, and uptake patterns of smallholder LED dairy practice at household and regional levels (Chapter 3). The processual design and choice for qualitative methods allowed for finding room for understanding how accommodation happens in practice, most notably in Chapters 4 and 5.

In my thesis, the lessons for coupling capturing and accommodating only emerged after the research design was established and research activities commenced. A main reflection is therefore that it is valuable to connect methods for capturing and accommodating more systematically in the future. For example, more systematic nested qualitative research in a quantitative household survey sample, such as in Chapter 4, could potentially reveal stronger conclusions about regionally embedded smallholder dairy practices over time. Qualitative findings could also inform quantitative research design better than was currently the case, making household surveys more valuable for finding spaces to accommodate, then to 'merely' capturing.

6.4.2 *Ex-ante diagnostics research*

My thesis was deliberately not designed as an evaluative study of LEDS as a transformative intervention. The research can be characterised as an ex-ante effort to investigate how LEDS can be embedded in the diverse realities of Kenya's dairy sector. A diagnostic (Rodrik, 2010) orientation to research for development highlights the importance of the links between actors, practices, and context. Ex-ante diagnostics means to assess the current situation and to do foresight by building on or connecting to what is available and what works in real settings. It was therefore not an outcome-oriented search for inclusion of cow owners in LEDS. Rather, it looked at inclusion as an unfolding process that is already takes place in practice, for example in a milk catchment area (Chapter 5) and in a community that feeds cows (Chapter 4), which is not always visible in research or policy. Therefore, integrating the findings from the empirical chapters in ex-ante diagnostics can inform LEDS to build on currently available adaptive capacities. Such an integrative lens emphasises the relevance of configuring multiple processes, in the case of this thesis for example developments in land sizes, the effects of climate change on agricultural production, and market developments.

Relatedly, the type of research that I conducted could be labelled as diagnostics research, borrowing from healthcare, to first identify the symptoms before prescribing the medicine, or solution. In a way, this thesis entails two lines of diagnostic inquiry, namely (a) capturing diverse actors and practices, and (b) identifying spaces that either accommodate or likely hamper the accommodation of diverse actors and practice. From these lines the need for a third diagnostic arises, labelled as institutional diagnostics (Rodrik, 2010). Institutional diagnostics aims to identify which institutional elements are hampering or accommodating agency expressed in the performance of agrarian practices. Institutional diagnostics can help to uncover the caveats to the findings in Chapter 2 by exploring the intensification and livelihood diversification dynamics in the most specialized dairy households in semi-intensive dairy production systems. This can be done via study of practices: Schoonhoven-Speijer (2021) shows that the study of practices can uncover how institutions are (re)produced and made viable. 'Pockets' and 'layers' are further interesting concepts that can help define socio-institutional contexts that support of hamper the unfolding of socio-technical transitions in contexts of scarcity (Ramos-Mejía et al., 2018). These are broad suggestions for further research that addresses more explicitly the structural elements, or structuring institutions, relevant for understanding how actor's agency in the performance of practices can be accommodated.

6.5 Implications for policy and development

The societal objective of the thesis was to inform the design of transformative agendas that address both human development and climate change ambitions in Kenya's dairy sector. Based on my research, I suggest rethinking target groups approaches, and outline some of the implications for LEDS for Kenya's dairy sector.

6.5.1 Rethinking target groups for interventions

A key implication for policy and development is to rethink target group approaches, which start from 'what can we do to target this specific group' and move to 'how can we intervene to accommodate agency and agrarian diversity'. This implication for development stems first from coupling agency to the performance of practices, complementing not only conceptual directions but also development practice directions that deduce agency as a property of actors. Instead, agrarian practices are partly networked responses extending beyond the individual or household (Chapters 4 and 5). Second, observed practices at actor level can be emergent outcomes of regional processes (prevalence of zero-grazing in Murang'a, Chapter 3), potentially undermining the effectiveness of actor level interventions. An implication for policy and development is to intervene where opportunities for actors to perform their practices can be enlarged. Examples are to invest in Research & Development to predict and respond to feed (and food) crop diseases as a result of climate change, or to organise communities around situated climate change adaptation responses to support the incorporation of farmer skills in initiatives such as LEDS (Habermann et al., 2022).

