Designing climate change adaptation tracking in the livestock sectors of Eastern Africa

A case for creating cross-scalar linkages

Lucy Wanjiku Njuguna

Propositions

1. Climate change adaptation progress is best captured by assessing evidence beyond policy documents.
   (this thesis)

2. The success of tracking adaptation to climate change is contingent upon the contextual fit of measurement methods.
   (this thesis)

3. Tracking climate change mitigation and adaptation are fundamentally distinct.

4. Universal indicators are a good servant, but a bad master.

5. The traditional formal education system has exhausted its utility.

6. The impact of research strongly depends on the channels used to disseminate findings.

Propositions belonging to the thesis, entitled

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Thesis

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To my nieces and nephews.

I hope this inspires you.

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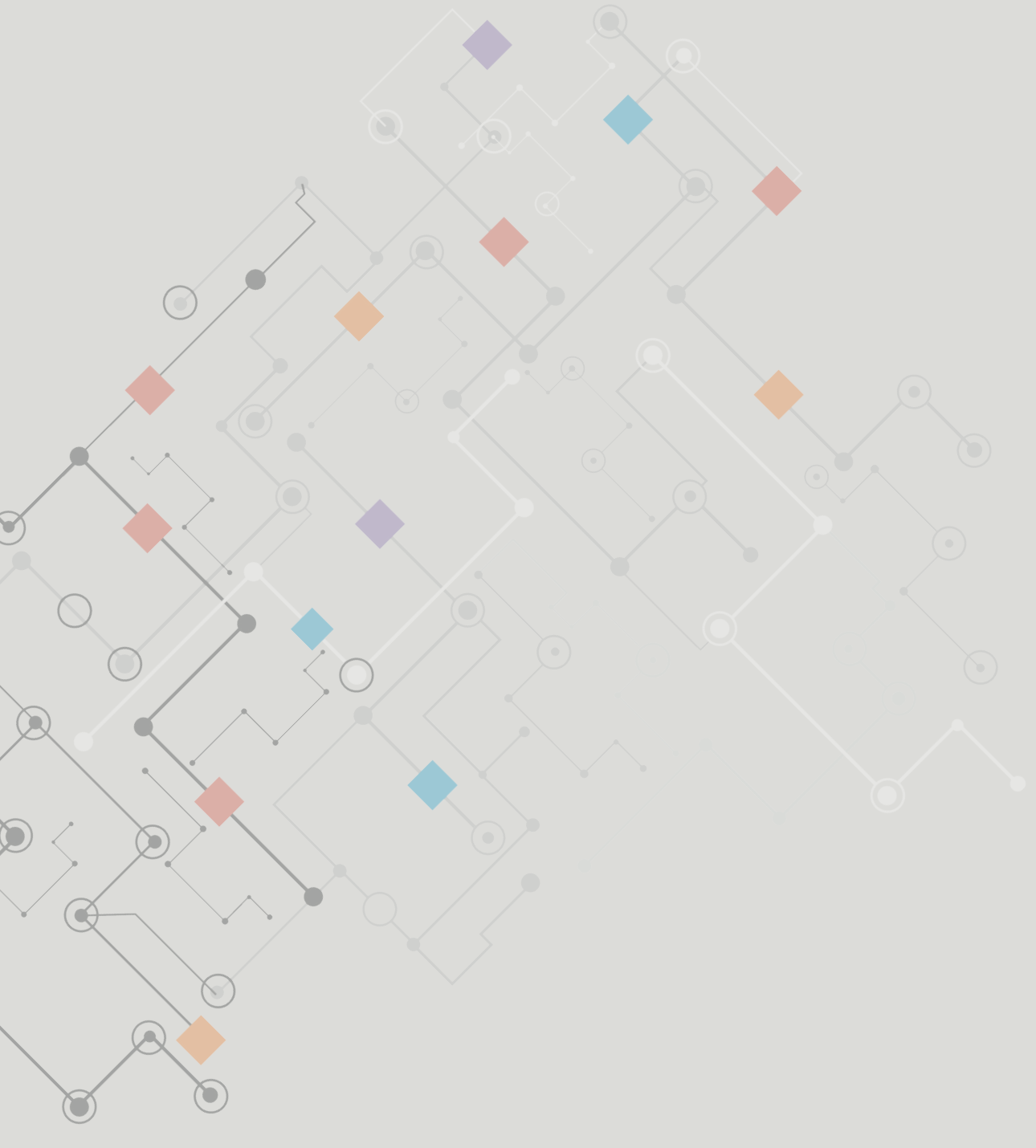


Chapter 1

General introduction

1.1 Background and problem definition: Climate change impacts and the imperative for adaptation tracking

Climate change is a major societal challenge, with its devastating impacts increasingly being felt worldwide. Extreme weather events and environmental changes attributable to fluctuations in climatic conditions have widespread impacts, including altering ecosystems, reducing agricultural production, and increasing the prevalence of pests and diseases, with significant economic, social, and ecological consequences (Intergovernmental Panel on Climate Change (IPCC), 2022d). Climate change impacts are evident in the livestock sector. After four years of shifts in the rainy seasons and drought in the Horn of Africa, by 2022, close to nine million livestock had died, adversely impacting livestock keepers' food security, incomes, and countries' economic stability (OCHA, 2022). As temperatures continue to rise, it is estimated that in the next 60 years, annual losses in global cattle production could reach 40 billion US Dollars due to heat stress on livestock (Ericksen et al., 2022).

Since the livestock sector plays a crucial role in national economies and livelihoods, state and non-state actors continue to adopt measures to respond to the impacts of climate change. Such measures include adjustments in farm practices such as water harvesting and storage, feed production and conservation, and diversification of livelihood options (Mubiru et al., 2018; Rojas-Downing et al., 2017). In terms of policy efforts, more than a third of Nationally Determined Contributions (NDCs) identify the livestock sector as one of the areas where adaptation is desperately needed (Rose et al., 2021). In Ethiopia, Kenya, and Uganda, the three countries central to this dissertation, the livestock sector is also prominently featured in multiple national policies, such as national adaptation plans and strategies, as well as in sub-national and sectoral plans relevant to climate change adaptation, highlighting a wide range of adaptation priorities (Ashley, 2019). As such, systematically assessing progress on efforts to respond to current and future impacts of climate change across and within sectors and populations, across space and time, is essential for understanding if adaptation is taking place and its effects. This assessment process is referred to as *adaptation tracking* (Berrang-Ford et al., 2019; Ford et al., 2013)[1].

[1] Although the process of monitoring and reporting on adaptation is also commonly referred to as adaptation Monitoring and Evaluation (M&E), I prefer to use the term *adaptation tracking* to distinguish the process from the traditional M&E which is often associated with interventions monitoring and evaluation within programs and projects. Adaptation tracking involves broader temporal and spatial scales that go beyond the typical time and spatial boundedness of programs and projects.

Adaptation tracking can serve multiple interrelated objectives. First, tracking adaptation is useful for collating information on the adaptation efforts of different actors, thus supporting the management of knowledge on adaptation, sharing of lessons through the documentation of adaptation strategies and the conditions under which they are effective, and cooperation between actors (Craft & Fisher, 2018; Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP), 2023; Leiter, 2015). For example, Kenya has established a system for monitoring the implementation of climate-smart agriculture by state and non-state actors, including adaptation actions in the livestock sector, thus allowing the government to keep track of ongoing interventions and further inform efforts to mainstream climate-smart agriculture (Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP), 2023). Secondly, by assessing adaptation progress against quantitatively or qualitatively defined adaptation milestones, adaptation tracking can support accountability across scales. Accountability can be demanded by a wide range of actors, from showing the utilization and effectiveness of donor support to a government showing how it is fulfilling adaptation mandates to its constituents and its peers within the global climate governance regime (Ford et al., 2013; Hammill & Dekens, 2014; Jernnäs, 2023). Thirdly, in supporting the generation of and access to information on adaptation progress, adaptation tracking is crucial for adaptation planning and decision-making. Ideally, evaluating adaptation outcomes should indicate the adequacy and effectiveness of adaptation efforts considering current and future climate risks, thus providing the basis for adjusting adaptation plans and priorities across global, national, and sub-national scales (Craft & Fisher, 2018; Tompkins et al., 2018). This rationale is reiterated by countries in their stated intent to track adaptation progress nationally and globally (Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP), 2023; Jernnäs, 2023).

In tandem with the continued rise of adaptation in the global climate agenda (Lesnikowski et al., 2017; Persson, 2019), the need to track adaptation progress at aggregated scales has increasingly received attention (Leiter, 2022). For instance, the Cancun Adaptation Framework, which was adopted in 2011, laid the foundation for an expanded scope of reporting under the United Nations Convention on Climate Change (UNFCCC) to include adaptation (Ellis & Moarif, 2015). In response, countries submitted National Adaptation Plans (NAPs) and National Communications and have committed to establishing adaptation monitoring systems (Ellis & Moarif, 2015; United Nations Environment Progrmme (UNEP), 2021). The

2015 Paris Agreement builds on this by encouraging countries to report progress in implementing their NDCs, most of which outline adaptation priorities. It further established an Enhanced Transparency Framework (ETF) and a Global Stocktake (GST) process through which countries can assess the "adequacy and effectiveness of adaptation and support provided for adaptation" and the collective progress towards the Global Goal on Adaptation (GGA) (United Nations Convention on Climate Change (UNFCCC), 2015, Art. 7.14).

However, tracking progress at aggregated scales is complex, and there is a pressing need for appropriate methodologies and guidance on how to track and report on adaptation. While there are ongoing discussions on how to track and report on adaptation across countries, there needs to be more attention to how adaptation tracking will be situated within countries. Moreover, there are divergent ideas on what counts as adaptation progress and from whose perspective to measure it. Consequently, there are also knowledge gaps in how to develop adaptation tracking tools that are fit for context. Therefore, this dissertation contributes to the rapidly evolving academic and political discussions on how to design adaptation tracking, focusing on the livestock sectors of Ethiopia, Kenya, and Uganda.

The remainder of this introductory Chapter proceeds as follows: section 1.2 elaborates on the conceptual, methodological, and empirical challenges inherent in adaptation tracking and the current debates on how to address them. Section 1.3 presents the theoretical foundation of this dissertation, and section 1.4 the research questions. Section 1.5 provides an overview of the research approach, which entailed a comparative case study approach to answer the analytical questions as well as the application of research findings to inform the development of the Tracking Adaptation in Livestock Systems (TAiLS) tool. Finally, section 1.6 describes the structure of the dissertation.

1.2 Challenges of tracking adaptation to climate change and the need for linkages across scales

1.2.1 Conceptual challenges

Conceptually, terminologies central to adaptation tracking are abstract and have diverse definitions and approaches to their operationalization. In 2015, countries agreed on a collective adaptation goal of "… enhancing *adaptive capacity*, strengthening *resilience* and reducing *vulnerability* to climate change, with a view to contributing to sustainable development and ensuring an *adequate adaptation* response in the context of the temperature goal" (United Nations Convention on Climate Change (UNFCCC), 2015, Art. 7.1). Despite their connections,

the concepts of adaptation, vulnerability, adaptive capacity, and resilience have been evolving, and each has multiple understandings and frameworks associated with it (Béné et al., 2012; Delaney et al., 2016; Füssel & Klein, 2006; O'Brien et al., 2007). Furthermore, what does "adequate" adaptation look like, and for whom? Diversity in how these concepts are understood and operationalized has consequences since the ensuing frameworks and tools prioritize distinct and often narrow framing of adaptation progress (Donatti et al., 2020; Singh et al., 2021). For instance, while some scholars consider enacting adaptation policies as an adequate measure of adaptation progress (e.g., Moehner et al., 2021), other scholars have criticized such methodologies for their inability to capture substantive adaptation results (e.g., Dupuis & Biesbroek, 2013; Ford & Berrang-Ford, 2016).

Some scholars prefer using standardized adaptation tracking metrics developed through the identification of common climate risks, adaptation planning steps, and universally desired outcomes such as poverty reduction (Magnan & Chalastani, 2019; Michaelowa & Stadelmann, 2018; Moehner et al., 2021). While leveraging such cross-cutting themes could be useful for comparing adaptation globally, such an approach may not capture context-specific nuances. For example, stark variations exist within the livestock sector. In contrast to industrialized countries, where the livestock sector is characterized by specialization in meat or milk production centered around economic benefits, in developing countries, the livestock sector has diverse roles, including the provision of economic, ecological, and cultural benefits with related variations in adaptation needs, options, and aspirations within and across production systems (Rivera-Ferre et al., 2016). In addition, inter- and intra-household variations shape livestock keepers' vulnerability and adaptive capacities (Marty et al., 2022; Ng'ang'a & Crane, 2020). Therefore, it is crucial to clarify definitions of concepts and operationalize them in a way that allows adaptation tracking to capture dynamics within and across local, sub-national, and national scales.

Cognizant of the dynamic and persistent nature of climate risks and the continuous need to adapt, Dilling et al., (2019) recommend the evaluation of adaptation success by assessing changes in the capacity of people and systems to adapt. Whilst this may be a more nuanced measure of adaptation potential, there is high uncertainty in evaluating adaptive capacity, including the intricate link between adaptive capacity and the likelihood or desire to adapt (Adger & Vincent, 2005). Similarly, what constitutes adaptation success is still very much debated. The Intergovernmental Panel on Climate Change (IPCC) recently defined successful adaptation in relation to "… actions and policies that effectively and substantially reduce

climate vulnerability, and exposure to and/or impacts of climate risk, while creating synergies to other climate-related goals, increasing benefits to non-climate-related goals and minimize trade-offs across diverse objectives, perspectives, expectation, and values" (Intergovernmental Panel on Climate Change (IPCC), 2022c, p. 2600). This definition strengthens growing calls to embrace plurality in the definition and evaluation of adaptation outcomes to capture diverse experiences and contexts (e.g., Dilling et al., 2019; Eriksen et al., 2021). It also suggests that it is necessary to integrating the perspectives of state and non-state actors operating at various scales in designing adaptation tracking. However, there are no concrete empirical illustrations of how this could be done in practice and the need to address conceptual challenges remains.

1.2.2 Methodological challenges

Besides questions of how to operationalize the concepts, there are additional methodological challenges to be addressed. Existing adaptation tracking frameworks are inadequate for adaptation tracking due to their limited focus on longitudinal comparisons, inability to support aggregation of adaptation results across spatial scales, and exclusion of the actions of critical actors such as the private sector (Ford, Berrang-Ford, Bunce, et al., 2015; Lesnikowski et al., 2015). There is also the dilemma over how to evaluate progress, including the difficulty of agreeing on a reference point or baseline. In this regard, authors have highlighted the need to define, for instance, a reference year against which adaptation results can be compared (Ford, Berrang-Ford, Biesbroek, et al., 2015; Magnan & Chalastani, 2019). Others suggest using proximity-to-target measurement, where adaptation actions are evaluated based on a theoretically defined ideal adaptation scenario or predefined adaptation goals (Dupuis & Biesbroek, 2013). However, there is still no consensus on the best way forward and few steps have been made in clarifying the methodological details for adaptation tracking.

In the political sphere, in 2018, governments adopted the Paris Rulebook, within which reporting Modalities, Procedures, and Guidelines (MPGs) are outlined. Specific to adaptation, Chapter Four of the MPGs encourages countries to provide information on their national context; climate change impacts, risks, and vulnerabilities; adaptation priorities, efforts, and barriers to adaptation; progress in implementing adaptation; and the effectiveness of adaptation in meeting adaptation needs, increasing resilience, and reducing impacts and vulnerabilities. Since countries are expected to use country-driven systems to track adaptation, the specifics of the indicators, methods, or frameworks to be used were not defined in the MPGs. However, the Glasgow-Sharm-el-Sheikh Work Programme on the GGA is mandated to explore what a common reporting framework could look like and corresponding methodologies and indicators

for tracking adaptation at the global scale (United Nations Convention on Climate Change (UNFCCC), 2022b). Besides the anticipated difficulty in operationalizing a standardized framework across diverse national contexts, there is a contradiction between prescribing adaptation tracking indicators and the flexible, country-driven planning and reporting processes envisioned by the Paris Agreement (Leiter, 2022). Besides, while defining a universal reporting framework and indicators will be useful for taking stock of global adaptation progress, it is unclear how they would reflect the context-specificity of adaptation priorities and experiences or how information from a global assessment would be used to guide adaptation planning within countries meaningfully. Considering scholarly evidence of the crucial role of national contexts in the success of global goal setting and monitoring mechanisms (e.g., Hickmann et al., 2022; Morita et al., 2020), understanding how to align adaptation tracking across local, sub-national, national, regional, and global scales is an important research agenda (see also Beauchamp, 2023; Leiter, 2021). For the livestock sector, this means examining how to develop adaptation tracking methodologies that capture spatial variations and aligning with how the sector is administratively organized in each country.

1.2.3 Empirical challenges

Data availability and quality is yet another challenge pertinent to adaptation tracking. Although the Paris Agreement envisages the use of multiple sources of input such as national communications, biennial transparency reports, adaptation communications, and reports from non-state actors, data comparability, completeness, and coherence are prerequisites for understanding adaptation progress across space and time (Ford, Berrang-Ford, Biesbroek, et al., 2015; Ford & Berrang-Ford, 2016; Olhoff et al., 2018; Qi, 2022). This means having data that is compatible in terms of how it is produced, has wide coverage, and is representative. The data issues tie back to whether adaptation tracking is based on standardized methodologies and indicators with assessments being undertaken centrally versus a bottom-up approach that builds on contextualized assessments that are integrated to provide insights into overall progress (Gao & Christiansen, 2023). In relation to the former approach, efforts to take stock of adaptation based on existing information, such as national communications and published literature, show that despite variations in the availability of evidence of adaptation within and across countries and sectors, there is limited information available, making it difficult to sufficiently assess and compare adaptation progress across space and time (Craft & Fisher, 2018; Ford, Berrang-Ford, Bunce, et al., 2015; Intergovernmental Panel on Climate Change (IPCC), 2022d; Lesnikowski et al., 2015; Tompkins et al., 2018). Other approaches, such as using expert judgment to

circumvent the data scarcity (e.g., Magnan et al., 2021), risk excluding the perspectives of many other actors. Similarly, for a contextualized bottom-up approach, scholarly evidence shows that existing tools for adaptation tracking do not offer data that can be directly aggregated, and the establishment of national adaptation monitoring systems is still at a nascent stage (Berrang-Ford et al., 2017; Leiter, 2021; United Nations Environment Progrmme (UNEP), 2021). Therefore, regardless of whether adaptation tracking will involve centralized or bottom-up assessments, it is important to consider the data required, how it will be accessed, and its suitability for understanding adaptation progress.

Expanding on the bottom-up approach, in the livestock sector, diverse streams of evidence are produced at various scales that can strategically be used to support adaptation tracking. At the local level, a wide array of tools are designed to assess the characteristics of communities, for instance, by evaluating the vulnerability or resilience of livestock-keeping communities (Food and Agriculture Organization of the United Nations (FAO), 2015; Fuchs & Njuguna, 2019; Jones, 2019). At this level, there are also monitoring activities geared toward evaluating investment portfolios and programs for adaptation. Such localized assessments can be valuable in mapping adaptation interventions implemented in various localities and their outcomes and the effects of adaptation efforts implemented elsewhere. They can also capture local experiences, thus providing the basis for building adaptation progress narratives as well as validating coarse assessments of progress at national and global scales (Dilling et al., 2019). At the national level, although most countries are at varying stages of developing adaptation assessment systems, continued advancement in these systems also has the potential to support adaptation tracking. Typically, assessments at this level are tailored to national circumstances, including the definition of the roles of various administrative units at national and sub-national scales as well as specificity to sub-national, national, or regional policies and priorities (Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP) , 2023; Hammill & Dekens, 2014; Klostermann et al., 2018). For example, Kenya and Uganda, have built adaptation monitoring systems around priority sectors, such as agriculture, thus providing a reasonable basis for integrating adaptation tracking and reporting (Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP) 2023; Hammill & Dekens, 2014). To build on these systems practitioners must understand important aspects, such as the existing legal frameworks and monitoring standards, institutional mandates, and coordination mechanisms and align adaptation tracking accordingly.

In sum, as illustrated in this section, a wide range of options on how to address the conceptual, methodological, and empirical challenges inherent in adaptation tracking exist in scientific and political discussions. However, there is still no agreement on how to track and report on adaptation, and fundamental knowledge gaps remain. This dissertation responds to these identified challenges, thus advancing knowledge on how to design adaptation tracking.

1.3 A theory-informed approach to designing adaptation tracking

With a focus on providing practical insights into how to design adaptation tracking and reporting, the theoretical grounding of current literature on adaptation tracking is often implicit. Using a theory-informed approach to designing adaptation tracking is necessary for identifying key issues that need to be addressed, providing a transparently structured way of addressing those issues, and guiding how to translate knowledge into practice (Angus et al., 2006; Nilsen, 2015). Three literature streams constitute the theoretical foundation for this dissertation: science and technology studies (STS), public administration, and public policy. These literature streams are well-suited to support the design of adaptation tracking that is centered around cross-scalar linkages.