Essentially, the above argues in favour of starting from another question raised by Meadows (1999), namely, where to intervene in systems? This question, following the approach of this thesis, shifts attention from intervening in captured categories, such as target groups, to directing interventions to spaces where broader and diverse actor and practice accommodation can be supported. Further, this is an argument for centralising practices over actors. For supporting diverse livelihood strategies (Chapter 2), which people enact in their adaptive practices (Chapters 3, 4, 5), interventions should enable and support people to realise their aspired actions and enlarge the array of actionable opportunities. Figure 6.2 visualises this.

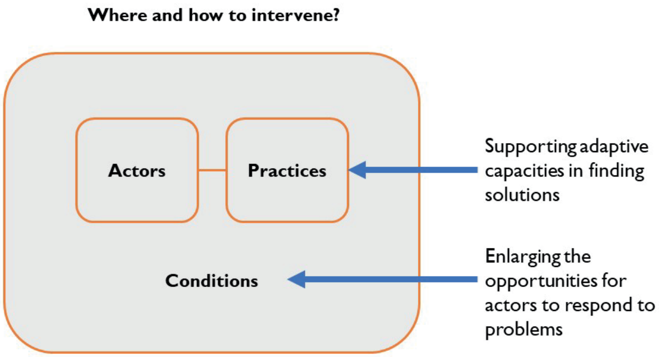

Figure 6.2: Overview of lessons about how and where to intervene in the system.

6.5.2 *Implications for making Low Emission Development inclusive*

A key implication for making LEDS inclusive is to recentre away from inducing or evaluating predefined fixes, either technical or institutional, to detecting and supporting adaptive capacities and the consequential inclusion of situated solutions in LEDS. Predefined fixes, such as formalisation (Chapter 5) likely limit opportunities for actors to respond to problems, thereby limiting their ability to perform situated solutions. The insights from this thesis support a steering away from the dominant pathway that was problematized at the start of this thesis, and, instead, support and encourage the unfolding of multiple development pathways.

A second key implication for inclusive LEDS is to develop less actor-oriented and more practice-oriented action perspectives. Specifically, Chapter 2 shows to consider the wider production system and multiplex livelihoods that dairy is a part of. LEDS exclusively for the dairy sector are in that sense already limiting. Rather, interventions that support the synergistic integration between crops and livestock are particularly promising to resonate with smallholder priorities. Chapter 3 suggests how technical one-size-fits-all LED practices can be embedded in local contexts and makes sense for differentiated smallholder type and warrants against an exclusive household intervention focus. Understanding regional uptake of LED-practices shows that interventions at household level might not be sensible, such as pushing zero-grazing in relatively land abundant farming areas or pushing manure collection in semi-grazing systems. Additionally, an exclusive household focus might limit the ability to see region-specific solutions where different types of households could perform complementary rather than similar dairy intensification practices. Chapter 4 highlights the importance of understanding dairy farming practices through time, and balancing mitigation and adaptation. Instead of a strong emphasis on what smallholders are currently *not* doing to mitigate climate change, translating into interventions to intensify milk production per cow, intensification can be catalysed by configuring interventions to what people *are* currently doing to produce milk. The findings of Chapter 5 suggest that perhaps market formalisation is not a necessary precondition for intensification and commercialisation. The existing web of commercial practices already opens space to explore opportunities and solutions that work in local realities, rather than rely on solutions working on paper.

6.6 Suggestion for further research

Further ex-ante diagnostics research could help inform potential synergies between human development and climate change ambitions in agrarian sustainability transitions. Specifically, Chapter 2 suggests further sense-making of the conditions under which households make livelihood decisions, and to the implications of dairy intensification on intra-household dimensions. Chapter 3 suggests exploring the institutional conditions for creating or reinforcing horizontal and vertical alignments of LEDS with the variation of and dynamics in Kenya's dairy sector. This could involve vertical alignments between relevant administrative offices. Chapter 4 invites agricultural research for development to enhance evolving context-specific practices (more), which involves aligning interventions to the rhythms of agriculture. It could be interesting to investigate how institutional developments in a region, in addition to agro-ecological development, influence the rhythms of agriculture. For example, fodder crop production seasons plausibly shape fodder market dynamics, which might influence smallholder decisions regarding purchasing feeds or finding alternative ways to access feeds. Chapter 5 invites to explore institutional leverage points to support intensification and commercialisation efforts that do not involve formalisation of all economic milk market relations.

6.7 Concluding

The findings of this thesis shift attention away from the one-size-fits-all options of intensification practices and formalisation as starting points for interventions. It recentres the research gaze on situated agency emerging in the performance of agrarian practices. Building from observed solutions rather than from perceived solutions is likely to enhance overall success of integrated human development and climate change interventions. Such an approach plausibly creates a better fit with a larger sample of the relevant population and sectors needed to effectively address the human development and climate change concerns. Instead of focusing on pushing perceived big solutions to big problems, there is added value in finding and supporting contextualized solutions fitting evolving diverse realities. Consequently, the insights form this thesis call for ex-ante diagnostics approaches to anticipate future accommodation of diverse actors and practices in the climate-development nexus.

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English summary

A complex challenge for Kenya's dairy sector is how to balance realizing human development and addressing climate change. From a climate change perspective, greenhouse gas (GHG) emissions from dairy production systems should be reduced via sector transformations. Yet, from a human development perspective, the dairy sector is expected to continue to offer valuable nutrients and to meet the increasing demand for animal products. Additionally, dairy is part of people's cultural identities and livelihoods. A dominant development pathway at the climate-development nexus is unfolding in Kenya to address the challenge. This pathway is characterized by an emphasis on one-size-fits-all technical climate change mitigation interventions at the level of smallholder dairy farming practices, coupled with market formalization.

This thesis aims to address concerns about a disconnect of the emerging pathway with diverse livelihood priorities and embedded agricultural and commercial practices. It, therefore, examines how diverse actors and their situated practices can be captured and accommodated in sustainability transitions. The guiding research question is: *'What conditions and processes are likely to accommodate a diversity of actors and practices in climate-development initiatives in Kenya's dairy sector?'*. All empirical chapters examine how diverse and situated actors and practices can be captured and accommodated, with an emphasis on 'capturing' in Chapters 2 and 3, and on 'accommodating' in Chapters 4 and 5.

Chapter 2 draws on data from Tanzania and Kenya and captures the roles of dairy in various livelihood strategies of smallholder farmers. It specifically explores whether dairy intensification threatens livelihood diversification, dietary diversity, and wealth. The results show that under certain conditions, dairy intensification can be part of a diversified livelihood portfolio, and a win-win-win for people, profit, and planet can coexist. This win-win-win potential, however, only applied to intensified dairy households, while semi-intensified dairy households specialized mostly in dairy and displayed the least diversified livelihood portfolios. Relevant conditions in our findings are related to access to production assets, notably land, and input market dynamics, notably access to and prices of feed.

Chapter 3 investigates in more detail who farmers with cows are and what dairy farming practices they employ in three countries in Kenya. A household typology is presented, and dairy farming practices are further investigated per household type and at the county level. It finds that the six household types are almost equally present in the three counties, but there are regional differences in the uptake of particularly zero-grazing between one and the other two counties. For Low Emission Development

(LED), this implies that its design should depart from one-size-fits-all technical fixes. Rather, LED should attune to both household and regional dimensions that influence the uptake of practices to find a contextual 'fit' with household priorities and regional conditions.

Moving to Chapter 4 marks a shift from a focus on capturing smallholder actors and dairy farming practices from livelihood, socio-economic, and technical dimensions to a search for a better understanding of how dairy farming practices evolve over time. Chapter 4 adds time and agency elements to understanding how the practice of feeding cows is performed through seasons and lifetimes, and in sub-optimal conditions of a maize disease and (prolonged) dry periods. It finds that households are not permanent (non-)adopters of certain technologies; rather, they employ networked adaptive capacities to feed their cattle through seasons, moving along with the rhythms of agriculture. The outlook for agricultural research for development consequently advocates for offering more space and potentially catalysing or adding to contextualised practices, via integrating multiple and consecutive solutions constructed by people under vulnerable conditions.

In the search for spaces where a diversity of practices is already accommodated, I embark on deep diving into a milk catchment area harbouring a variety of corporate and owner-operated milk collectors, ranging from formal to "informal". Chapter 5 portrays an interconnected variety of milk collection practices on a formal-informal continuum. A certain degree of competition and the coexistence of a multiple diverse market outlets in the catchment area appears to be conducive to sustaining a variety of commercial practices. The findings question the need for formalisation to achieve intensification and commercialisation objectives, and how accommodation of diversity is already happening in practice, instead of something that must be externally 'introduced'.