STS, particularly the literature on co-production, underscores the mutual relationship between knowledge[2] and social order by highlighting how power relations influence knowledge production and in turn, how the produced knowledge is used to justify governance decisions (Jasanoff, 2004). Focusing on the first part of this relationship, with respect to processes akin to adaptation tracking, these power relations determine who gets involved in knowledge production and the related influence of their assumptions, values, and preferences on *what* is measured, *how, where, when, why*, and *for whom* (Crane et al., 2016; Gupta et al., 2012; Jasanoff, 2004; Luke, 2009; Turnhout et al., 2014). For complex phenomena such as accounting for adaptation outcomes on the vulnerability and resilience of systems, the effects of these normative choices on the parts of reality that are obscured or espoused are crucial. For example, Crane et al. (2016) and Pronk et al. (2017) demonstrated how the technical background of experts, the limited consideration of other forms of expertise, and a policy context focused on spatial planning led to the development of a vulnerability assessment framework that privileges economic and physical aspects of risk and short-term response measures at the cost of representing the complex social factors that shape vulnerability. Many

[2] This dissertation uses the term policy knowledge (henceforth knowledge) as a general term for statistical and qualitative information that is regularly produced and used for various functions, including monitoring the implementation of policies and general evaluation of the social, ecological, and economic conditions of society (Boräng et al., 2018)

other scholars also conclude that, for highly contextual and dynamic concepts like adaptation, vulnerability, and resilience, choices on how to assess them do not always reflect the diversity of understandings and experiences (e.g., Beauchamp et al., 2019; Dilling et al., 2019; Eriksen et al., 2021; Singh et al., 2021). This stream of literature justifies and guides the consideration of how social relations across relevant scales influence adaptation tracking and reporting.

Focusing on state-led adaptation tracking and reporting, I adopt the concept of civic epistemology (Jasanoff, 2005) to explore state-society relations and how they influence knowledge production and use in the livestock sector. State-society relations determine the degree of involvement of actors outside the government in knowledge production and the accessibility of produced knowledge to non-state actors (Jasanoff, 2005). In the livestock sector, this concept can be useful in understanding the interactions between the government and non-state actors, such as technical experts and livestock keepers in knowledge production and use. Moreover, adaptation tracking and reporting also require the collaboration of different entities within the government to allow the flow of knowledge between sub-national and national scales as well as between administrative units with distinct mandates at the national level (Leiter, 2015). Given that the relations within government are not strongly captured through the framework provided by the literature on civic epistemology, I drawn on the public administration and public policy literature which is concerned with intragovernmental dynamics and how they vary across countries (Howlett, 2018; Painter & Peters, 2010b). This literature also foregrounds the need to align novel processes, such as adaptation tracking, within existing rules and practices to increase the chances of adoption (Hargadon & Douglas, 2001; Howlett, 2018).

Shifting to the second part of the relationship between knowledge and social order, the co-productionist approach taken in this dissertation underscores knowledge as a *de facto* governance tool. Knowledge and how it is produced legitimize certain ways of knowing and acting, thus (re)creating identities, discourses, representations, and power arrangements (Jasanoff, 2004). The design of global transparency arrangements and the knowledge disclosed therein is pertinent to their effectiveness in delivering more ambitious climate action. For instance, while the ETF and the GST are expected to be transformative in steering climate action, realizing this effect will depend on the nature of the information provided and its usefulness in informing adaptation planning and decision-making across scales (Fisher, 2023). Studies from measuring carbon sequestration in forests exemplify how standardized assessments of forests promote a narrow view of the value of forests, thereby excluding local

priorities, values, and ways of knowing in the management of forests (Eva et al., 2006; Green & Lund, 2015; Gupta et al., 2012). Furthermore, imposing abstract and externally defined indicators could create a perversive incentive for countries to only focus on those actions that might give them a favorable evaluation at the expense of meaningful climate action (Brand, 1975; Löwenheim, 2008).

A more effective approach to adaptation tracking necessitates anticipating the potential effects of design choices on adaptation governance reflecting on how best to design adaptation tracking. This involves engaging with questions of whose values and perspectives are prioritized in the definition of adaptation progress, its evaluation metrics, the consequences of measurement choices in obscuring or disclosing certain aspects of adaptation, and how this might affect adaptation governance moving forward (Dilling et al., 2019; Gupta & Mason, 2016). Therefore, I apply an instrumental co-production approach to explore how integrating various aspects, including governmental and livestock keeper perspectives and the knowledge of how governments are organized, could inform the design of adaptation tracking in a manner that it will be meaningful to their diverse experiences and priorities. In the context of this dissertation, instrumental co-production refers to the iterative process through which diverse individuals and groups contribute to the design of adaptation tracking using a mix of activities (Bremer & Meisch, 2017; Brix et al., 2020; Miller & Wyborn, 2018; Turnhout et al., 2020). This definition highlights the processual aspects of co-production (*active and tailored engagement*) as well as direct and indirect results, including the development of *a tool* that *supports* the consideration of institutional structures and stakeholder perspectives. Unlike "classic" participatory processes, a co-production approach distributes the power to designing adaptation tracking to diverse stakeholders through their active involvement at various stages of the process to produce multiple outcomes that are of relevance to the stakeholders engaged in the co-production process (Brix et al., 2020; Wyborn et al., 2019).

In Chapter 6, I reflect on the value of this dissertation's theoretical foundation and its overall scientific contribution to these debates.

1.4 Research questions

This dissertation aims to build knowledge on how to design adaptation tracking. Cognizant of the challenges inherent in adaptation tracking, existing knowledge gaps, and the key issues espoused by the theoretical approach adopted for this research, the dissertation answers the following overall research question: *How does the design of adaptation tracking benefit from*

considering existing institutional structures, plural perspectives on adaptation, and adopting a co-production approach?

To answer the overall research question, I focus on three specific research questions:

Research question 1 (RQ1)*: How relevant are similarities and differences in countries' institutional structures of knowledge production and use for the design of adaptation tracking? (Chapters 2 & 3)*

Established institutional structures play a notable role in the transposition of externally motivated mandates, including the policy responses to these mandates as well as the roles of state and non-state actors (Biesbroek, Lesnikowski, et al., 2018; Dubash, 2021; Pillai & Dubash, 2021; Vink & Schouten, 2018). As such, alignment with the established institutional structures is paramount in building on existing capacities and mandates thus enhancing the chances of successful and sustained implementation of global policies within countries (Brendler & Thomann, 2023; Hargadon & Douglas, 2001; Hickmann et al., 2022; Howlett, 2018; Tosun & Howlett, 2022). Therefore, this question aims to 1) characterize the institutional structures that guide knowledge production and use, 2) compare how countries produce and use relevant knowledge, and 3) discuss the implications for adaptation tracking. To answer this question, I first develop a framework for examining institutional structures. I then apply the framework in a comparative study of the institutional structures of producing knowledge in the livestock sectors of Ethiopia, Kenya, and Uganda to provide insights into the differences within and across countries and the implications for adaptation tracking.

Research question 2 (RQ2): *What differences exist in how actors perceive climate risks, adaptative capacities, adaptation options, and goals, and how are these differences important for the design of adaptation tracking?* (Chapter 4)

Divergent ideas exist in the literature on how to define and measure adaptation progress. While much focus has been placed on tracking planned adaptation with government plans and policies as the primary reference points (e.g., Berrang-Ford et al., 2019; Moehner et al., 2021), other scholars call for the consideration of multiple perspectives when designing and applying adaptation tracking methodologies (e.g., Dilling et al., 2019). However, there are knowledge gaps in the specifics of what different perspectives offer for adaptation tracking. This research question addresses this gap by comparing the perspectives of livestock keepers and governments to illuminate the differences and similarities in how these two actor groups

discuss themes relevant to adaptation tracking. In doing so, I illustrate the value of complementing them and allowing the contribution of different actors in informing the design of adaptation tracking.

Research question 3 (RQ3): *How does the co-production of the TAiLS tool shape its sensitivity to existing institutional structures of knowledge production and use and the diversity of stakeholder perspectives?* (Chapter 5)

This research question builds on RQ1 and RQ2. It draws on insights from the consultative design of the TAiLS tool to explore the value of a co-production approach in the design of adaptation tracking. In answering the research question, I pay attention to how co-production supports the design of tools that can be embedded within the existing institutional structures, thus catalyzing linkages between local, sub-national and national scales. I also consider how to integrate adaptation experiences and priorities of different actors, such as livestock keepers, government officials, and researchers, while developing a tool that can feasibly be used to track adaptation over broad temporal and spatial scales.

1.5 Research approach and methods

There are three notable aspects of this dissertation's research design. First, this research uses a comparative case study approach whereby equivalent research was conducted across cases, thus supporting an in-depth study of similarities and differences within and between the cases along the various research questions (Bartlett & Vavrus, 2017; do Amaral, 2022). By paying attention to configurations within and between cases, this approach allowed me to study and reflect on the implications of the specifics within each country and the differences between countries for adaptation tracking.

However, cases do not exist naturally since their boundaries are "constructed" to suit the research objectives (Carter & Sealey, 2009; do Amaral, 2022; Lund, 2014). Therefore, in line with a constructivist stance, I acknowledge my role in creating the cases. This research focuses on selected components of the livestock sectors of Ethiopia, Kenya, and Uganda, with data collection activities at the farm level across four livestock production systems as well as at national and sub-national levels of government (Figure 1.1). The study sites were selected based on the differences and similarities that exist between them. For instance, although Ethiopia, Kenya, and Uganda have comparable structures that govern the livestock sector, there are notable differences in their institutional structures which can partially be attributed to their respective governance systems or cultural context (Enserink et al., 2007; Hofstede et al., 2010).

Similarly, the four livestock production systems selected for this research – grazing pastoral, grazing pastoral non-pastoral, lowland mixed crop-livestock, and highland mixed crop-livestock – have similarities and differences owing to variations in agro-ecological zones and cultural practices. The selection of the countries and production systems sites was also based on broader programmatic interests of the Program for Climate Smart Livestock (PCSL), implemented by the International Livestock Research Institute (ILRI), to which this research contributed. These interests included the opportunity to build on the knowledge and networks from previous research projects. After selecting the study sites, I delimited the cases based on the focus of the research question, thus supporting the study of complex phenomena by examining a contextually bound unit of analysis. For instance, while in RQ1 the three study countries were the cases, in RQ2 the cases were livestock keepers and governments. In RQ3, the TAiLS tool was the case. As the cases were not randomly selected, there are limitations in the extent to which the findings of the dissertation can be generalized. In section 6.3.2, I reflect more on my influence on the research process and output.

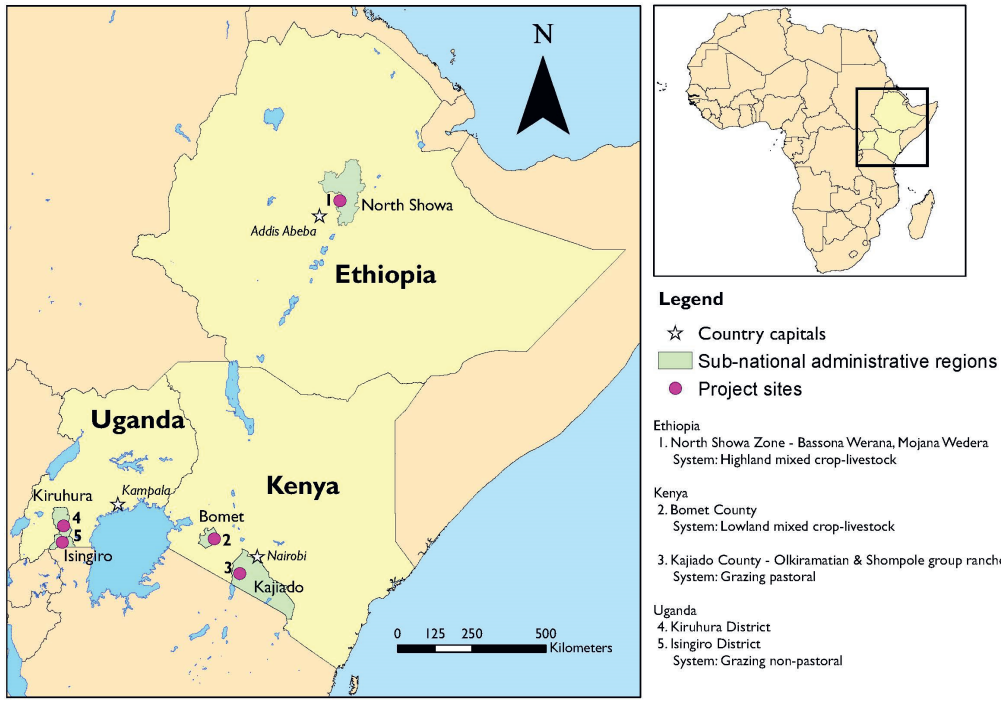


Figure 1.1 Map showing the study sites. (Nairobi, Kenya: M. W. Graham, 28 April, 2023. ArcMap v. 10.6. ESRI Software, USA, 1995 – 2023)

Secondly, the study follows a qualitative research design. Qualitative methods are suited for an in-depth study of phenomena by considering the perspectives of the researcher and the research objects and the representation of findings through detailed descriptions (Merriam & Tisdell, 2016). Qualitative research also allows the research design to be responsive to the dynamic conditions of the research process (Merriam & Tisdell, 2016) which is appropriate when the purpose is to build theory by identifying what matters and how it matters. Therefore, appropriate methods for collecting qualitative data were selected for their suitability in enabling me to answer the research questions. For example, the use of literature review in Chapter 1 to develop a framework for analyzing institutional structures for knowledge production and use supported the operationalization of the theoretical dimensions based on established scholarly knowledge of why the dimensions are important in the context of adaptation tracking and how to examine them empirically. Thereafter, interviews, Focus Group Discussions (FGDs), workshops, and a review of policy documents helped contextualize the framework by empirically examining what matters concerning the rules and practices that are dominant in the three study countries (Chapter 3). In Chapter 4, I used thematic analysis of FGDs data and policy documents to compare livestock keeper and governmental perspectives. Table 1.1 provides an overview of the data sources for each research question. Details of each study component are discussed in Chapters 2, 3, 4, and 5.

Table 1.1 Summary of data sources

Research question	**Chapters**	**Objective**	**Data sources and methods of analysis**
RQ 1	2, 3	To develop and apply a framework for characterizing relevant institutional structures for knowledge production and use.	Literature review, Document analysis, Interviews, Workshops with government officials, FGDs with livestock keepers
RQ 2	4	To assess the value of different perspectives in informing the design of adaptation tracking by comparing how governments and livestock keepers discuss climate risks, adaptive capacities, adaptation options and goals.	Thematic analysis of relevant policies and data from FGDs with livestock keepers
RQ 3	5	To explore the use of co-production of adaptation tracking	Co-production of the TAiLS tool through tailored engagements with livestock keepers, governments, and researchers.

Thirdly, this research adopts an applied research approach valued for its contribution to a better understanding of phenomenon while generating products of practical utility in problem-solving (Holmström et al., 2009; Merriam & Tisdell, 2016; Niiniluoto, 1993). Using a theoretically grounded approach, this dissertation advances knowledge on the design of adaptation tracking (epistemic contribution) while applying that knowledge to develop a tool for tracking adaptation in the livestock sector (instrumental value). This way, an applied research approach was useful in providing contextualized insights into the design of adaptation tracking while also contributing to strengthening the capacities of the governments of Ethiopia, Kenya, and Uganda to track and report on adaptation in the livestock sector. In Chapter 6, I elaborate on the dissertation's theoretical, empirical, and practical contributions.

1.6 Overview of the dissertation

The remainder of the dissertation comprises five chapters: three article-based chapters, one empirical application chapter (Chapter 5), and a general discussion (Chapter 6). Chapter 2 has been published, Chapter 3 has been accepted, and Chapter 4 is under review (revise and resubmit).

Chapter 2 presents a framework for analyzing institutional structures for knowledge production and use. Drawing on the literature on civic epistemology, public administration, and public policy, the chapter outlines six dimensions and their related variables that can support the analysis of relevant government rules and practices. **Chapter 3** illustrates the application of this framework to compare the institutional structures of producing and using knowledge of livestock systems in Ethiopia, Kenya, and Uganda. Besides supporting the mapping of the rules and practices within which adaptation tracking could be embedded, the findings from this chapter foreground the differences within and across countries, thus reiterating the need to customize adaptation tracking to align with country-specific systems. **Chapter 4** highlights the differences and similarities between livestock keeper and governmental perspectives on dimensions that should be tracked to understand adaptation progress. Insights into the similarities and differences in perspectives provide an imperative for considering multiple perspectives in designing an adaptation tracking tool that captures diverse experiences and priorities across scales and livestock production systems. Building on insights from the previous chapters, in **Chapter 5,** I exemplify how to design a tool for tracking adaptation in livestock systems. Besides illustrating the steps that could be followed, this chapter is an empirical demonstration of how the findings in Chapters 2, 3, and 4 could inform the designing of adaptation tracking tools. **Chapter 6** synthesizes the insights from the

preceding chapters to answer the research questions, discuss the implications for adaptation tracking more broadly, and lay out a future research agenda.

Figure 1.2 illustrates the focus of the chapters and the connections between them.

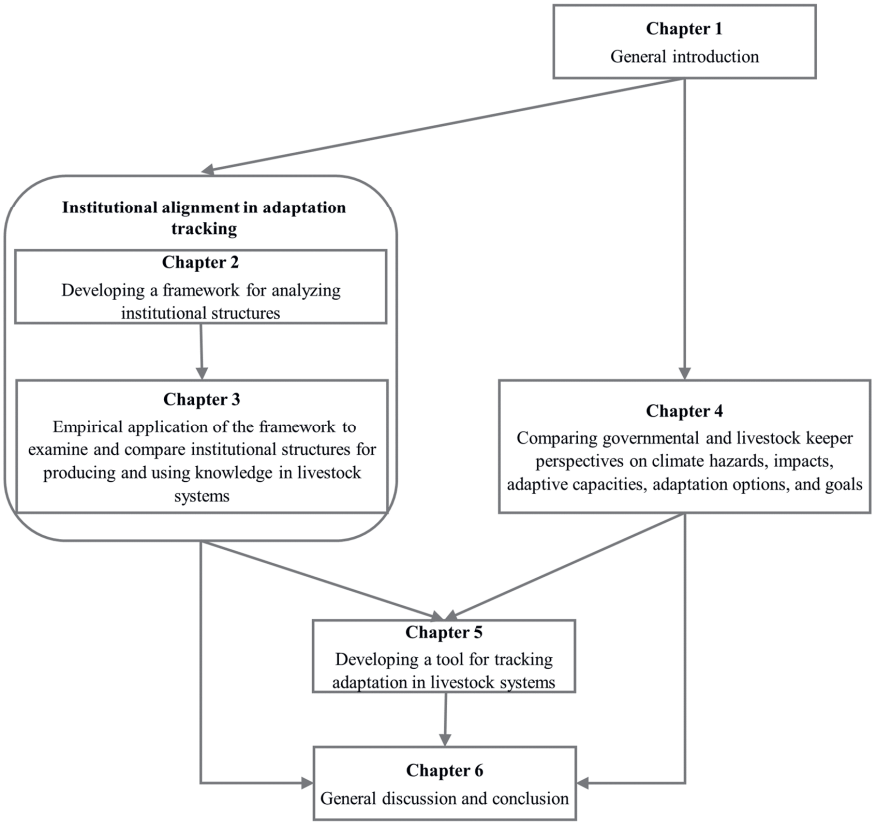
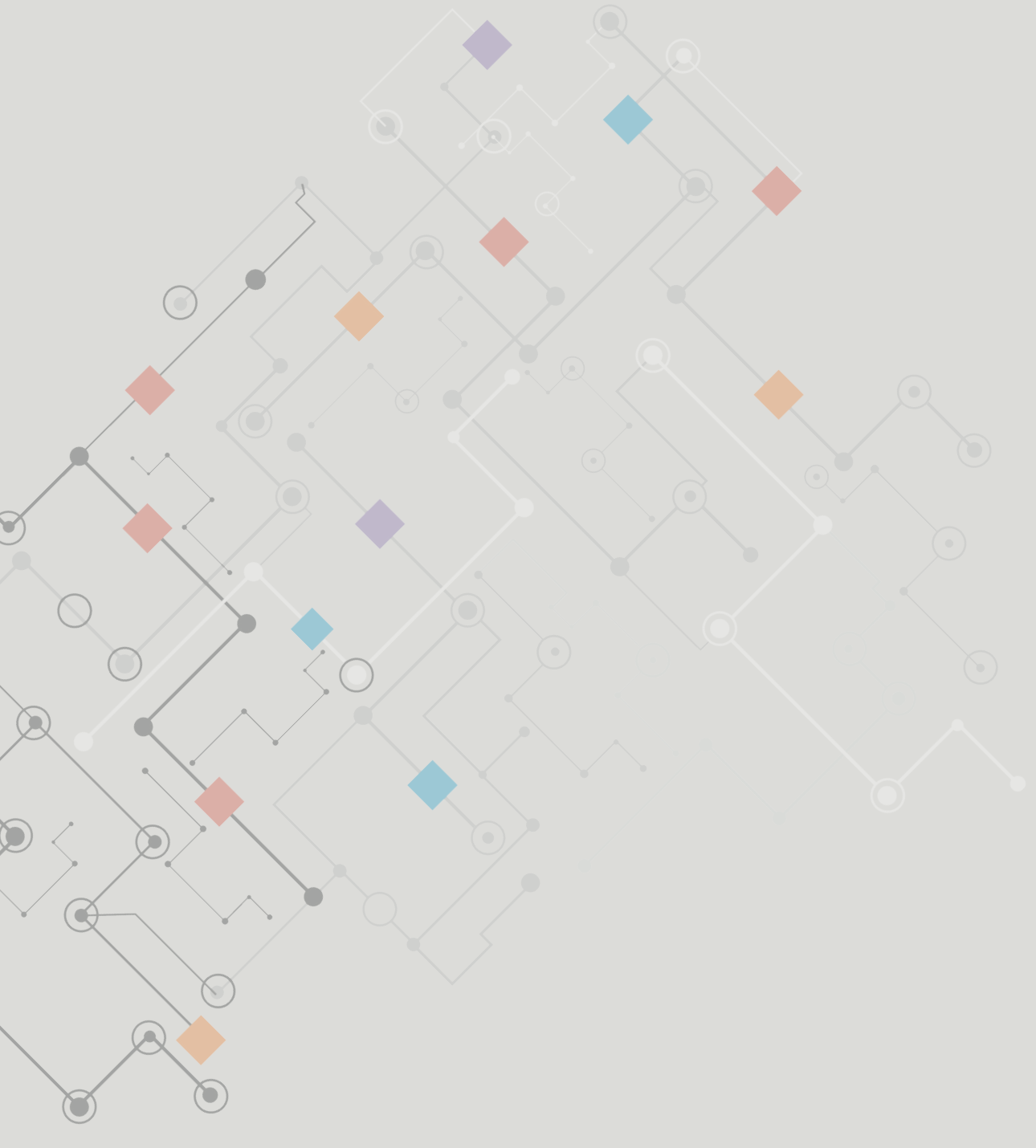


Figure 1.2 An overview of the dissertation



Chapter 2

Designing fit-for-context climate change adaptation tracking: Towards a framework for analyzing the institutional structures of knowledge production and use

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Abstract

The Paris Agreement encourages countries to monitor and regularly report on their progress in responding to the impacts of climate change. So far, discussions on adaptation tracking have focused on the technocratic reasons for limited progress on adaptation tracking, for example, financial, methodological, and technical capacity gaps. Substantial variation exists in the institutional context within which adaptation takes place and is being tracked. Yet, recent discussions overlook the importance of the extent to which new systems of adaptation tracking fit within the prevailing rules and practices of knowledge production and use. Although such a fit-for-context approach has been considered important in other fields, no adequate frameworks exist to operationalize it within adaptation tracking. We develop a six-dimensional framework for analyzing institutional structures as the first step towards alignment in the design and use of adaptation tracking: 1) stakeholder participation, 2) transparency, 3) bureaucratic accountability, 4) engagement with experts, 5) politico-administrative relations, and 6) coordination within the administration. For each dimension, we synthesize academic literature, provide variables for operationalization, and provide examples drawn from various regions. The resulting framework allows the description of the institutional structures of knowledge production and use and supports the context-specific design of new programs, tools, and practices for tracking adaptation progress.

2.1 Introduction

Governance by disclosure has become a popular mechanism for catalyzing action and keeping countries accountable to their peers and their constituents. Although there are no 'hard' sanctions for not fulfilling commitments made, disclosure mechanisms aim at raising ambitions and enhancing accountability through informal praising and shaming of government efforts as information on their performance becomes accessible to other state and non-state actors (Gupta & van Asselt, 2019; Karlsson-Vinkhuyzen et al., 2018; Weikmans et al., 2020). While recognizing the varying capacities among countries, the Paris Agreement requires countries to submit Nationally Determined Contributions (NDCs) to communicate their ambitions for climate action and regularly report on progress and achievements through the Enhanced Transparency Framework (ETF). Although making adaptation commitments and reporting on adaptation is voluntary, many countries have included adaptation commitments in their NDCs (United Nations Convention on Climate Change (UNFCCC), 2021) and discussions are underway on how to monitor and evaluate progress towards enhancing adaptive capacity, strengthening resilience, and reducing vulnerability. This process of assessing adaptation progress and reporting on achievements is known as adaptation tracking and involves the systematic application of tools to monitor and evaluate progress across broad spatial and temporal scales (Berrang-Ford et al., 2019; Ford et al., 2013). The Paris Agreement encourages countries to submit and regularly update Adaptation Communications (United Nations Convention on Climate Change (UNFCCC), 2015, Article 7.10). Thereafter, a constituted body will use multiple information sources, including national communications such as Biennial Transparency Reports and reports from non-state actors, to determine collective progress on adaptation through the global stocktake (Adaptation Committee, 2021). As a process of monitoring and making information on countries' efforts towards adaptation available, adaptation tracking is a crucial component of the ETF.

But tracking progress is not necessarily simple. Literature indicates a range of conceptual, methodological, empirical, and political challenges. These include, inter alia, lack of consensus on the definition of key concepts around adaptation tracking, uncertainty and complexity inherent in evaluating an ongoing process with shifting baselines, diversity of contexts and scales within which adaptation takes place, lack of universally applicable methodologies for tracking adaptation, and data limitations (Berrang-Ford, 2017; Bours et al., 2014; Craft & Fisher, 2018; Dilling et al., 2019; Ford, Berrang-Ford, Biesbroek, et al., 2015). To address some of these challenges and to advance reporting on adaptation, practitioners and scholars are

discussing how to design adaptation tracking. However, most adaptation tracking discussions focus on technicalities, primarily through the development of adaptation tracking frameworks that are applicable across countries and emphasize the need for capacity-building (Klostermann et al., 2018; Olhoff et al., 2018; Tompkins et al., 2018). These discussions are based on the presumption that the limited progress in adaptation tracking is attributable to technical capacity gaps such as knowledge, staff, time, financial resources, and monitoring tools. For instance, Klostermann et al (2018) propose a common framework for designing adaptation monitoring and evaluation. The framework recommends the use of local research and stakeholder participation to define adaptation and the elements to be monitored, the designation of a trusted and independent organization to monitor and report on adaptation, and the adoption of a flexible monitoring approach. While these are useful recommendations, it is highly uncertain to what extent existing institutional structures in different countries would adequately be able to support them.

We argue that efforts to design and implement adaptation tracking tend to overlook the broader question of institutional alignment and fit: the compatibility between the design of new adaptation tracking programs, tools, and practices, and the institutional structures already in place, such as formal rules, processes, relations, meanings, and practices for collecting, analyzing and using policy-relevant knowledge (Hargadon & Douglas, 2001; Howlett, 2018). Countries have unique ways of knowledge production and use that are codified in their institutional structures through formal and informal rules (Howlett, 2018; Howlett & Tosun, 2019). These institutional structures play an important role in determining the diversified response to policy issues, including climate change policies (Biesbroek, Lesnikowski, et al., 2018; Biesbroek, Peters, et al., 2018; Vink & Schouten, 2018). (Vink and Schouten, 2018), for example, found that policy blueprinting, whereby certain adaptation planning criteria are forced on countries, creates institutional misalignment and potentially hampers progress and usefulness of adaptation (Vink & Schouten, 2018). Similarly, in a study of biotechnology knowledge production and use in the US, Britain, and Germany, Jasanoff (2005) found that the three countries have distinct styles, which she associated with variation in the formal and informal rules in place.

Prevailing institutional structures are thus important to consider in the design of new adaptation tracking programs, tools, and practices, since, for instance, having in place climate change laws and plans that outline knowledge production mandates, level of advancement in the design and implementation of knowledge production systems, and the purpose for which these systems

are designed are found to matter (Hammill & Dekens, 2014; Leiter, 2021; Price-Kelly et al., 2015). Strengthening institutional alignment may enhance bureaucrats' willingness and ability to implement adaptation tracking while reducing potential conflicts by building on established knowledge production mandates thus, contributing to the continuity and effectiveness of adaptation tracking (Howlett, 2018; Leiter, 2021). Bureaucrats' willingness and capacity are vital given the nature of actor relations required for the government to provide a nationwide account of progress in adaptation, including understanding the effects of adaptation policies among its diverse constituents (Ford et al., 2013).

Although some studies like (Hammill and Dekens, 2014; Price-Kelly et al., 2015) consider institutional context as an important dimension in the design of national adaptation tracking systems, they tend to focus on the policy context of adaptation tracking, the rationale behind tracking, and the purpose and scale of application. These studies, therefore, omit critical aspects such as the broader institutional structures within which the adaptation tracking systems are embedded and, in turn, the suitability of those systems. Therefore, despite evidence in broader policy studies literature about the importance of institutional alignment and fit (Hargadon & Douglas, 2001; Howlett, 2018; Howlett & Tosun, 2019), and for national adaptation tracking in particular (Hammill & Dekens, 2014; Leiter, 2017), there are no frameworks for systematically and comprehensively analyzing institutional alignment. To fill this gap, we develop a six-dimensional framework for characterizing the institutional structures of producing and using policy knowledge that is relevant for adaptation tracking, as the first step towards strengthening alignment in designing adaptation tracking.

In section 2.2, we introduce the general principles of the framework and the underlying assumptions. In section 0, we discuss the relevance of each of the six dimensions for adaptation tracking and review diverse streams of academic literature to identify the key variables for operationalizing the dimensions. In section 0, we reflect on the implications of this framework for adaptation tracking and discuss opportunities for further research.

2.2 Theoretical foundations of the framework for examining institutional structures of knowledge production and use

There are two main aspects of institutional structures that are critical for knowledge production and use: the interaction between the government and society, and how the government is organized internally. The interactions between government and society are important as they influence how knowledge produced and used, including integrating the adaptation experiences

and needs of non-state actors. Adaptation tracking also requires collaboration within the government to account for the activities of the various sectors and to ensure that there is adequate government support towards the production and use of knowledge related to adaptation tracking, making intra-governmental dynamics and relations equally important.

To understand the relations between the government and society, we draw from science and technology studies which are concerned with the mutual relationship between social contexts and knowledge (Gupta et al., 2012; Jasanoff, 2004). The concept of civic epistemology, in particular, captures the institutionalized relations between the government and non-state actors in the production, dissemination, and use of knowledge (Jasanoff, 2005). Perspectives and narratives are found to be established, reinforced, or changed through such relations as they determine which knowledge claims are considered legitimate and credible (Jasanoff, 2005). This concept positions adaptation tracking within state-society relations, focusing on the various stages of the knowledge production cycles, including decision-making on what knowledge is produced, development of tools, knowledge production, validation, dissemination, and use. From this literature, we identify four relevant dimensions Table 2.1. The first dimension is stakeholder participation in knowledge production and use (Jasanoff, 2005). We define stakeholders as those societal actors who affect or are affected by a particular adaptation decision, and they vary depending on the sector and system of interest (Kaur & Lodhia, 2018; Reed, 2008). For this dimension, we have drawn on relevant points of consensus in the diverse literature that addresses stakeholder participation (Ayantunde et al., 2015; Glucker et al., 2013; Luyet et al., 2012; Reed et al., 2008). The second dimension is transparency, by which we understand the accessibility of government-held knowledge by non-state actors. Examples of literature that is relevant for this dimension include (Meijer et al., 2018, 2012). The third dimension is bureaucratic accountability, which subsumes several elements discussed by (Jasanoff, 2005), including measures of objectivity and credibility. For this dimension, we draw on the literature that focuses on the arrangements for keeping the behavior of bureaucrats in check (Bovens, 2010, 2007; Brandsma and Schillemans, 2013; Mees and Driessen, 2019). The fourth dimension considers how knowledge and expertise get into bureaucracies. For this dimension, we draw on the literature on Policy Advisory Systems (PAS), which is concerned with the constellation of actors who guide policymakers (Craft and Howlett, 2013; Howlett and Fraser, 2014; Howlett and Migone, 2017; Veselý, 2013).

To understand how governments are organized internally, we primarily draw on public administration and public policy literature which is concerned with the underlying

administrative routines and institutions that influence policymaking and implementation. From this literature, we identify two dimensions that are relevant for knowledge production and use within the government: the relations between political and bureaucratic realms and coordination within the administration (Jamil et al., 2013; Painter & Peters, 2010a). Concerning the relations between political and administrative realms, which is the fifth dimension, we draw on literature that characterizes the politico-administrative linkages (Ayee, 2013; Demir, 2009; Svara, 1999). In addition to the literature on coordination among government agencies as the sixth dimension (6, 2004; Peters, 1998, 2018), we also use literature that discusses data sharing within governments (Bellamy et al., 2008) and institutional logics in knowledge management (Laihonen and Huhtamäki, 2020; Laihonen and Kokko, 2019).

The proposed framework, therefore, has six dimensions: 1) stakeholder participation, 2) transparency, 3) bureaucratic accountability, 4) engagement with experts, 5) politico-administrative relations, and 6) coordination within the administration. As shown in Table 2.1, we also adapted the framing and the definitions of the dimensions to limit the focus to knowledge production and use.

There are several underlying assumptions in this framework. First, countries have distinct and internally heterogeneous combinations of these six dimensions because of differences in governance and administrative systems as well as due to external influences (e.g., international agreements and the rise of new public management) (Dubash, 2021; Howlett, 2002; Painter & Peters, 2010b). We recognize that countries may vary along a spectrum within the dimensions. Contrary to deficit models that see divergence from an ideal characteristic as inadequacy, our 'scores' are descriptive and have no basis that supports a normative evaluation of the prevailing institutional structures. Second, although countries might undergo reforms that influence these dimensions, change typically follows the existing rules and practices, which strongly suggests path dependency in the institutionalization of policy innovations (Dubash, 2021; Pierson, 2000). Third, the framework aims to capture the formal and informal rules which we presume determine the behavior of government officials in knowledge production and use. However, we recognize that actors' behavior is also key in setting the course for deviating or following what is prescribed by the formal and informal rules (Howlett & Tosun, 2019). Fourth, the framework identifies the rules of knowledge production and use, thus broadening the focus beyond ad hoc practices such as those associated with project monitoring and evaluation. Fifth and finally, the framework is scale neutral and can be applied to one or multiple levels of government. While discussions on adaptation tracking primarily focus on the national level,

this framework intends to capture how other scales within which adaptation takes place are incorporated in knowledge production and use as this will affect their inclusion in adaptation tracking.

Table 2.1 Summary of dimensions and variables for characterizing institutional structures of Knowledge production and use

Dimension	**Definition**	**Variables**
Stakeholder participation in knowledge production and use	Engagement between the government and relevant stakeholders in knowledge production and use	Nature of participation
		Participation criteria
Transparency	Accessibility of government-held knowledge by non-state actors	Established transparency rules
		Characteristics of accessible knowledge
Bureaucratic accountability in knowledge production and use	Mechanisms for holding bureaucrats accountable in their activities of producing and using knowledge	Established knowledge production standards and procedures
		Accountability forums
Engagement with experts in knowledge production and use	Modalities of engagement with individuals or organizations that government relies on for specialized advice on knowledge production and use	Location of experts relative to the bureaucratic structure
Politico-administrative linkages in relation to knowledge production and use	Interactions between the political and administrative realms of the government and their implication on knowledge production and use	Bureaucratic autonomy
Coordination within the administration in knowledge production and use	Interactions between interdependent administrative units and how they consider each other's decisions and actions in knowledge production and use	Administrative structure
		Degree of formalization of coordination

2.3 The six-dimensional framework for characterizing the institutional structures of knowledge production and use

In this section, we elaborate on each of the six dimensions. We start by defining the dimension, how it relates to adaptation tracking, followed by one to two variables that can be used to characterize it. We also outline possible variations and draw on cases from different geographical regions to show how countries may vary along the dimension.

2.3.1 Stakeholder participation in knowledge production and use

This dimension is concerned with the engagement between the government and relevant stakeholders in designing, producing, and using knowledge (Jasanoff, 2005; van Kerkhoff & Pilbeam, 2017).

Adaptation strategies should ensure that stakeholders effectively respond to climate risks, underscoring their critical role in planning and assessing the outcomes of adaptation policies, interventions, and practices (Dilling et al., 2019; Falzon, 2021). Stakeholder participation can facilitate the integration of multiple knowledge types in vulnerability and adaptation assessments, thus offering a better understanding of the various priorities and experiences (Falzon, 2021). For instance, integrating contributions formed through contextual perspectives and experience has been found to lead to holistic indicators (Reed et al., 2008) and could be a strategic approach to identifying appropriate indicators for adaption tracking. Stakeholder participation could also enhance the consideration of dimensions that are critical for adaptation, including contextualized understanding of adaptive capacity and the socially differentiated adaptation strategies and aspirations (Dilling et al., 2019). Participatory processes contribute to knowledge exchange on experiences and adaptation strategies and could facilitate closer collaboration between the various stakeholder groups in addressing climate vulnerability (Ayantunde et al., 2015; Fazey et al., 2010). However, participatory styles vary depending on external influence and the capacity of governments to steer participation processes (Holler et al., 2020; Sherman & Ford, 2014). Two variables help in understanding the engagement between the government and relevant stakeholders.

The first variable, the nature of participation, considers the influence stakeholders have in knowledge production and use (Fazey et al., 2010; Glucker et al., 2013; Hassenforder et al., 2015; Luyet et al., 2012; Rowe & Frewer, 2005). For instance, when the objective is to have stakeholders substantially contribute to knowledge production, they are likely to be involved at the design stages, where they can influence the tools and indicators used as well as in knowledge production (Kaur & Lodhia, 2018). On the other extreme, stakeholders might only be seen as data sources or peripheral to knowledge production processes.

The second variable considers the criteria used to determine who participates. For stakeholder participation to be effective, a widely shared argument is that the participants should be representative of the broad population affected by a certain issue (Hassenforder et al., 2015) or have a specific goal of empowering the marginalized to engage in decision making (Glucker et

al., 2013). As such, stakeholder selection criteria should be centered on making participation effective and fair, including organizing participation in a manner that encourages active contribution and consideration of heterogeneity among stakeholders (Ayantunde et al., 2015; Glucker et al., 2013; Hassenforder et al., 2015; Zuhair & Kurian, 2016). Although stakeholder participation in climate change adaptation is often concerned with the engagement with local communities, for adaptation tracking, determination of the relevant stakeholders should be based on the policy domain of interest and could include various stakeholder groups operating at various levels such as producers within agricultural systems, business operators at various stages of the value chain, or sub-national and national input suppliers.

Given the variables, the nature of participation and the identity of participants, we identify three examples of varieties of stakeholder participation styles (Table 2.2). Under the top-down communicative style (Luyet et al., 2012; Reed et al., 2018), stakeholders' degree of influence is limited since participation is only geared towards informing the stakeholders without really seeking their input in knowledge production. In such systems, there are no defined criteria that describe with whom the government engages (Reed et al., 2018; Rowe & Frewer, 2005). In the consultative style (Rowe & Frewer, 2005), the government informs and seeks input from stakeholders but only at selected stages of the process. For instance, stakeholders serve as sources of data, and in some cases, they engage in the validation of the knowledge produced. Often, defined criteria determine who participates in these consultative processes, although the input may not necessarily be representative (Brombal et al., 2017; Rowe & Frewer, 2005). In the deliberative style (Reed et al., 2018), stakeholders have shared roles with the government in designing and implementing knowledge production. Participation aims at allowing those who are engaged to have substantive influence, including in setting the objectives of knowledge production, co-designing tools, data collection, and translating knowledge into reports and decisions. The participation criterion involves deliberately seeking the representation of various stakeholder groups, and strategies are used to maximize their contributions. In a study of stakeholder engagement in sustainability reporting in Australia, (Kaur and Lodhia, 2018) found that the local councils had varying participatory styles, including the stages at which stakeholders were involved. In some councils, stakeholders who included local businesses, residents, and transient resource users participated in the selection of sustainability indicators and in developing sustainability reports, while in other councils the council leadership had authority over specific stages of the accounting and reporting process (Kaur & Lodhia, 2018).

Table 2.2 Varieties of stakeholder participation styles

Communicative	Consultative	Deliberative
Stakeholders are informed but have low influence on knowledge production and use. Lacks elaborate participation criteria.	Stakeholders have moderate influence at selected stages. Participation criteria are defined, but not necessarily representative.	Stakeholders have high influence on knowledge production including in designing and producing knowledge. Participation criteria are geared towards representative participation.

2.3.2 Transparency

The second dimension considers the accessibility of government-held knowledge by non-state actors. Transparency can be proactive where the government voluntarily makes knowledge accessible or demand-driven, whereby government makes knowledge accessible following requests from stakeholders (Fox, 2007).

Transparency enhances the awareness of interested stakeholders on the state of adaptation within and beyond their local contexts, thus contributing to the gradual realization of the benefits of disclosure requirements while supporting the use of knowledge from adaptation tracking for sub-national and national adaptation planning (Gupta & Mason, 2014; Leiter, 2021). Transparency could also enhance the credibility of knowledge held by the government and the legitimacy of policy decisions and actions (Jasanoff, 2005). Making knowledge accessible has been argued to incentivize government integrity and effectiveness as information on government activities and outputs becomes accessible (Meijer et al., 2012; Ruijer and Meijer, 2016). The degree of transparency varies within and between countries depending on government capacity to process and publish knowledge and the extent of institutionalization of transparency requirements (Shao & Saxena, 2019; Tang & Jiang, 2020).

Two variables, rules governing transparency and the characteristics of accessible knowledge, are central to characterizing transparency. The first variable, the transparency rules, includes the formal rules that shape how knowledge is made accessible, such as the various forms of freedom of information legislation as well as informal rules that are formed through practice. These rules define the mandates for bureaucrats to support access to knowledge by assigning roles to individuals and administrative units while also outlining procedures for accessing that knowledge (Ruijer & Meijer, 2016; Shao & Saxena, 2019). Formal rules also reduce the perceived risks of transparency since bureaucrats have legal backing when sharing knowledge, and they have guidance on which knowledge should be made accessible and how (Huang et al., 2020; Shao & Saxena, 2019). Transparency rules may also help in setting the scope of transparency, thus avoiding overburdening bureaucrats with transparency demands, for

instance, by requiring interested parties to meet specific requirements before they can access knowledge that is yet to be made public.