Chapter 6 brings the main findings of this thesis together. It concludes that spaces to accommodate diversity can be found in a search for situated agency emerging in the performance of agrarian practices. An implication for research is that capturing should be secondary to the quest for finding room to accommodate agrarian diversity and actors' agency emerging in the performance of practices. An implication for integrated human development and climate change interventions, including LED, is that building from observed solutions rather than from perceived solutions is likely to enhance overall success. For research and development, the insights from this thesis call for ex-ante diagnostics approaches to anticipate future accommodation of diverse actors and practices in the climate-development nexus.

Nederlandse samenvatting

Een complexe uitdaging voor de zuivelsector van Kenia is het vinden van een balans tussen sociaaleconomische ontwikkeling en het aanpakken van klimaatverandering. Vanuit een klimaatverandering perspectief moeten de broeikasgasemissies van de zuivelsector worden verminderd. Tegelijkertijd wordt vanuit een sociaaleconomisch ontwikkelingsperspectief verwacht dat de zuivelsector blijft bijdragen aan voedselzekerheid, en een groeiende vraag naar dierlijke producten. Daarnaast maakt de zuivelsector deel uit van de culturele identiteit en het levensonderhoud van mensen. In Kenia ontvouwt zich een dominante aanpak op dit snijvlak van klimaat en sociaaleconomische ontwikkeling om deze uitdaging aan te gaan. Deze aanpak wordt gekenmerkt door de nadruk op eenduidige (‘*one-size-fits-all*’) agrarische technieken die de uitstoot van klimaat mitigeren op het niveau van kleinschalige zuivelboeren, en is gekoppeld aan het formaliseren van economische marktrelaties.

Dit proefschrift heeft als doel om zorgen te adresseren in relatie tot deze aanpak, namelijk het ogenschijnlijke gebrek aan verbinding tussen de eenduidige aanpak, en de diversiteit aan actoren en lokaal ingebedde agrarische praktijken. Het onderzoekt daarom hoe diverse actoren en hun agrarische praktijken vastgelegd of gekarakteriseerd kunnen worden, en hoe ze vervolgens beter geaccommodeerd kunnen worden in duurzaamheidsinitiatieven. De onderzoeksvraag is: 'Welke voorwaarden en processen zijn van belang om diverse actoren en praktijken te accommoderen in klimaat-ontwikkelingsinitiatieven in de zuivelsector van Kenia?'. Alle empirische hoofdstukken onderzoeken hoe diverse actoren en praktijken kunnen worden vastgelegd en geaccommodeerd, met de nadruk op 'vastleggen' in hoofdstukken 2 en 3, en op ‘accommoderen’ in hoofdstukken 4 en 5.

Hoofdstuk 2 maakt gebruik van huishouddata uit Tanzania en Kenia om de verschillende rollen van zuivel in complexe en diverse strategieën van levensonderhoud vast te leggen van kleine boeren. Het onderzoekt of de intensivering van zuivelactiviteiten bedreigend is voor de diversificatie van het levensonderhoud, diversiteit in voeding, en rijkdom van de huishoudens. De resultaten tonen aan dat onder bepaalde omstandigheden zuivelintensivering deel kan uitmaken van een gediversifieerde levensonderhoudsstrategie, en een win-win-win voor mensen, winst en planeet kan samengaan. Dit win-win-win potentieel was echter alleen van toepassing op geïntensiveerde zuivelhuishoudens. Semi-geïntensiveerde zuivelhuishoudens waren het meest gespecialiseerd in zuivel, en het minst gediversifieerd in hun levensonderhoudsstrategie. Belangrijke voorwaarden in onze bevindingen hebben betrekking op toegang tot productiemiddelen, met name land, en dynamieken op de inputmarkt, met name toegang tot en prijzen van veevoer.

Hoofdstuk 3 onderzoekt gedetailleerder wie de kleine boeren met koeien zijn en welke zuivelpraktijken zij toepassen in drie provincies in Kenia. Er wordt een typologie van huishoudens gepresenteerd en zuivelpraktijken worden onderzocht per huishoudtype en op provinciaal niveau. De zes huishoudtypes zijn bijna gelijk vertegenwoordigd in de drie provincies, maar er zijn regionale verschillen in het praktiseren van met name nulbegazing tussen één provincie en de andere twee. Voor zogenoemde lage-emissie-ontwikkeling (LED) betekent dit dat interventies niet moeten uitgaan van uniforme technische oplossingen op huishoudniveau. In plaats daarvan zou LED beter moeten afstemmen op zowel huishoudelijke als regionale dimensies die het praktiseren van bepaalde zuivelpraktijken beïnvloeden om een contextueel passende afstemming te vinden met de prioriteiten van huishoudens en regionale omstandigheden.

De overgang naar hoofdstuk 4 markeert een verschuiving van de focus op het vastleggen of karakteriseren van actoren en zuivelpraktijken naar een zoektocht naar een beter begrip van hoe zuivelpraktijken in de loop der tijd evolueren, om ze beter te kunnen accommoderen.

Hoofdstuk 4 onderzoekt in één provincie hoe vee wordt gevoerd door seizoenen heen, en onder suboptimale en kwetsbare omstandigheden van een maïsziekte en langdurige droge perioden. Het voegt daarmee tijd- en agentschaps-(‘*agency*’) elementen toe aan het begrip over deze landbouwtechniek. Het blijkt dat de huishoudens veevoerpraktijken niet permanent toepassen; in plaats daarvan bewegen ze mee met het ritme van seizoenen en persoonlijke levensgebeurtenissen, en laten ze op gemeenschapsniveau een aanpassingsvermogen zien om hun vee te blijven voeren onder kwetsbare omstandigheden. Voor verder agrarisch onderzoek voor sociaal-economische ontwikkeling pleiten deze resultaten voor het vinden van meer aansluiting van interventies bij oplossingen die mensen in hun kwetsbare realiteit toepassen.

In de zoektocht naar waar een diversiteit aan praktijken al wordt geaccommodeerd, duik ik dieper in een melkmarkt met een verscheidenheid aan melkhandelaren, variërend van formeel tot informeel. Hoofdstuk 5 schetst een onderling verbonden variëteit aan praktijken op een formeel-informeel continuüm. Een zekere mate van concurrentie en het naast elkaar bestaan van diverse marktkanalen lijkt bevorderlijk te zijn voor het behoud van een diversiteit aan commerciële praktijken. De bevindingen stellen de noodzaak van marktformalisering ter discussie om intensiverings- en commercialiseringsdoelstellingen te bereiken. Het hoofdstuk laat zien hoe het accommoderen van diversiteit al plaatsvindt in de praktijk, en niet noodzakelijk extern geïntroduceerd hoeft te worden.

Hoofdstuk 6 brengt de belangrijkste bevindingen van dit proefschrift samen. Het concludeert dat diverse actoren en praktijken geaccommodeerd kunnen worden in een zoektocht naar en ondersteuning van agentschap in de uitvoering van agrarische praktijken. Een implicatie voor onderzoek is dat vastleggen of karakteriseren van diverse actoren en praktijken secundair moet zijn aan de zoektocht naar hoe deze agrarische diversiteit geaccommodeerd kan worden. Een implicatie voor interventies op het kruispunt van sociaaleconomische ontwikkeling en klimaat, inclusief LED, is dat het bouwen op waargenomen oplossingen in de praktijk waarschijnlijk het algehele succes zal vergroten. Voor onderzoek en ontwikkeling roepen de inzichten uit dit proefschrift op tot ex-ante diagnostische benaderingen om diverse actoren en praktijken te accommoderen op de nexus van klimaat en sociaaleconomische ontwikkeling.

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About the author

Vera Vernooij (Woerden, 1992) is working as an international food supply chain researcher and project leader at Wageningen Food & Biobased Research (WFBR) since 2021. Her research supports non-governmental, public - and private sector organisations to enhance sustainability and circularity in agri-food sectors and food systems, both far away and closer to her home in Europe and the Netherlands.

She has an interdisciplinary educational background which allowed her to develop her human centred and systems-oriented research approach. She obtained a BSc in Cultural Anthropology and Development Sociology from the University of Amsterdam (2010-2014). She first got acquainted with the practices of international development during an internship with an NGO in Tanzania, before starting a two-year research MSc in Environmental Sciences (track: International Development) at Utrecht University (2014-2016). Agri-food became centre-stage during her MSc, and she followed elective courses at Wageningen University to further develop her knowledge in this domain. During her MSc she further conducted fieldwork research to the relationship between transport infrastructure, agricultural production, and trade in Ethiopia, and she studied options for inclusive and climate-smart dairy development in Kenya.

Vera Vernooij was an external PhD candidate at the Knowledge, Technology and Innovation Group of the Wageningen School of Social Sciences since 2017. The first four years of her PhD she worked as a PhD fellow based at the International Livestock Research Institute (ILRI) and with the Center for International Forestry Research (CIFOR-ICRAF) in Nairobi, Kenya. She has published peer-reviewed journal articles and various research reports.

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