The second variable is the characteristics of accessible knowledge. This variable reflects an understanding of transparency that goes beyond mere openness to consider the appropriateness of the accessible knowledge to diverse users (Meijer et al., 2012). For instance, although websites and other online portals are some of the popular channels for transparency (Huang et al., 2020), tailoring strategies to make knowledge suitable to the diverse information needs and capacities of users is vital (Meijer et al., 2018; Shao and Saxena, 2019; Tang and Jiang, 2020). The timing and frequency at which knowledge is released are critical determinants of its usefulness, including the government's responsiveness to access requests (Schapper et al., 2021). For instance, Shao and Saxena (2019) find that the success of the Tanzania open government data initiative is hindered by multiple challenges, including poor data quality that is availed in technical formats that impede its further use.

Possible variations in government transparency are exemplified in Table 2.3.

In closed systems, transparency is low since knowledge is essentially inaccessible (Fox, 2007; Ruijer et al., 2020). This closedness could be due to the absence of transparency rules assigning responsibilities and guiding bureaucrats' actions, inadequate compliance with transparency rules, or capacity limitations (Shao & Saxena, 2019). Bureaucrats may also exploit loopholes in existing rules to hinder transparency, for instance, by establishing overly bureaucratic processes or overusing disclosure exemptions (Schapper et al., 2021). In semi-open systems, bureaucrats release knowledge that does not necessarily reveal their actions (Greiling & Spraul, 2010). Here, transparency rules exist and, therefore, bureaucrats may only release knowledge as part of symbolic compliance resulting in moderate transparency. For instance, in a study of transparency in Taiwan, Huang et al. (2020) observed that, despite the enactment of Open Government Data (OGD) policies, bureaucrats show resistance by using workarounds, such as knowledge overload whereby they publish enormous amounts of knowledge, regardless of its usability. Under open systems, transparency is high, with bureaucrats adhering to established transparency rules and principles. There are clear mandates for bureaucratic units, and bureaucrats deliberately make knowledge accessible and usable. Strategies that have been argued to support this level of transparency include translating knowledge to overcome language barriers, releasing multiple formats to match the capacity and needs of different users, and simplifying accessibility requirements (Shao & Saxena, 2019; Tang & Jiang, 2020).

Table 2.3 Varieties of government transparency

Closed systems	Semi-open Systems	Open systems
Rules on transparency are lacking or misused. There is none to little access to knowledge, thus low transparency.	Transparency rules exist but the nature of knowledge that is made accessible only supports moderate transparency.	Rules defining roles and procedures for accessing knowledge exist and are adhered to. Strategic measures are taken to make knowledge accessible and useful resulting in high transparency.

2.3.3 Bureaucratic accountability

This dimension is concerned with the bureaucrats' conformity to knowledge production standards and the forums for holding bureaucrats accountable for their actions (Bovens, 2007, 2010).

Accountability mechanisms oblige bureaucrats to adhere to set standards on the assumption that this enhances government effectiveness in knowledge production while boosting the credibility of knowledge produced (Bovens, 2007; Jasanoff, 2005; van Kerkhoff & Pilbeam, 2017). This dimension provides insight into the existing and acceptable knowledge production standards and the mechanisms for holding bureaucrats accountable. It also considers the overall effects of accountability on knowledge production and use, given that bureaucratic accountability could also constrain knowledge production, for instance, in rule-based systems where rule-following overrides effectiveness (Ruijer & Meijer, 2016). Therefore, whereas accountability is often thought to consist of an interest in conformity to set standards, from our perspective, it should be sensitive to the risks of impeding the innovations needed to address emerging knowledge needs. Two variables support the characterization of bureaucratic accountability.

The first variable considers the standards available, including the formal and informal rules and procedures, for knowledge production and use (Bovens, 2010; Lindberg, 2013; van Kerkhoff & Pilbeam, 2017). These standards define the roles of bureaucrats and establish criteria for evaluating their activities (Lindberg, 2013; Mees & Driessen, 2019). For instance, most countries have enacted laws that outline which data bureaucrats should collect, from whom, and how. The general mandate often lies with a central statistics agency with support from sectoral units. Some countries complement this by formulating climate change policies that allocate knowledge production mandates to new or existing administrative units (Klostermann et al., 2018).

The second variable is the existing processes or forums for holding bureaucrats accountable, particularly concerning bureaucrats' answerability for their actions and the consequences for any observed deviations from expected behavior (Bovens, 2007; Brinkerhoff and Wetterberg, 2016; Lindberg, 2013; Schillemans, 2016). The configuration of accountability structures varies, depending on a country's governance system (Brinkerhoff & Wetterberg, 2016). Accountability can be hierarchical, whereby subordinate bureaucrats are answerable to those higher in the ranks or more networked, whereby relevant state and non-state actors engage in mutual oversight and control (Mees & Driessen, 2019). For instance, Rwanda, Indonesia, the Philippines, and Guinea vary in various aspects, including the willingness and institutional capacity to support social accountability, which leads to variation in the role of the public and the responsiveness of bureaucrats to the public (Brinkerhoff & Wetterberg, 2016).

At least three variations in bureaucratic accountability are possible, as summarized in Table 2.4. In a system with low accountability, there are no defined standards, hence the ambiguity in bureaucratic mandates (Bovens, 2007; Han, 2020; Mees & Driessen, 2019). Little information is available on how bureaucrats should produce and use knowledge, it is unclear who holds them accountable, and even where accountability structures exist, they are ineffective or conflicting (Brandsma and Schillemans, 2013; Kim and Lee, 2010). In moderate accountability, there are established standards that also enhance the authority and credibility of the bureaucrats. Clear linkages show who holds bureaucrats accountable as well as the consequences for not following established procedures (Brandsma & Schillemans, 2013). In such a system, accountability is geared towards effectiveness, thus allowing innovation and discretion of bureaucrats. In a system with high accountability, knowledge production standards and structures for holding bureaucrats accountable exist. However, strict rule enforcement leads to accountability overload and the dominance of short-term accountability goals may not translate to effective knowledge production and use (Bovens, 2010).

Table 2.4 Varieties of bureaucratic accountability

Low accountability	**Moderate accountability**	**High accountability**
No established standards for knowledge production and use. Accountability structures are non-existent or ineffective leading to an accountability deficit.	Standards for knowledge production and use are established and enforced. Clearly defined and effective accountability structures that are geared towards effectiveness.	Established knowledge production standards and accountability structures exist. Rule-based logic results in short-term accountability goals and accountability overload.

2.3.4 Engagement with experts

The fourth dimension is concerned with the engagement modalities with individuals or organizations that provide specialized advice on knowledge production (Jasanoff, 2005). Although the broader PAS literature is concerned with the configuration of overall advisory systems, this dimension focuses on experts because tracking of adaptation may require specialized skills. Such experts influence the choices of bureaucrats, thus affecting what gets counted and how. This perspective also recognizes the growing role of external experts emanating from previous governance reforms that led to the downsizing of the administrative workforce (Saguin, 2018; Veselý, 2013). We address the involvement of other relevant non-state actors under dimension one.

To characterize engagement with experts, this dimension focuses on the variable of experts' location relative to the bureaucratic structure, i.e., whether they are governmental, in the case of civil servants, or non-governmental actors (Craft and Halligan, 2015). Depending on the established knowledge production rules, experts have varying degrees of influence based on their proximity to bureaucrats (Craft and Halligan, 2015; Hustedt, 2019). In some contexts, bureaucrats may prefer advice from external experts partly because of inadequate capacity within the bureaucracy (Veselý, 2013), especially when experts come from organizations with established authority for knowledge production in certain issue domains. In other cases, personal relations may determine the influence experts have on bureaucrats (Hustedt, 2019). For a long-term process such as adaptation tracking, expert engagement modalities may affect learning and capacity development within the bureaucracy over time (Klostermann et al., 2018; Veselý, 2013). However, engagement with external experts could also enhance the design knowledge production through the use of appropriate expertise, for instance, in developing tools that might limit the use of subjective or political reasoning in evaluations (Kaur & Lodhia, 2018).

We exemplify three varieties of expert engagement, as summarized in Table 2.5. In externalized systems (Craft and Howlett, 2013; Hustedt, 2019; Veselý, 2013), bureaucrats strongly rely on non-governmental experts to design and implement knowledge production. Reliance on external experts may lead to standardization of knowledge production as specific non-governmental organizations or individuals strongly influence knowledge production over time or within regions (Wright et al., 2012). For instance, externalization is critical, especially in developing countries, where knowledge production is donor-driven, which leads to the misalignment between new knowledge production systems and the national knowledge

production practices and rules (Devarajan, 2013). A hybrid mode of engagement may lead to a complementary relationship between the bureaucrats and the external experts which enhances knowledge production and use by leveraging external and internal skills, experience, and expertise (Howlett and Fraser, 2014; Hustedt and Veit, 2017). An example of hybridization is in Finland, where the government established a coordination group constituted by different ministries, research institutes, funding agencies, and regional organizations to coordinate the assessment of adaptation across sectors (Klostermann et al., 2018). In internalized systems, bureaucrats use in-house expertise to design and implement knowledge production (Veselý, 2013). Internalization can involve engagement with individuals with specific skills who, by extension, become part of the bureaucratic structure permanently or for a defined period. For instance, in Israel, the government created chief scientist positions in relevant bureaucratic units to facilitate the entry of expert knowledge on climate change adaptation into the bureaucracy (Schmidt et al., 2018). This mode of engagement was found to be useful in brokering the linkage between technical expertise and policymaking and establishing long-term engagement between ministries (Schmidt et al., 2018)

Table 2.5 Varieties of expert engagement

Externalized expertise	Hybrid expertise	Internalized expertise
High reliance on experts that are outside the bureaucratic system.	Moderate reliance on external experts with the use of mechanisms to enhance collaboration between bureaucrats and external experts.	Dependence on in-house expertise through hiring or co-option of experts thus low reliance on external experts.

2.3.5 Politico-administrative relations

The fifth dimension considers the interactions between the political and administrative realms of the government. These realms comprise the elected officials and those employed to implement policies and serve the government of the day, respectively (Alford et al., 2017; Pepinsky et al., 2017; van Dorp & 't Hart, 2019).

This dimension captures the political context within which bureaucrats operate and its implications on the administrative capacity to produce knowledge (Ayee, 2013; Boräng et al., 2018). To support their political ambitions, elected officials influence knowledge production by determining if and how knowledge is produced, including regulating the available financial and human resources (Boräng et al., 2018; Devarajan, 2013). Politico-administrative relations may also influence the political value of adaptation tracking, thus determining its political

feasibility and usefulness for policymaking (Ford et al., 2013; Grasso, 2016; van Rüth & Schönthaler, 2018). For instance, the ease with which politicians are able to interpret and make use of knowledge for policymaking is relevant in the design of adaptation tracking systems (van Rüth & Schönthaler, 2018). Elected officials might also affect adaptation tracking by preferring indicators that can show quick results at the expense of more long-term targets.

Bureaucratic autonomy is central to understanding politico-administrative relations. Autonomy refers to the freedom of bureaucrats to determine their preferences in knowledge production and use (Maggetti & Verhoest, 2014). The degree of autonomy depends on several factors, including the influence of elected officials on hiring and dismissal of bureaucrats, which, in turn, shapes the technical capacity of bureaucrats and the opportunities for elected officials to influence knowledge production and use (Boräng et al., 2018; Dasandi & Esteve, 2017; Onyango, 2020; Zafarullah, 2013). Bureaucrats are accountable to their political counterparts, but the extent of recognition of their authority could influence the effectiveness of bureaucrats in fulfilling their tasks (Ayee, 2013; van Dorp & 't Hart, 2019).

In politically dominated systems, the autonomy of bureaucrats is limited due to political interference in the recruitment and dismissal of bureaucrats and in controlling resources for knowledge production (Pepinsky et al., 2017). Knowledge production is politicized, as bureaucrats aim at proving their political alignment (Boräng et al., 2018). For example, in India and the US, political agenda has been found to have a strong influence on climate action by determining the extent of institutional reforms for climate governance, bureaucratic capacity and in turn, the fulfillment of bureaucratic mandates towards climate action (Mildenberger, 2021; Pillai & Dubash, 2021). In complementary systems (Svara, 1999), there is a balance between political interests and bureaucratic freedom, which may lead to high political and technical capacity (Howlett et al., 2015). The complementary nature of the relations allows elected officials to provide oversight and political legitimacy while providing the autonomy required for bureaucrats to produce and use knowledge (Cameron, 2010). Such systems are observed, for instance, in countries such as the Netherlands, where bureaucrats balance between political responsiveness and professionalism (Alford et al., 2017; van Dorp & 't Hart, 2019). In bureaucratic-dominated systems, there is high bureaucratic autonomy but the lack of oversight results in bureaucratic clientelism. For example, in Bangladesh, public administration is bureaucratized, which despite its correlation with an increase in climate finance, could lead to the dominance of generalist bureaucrats who lack specialized expertise required for effective implementation and monitoring of adaptation policies (Rahman & Tosun, 2018).

Table *2.6* outlines these examples of varieties of politico-administrative relations.

Table 2.6 Varieties of politico-administration relations

Political Dominance	Complementarity	Bureaucratic Dominance
Elected officials control majority of bureaucratic decisions hence limited bureaucratic autonomy.	There is mutual respect between elected officials and bureaucrats, resulting in moderate bureaucratic autonomy.	Bureaucrats dominate the administrative structure leading to high bureaucratic autonomy.

2.3.6 Coordination within the administration

The sixth dimension involves the nature of interactions between interdependent administrative units and how they consider each other's decisions and actions (Bolleyer and Börzel, 2010; Koop and Lodge, 2014; Peters, 1998).

Adaptation cuts across multiple sectors and ministries, hence, adaptation tracking will require inter-administrative and intersectoral coordination to facilitate knowledge flow (Bauer et al., 2012; Laihonen & Huhtamäki, 2020; Laihonen & Mäntylä, 2018). Coordination has been argued to help overcome institutional and organizational barriers to knowledge production while boosting the government's capacity to address climate change adaptation (Shao & Saxena, 2019; Tosun & Howlett, 2021). It is also crucial to consider the competing perceptions that influence how bureaucrats make sense of and implement knowledge production (Hathaway & Askvik, 2020; Laihonen & Kokko, 2019) as their (non-)alignment may determine the compatibility of knowledge produced by different administrative units. Coordination is, therefore, essential for facilitating conceptual and methodological coherence and consistency between administrative units (Arnaboldi and Palermo, 2011; Peters, 2018). For instance, in Germany, close collaboration between national authorities has been shown to be valuable in ensuring cross-sectoral methodological consistency in adaptation monitoring (van Rüth & Schönthaler, 2018). Administrative coordination also facilitates the vertical integration of the subnational levels and established climate departments within broader knowledge production systems (Klostermann et al., 2018; Renner, 2020). Countries such as Kenya and the UK, for example, have established coordinating units that collate and synthesize adaptation knowledge (Klostermann et al., 2018; Renner, 2020). These units have been argued to be vital for aggregating and maintaining a broad view of adaptation (Klostermann et al., 2018).

Two variables are important for characterizing coordination. The first variable looks into the administrative structure and considers the institutionalized boundaries that demarcate

administrative units and the ensuing relations between them (Bellamy et al., 2008; Hathaway & Askvik, 2020). These demarcations influence the values and interests within administrative units and, in turn, the relations between them (Hathaway and Askvik, 2020; Peters, 2018). This variable helps in mapping the relevant administrative units, their approaches to knowledge production, information needs, and their roles in knowledge production. In addition, this variable identifies the linkages between administrative units or networks which influence the consistency in methods and outputs of policy knowledge production. Under this variable, administrative units can have strong or weak ties depending on the alignment of knowledge production activities and approaches.

The second variable, which captures the degree of formalization, is based on the extent to which procedures for interactions between relevant administrative units are embedded in agreements and laws and their degree of enforcement (Bolleyer & Börzel, 2010; Hathaway & Askvik, 2020; Jensen, 2014; Koop & Lodge, 2014). Formalization may enhance coordination by legitimizing the exercise of authority through the formal assignment of responsibilities to the various administrative units while determining the available coordination mechanisms (Bolleyer & Börzel, 2010).

At least three varieties of bureaucratic coordination are possible, as summarized in Table 2.7.

In individualistic systems, bureaucrats depend on loose networks and interests of individuals and fragmented administrative units since coordination is weakly formalized (6, 2004; Bellamy et al., 2008; Laihonen & Huhtamäki, 2020). Coordination is maintained only to the extent to which it aligns with individual interests and could result in incompatibility as different rationales drive processes of knowledge production (Bellamy et al., 2008; Laihonen and Huhtamäki, 2020; Yang and Wu, 2014). Inadequate formalization of coordination and the weak ties between the various bureaucratic units limits bureaucratic coordination. In bureaucratic systems, coordination is formalized, with procedures for knowledge production and dissemination providing a clear distinction of roles between the various administrative units (6, 2004; Bellamy et al., 2008; Hathaway & Askvik, 2020). However, emphasis on rules and procedures leads to rigidity resulting in moderate coordination (Hathaway & Askvik, 2020). For instance, in India, (Pillai and Dubash, 2021) find that climate commitments are typically distributed across line ministries which are expected to outline how they are going to support the implementation of national ambitions. However, planning and reporting follow a ‘rule of appropriateness’ logic that is based on short-term results that follow pre-defined targets and

actions, limiting the sustainability and effectiveness of coordination (Pillai & Dubash, 2021). In mutualistic systems, bureaucrats prefer mutual and voluntary commitments to produce and share knowledge resulting in flexibility in the otherwise formalized coordination (6, 2004). As a result, there is a high degree of coordination with strategic and strong ties between administrative units (6, 2004).

Table 2.7 Varieties of bureaucratic coordination

Individualistic coordination	Bureaucratic coordination	Mutualistic coordination
Weak formalization and weak ties. Coordination is driven by interests of individuals or specific administrative units, leading to low administrative coordination.	Clear distinction of roles between multiple administrative units. High formalization of coordination with rigid rule-following, leading to moderate administrative coordination.	Flexible application of coordination rules. Mutual agreements facilitate strong ties in knowledge production, sharing, and use, resulting in high administrative coordination.

2.4 Discussion and conclusion

In the previous sections, we have presented a theory-informed framework for analyzing the institutional structures of knowledge production and use relevant to the institutionalization of adaptation tracking. This framework contributes to scientific and policy discussions by proposing the use of Science and Technology studies, public administration, and public policy theories to guide contextually appropriate design of adaptation tracking. These theories provide insights into prevailing state-society relations and intra-governmental dynamics which are fundamental for knowledge production and use. The framework proposed in this paper helps to unpack the starting conditions of relevant institutions based on six dimensions that are relevant when designing adaptation tracking that aligns with the prevailing institutional structures. By highlighting the dimensions that will shape the adoption and effectiveness of adaptation tracking, this diagnostic approach enriches technical conceptualizations of adaptation tracking that typically only look at indicators and frameworks.

If the influence of the established organizational structures and rules matters, then institutional alignment is integral to the successful uptake of adaptation tracking. Institutional alignment will entail a determination of whether the existing institutional structures support the ambitions of adaptation tracking as conceived, including maintaining a broad view over space and time while ensuring quality knowledge production. Alignment may range from complementarity, where the prevailing institutional structures are supportive of adaptation tracking, to competitive, in cases where the new reporting requirements come at the expense of existing

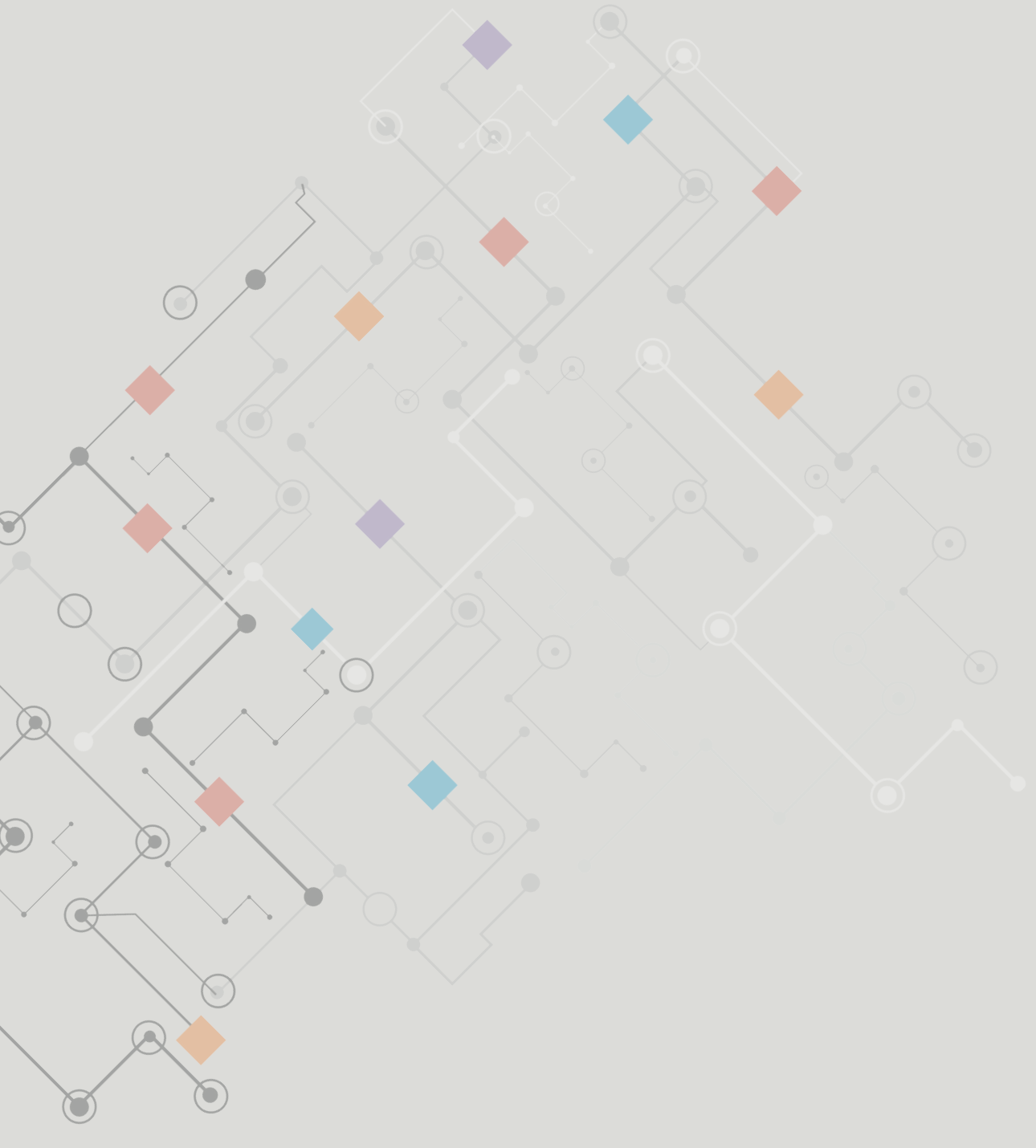
requirements within the institutional structures or vice versa (Helmke & Levitsky, 2012). It is also crucial to understand the suitability of the existing systems of knowledge production and use, as this may affect the usability and comparability of knowledge from adaptation tracking across countries (Jerven, 2013) and sectors. The study of institutional characteristics may also provide insights into the feasibility of strategies for enhancing governance by disclosure. For instance, for domestic organizations to hold the governments accountable, as suggested by Karlsson-Vinkhuyzen et al. (2018), they will require supportive political and administrative relations, administrative coordination, transparency, and functional accountability structures; and these vary across and within countries. For successful institutionalization of adaptation tracking, its design should incorporate existing elements that invoke familiarity and legitimacy while maintaining the flexibility required to catalyze reforms towards more effective knowledge production and use (Hargadon & Douglas, 2001).

There are diverse perspectives on the dimensions included in this framework. Our goal was to provide a workable framework for characterizing the institutional structures of knowledge production and use by outlining a set of dimensions and variables that are applicable to diverse governance contexts and capture both the national and sub-national levels. The operationalization of the dimensions should be guided by the sector of interest. This framework, we are convinced, is a useful step towards institutional alignment. However, our work serves as a starting point. Further research is required to test and improve the framework so that it can usefully guide a contextually appropriate design of adaptation tracking. This framework is by no means self-sufficient, and we anticipate that new dimensions may emerge as more empirical assessments are conducted. Although presented as distinct, the six dimensions are interrelated. For example, coordination between administrative units could reinforce transparency as coordination facilitates knowledge integration and ease of access, for instance, through the establishment of a central knowledge base. It is also likely that more transparent systems will score high on accountability as more disclosure increases bureaucratic answerability (Fox, 2007). Trade-offs might also exist between the dimensions. On the one hand, transparency and participation can be complementary or synergistic as stakeholder participation contributes to innovative approaches to government transparency (Kim and Lee, 2019; Meijer et al., 2012). On the other hand, more participation may lead to less transparency as governments avoid scrutiny (Meijer et al., 2012). This means that a high representation of a particular dimension is not always ideal. Therefore, to develop a comprehensive strategy for designing adaptation tracking, the characteristics of each dimension should be interpreted in

light of the other dimensions. Empirically, the interactions between the variables may be more complex, resulting in context-specific characteristics that extend beyond those exemplified in this paper. The examples provided above aim to illustrate the possible contextual diversity.

We suggest three areas of work that may be useful in advancing discussions on institutional alignment in adaptation tracking. First, our proposed framework should be empirically tested. Empirical studies could involve examining whether the dimensions and variables have equal importance across diverse governance arrangements and if there are dimensions not captured by the framework. This will help prioritize which dimensions to pay most attention to, depending on their characteristics and influence on adaptation tracking. Secondly, it may be helpful to examine the utility of the framework in evaluating the extent to which emerging adaptation tracking methodologies align with knowledge production and use systems. In addition to testing the framework, this would predict the degree of institutionalization of such methodologies. Thirdly, it would be useful to test the framework's usefulness in guiding the design of more effective adaptation tracking interventions. We presume that guided by the framework, practitioners will develop a better understanding of the institutional structures of knowledge production and use within a targeted policy domain, more accurately evaluate the feasibility of specific designs of adaptation tracking, and plan for future reforms. Applications of this framework should consider the uniqueness of the formal and informal rules to policy domains and not the general country characteristics (Howlett & Tosun, 2019).

To conclude, countries vary in state-society relations, dynamics within their governments, and in the institutional structures that shape knowledge production and use. These country-specific characteristics, as well as differences within countries, will influence the institutionalization of adaptation tracking, making institutional alignment fundamental for the effectiveness of adaptation tracking. As adaptation tracking remains to be of global and national value, adding to technocratic framings of adaptation tracking more deliberate consideration of how adaptation tracking frameworks align with the institutional structures of each country is not only strategically important but also crucial to the success and effectiveness of adaptation tracking in the long-term.



Chapter 3

Do government knowledge production and use systems matter for global climate change adaptation tracking and reporting? Insights from Eastern Africa

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Abstract

National contexts play a critical role in shaping the transposition of international laws and agreements, such as the Paris Agreement. However, the relevance of national contexts when assessing global progress in adaptation to climate change has received little theoretical and empirical attention. To bridge this gap, we conduct a comparative study of government systems for producing and using policy knowledge on livestock systems of three Eastern Africa countries. We find distinct features within and between countries, which may explain variations in how adaptation progress is tracked. In particular, our study shows that prevailing administrative structures influence horizontal and vertical coordination, with implications for the flow of knowledge within government. The extent of coordination and the establishment of knowledge production procedures and accountability mechanisms affect the compatibility of the various knowledge streams in each country which, in turn, determines the potential for integrating adaptation tracking across the various administrative units. Our findings suggest that the effectiveness and feasibility of tracking adaptation progress over time and space will depend on the adequacy and successful linkage of tracking programs with existing systems of knowledge production and use. These findings underscore the relevance of a fit-for-context approach that examines how adaptation tracking can effectively be integrated into existing structures and processes while developing strategies for improving knowledge production and use.

3.1 Introduction

Following the adoption of the Paris Agreement in 2015, attention to the centrality of national contexts to the success of international climate agreements has increased. Studies are increasingly showing that the prevailing governance systems and practices play a critical role in shaping climate politics within a country and, in turn, the nature and outcomes of the institutionalization of national and international climate policies (Bernauer, 2013; Teng & Wang, 2021). Climate policies' effectiveness can be enhanced through the alignment between international climate goals and national government interests. These policies can then strategically be implemented by gradually layering climate action responsibilities onto existing administrative units or creating new organizational structures (Teng & Wang, 2021). However, in some cases, this layering approach can reinforce functional incompatibility between national bureaucratic practices and structures and externally mandated expectations, which may hinder the implementation of national and international climate policies (Pillai & Dubash, 2021). Relatedly, while there is widespread adoption of national adaptation policies, countries are at varying stages in the development of adaptation tracking systems (Leiter, 2021). This variation is associated with differences in legal mandates, availability of human and financial resources, and national politics and priorities. Experience from other domains that are shaped by global goal setting and require national reporting, such as the Sustainable Development Goals (SDGs) further shows that the capacity of governments and alignment of global programs with national interests are critical success factors (Hickmann et al., 2022; Nilsson et al., 2022). Despite evidence of variations in national systems and the need for coherent links between the scales within which global challenges are addressed, the consideration of national administrative contexts in relation to advancing adaptation tracking and reporting is limited.

Adaptation tracking entails the systematic assessment of progress in responding to the impacts of climate change across and within populations and sectors, over time (Berrang-Ford et al., 2019; Ford et al., 2013). The temporal and spatial scope for adaptation tracking distinguishes it from the more traditional Monitoring and Evaluation (M&E), which typically focuses on specific interventions and outcomes bounded in time and space. Compared to monitoring greenhouse gas emissions – which has advanced tools and metrics – adaptation tracking is hindered by conceptual, methodological, empirical, and political challenges (Bours et al., 2014; Delaney et al., 2016; Ford, Berrang-Ford, Biesbroek, et al., 2015; Ford et al., 2013). However, there are growing efforts to identify the best methods for adaptation tracking and reporting to support the assessment of collective progress in light of the global goal on adaptation. Although

the Paris Agreement recommends a country-driven approach to adaptation, some of the guiding principles of adaptation tracking include the need for comparability and aggregability of information across countries and over the years (Ford & Berrang-Ford, 2016). Consequently, divergent proposals for advancing adaptation tracking have emerged. On one hand, considerable work aims to establish standard metrics and frameworks applicable across countries without necessarily relying on countries reporting on their adaptation progress (e.g., Magnan and Chalastani 2019; Moehner et al. 2021). On the other hand, there is literature, albeit more limited in scope, that analyzes how adaptation is tracked in diverse country contexts (European Environment Agency, 2015; Hammill & Dekens, 2014; Leiter, 2021). This literature recognizes that for adaption tracking to be meaningful to countries and sustainable, it is important to strategically integrate adaptation tracking into existing national knowledge production and use systems. Each nation's system consists of unique interlocking practices, laws, funding mechanisms, and structures for producing and using statistical and qualitative evidence of social, economic, and environmental conditions (Anderson & Whitford, 2017; Boräng et al., 2018)[3]. Variations within and across these systems can reasonably be expected to shape to the institutionalization and outcomes of adaptation tracking.

In this paper, we present a comparative analysis of the institutional structures of knowledge production and use in the livestock sectors of Ethiopia, Kenya, and Uganda to provide insights into the nature of and variations between national administrative contexts for adaptation tracking. We ask: what rules and practices characterize systems for producing and using knowledge on livestock systems in Ethiopia, Kenya, and Uganda? How do these systems vary within and across countries? What are the implications of variations for the assessment of collective progress in climate change adaptation? In answering these questions, we build on findings in previous assessments of national adaptation tracking systems (e.g., Hammill and Dekens 2014; Price-Kelly et al. 2015; Leiter 2021) by considering more explicitly the implications of how they are organized for the introduction of adaptation tracking that is geared towards international reporting. By applying a systematic assessment of government systems that considers interactions between state and non-state actors, this study also provides results

[3] Henceforth, we use the term "(policy) knowledge" (Boräng et al., 2018) to refer to the statistical and qualitative information that is regularly produced and used by governments for various functions, including monitoring the effectiveness of policies, general evaluation of the social and economic conditions of the country as well as monitoring and reporting on international commitments. For livestock systems, policy knowledge includes data on livestock production, traded volumes of livestock and livestock products such as meat and milk, the contribution of livestock to the national economy and livelihoods, impact of livestock diseases, among others.

that are relevant for other structurally similar domains such as monitoring and reporting on SDGs.

3.2 Framework for analyzing institutional structures of knowledge production and use

The theory-informed framework used to structure data collection and analysis in this study draws on science and technology studies (STS), public policy, and public administration theories. STS work on civic epistemologies focuses on the relationship between state and society in knowledge production, particularly how the relationship determines the interests that influence knowledge, how it is produced, and its deployment (Jasanoff, 2005). Public policy and public administration theories foreground the internal organization of government, including the norms and values that shape the roles of those in government (Jamil et al., 2013; Painter & Peters, 2010a). The framework has been developed and discussed elsewhere (Njuguna et al., 2022) and consists of six distinct but interrelated dimensions: i) coordination within the administration, ii) bureaucratic accountability, iii) politico-administration linkages, iv) transparency, v) engagement with experts, and vi) stakeholder participation. Table 3.1 outlines the definition of each dimension and its relevance for adaptation tracking.

The framework and its application in the study are based on several assumptions. First, given the potential of local, national, and regional assessments to inform the evaluation of collective progress in adaptation, we contend that the national contexts within which these foundational levels subsist are crucial for effective and meaningful adaptation tracking. Therefore, the framework is designed to support the examination of two crucial elements that shape how governments produce and use knowledge about society: intra-governmental dynamics and state-society relationships (Jamil et al., 2013; Jasanoff, 2005; Njuguna et al., 2022; Painter & Peters, 2010a). Intragovernmental dynamics shape the capacity of governments to produce knowledge and its flow between different administrative units, which is important considering the need for adaptation tracking to draw on the evaluation and reporting of adaptation efforts across sectors and scales (Klostermann et al., 2018; Leiter, 2015). Similarly, adaptation tracking requires contribution from both state and non-state actors to capture diverse adaptation priorities, actions, and outcomes (Bartelet et al., 2022; Dilling et al., 2019) making state-society relations an essential element to consider. Secondly, countries are expected to have distinct ways of organizing their government, hence the variation in institutional structures of producing and using knowledge (Howlett, 2002; Howlett & Tosun, 2019). Thirdly, countries exhibit path dependency in policy processes, with established rules and practices influencing

the design and implementation of new policies (Pierson, 2000). The uniqueness of policy styles and path dependency underscore the need to understand how national contexts will shape adaptation tracking. Fourth, sectors or administrative levels may have distinct institutional structures (Howlett, 2002). Consequently, it is critical to account for variations that might exist within a government, as opposed to treating a country as a homogenous unit of analysis. In this regard, in each country, we focus on one sector – the livestock sector – and pay attention to institutional structures at national and sub-national levels.

Table 3.1 Framework for analyzing institutional structures of knowledge production, relevance, and operationalization

Dimension	Definition	Relevance	Variables	Data sources & analysis
Coordination within the administration	Interactions between interdependent administrative units and how they consider each other's decisions and actions in knowledge production and use	Coordination supports the integration of adaptation reporting at national and subnational levels, thus allowing the inclusion of aspects that are specific to livestock sectors or scale-specific issues into the national assessments of adaptation (Leiter, 2015; Lesnikowski et al., 2016).	Degree of formalization of coordination	Reviewing government documents to identify the established guidelines on how coordination in knowledge production should be achieved.
			Administrative structure	Using government documents and interviews to map the relevant administrative units at national and subnational levels. Interviews also helped us to understand the extent to which administrative units work together to produce knowledge.
Bureaucratic accountability	Mechanisms for holding bureaucrats accountable in their activities of producing and using knowledge	The establishment of standards and accountability mechanisms ensures that knowledge is produced by designated people, using appropriate methods (Jasanoff, 2005; van Kerkhoff & Pilbeam, 2017).	Established knowledge production standards and procedures	Reviewing government documents to identify the rules that define which knowledge is produced, how, in what frequency, and by whom. Also using interviews to identify the standards and procedures that bureaucrats follow.
			Accountability forums	Reviewing government documents and using interviews to identify to whom the bureaucrats give an account of their knowledge production activities, how (frequency, what they account for), and the consequences
Politico-administrative relations	Interactions between the political and administrative realms of the government and their implication on	The nature of politico-administrative linkages influences data availability and quality, for instance, considering politicization of knowledge which might incentivize non-disclosure	Bureaucratic autonomy	Using interviews to identify how bureaucrats perceive politics to be influencing their knowledge production activities.

	knowledge production and use	(Aragão & Linsi, 2020; Boräng et al., 2018; Ford et al., 2013)et al., 2018; Ford et al., 2013).		
Transparency	Accessibility of government-held knowledge by non-state actors	The extent of access to government-held knowledge determines the effectiveness of efforts by the public to keep governments accountable for adaptation commitments as well as in facilitating secondary uses of the accessible knowledge (Karlsson-Vinkhuyzen et al., 2018; Leiter, 2021).	Established transparency rules	Reviewing government documents to identify provisions related to access to knowledge on livestock that is held by the government
			Characteristics of accessible knowledge	Using interviews to identify the main channels used to disseminate knowledge on livestock.
Engagement with experts	Modalities of engagement with individuals or organizations that government relies on for specialized advice on knowledge production and use	Expert engagement can facilitate the involvement of various actor groups such as academia and other non-state actors in adaptation tracking but might also lead to the exclusion of 'non-experts' through the technocratization of knowledge production (Green & Lund, 2015; Gupta et al., 2012).	Location of experts relative to the bureaucratic structure	Using interviews to identify the experts that bureaucrats rely on in designing knowledge production and establishing whether the experts are internal or external to the bureaucratic structure.
Stakeholder participation	Engagement between the government and relevant stakeholders in knowledge production and use	Stakeholder participation can facilitate the integration of diverse contextual adaptation experiences and priorities through the involvement of stakeholders in defining metrics for tracking adaptation and in knowledge production (Dilling et al., 2019; Falzon, 2021).	Participation criteria	Using interviews to identify the guidelines used in determining the inclusion of livestock keepers in knowledge production.
			Nature of participation	Using FGDs to determine if and how livestock keepers engage in knowledge production.

3.3 Methods

3.3.1 Study context

The livestock sector is an integral part of the livelihoods and the economy of the three study countries, as shown in Table 3.2. However, fluctuation in temperatures, variability in rainfall patterns, and increase in CO2, directly and indirectly, impact livestock systems, hence the need for measures to respond to observed and anticipated impacts of climate change (Rojas-Downing et al., 2017; Thornton & Herrero, 2014) and to assess adaptation outcomes across space and time.

Ethiopia, Kenya, and Uganda have included the livestock sector in their NDCs as one of the sectors vulnerable to climate change and in need of adaptation (Federal Democratic Republic of Ethiopia, 2021; Government of Kenya, 2020; Government of Uganda, 2015). In addition, Ethiopia and Kenya have adopted National Adaptation Plans (NAPs) that outline adaptation priorities and the commitment to monitor implementation progress. Uganda has an adaptation plan for the agriculture sector and is in the process of developing a NAP. In addition, the three countries have other national and sectoral plans whose priorities and their monitoring are relevant for adaptation tracking. However, the three countries have varying government systems (Table 3.2), making them suitable for comparison.

Table 3.2 Summary of economic and governance context of the three cases

	Ethiopia	**Kenya**	**Uganda**
Share of GDP from agriculture	48.6%	29.9%	25%
Livestock contribution to agricultural GDP	45%	42%	13%
Governance structure	Federalized system with subnational administrative structure comprised of nine regional states that are further divided into zones, *woredas* (district), and *kebeles*	Devolved governance system with subnational administrative structure comprised of 47 county governments which are further broken down into sub-counties and wards	Deconcentrated governance system with subnational administrative structure comprised of 135 districts which are further divided into sub-counties and parishes

3.3.2 Data collection and analysis

We used a comparative case study approach, which requires equivalent research across several sites, thus allowing an in-depth comparative study of phenomena (Bartlett & Vavrus, 2017).

Each case drew on diverse contextually appropriate data sources, thus supporting meaningful comparison. We focused on organizational structures, processes, and rules for producing knowledge that is relevant for tracking and reporting on adaptation in livestock systems. Data sources included document review, interviews, and Focus Group Discussions (FGDs). For each country, we reviewed relevant government laws and policies that guide knowledge production and use (Annex 1). These documents capture rules and formally expected behavior of bureaucrats in knowledge production and use (Howlett, 2018). However, practices and formal rules shape institutional structures (Howlett & Tosun, 2019). To understand bureaucrats' practices, in 2019 and 2020, the first author conducted semi-structured interviews with selected administrative officers in the three countries (n=32). The interviewees included representatives from the administrative units in charge of the livestock sector at national and sub-national levels, climate action coordination units, and the agencies mandated to produce national statistics (Annex 2). The interviews were audio-recorded, with consent from interviewees and afterwards anonymized through a coding system that only identified the country and administrative unit.

The first author also organized 48 FGDs with livestock keepers across the three countries to discuss their involvement in knowledge production processes that are similar to those required in adaptation tracking (Annex 3). We engaged livestock keepers as they are critical for knowledge production on livestock systems. Since adaptation needs and priorities vary across livestock production systems (Rivera-Ferre et al. 2016), the location of the FGDs captured practices typical of four major livestock production systems within the region, that is, highland and lowland mixed crop-livestock, grazing-pastoral, and grazing non-pastoral. We analyzed the interviews, translated FGD transcripts, and the government documents with ATLAS.ti 9 software. Table 3.1 summarizes the data sources used to characterize each variable of the framework.

Data analysis entailed two main steps. First, we deductively coded the data using the dimensions and variables from the framework, making it possible to focus on dimension-specific data (Alexiadou, 2001). Second, we analyzed the structured information on the practices and the formal rules of knowledge production to come up with a description of the institutional structures of each country before comparing.

The findings from the analysis were then presented during workshops with government officials for critical discussion. The three workshops, one for each study country, were

conducted between November 2021 and March 2022. Based on the discussions on the analytical framework and the results, we validated and updated the findings. The workshops also provided a platform for government officials to deliberate on how to implement adaptation tracking in consideration of the prevailing institutional structures.

3.3.3 Study limitations

First, the scope of the analysis omits certain aspects, such as the participation of businesses and civil society in knowledge production and use. The nature of climate risks and adaptation needs compelled us to prioritize livestock keepers. Our results suggest that it is reasonable to anticipate policy relevant heterogeneity in the involvement of these actors, but it would be prudent to extend our work by engaging other non-state actors in future research. Secondly, livestock systems are particularly complex, diverse, and dynamic, creating unique challenges and data needs for adaptation tracking. While the findings presented in this paper are specific to the livestock sector and do not necessarily offer a sufficient basis for generalization to other domains, our study allows us to confirm that variation in government systems for producing knowledge matters, and therefore, the findings remain relevant to discussions of adaptation tracking. Thirdly, although the premise and application of this framework stem from the presumption that adaptation tracking will be instrumental in enhancing accountability and transparency among countries and in providing information for adaptation planning and decision making, we also note longstanding arguments in the literature highlighting the limitations of governance-by-disclosure mechanisms (Gupta & Mason, 2016; Weikmans et al., 2020) which we do not extensively address in this paper.

3.4 Findings: Institutional structures of knowledge production in livestock sectors of Kenya, Uganda, and Ethiopia

This section presents the findings of the analysis, focusing on a comparison of the salient features of the institutional structures of each country based on the six dimensions of the analytical framework. Table 3.3 summarizes the findings. For all the dimensions and variables, we only include elements we identified as relevant for tracking adaptation in the livestock sector of each country.

3.4.1 Coordination within the administration

To understand coordination, we analyzed two variables: degree of formalization of coordination and administrative structure in place. The nature and extent of coordination are important determinants of how adaptation tracking can be integrated across scales considering

the flow of knowledge between administrative units and the integration of the different knowledge streams. We find that the degree of formalization of coordination varies between the countries. In Kenya and Uganda, coordination is highly formalized through various Acts of parliament that outline knowledge production and dissemination channels and the mechanisms for achieving coordination. For instance, the Statistics Act of 2006 (Art. 4) and the Uganda Bureau of Statistics Act of 1998 (Art. 4) mandate the Kenya National Bureau of Statistics (KNBS) and the Uganda Bureau of Statistics (UBOS), respectively, to coordinate activities within the national statistical system. Relatedly, KNBS and UBOS collaborate with the ministries of agriculture to develop methodologies and consolidate human and financial resources for knowledge production. In contrast, coordination is implicit in the formal rules in Ethiopia. Proclamation 442/2005, which establishes the Central Statistics Authority (CSA), compels CSA (now referred to as the Ethiopia Statistics Service[4]) to support other government agencies in knowledge production and monitor the implementation of national statistics programs (Art 7.7). While Kenya and Uganda have enacted Acts of parliament to guide the production and dissemination of knowledge on climate change, Ethiopia is yet to pass a law that is specific to climate change. The Kenya Climate Change Act of 2016 (Art. 9) and Uganda's Climate Change Act of 2021 (Art 14) establish national climate change units to collate knowledge and coordinate reporting on climate action for all sectors at national and sub-national levels. These climate change laws also mandate government agencies to designate units to plan and provide information on their climate actions to the Climate Change Directorate, which is responsible for collating reports for international reporting. M&E plans within policies, such as the NAP, refer to the provisions of these Acts. In Ethiopia, due to the absence of a climate change law and frequent changes in the administrative structure, there are differences in names used by different plans. For instance, the Climate-Resilient Green Economy (CRGE) strategy mandates the Environmental Protection Authority (EPA) to supervise, regulate, and monitor the implementation of the strategy in each sector (p. 47-48). As per the updated NDC and recently adopted ten-year development plan, the Planning and Development Commission will oversee the production of national statistics and monitor the

[4] At the time of data validation, the administrative structure of Ethiopia was under review. Some of the planned changes involve the transfer of mandates between administrative units as well as a change in names. While some of these changes have implications on some elements of knowledge dissemination, we recognize institutional changes as an infinite process and, therefore, had to define the temporal boundaries of our cases. Furthermore, the new structures still exhibit much of the existing styles of knowledge production and use.

actions of various ministries, including sectoral climate actions and the Environment, Forest, and Climate Change Commission will coordinate international reporting.

Regarding administrative structure, the three countries studied have multiple administrative units engaging in knowledge production, resulting in three main streams of knowledge: national statistics that are produced by designated semi-autonomous government agencies, administrative data, and data specific to climate action. However, the coordination structures and practices distinguish the three countries, including the compatibility of the three knowledge streams in two main aspects. First, we see differences in the degree of horizontal coordination. In Uganda and Kenya, horizontal coordination is achieved through the collaboration between bureaus of statistics and ministries of agriculture, hence the integration of official statistics and administrative data. For instance, the bureaus and the ministry of agriculture have joint committees where they discuss methodologies and plans for knowledge production activities. In contrast, in Ethiopia, the Ministry of Agriculture and Natural Resources (MANR) and CSA collect data independently, and administrative and official statistics exist in parallel. CSA primarily consults MANR on specific technical issues, such as the definition of terms. Differences in the methodologies used to produce administrative and official statistics have resulted in inconsistencies in the two knowledge streams, in turn, hindering their integration and perceived utility for different purposes. CSA perceives administrative data to be inaccurate for inclusion in the official statistics, while MANR considers official statistics not representative enough to support its administrative functions. As explained by one official at the ministry,

> *"They (Central Statistics Agency) are not fully operational in the pastoral areas. This is their weakness. We complain many times in the national meeting. The information is not adequate to plan for development ... because their data collection frequency and sampling are not adequate for decision making in the pastoral areas."*

Regarding the production of data on climate action, Ethiopia's MANR has established an environment and climate change coordination directorate that reports on the climate actions of the ministry to the EPA.

The second aspect relates to vertical coordination, with the form of decentralization and the ensuing coordination structures and practices shaping the flow of knowledge between national and sub-national levels of governments. In Kenya, county governments have a considerable degree of self-determination. For instance, agriculture is a devolved sector, and the county

governments, through the relevant county departments, have the mandate to implement policies depending on local needs and report on progress to the Ministry of Agriculture Livestock Fisheries and Cooperatives (MALFC) at the national level. The county departments are constituted by various directorates, including one on livestock, which is further decentralized to facilitate implementation and regular reporting from the various sub-counties and wards, thus enabling the vertical flow of administrative data related to livestock from the local to the national level. However, power dynamics between national and county governments, capacity limitations at the county level, and coordination gaps create a disconnect in the flow of administrative data. As was noted by one respondent:

> *"You see, years back, before devolution, … there was a clear reporting structure. If it is a progress report on crop development, you would have the person at the location level write a report to the division, the person at the division compiles the reports of various locations and the reports go all the way to the ministry. This structure broke down with the devolution because there are still issues of who has the obligation to report to whom."*

To overcome these coordination challenges and to enhance monitoring of climate actions, the Climate Change Unit at MALFC is spearheading the establishment of the Climate Smart Agriculture Multi-Stakeholder Platforms at national and county levels to facilitate networked coordination. This unit also coordinates the mainstreaming of climate change issues in the various agricultural sectors, including developing tracking tools and collating climate change information and further dissemination to the Climate Change Department. The Climate Change Unit is supposed to aggregate information on climate action within the agriculture sector from the county climate change units. However, most counties are yet to fully establish county climate change units, making it challenging to coordinate reporting between the counties and the national government. To produce annual national statistics, Kenya National Bureau of Statistics (KNBS) engages with the agriculture departments at the county level to gather and validate data estimates, thus providing the opportunity to harmonize differences between official statistics and administrative data.

In Uganda and Ethiopia, while local administrative responsibilities have been allocated to the district and regional governments, respectively, the central government maintains a significant degree of control, thus catalyzing vertical coordination. For instance, in Ethiopia, regional governments are expected to establish administrative structures and to report on key aspects

such as climate action to the federal level. In Ethiopia and Uganda, extension officers facilitate the collection of administrative data from the livestock keepers and this data is aggregated upward to the national level. Some of the regional governments in Ethiopia have not established structures for reporting on climate action. Therefore, the environment and climate change coordination unit at MANR uses administrative data to identify knowledge that is relevant for climate action for reporting to the EPA.

In sum, the three countries differ in the extent of consideration of coordination in existing laws including having laws specific to climate change. Also, coordination structures and practices distinguish the three countries in their degrees of vertical and horizontal coordination with possible implications on how knowledge on adaptation can flow between administrative units at national and sub-national levels.

3.4.2 Bureaucratic accountability

Bureaucratic accountability is concerned with the existence and enforcement of knowledge production standards. We analyzed the relevant knowledge production standards and mechanisms for holding bureaucrats accountable to understand how accountability in knowledge production and use is organized. The definition of knowledge production standards and procedures and the available accountability forums and their functions vary across the countries. In Ethiopia, there are standards for producing administrative data and monitoring government's climate actions, with each sector reporting on its activities monthly, quarterly, and annually. For instance, as part of the routine production of administrative data, the agricultural extension officers across the country use common forms to collect livestock data, including data on livestock population, livestock production, fodder availability, and uptake of technologies and practices. Livestock officers aggregate this data as it moves upwards to the wo*reda* (district), zone, regional and national levels of government. The Environment Protection Agency, which has the mandate to collate knowledge on climate action, oversees the development of sector-specific indicators against which the various ministries and departments report on climate actions. CSA has established methodologies that it has been using over the last decade to conduct surveys. While having knowledge production standards ensures consistent knowledge production within each knowledge stream, the lack of harmonization of methodologies across knowledge streams hinders knowledge integration and use.

In Uganda, extension officers occasionally use paper-based forms to prepare field reports on aspects such as livestock production, animal health, and vaccination coverage. UBOS, in collaboration with other government agencies, is developing a standard indicators framework to harmonize monitoring and reporting on national and international targets. The Climate Change Act of 2021 mandates the minister in charge of climate change issues to provide regulations to guide reporting on climate action. In Kenya, regular production of administrative knowledge is hindered by the absence of extension officers and common reporting formats. Although the government has established integrated reporting systems at county and national levels, these systems are rarely used. To guide standardized reporting on climate actions, the climate change unit under the MALFC is coordinating the development of indicators and a tool for reporting on the contribution of state and non-state actors in the implementation of Kenya's Climate Smart Agriculture Strategy. KNBS also provides a list of indicators on which counties need to provide data, but the county officers often rely on estimates and expert judgments to provide this data.

In the three countries, various accountability mechanisms have been established, but their roles differ. In Kenya, the Climate Change Act of 2016 requires county governments to report on their progress in implementing climate actions to the County Assembly and later to the climate change department at the national level. The cabinet secretary in charge of climate change matters then collates all the information and reports to parliament biennially. However, it is unclear how the accounts rendered by the different administrative units support the verification of how the knowledge is produced or the adequacy of efforts. For instance, the Climate Change Act of 2016 requires county governments to submit annual reports on climate actions to the county assembly for "review and debate" and to the climate change directorate "for information purposes" (Article 19 (5)). Similarly, state departments and other public entities are directed to report to the climate change council, which checks whether their performance is satisfactory (Article 15(5)). This contrasts with the official statistics knowledge stream where there are mechanisms for ensuring accountability in the produced data. For instance, KNBS uses its databases to verify data provided by the various actors and to check for anomalies in the data. The sampling department at KNBS also checks that the appropriate sampling strategy is used. Similarly, In Uganda, the climate change department is expected to submit biennial reports to the minister in charge of climate change issues who then submits the report to the Cabinet to review and approval. The report is then submitted to parliament for feedback. UBOS has established a quality assurance department that ensures that knowledge production follows best

practices and methods. The Uganda Bureau of Statistics Act also encourages UBOS to review and approve knowledge production instruments in use at the national and sub-national levels. In Ethiopia, every quarter, the government organizes a high-level meeting with regional representatives and technical officers to discuss the knowledge produced within the period. In addition to assessing the achievements of the various administrative units against predetermined target, these meetings also serve to provide feedback on the knowledge produced. Proclamation 442/2005 establishes a statistics council, whose functions include reviewing the implementation of statistical programs and making recommendations for improvement. However, data quality issues persist.

Therefore, although the three countries have established standards and procedures that guide the production, dissemination, and use of knowledge on livestock systems, these vary in the degree of standardization between and within administrative units, affecting the compatibility of different knowledge streams within the country. Accountability forums and the extent to which they explicitly aim at reviewing and keeping bureaucrats accountable in knowledge production also vary, influencing the ability to ensure that the produced knowledge is accurate and useful.

3.4.3 Politico-administrative relations

Politico-administrative relations dimension is concerned with the linkages between administrative and political spheres of government, which shape knowledge production. For instance, politico-administrative relations may influence the resources available, the freedom of bureaucrats to publish and use knowledge, or the focus on knowledge production.

For this dimension, we examined bureaucratic autonomy, that is, the freedom of bureaucrats to design and implement knowledge production. Bureaucratic autonomy in knowledge production varied within and across the countries, with distinct forms and extent of politicization of knowledge production. In Kenya, the politico-administrative relations are apparent in three main aspects and are more pronounced at the sub-national level. The first aspect relates to the budgetary allocation for activities within the agriculture departments which affects the financial resources available for knowledge production within the counties. For instance, county governments focus on projects that give them political mileage, which often does not include adaptation projects or long-term monitoring initiatives. This also means that decision making is based on political priorities as opposed to knowledge that may be produced through sustained knowledge production. Inadequate budgetary allocation to the agriculture sector contributes to

the lack of extension officers in most wards, further hindering knowledge production. In one of the sampled counties, only four of the 25 wards had an extension officer:

> *"We are supposed to monitor livestock diseases regularly, but due to limitations in available resources, we might not do it as frequently as expected. Everything that touches on the general population gets the attention of the political class. When they (politicians) meet people, and they are told that goats and sheep are dying, that is when they pay attention to us (agriculture department). But usually, the problem is that there will be no correlation between this attention and the budgeting processes."*

The second aspect relates to the institutionalization of knowledge production strategies. The agenda and priorities of the Countries change every five to ten years upon the election of new political leadership within the county, which is not ideal for the establishment and continued use of knowledge production methods. Monitoring and reporting only focuses on financial reporting and not the evaluation of activity outcomes. Sometimes, the political leaders discredit any data that does not favor their public image. As one county official posited,

> *"We need a reporting system that can be institutionalized. You know, one challenge with integration is [that] regimes come with different issues. When one exits, another one comes in, pretends it knows better than the other one, demolishes the systems that were there, and starts its own systems. ... So, we should be courageous enough to say no, there should be systems like this, and it should be like this. When you come in, adopt that system. That way, you will have consistency over the years. But now, when you keep changing, you distort many things."*

The third aspect is the staff recruitment within the departments. The heads of the departments are political appointees, which affects the technical capacity available to spearhead knowledge production. The political dynamics within the counties have contributed to the variation between counties in their ability to implement and monitor policies. Nonetheless, the retention of some of the county technical officers after regime changes has been useful in gradually building the technical capacity, but they still struggle to assert influence on the political leadership.

In Uganda, bureaucratic autonomy is contingent on the financial resources available to the units that produce knowledge on livestock systems, which, in turn, determines the human capital that is available through the extension service and the frequency of knowledge production. For instance, due to inadequate budgetary allocations and the continued subdivision of local

administrative boundaries, the districts can only afford to have one extension officer in some of the sub-counties, hindering the production of administrative data on livestock systems. In Ethiopia, politico-administrative relations are evident in the dominance of a surveillance logic in knowledge production and use. With the political power being pegged on surveillance and control, knowledge production aims at showing alignment with the predetermined activities and targets and hierarchical reporting thus determining which knowledge is produced and how. Political interests motivate the frequent review of administrative structures at the national level. For instance, the Planning and Economic Development Commission now has the mandate to regulate knowledge production following the recognition of climate action and development as high-level political issues. Previously, this was CSA's mandate.

Although across the three countries we observe political influence in knowledge production and use, the specific ways in which the relationship between politicians and bureaucrats plays out distinguishes the three countries, which could influence if and how adaptation tracking is implemented.

3.4.4 Transparency

To understand the accessibility of knowledge held by the government, we analyzed rules on transparency and how knowledge is accessible. Concerning transparency rules, the three countries have enacted various formal rules and make knowledge accessible, to varying degrees. Kenya has an elaborate legal framework safeguarding access to knowledge. In Kenya, the Statistics Act of 2019 allows KNBS to respond to data requests or undertake the necessary knowledge production processes to make knowledge available. The Act also requires KNBS to disseminate knowledge to the public after ensuring that the knowledge is accurate and anonymized. The Data Access and Dissemination policy of 2012 mandates KNBS to produce knowledge that meets the needs of various users and to disseminate it promptly. The policy further outlines the various channels for disseminating available knowledge, including seminars, and electronic and print media. It also outlines the procedure for requesting access to datasets. The Climate Change Act of 2016 compels the climate change council or the CCD to publish the relevant information within their mandate and defines the procedure for any person to request information. These formal transparency rules are reflected in the current transparency practices. KNBS has a website where most reports are available as well as the tabulated data which is accompanied by a description of methodologies used to produce the data.

Similarly, in Uganda, several rules are relevant for transparency. The UBOS Act of 1998 designates UBOS as the main source of official statistics and is supposed to guide users and providers of statistics, organize, and maintain a central repository of statistical reports. In line with this provision, there is an operational UBOS website where annual and periodical statistical reports and tabulated data are freely available. MAAIF in consultation with UBOS also publishes annual statistical abstracts and sector performance reports. Since not all the data that is collected is analyzed and published, at their discretion, UBOS also allows people to request access to raw data, for use, for instance, in research. However, the emerging laws seem to restrict the accessibility of knowledge held by the government. For instance, although biennial reports on climate action can be made public, the Climate Change Act of 2021 states that only registered verifiers can access and comment on information related to climate change.

In Ethiopia, Proclamation number 442/2005 mandates the CSA to publish and disseminate knowledge from censuses, sample surveys, and administrative records. Reports from knowledge production activities of CSA such as agricultural sample surveys are occasionally available online. It was reported that CSA minimizes the data published online to avoid incidences of data 'misuse', especially in cases where actors come up with contradictory messages after analyzing the data. The Climate Resilient Green Economy Strategy mandates the EPA to monitor the implementation progress of the various sectors and make the reports available to the public.

Therefore, country variations in the elaboration of transparency mandates, the extent to which the rules safeguard transparency, and the efforts put into making knowledge accessible will determine access to knowledge on adaptation tracking, including the ability of non-state actors to verify and use that knowledge in each country.

3.4.5 Engagement with experts

For this dimension, we analyzed the location of people who provide specialized guidance on knowledge production, whether they are civil servants or not, and the nature of their engagement. Uganda uses internal expertise but, in few cases, local external experts are hired to support the government officials in knowledge production. For instance, the statistics unit at MAAIF works with UBOS to generate protocols for knowledge production and they also collaborate to provide technical support for knowledge production in the agriculture sector in general. In addition to having representation from the relevant government agencies in the agricultural statistical working group, the group also co-opts members from non-state

organizations depending on capacity needs. Similarly, in Kenya, although some of the ongoing activities in developing knowledge production systems are supported by development partners, the MALFC has been keen on bringing together local state and non-state actors to bridge capacity gaps in the development and application of tools for tracking adaptation. This approach is considered to enhance ownership of the ensuing knowledge production tools and ensure that the tools align with the government's interests and capacities. At the county level, most responses indicated a reliance on external experts through development partners in designing knowledge production systems. In Ethiopia, most of the knowledge production methodologies are developed by individuals outside the bureaucracy, often with the support of international experts. For instance, support from projects and external consultants is being channeled to develop a database that will be administered by the National Genetics Improvement Institute to monitor livestock breeds and production. Another consultant is developing a digital data system that is aimed at enhancing the integration of the *Kebeles* (lowest administrative unit in Ethiopia) in the production of knowledge on livestock systems.

In sum, in the three countries, we see variations in modes of engagement with experts, with expected implications on the collaboration between administrative units with different expertise in designing and implementing adaptation tracking. The extent of dependence on external experts could also affect the harmonization of efforts to design knowledge production and sustained implementation.

3.4.6 Stakeholder participation

To understand stakeholder engagement, we analyzed the criteria for engaging livestock keepers and the extent of their involvement in knowledge production. Ethiopia has the highest degree of participation of livestock keepers in the production of administrative data. Every month, livestock keepers provide data on their production activities which is then aggregated and disseminated through the government system. To report and conduct development activities in the community, livestock keepers are organized in one-to-five community groups called *Gots*. This means that five households come together, and they have one representative. The representative collects data from the five households and then forwards it to the extension officer who aggregates the data for the whole *Kebele* before forwarding it to the w*oreda* for further aggregation and forwarding it to the zonal and regional agriculture offices. This system covers the livestock keepers in diverse production systems, including rural and urban agricultural systems. As one livestock keeper noted,

> *"The agricultural expert comes and collects information from us every month. They ask us to record or collect the number of livestock available at Got level. I record such kind of data most of the time."*

However, the official statistics produced by CSA only cover rural sedentary livestock keepers, thus excluding pastoralists and agricultural activities in peri-urban and urban areas. For the CSA data, livestock keepers are only sources of data since data is collected by enumerators with minimal participation in the design or production of knowledge.

In Kenya, there is minimal participation of livestock keepers in knowledge production, which could be linked to the limited presence of extension officers who would be responsible for producing administrative data. In the design of data collection, livestock keepers are left out in what is seen as a "scientific process". Livestock keepers are only important when it comes to providing data and receiving the decisions arising from analyses. During censuses, KNBS uses targeted strategies to ensure the inclusion of livestock keepers in pastoral and sedentary systems in their sample. Based on the responses from the FGDs, livestock keepers are vaguely aware of ongoing knowledge production activities. In some areas, they have seen people who collect data on livestock, but they are not aware of the objectives of collecting the data and the institutions collecting it. Similarly, in Uganda, livestock keepers are often not involved in knowledge production. Although the extension officers facilitate the collection of data from livestock keepers, the interaction between the livestock keepers and extension officers varies by locality. During the annual agricultural surveys, UBOS samples the districts based on their production activities by distinguishing the cattle and non-cattle enumeration areas. In areas where livestock keeping is the main livelihood activity, they collect data from all the households while in the rest of the areas only 20% of the households are sampled. There have also been attempts to involve farmers in the designing of knowledge production through the inclusion of the national farmers' federation in the national agricultural statistics technical committee. The government is also implementing a Parish Development Model, through which it plans to select 10-15 sentinel farmers who will be providing seasonal data on the different agroecological zones.

The extent of stakeholder involvement, with the example of livestock keepers, varies across the countries. Their involvement also differs along the different knowledge streams. Variation in stakeholder engagement could affect the extent to which adaptation tracking will capture contextual adaptation experiences and priorities.

Table 3.3 Summary of institutional structures for knowledge production in the livestock sectors of Kenya, Uganda, Ethiopia

	Ethiopia	**Kenya**	**Uganda**
Coordination within the administration	Multiple administrative units producing knowledge on livestock systems. Coordination implied in existing laws. Low horizontal coordination but strong vertical coordination.	Multiple administrative units producing knowledge on livestock systems. Formalized coordination through laws and establishment of coordination units. Strong horizontal coordination at national level. Gaps in vertical coordination.	Multiple administrative units producing knowledge on livestock systems. Coordination is formalized through laws and establishment of coordination units. Strong horizontal coordination at national level strong vertical coordination.
Bureaucratic accountability	Standardized knowledge production using common frameworks and indicators for each of the three knowledge streams. Processes for keeping bureaucrats accountable in knowledge production established but focused on assessing performance.	Knowledge production standards in place, defining how knowledge should be produced and by whom. Production of administrative data not standardized. Accountability forums and processes not explicitly focused on holding bureaucrats accountable in the production of knowledge.	Knowledge production standards in place, indicating how knowledge on climate should be produced and by whom. Moderate standardization of administrative knowledge. Mechanisms for reviewing knowledge on climate actions explicitly established in climate laws.
Politico-administrative relations	Bureaucratic autonomy influenced by a governance system that is centered on surveillance logic in knowledge production through the use of top-down targets and activity-based reporting. Frequent changes in administrative structures.	Bureaucratic autonomy determined by budgetary allocation, institutionalization of monitoring initiatives, and recruitment of staff to undertake effective production of administrative data, especially at the county level.	Bureaucratic autonomy influenced by inadequate funding for knowledge production and frequent subdivision of local administrative boundaries.
Transparency	Provisions for knowledge dissemination exist. Knowledge produced by CSA occasionally accessible online.	Transparency rules elaborated in government policies. Knowledge accessible through online data portals and reports from KNBS.	Transparency rules in place. Emerging laws restrict transparency on climate action. UBOS and MAAIF partner in publishing knowledge online and through print media.
Engagement with experts	Mostly externalized with high reliance on international consultants to design knowledge production systems.	At national level, collaboration between state and non-state actors bridges capacity gaps in the design of knowledge	Collaboration between government agencies to capitalize on the available

		production. Externalized engagement with experts at county level.	technical capacity within government. Occasional support from external experts.
Stakeholder participation	Livestock keepers actively involved in the production of administrative knowledge. Knowledge production process and criteria aim at inclusion of all households in producing administrative data. Pastoral and urban agricultural systems excluded from official statistics.	Livestock keepers marginally involved in designing and implementing knowledge production. They are primarily sources of data. Targeted sampling to ensure inclusion of livestock keepers in various production systems in official statistics.	Livestock keepers are primarily data sources during surveys, censuses as well as based on the knowledge produced by extension officers. In some cases, farmers represented in designing knowledge production. Sampling criteria based on agricultural production activities and agroecological zones.

3.5 Discussion and conclusion

Analyzing and comparing institutional structures of knowledge production and use in the livestock sectors of Ethiopia, Kenya, and Uganda reveals dynamics that are critical for adaptation tracking. Our findings demonstrate the diversity in knowledge production and use both across and within countries, implying the need to consider national contexts when tracking adaptation at the global level. In this section, we discuss the implications of the study's findings, focusing on emerging ideas on how to design adaptation tracking. We also reflect on the strengths and weaknesses of the analytical framework, before concluding.

The integration of adaptation tracking across various administrative units is expected to support the comparison and aggregation of adaptation progress across scales while linking adaptation outcomes with the efforts of national and sub-national governments and the private sector actors (Klostermann et al., 2018; Price-Kelly et al., 2015). Coordination (Dimension 1) and the harmonization of knowledge production standards (Dimension 2) are important because, as this study shows, countries have multiple knowledge streams relevant for adaptation tracking, yet variation in methodologies might result in incompatibility between the knowledge streams. For instance, as in the case of Ethiopia, despite similarities in the indicators used by different administrative units, differences in how data is collected has resulted in inconsistencies in the knowledge produced by each unit. Furthermore, our study shows that rules, structures, and practices of vertical and horizontal coordination within the governments vary, impacting the extent to which current knowledge production systems of governments can support the integration of adaptation tracking across scales. These results highlight the need for locally appropriate ways of supporting linkages across administrative units at national and sub-national levels. While some countries' existing coordination mechanisms can feasibly support adaptation tracking, in other countries, integration of knowledge requires designing contextually appropriate strategies for harmonizing knowledge production across administrative units.

Relying on existing national knowledge streams could ensure that adaptation tracking and reporting does not overburden developing countries with unfeasible reporting mandates while enhancing effective tracking and use of the information in decision making (Berrang-Ford, 2017; Craft & Fisher, 2018). However, countries are at varying stages in establishing systems for tracking adaptation (Leiter, 2021). Therefore, it is important to consider how to leverage diverse sources of evidence of adaptation progress. For instance, although the periodic reporting on climate action as institutionalized in the three countries could be a vital source of

knowledge for adaptation tracking, given the established knowledge production standards (Dimension 2), this knowledge is likely to be activity-based because state and non-state actors are primarily required to report on measures taken during a particular period to respond to climate change and the immediate results. An assessment of the effectiveness of adaptation might require drawing on other sources of data, such as national surveys of socio-economic and ecological conditions, databases that track the impacts of natural hazards, or integration of outcome indicators into regular government reporting (Ford et al., 2013), further highlighting the importance of considering established knowledge production standards (Dimension 2) and coordination between the relevant administrative units (Dimension 1). For instance, if strategic indicators are integrated into the national periodic surveys, processes of producing official statistics could support the evaluation of adaptation outcomes and effectiveness. However, more research is needed on how to select adaptation indicators and metrics that account for system- and country-specificity as well as distinct levels of adaptation results.

One of the rationales for adaptation tracking is to enhance accountability and catalyze more ambitious climate action. However, because there are no consequences for countries that do not fulfill their commitments, domestic accountability has been proposed as an important approach to linking transparency and accountability (Karlsson-Vinkhuyzen et al., 2018; Teng & Wang, 2021). Our findings suggest that the effectiveness of these domestic mechanisms will vary by country, depending on how their governments are organized and the availability of knowledge to support accountability, which are contingent upon the presence of clear knowledge production standards and mechanisms to hold bureaucrats accountable (Dimension 2). Similarly, public accountability will also vary, given the differentiated accessibility of adaptation knowledge by actors outside the government (Dimension 4). As shown in section 4.4, while some countries encourage and support access to knowledge, in other countries, the emerging climate change laws introduce more stringent prerequisites for people to access and review reports on climate action. To realize the use of domestic processes of holding governments accountable, adaptation tracking needs to be built on knowledge that is meaningful to local actors and support opportunities for state and non-state actors to access this knowledge.

We have presented findings for each dimension separately to illustrate how each dimension manifests in the three countries. However, we recognize the interactions between the dimensions and the need for strategies for designing adaptation tracking to consider institutional structures and processes holistically. For instance, in Ethiopia, we see an

intersection between bureaucratic accountability (Dimension 2) and politico-administrative relations (Dimension 3), which is becoming even more pronounced as knowledge production rises on the political agenda. Similarly, this study suggests that coordination (dimension 1), engagement with experts (Dimension 5), and bureaucratic accountability (Dimension 2) are critical for integrating knowledge because relevant administrative units would need to work together to harmonize the methods for producing the various knowledge streams. Although stakeholder participation (dimension 6) is important for incorporating diverse perspectives and experiences (Dilling et al., 2019; Falzon, 2021), striking a balance in the involvement of bureaucrats, stakeholders, and politicians in designing and implementing adaptation tracking is necessary (Wellstead & Biesbroek, 2022).

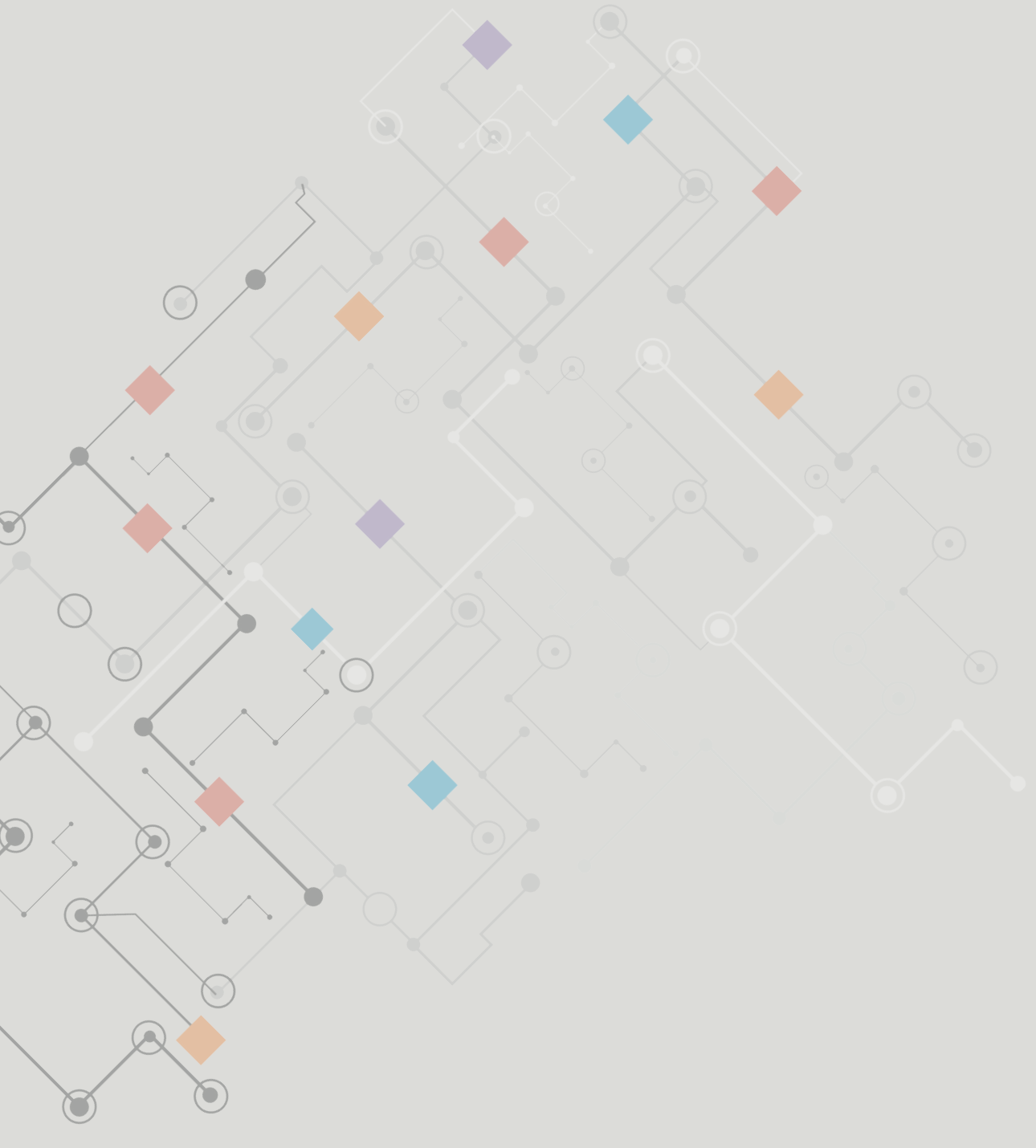
Our analysis demonstrates that the analytical framework supports a better understanding of how knowledge is produced, particularly the rules and practices that are relevant for a country-driven approach to adaptation tracking. However, during analysis, we identified additional variables, which we recommend including in future studies.

The first variable relates to the intended *uses* of knowledge, which affects *how* knowledge is produced. Countries adopt knowledge production systems for various purposes, in turn, shaping which knowledge is produced and how (Behn, 2003). The emphasis on specific purposes and knowledge production approaches can be linked to country-specific governance styles (Tosun & Howlett, 2022). In the three study countries, various uses of knowledge were mentioned, including policy monitoring and evaluation, international reporting, supporting decision-making and planning, assessing the performance of different administrative units, supporting research, and establishing country's social and economic status. The emphasis on surveillance and performance assessment in Ethiopia relates to the focus on monitoring the activities of bureaucrats and communities against predetermined targets and activity areas. This contrasts efforts to establish robust knowledge systems for monitoring policies and supporting decision making, research, and international reporting in Kenya and Uganda. The dominant purposes of knowledge production are important considering that they will likely influence the usefulness of existing knowledge for adaptation tracking. Therefore, under dimension 2, besides examining the established standards for knowledge production, analyzing the purpose for which knowledge is produced is also important.

The second variable is the role of bureaucrats in everyday practices of knowledge production, which varies depending on the country's administrative culture (Biesbroek, Lesnikowski, et

al., 2018; Painter & Peters, 2010a). For instance, in Kenya, the livestock experts are expected to guide knowledge production, with support from relevant administrative units such as the Kenya National Bureau of Statistics, which have specialized expertise in knowledge production. This collaboration helps ensure that knowledge production captures domain-specific issues while using appropriate knowledge production methods. In contrast, in Ethiopia, domain experts receive knowledge production guidelines through a top-down, hierarchical governmental structure, limiting collaboration opportunities that could strengthen data quality. Therefore, besides looking at the engagement with external experts (Dimension 5), examining the role of domain experts in designing and implementing knowledge production is important, as this might determine the consideration of domain issues in adaptation tracking.

In conclusion, paying attention to how adaptation will be tracked across countries with diverse institutional structures is critical if enhanced transparency is to catalyze more ambitious climate action, particularly in ensuring that adaptation is effective across scales. Contrary to discussions that recommend the use of standardized top-down approaches to assessing adaptation progress at the global level (Magnan & Chalastani, 2019; Moehner et al., 2021), we emphasize the importance of linking sub-national, national, and global scales in adaptation tracking. However, as this study has shown, countries have distinct rules and practices of knowledge production and use, underscoring the value of contextualizing adaptation tracking and using a country-driven approach to inform the design of a framework to guide adaptation tracking at the global level. Such an approach will be instrumental in getting a complete picture of progress through enhanced cross-scalar linkages and sustaining adaptation tracking over time, while leveraging alternative, but complementary, approaches to state accountability. A country-driven approach to adaptation tracking will entail aligning with the established government systems while also planning for the necessary reforms to implement adaptation tracking and reporting sustainably and effectively, including capacity building and availing additional financial and human resource for adaptation tracking. With such a fit-for-context approach, adaptation tracking can maintain sensitivity to country contexts while also ensuring that the knowledge required to track and report on adaptation is produced and used to inform adaptation.



Chapter 4

Embracing plurality: Integrating governmental and livestock keeper perspectives in the development of climate change adaptation tracking indicators

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Abstract

While there has been significant focus on government plans and other documented adaptation as the basis for developing and applying adaptation indicators, emerging literature also advocates for opening up spaces to allow the consideration of multiple experiences in the development of adaptation tracking indicators. However, the specifics of what this integrated approach could achieve have received little attention. We address this gap by using a thematic analysis of 48 focus group discussions and government policies to compare the perspectives of livestock keepers and governments in Eastern Africa on climate risks and adaptation in livestock systems. The results show considerable similarities in how they perceive climatic hazards, impacts, adaptation strategies, aspirations, and adaptive capacities, highlighting corresponding indicators that could be recognized as relevant by multiple stakeholders. However, there are also important differences, which underscore the value of an integrated approach in tracking adaptation. Integration supports the recognition of variations in climate risks and adaptation options across contexts as well as capturing diverse outcomes of adaptation across scales. Insights from this paper contribute to discussions on the use of integrated adaptation tracking frameworks that utilize cross-cutting indicators as well as context-specific ones that account for the contextual nature of climate risks, adaptation options, adaptive capacities, and indicators of progress in adaptation.

4.1 Introduction

The Paris Agreement established an enhanced transparency framework and a global stocktake (GST) process through which countries assess their collective progress on the reduction of greenhouse gas emissions, adaptation to the impacts of climate change, and mobilization of support for climate action (United Nations Convention on Climate Change (UNFCCC), 2015). The Paris Agreement further defined a Global Goal on Adaptation (GGA) against which adaptation progress can be tracked. The GGA aims to build adaptive capacity and resilience and reduce vulnerability to climate change (United Nations Convention on Climate Change (UNFCCC), 2015). However, the Paris Agreement, the ensuing Rulebook United Nations Convention on Climate Change (UNFCCC), 2018), and the recently established work program on the GGA (United Nations Convention on Climate Change (UNFCCC), 2022c) have so far provided little guidance on how these broad concepts should be measured. Given the critical importance of adaptation tracking in assessing progress under the enhanced transparency framework and informing adaptation planning, there is an emerging body of literature discussing how to design and implement adaptation tracking. This literature proposes two distinct approaches to tracking adaptation, based on different suppositions about what constitutes adaptation and how to measure it.

One stream of literature focuses exclusively on planned adaptation. The approaches suggested in this literature privilege government policies – such as Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs), and National Communications – and other published documents as the main reference points for developing and applying adaptation tracking indicators. For instance, Moehner et al., (2021) suggest a criterion for tracking national adaptation progress based on a cross-country comparison of the comprehensiveness, inclusiveness, feasibility, integration, and monitoring and evaluation efforts of government adaptation plans. Similarly, Berrang-Ford et al., (2019) develop a framework that considers a country's vulnerability profile, government's adaptation goals and targets, organization of adaptation planning, factors constraining government efforts, and the extent of achievement of the government's predefined adaptation goals and targets. Such approaches to adaptation tracking align with the accountability narrative within the UNFCCC, where governments are presumed to be the key actors responsible for planning, determining policy outcomes, and mobilizing support (Ford et al., 2013). Such approaches also highlight convergence in adaptation policies, hence supporting comparisons across countries, an aspect that is essential for the GST (Olhoff et al., 2018). Besides, the focus on established government adaptation

plans and policies has been argued to track progress in governments' preparedness to deal with climate change impacts and provision of an enabling environment for public and private adaptation (Moehner et al., 2021). However, approaches that assume the centrality of and focus on the official records of national governments may not be adequate for understanding the effectiveness and adequacy of adaptation efforts (Lesnikowski et al., 2016; United Nations Environment Progrmme (UNEP), 2022), which is critical if adaptation tracking is to catalyze more ambitious actions and commitments.

The other stream of the literature recognizes that drivers of impacts, adaptation choices, and aspirations are diverse. As opposed to developing standard indicators and frameworks, this literature stream emphasizes the contextual nature of adaptation, the interconnectedness of the various scales at which adaptation takes place, and the need for integrating diverse experiences and priorities when designing and applying adaptation tracking indicators (Dilling et al., 2019; Eriksen et al., 2021; Singh et al., 2021). Adaptation is recognized to be occurring through both planned government policies and programs as well as through autonomous actions, for example, by farmers and other private sector actors (Craft & Fisher, 2018; Crane et al., 2011; Rahman & Hickey, 2019). This recognition requires assessment strategies that capture adaptation efforts and outcomes beyond planned interventions. Further bolstering these arguments, several studies show how differences in how adaptation is understood lead to distinct choices of indicators whose operation makes specific aspects of reality salient by highlighting some elements while obscuring others (e.g., Eriksen et al., 2021; Singh et al., 2021). Growing evidence also shows that privileging top-down framings of adaptation excludes interventions and adaptation evaluations that account for local realities (Piggott-McKellar et al., 2020; Rahman & Hickey, 2019). However, local perspectives might be limited in their temporal and spatial scope, necessitating the integration of top-down and bottom-up perspectives (Mehta et al., 2019). Embracing the plurality of perspectives in the design of adaptation tracking has several merits, including supporting the evaluation of the responsiveness of adaptation efforts to socially and geographically differentiated vulnerabilities (Dilling et al., 2019; Eriksen et al., 2021; Falzon, 2021; Piggott-McKellar et al., 2020). It can also support a better understanding of how the adaptation efforts of different stakeholders are connected (Malik et al., 2010; Urwin & Jordan, 2008).

Despite the growing recognition of the importance of drawing on the diversity of perspectives that are programmatically relevant when assessing adaptation, there is limited work that describes and then traces forward the implications of stakeholders' varied perspectives for the

development of adaptation tracking indicators. In this paper, we analyze how governmental actors and livestock keepers discuss topics relevant for assessing adaptation progress to provide insights into what integrating diverse inputs has to offer for designing and implementing adaptation tracking. We draw on empirical research supporting the co-production of adaptation tracking indicators for the livestock sectors of Ethiopia, Kenya, and Uganda. We build on works that identify fundamental dimensions of assessing climate risks and adaptation progress (Berrang-Ford et al., 2019; Park et al., 2012; Turner et al., 2003; United Nations Convention on Climate Change (UNFCCC), 2022a): climatic hazards, impacts, adaptation options, adaptation capacities, and adaptation goals. These dimensions are constituted by various themes, which are explained in the methods section. We ask: What salient themes do livestock keepers and governments in Eastern Africa use to discuss dimensions relevant for tracking adaptation in livestock systems? What similarities and differences exist in the themes used by livestock keepers and governments? How do the observed similarities and differences affect the development of adaptation tracking indicators? We posit that by developing indicators that are sensitive to the perspectives of both governments and livestock keepers, tracking progress on adaptation can get closer to ensuring that the conceptualization of adaptation and its assessment does not reinforce the silencing of the diverse actors affected by climate change. Such an approach to adaptation tracking can also help sustain the momentum for adaptation tracking as actors at national and subnational levels will be able to focus on the indicators they recognize as meaningful.

4.2 Methods

4.2.1 Study context

The livestock sector is affected by climate change both directly and indirectly. Rainfall patterns affect livestock feed and water availability while shifts in ambient temperatures cause physiological stress on livestock, with significant economic, bio-physical, and social implications (Godde et al., 2020; Rojas-Downing et al., 2017; Thornton et al., 2021). Furthermore, livestock systems in Eastern Africa are diverse (IFPRI, 2014), and adaptation involves a wide range of actors, providing a suitable context for exploring the diversity of perspectives. Our three case studies are Ethiopia, Kenya, and Uganda where the livestock sector contributes significantly to the economy and livelihoods (Federal Democratic Government of Ethiopia, 2011; Government of Kenya, 2018; Government of Uganda, 2018). As such the governments of the three countries have included the livestock sector in their adaptation plans, such as in the NDCs and NAPs. Several national development policies also prioritize efforts that are relevant for adaptation in the livestock sector. At the same time,

livestock keepers are adjusting their farming practices to adapt to the impacts of climate change. However, adaptation patterns vary, depending on factors such as understanding of climate risks, agroecological conditions, market opportunities, and access to resources that support adaptation (Berman et al., 2015; Mubiru et al., 2018). The selection of the three cases allows us to consider the variation in governance contexts. Ethiopia has a federal government system while Kenya and Uganda have devolved and decongested systems, respectively. The nature of the governance systems determines the role of subnational governments in designing and implementing adaptation plans that need to be considered.

4.2.2 Data collection

Data collection focused on three sources of qualitative data: Focus Group Discussions (FGDs), document analysis, and key informant interviews, as described below.

To capture livestock keepers' perspectives, the first author organized 48 FGDs with livestock keepers in Ethiopia, Kenya, and Uganda between 2020 and 2021. FGDs allow a selected group of actors to provide in-depth information on a specific topic, as guided by a facilitator to ensure consistent coverage and depth across groups (Morgan, 1996). The FGDs were distributed across four study sites representative of the livestock production systems in Eastern Africa: highland Mixed Crop-Livestock (MCL), lowland MCL, grazing-pastoral, and grazing non-pastoral. Each FGD was constituted by livestock keepers of a specific age and gender group to introduce more variation in the captured perspectives (Annex 3). In the study areas, social differentiation influences perceptions of climate risks, possible adaptation options, and aspirations (Djoudi et al., 2016; Marty et al., 2022; Ng'ang'a and Crane, 2020). Given the cultural context, the composition of the FGDs also helped create a conducive environment where participants felt comfortable expressing themselves.

The FGDs focused on changes associated with climate change and variability within the locality, the impacts of these changes on livestock systems, and the non-climatic drivers that also shape these impacts. We also discussed livestock keepers' adaptation strategies, factors that support or constrain their capacities to adapt, and their adaptation aspirations (Annex 4). After explaining the objectives of the discussions, the participants gave verbal consent and signed participation forms. The FGDs were conducted in four local languages by trained research assistants who understood the local language and cultural dynamics that would shape participation in and contributions to the discussion. The research assistants then transcribed and translated the recorded audio from the FGDs into English in consultation with the first author to improve the integrity of the data as it moved from its source context and language

into the culturally and linguistically foreign context in which it would be subsequently processed and analyzed.

In addition, we analyzed published plans and strategies, (henceforth, policies (Olazabal et al., 2019)), to understand the formally stated governmental perspectives. Policies were solicited and then retained for review when they were directly relevant to adaptation in livestock systems and when those policies were still in effect (for details see Annex 5). Although the subnational administrative units are supposed to enact local plans, we found these to be scarce, and hence, the government side of our dataset was primarily comprised of national policies. In Kenya, county governments have enacted development plans, but these plans give little attention to climate change issues. To compensate for the absence of formal local-level plans, we conducted an additional step that involved key informant interviews with selected government officials to support the interpretation of the findings from the analysis of the policies. The interviewees were selected for their ability to place our findings in the contexts of the livestock production systems we examined in each country. These respondents' answers, unfortunately, tended to be general which did not help us understand governmental perspective with regard to these local contexts. Therefore, only the FGD transcripts and policies were used for further analysis.

4.2.3 Data coding and analysis

We used thematic analysis (Braun & Clarke, 2006) to identify and then compare the themes used by livestock keepers and governments. The presence of themes points to the possibility of certain indicators being recognized as relevant, hence the focus on their presence or absence in the comparison. First, we coded data deductively by placing text segments from FGD transcripts and policies into components corresponding with the five dimensions guiding the study: climatic hazards, impacts, adaptation strategies, adaptation goals, and adaptive capacity. Next, we coded the structured data inductively, using themes that we identified from the data. For instance, while we had placed data into a predefined component of adaptation strategies, the themes were informed by specific technologies and practices mentioned by governments or livestock keepers. Applying the same analytical framework across FGD transcripts and the policies allowed for comparability between the perspectives of livestock keepers and those of the government.

4.2.4 Study limitations

While the conceptual framework guiding this study is useful in identifying elements that are relevant for adaptation tracking, we recognize that this framework is an oversimplification of reality. For instance, farmers develop strategies to respond to multiple pressures, not just

climate change (Crane et al., 2011; Ensor et al., 2019). However, for adaptation tracking, indicators should have a recognized link to climate change adaptation (Leiter et al., 2019), hence we centered data collection and analysis around climate change. Nevertheless, our approach captures other non-climatic issues that determine the vulnerability of people and systems. In addition, while focusing on government policies is based on their fundamental role in guiding climate action, these policies tend to cover a wide array of issues and there are often variations in implementation that are associated, not least, with shifts in priorities and the availability of resources (Faling, 2020).

4.3 Results

In this section, we highlight the differences and similarities in the perspectives of livestock keepers and those of governments. The results are presented following the five dimensions selected for initial deductive analysis of our data: climatic hazards (section 3.1), impacts (section 3.2), adaptation strategies (section 3.3), adaptive capacity (section 3.4), and adaptation goals (section 3.5).

4.3.1 Climate change hazards

We found strong similarities in how government and livestock keepers discuss climate hazards, with more than half of the hazards being mentioned by both governments and livestock keepers (Table 4.1). Across the three countries, livestock keepers and governments stressed increasing temperatures, prolonged dry seasons, unpredictable rainfall patterns, and flooding, as illustrated below:

> *…[E]experience has shown that the country (Ethiopia) is exposed to unpredictable rains, including the complete failure of rains, seasonal shifts in rainfall patterns and shortage of rainfall (drought) and this uncertainty is expected to increase with climate change*. National Adaptation Plan, p. 19, Ethiopia

> *There is unseasonal rainfall, which affects farm activities and livestock production. For instance, … we do not need rainfall during this time because it is the harvesting season. When there is rainfall during this period, it affects our crop production, and it also damages livestock fodder because it rains before the fodder is harvested and stored.* Livestock keeper, Highland MCL, Ethiopia

However, we observe that the degree of agreement on the hazards differs by country and production system under consideration, with the smallest (50%) and greatest (100%) proportion of hazards referred to by both governments and livestock keepers being observed in

Ethiopia and Kenya (in grazing-pastoral systems), respectively. Whilst in Kenya and Uganda, both the government and livestock keepers talked about the decreasing rainfall patterns and the increasing intensity and frequency of droughts, livestock keepers in the highland MCL did not mention these hazards despite their recognition by the Ethiopian government. Further, although livestock keepers in the grazing non-pastoral and highland MCL systems discussed temperature fluctuations between cold and hot extremes, the governments of Uganda and Ethiopia only mention the warming trends. In Kenya, the degree of alignment differs across the two production systems that were sampled. For instance, although the government recognizes the increasing frequency and intensity of floods, this hazard was not mentioned in the lowland MCL system, but it is a key hazard in grazing pastoral systems. Livestock keepers in lowland MCL and grazing non-pastoral systems were concerned with waterlogging of pastures, yet the Kenya and Uganda governments did not mention these hazards. In Ethiopia, livestock keepers in the highland MCL mentioned the issue of frost, but this hazard was not mentioned by the government of Ethiopia. In sum, the differences between the hazards mentioned by government and livestock keepers underscore the context-specificity of climatic hazards and the related need for adaptation tracking indicators to be sensitive to the relevant contextual differences.

Table 4.1 Summary table comparing governmental and livestock keeper perspectives on climatic hazards.

Actor group / Hazards	Ethiopia		Kenya			Uganda	
	Govt	**Livestock keepers (Highland MCL)**	**Govt**	**Livestock keepers (Lowland MCL)**	**Livestock keepers (Grazing-pastoral)**	**Govt**	**Livestock keepers (Grazing non-pastoral)**
Warmer temperatures	✓	✓	✓	✓	✓	✓	✓
Prolonged dry seasons	✓	✓	✓	✓	✓	✓	✓
Increase in rainfall amount and intensity	✓	✓	✓	✓	✓	✓	✓
Shift in temporal rainfall patterns and unpredictability	✓	✓	✓	✓	✓	✓	✓
Decrease in rainfall amount & intensity	✓	✕	✓	✓	✓	✓	✓
More intense & frequent droughts	✓	✕	✓	✓	✓	✓	✓
Wildfire outbreaks	✓	✕	✓	✕	✓	✓	✓
Floods	✓	✓	✓	✕	✓	✓	✓
Water logging	✕	✓	✕	✓	✕	✕	✓

Fluctuations between warm & cold extremes	✗	✓	✗	✓	✗	✗	✓
Wind	✓	✓	✓	✓	✓	✓	✓
Frost	✗	✓	✗	✗	✗	✗	✗

Similarities	50%	67%	100%	83%
Differences	50%	33%	0%	17%

Note: ✓indicates where the hazard was mentioned and ✗indicates where the hazard was not mentioned

4.3.2 Impacts of climatic hazards on livestock systems

As shown in Table 4.2, across the three countries, there are more similarities – ranging between 67 (Ethiopia and Uganda) and 83% (Kenya – grazing pastoral) than differences in the impacts discussed by governments and livestock keepers. Both livestock keepers and governments mentioned the effects of climate change on the availability and quality of livestock feeds and water since rainfall patterns affect the growth of pastures, production of crop residues, and water availability. They also mentioned the impacts on the prevalence of livestock pests and diseases, livestock mortality, production of meat and milk, and contribution of livestock to livelihoods. Climate change is also reported by all as a driver of ecological degradation due to soil erosion, landslides, and flooding, which affect pastures and soil quality.

Nonetheless, there are notable differences that point to the importance of paying attention to variations in the relevance of climate change impacts across production systems. For instance, in Kenya and Uganda, both governments and livestock keepers recognize physiological stress on livestock and the increasing cost of production pushing household spending higher as they deal with climate change impacts. However, in Ethiopia, although these impacts were mentioned by livestock keepers, they were absent in the policies. Similarly, in Uganda, livestock keepers mentioned the contribution of drought to the spread of invasive grass species, but this impact was not mentioned by the government. Although in Kenya livestock keepers in the grazing-pastoral system mentioned the effects of increasing severity of hazards such as flooding and droughts on the displacement of human settlements causing displacement and the disruption of livestock migratory patterns, the government of Kenya did not mention these impacts. Similarly, all three governments discussed the impacts of climate change on food security, but this only aligns with discussions with livestock keepers in the grazing-pastoral system. In grazing non-pastoral, lowland MCL and highland MCL systems, households depend on diverse food sources including crop farming compared to the grazing-pastoral systems where livestock contribute significantly to households' dietary needs (Rufino et al., 2013).

The differences additionally highlight the need for appropriate indicators of climatic impacts at multiple scales. Governments in the three countries included higher scale impacts, for instance, in relation to the reduced contribution of livestock to the national economy, compared to the livestock keepers who focused on the farm and landscape level impacts.

Table 4.2 Summary table comparing governmental and livestock keeper perspectives on climate change impacts.

Actor group / Impacts	Ethiopia		Kenya			Uganda	
	Govt	**Livestock keepers (Highland MCL)**	**Govt**	**Livestock keepers (Lowland MCL)**	**Livestock keepers (Grazing-pastoral)**	**Govt**	**Livestock keepers (Grazing non-pastoral)**
Low feed availability and quality	✓	✓	✓	✓	✓	✓	✓
Low water availability and quality	✓	✓	✓	✓	✓	✓	✓
Increased prevalence of livestock pests and diseases	✓	✓	✓	✓	✓	✓	✓
Reduced livestock production	✓	✓	✓	✓	✓	✓	✓
Physiological stress on livestock	✗	✓	✓	✓	✓	✓	✓
Livestock deaths	✓	✓	✓	✓	✓	✓	✓
Loss of livelihood	✓	✓	✓	✓	✓	✓	✓
Increased cost of production	✗	✓	✓	✓	✓	✓	✓
Destruction of infrastructure	✓	✗	✓	✓	✓	✓	✓
Ecological degradation	✓	✓	✓	✓	✓	✓	✓
Food insecurity	✓	✗	✓	✗	✓	✓	✗
Low livestock reproduction	✓	✗	✓	✓	✓	✓	✗
Reduced contribution of livestock to national economy	✓	✗	✓	✗	✗	✓	✗
Intercommunity conflicts	✗	✗	✓	✗	✓	✓	✓
Human displacement	✗	✗	✗	✗	✓	✗	✗
Disrupting migration patterns	✗	✗	✗	✗	✓	✓	✗
Increased workload for women	✗	✗	✓	✗	✓	✓	✗

Spread of invasive species	✗	✗	✓	✗	✓	✗	✓

Similarities	67%	72%	83%	67%
Differences	33%	28%	17%	33%

Note: ✓indicates where the impact was mentioned and ✗indicates where the impact was not mentioned

4.3.3 Adaptation strategies

Similar to the other two dimensions, there is a 53% (Uganda) to 73% (Ethiopia) overlap in measures prioritized by livestock keepers and governments to deal with climate change impacts (Table 4.3). Across the three countries, livestock keepers and governments talked about technological and farm management strategies such as treating and vaccinating livestock against pests and diseases, diversifying livelihood sources, producing and managing livestock feeds to ensure sustained availability even during the dry seasons, and improving livestock breeds.

There are also subtle differences in the strategies mentioned, illuminating the broad spectrum of strategies for dealing with climate risks. For instance, regarding strategies for addressing water scarcity, while the common strategy entailed harvesting and storing water, the policies of the three countries also mentioned additional measures such as mapping water demand and supply to inform the development and management of water resources. This contrasts with the strategies mentioned by livestock keepers who understandably mostly discussed farm and community-level strategies, such as seeking alternative water sources, including through buying water and/or taking livestock to the nearby watering points.

Distinct roles of the two actor groups are also visible through the differences. On the one hand, given governments' mandate in developing and implementing policies, the documents of the three countries mentioned policy-related interventions such as establishing incentives for the private sector to engage in adaptation as well as enacting regulations and developing programs to support adaptation. Governments are also key in introducing innovative approaches. For instance, the governments of Kenya, Uganda, and Ethiopia mentioned the promotion of livestock insurance as a financial risk management mechanism. However, livestock keepers did not mention taking up insurance to respond to climatic impacts. On the other hand, the adaptation strategies mentioned by livestock keepers underscore the importance of farm management strategies, some of which are not always recognized in the policies. They also talked about using their social networks to pool the labor required to undertake various

adaptation strategies, such as collecting and storing livestock feeds before the onset of the rainy season as well as restoring critical infrastructure. As the livestock keepers explained:

> *We have this river and there are other rivers as well. For example, today we have 50 or 100 men on that swamp who are building a bridge ... so that the livestock can cross the other side where we have the pastures. That is a strategy that men have adopted for the livestock to cross, including the lambs who otherwise cannot cross the river*. Livestock keeper, Grazing-pastoral system, Kenya

> *We must work as Debo (working together). For instance, we have only October to collect crop residue. If he is alone, he cannot collect all his residue within two months. But through the group, this residue can be collected within a shorter time – even within one day*. Livestock keeper, Highland MCL, Ethiopia

The differences also point to the contextual relevance of adaptation options. In Kenya, some of the strategies mentioned by the government, such as supporting livestock mobility and dealing with invasive species, only align with the strategies mentioned by livestock keepers in the grazing-pastoral system. Moving livestock in search of pasture is less systematic in other production systems compared to the grazing-pastoral systems.

Overall, these differences highlight the importance of integrating the perspectives of livestock keepers and governments in mapping a broader typology of adaptation strategies and their linkages while capturing the roles of diverse actors in adapting to climate change.

Table 4.3 Summary table comparing government and livestock keeper perspectives on climate change adaptation strategies.

Actor group / Adaptation strategies	Ethiopia		Kenya			Uganda	
	Govt	**Livestock keepers (Highland MCL)**	**Govt**	**Livestock keepers (Lowland MCL)**	**Livestock keepers (Grazing-pastoral)**	**Govt**	**Livestock keepers (Grazing non-pastoral)**
Treatment and vaccination against pests and diseases	✓	✓	✓	✓	✓	✓	✓
Dealing with water stress	✓	✓	✓	✓	✓	✓	✓
Herd management	✓	✓	✓	✓	✓	✗	✓
Diversification of livelihood sources	✓	✓	✓	✓	✓	✓	✓

Livestock feed production and management	✓	✓	✓	✓	✓	✓	✓
Improving livestock breeds	✓	✓	✓	✓	✓	✓	✓
Natural resource management	✓	✓	✓	✓	✓	✓	✓
Insurance schemes	✓	✕	✓	✕	✕	✓	✕
Animal care/ husbandry practices	✓	✓	✓	✓	✓	✕	✓
Labor management	✕	✓	✕	✕	✓	✕	✓
Livestock fattening	✕	✓	✕	✕	✕	✕	✓
Policy-related interventions	✓	✕	✓	✕	✕	✓	✕
Conflict management	✕	✕	✓	✕	✕	✓	✕
Dealing with invasive species	✕	✕	✓	✕	✕	✓	✓
Livestock mobility	✕	✕	✓	✕	✓	✕	✕

Similarities	73%	67%	67%	53%
Differences	37%	33%	33%	47%

Note: ✓indicates where the adaptation strategy was mentioned and ✕indicates where the adaptation strategy was not mentioned

4.3.4 Adaptive capacity

Under the adaptive capacity dimension, between 53% (Ethiopia) and 71% (Uganda) of the factors were discussed by both governments and livestock keepers (Table 4.4). For instance, across the three countries, governments and livestock keepers mentioned access to production inputs to be key in supporting strategies geared towards dealing with livestock pests and diseases, enhancing production using processed feeds, and improving breeds. They also noted that access to extension and veterinary services is necessary for disseminating knowledge on adaptation, improving livestock health, and facilitating access to inputs such as breeding technologies. Access to output markets was also commonly mentioned by livestock keepers and governments. Government support through investments towards the development and access to infrastructure such as markets, roads, and water supply systems as well as the implementation of adaptation programs, such as awareness creation, was also noted as a crucial factor by governments and livestock keepers in the three countries. For example, in Ethiopia, since the delivery of most agricultural inputs and services is facilitated by the government, government support is critical in accessing inputs and the uptake of adaptation practices and technologies by livestock keepers:

> *[I]t is difficult to get the best breed .... Where do we get good breeds? Unless the government provides improved breed through the agriculture officer (extension officer), we cannot do anything at our level. What we know is that we buy oxen from the market, which we use for plowing our agricultural land. Besides, we are only getting breeds for dairy production, but it is difficult for us to get the best bull and bull service. Even if we get good cattle breeds, they are useless if there is no good bull.* Livestock keeper, Highland MCL, Ethiopia

Differences in how governments and livestock keepers refer to adaptive capacities again point to the importance of context in determining the relevance of specific determinants of adaptative capacities given existing conditions. Membership in marketing organizations such as cooperatives supports bulking of milk and negotiating the selling price, making it a critical factor for supporting market access. Although in Ethiopia and Uganda both governments and livestock keepers mention marketing associations, in Kenya this factor was not mentioned by livestock keepers in the grazing-pastoral system.

The importance of policies and priorities that recognize the factors that constrain livestock keepers' ability to adapt to climate change is also crucial. For instance, livestock keepers across the three countries discussed the role of access to labor in the uptake of adaptation strategies such as producing animal feeds and maintaining the improved breeds which are labor intensive. Only the government of Kenya recognizes labor as an adaptive capacity factor, and only in reference to grazing-pastoral systems. Livestock keepers in the three countries also talked about access to land. For instance, livestock keepers in the highland MCL system of Ethiopia mentioned the inadequacy of land for competing uses, including crop production, pastures, and government-led soil and water conservation activities, limiting their ability to produce enough livestock feeds. Livestock keepers in Kenya and Uganda pointed out problems of land fragmentation and reducing land sizes which reduce the land available for livestock-keeping activities. The governments of Kenya and Uganda recognized this issue and articulate their intent to address land tenure issues. In contrast, the government of Ethiopia frames issues related to land as a problem of low productivity and land degradation caused by unsustainable land management practices. This framing is consistent with the government's emphasis on increasing livestock productivity and reducing livestock population as strategies for reducing greenhouse gas emissions as opposed to focusing on the impacts of climate change on production and the declining land resources:

> *Historical practices, rapid expansion, and inappropriate agricultural techniques have resulted in poor soil quality. Soil management is therefore a fundamental component of the country's agricultural strategy and, because of the carbon content of land, can also be an important initiative to control and manage carbon emissions as the country grows. Additionally, careful soil management can stem the growth of cropland needed and avoid further deforestation*. CRGE p. 63, Ethiopia

Regarding institutions that shape adaptation, while the governments of the three countries mentioned supporting formal institutions by enacting policies, laws, and adaptation plans, only Kenya and Uganda governments plan to support informal institutions. Informal institutions are typically rules and governance structures established by resource users to safeguard the use and management of resources. For instance, livestock keepers in the grazing-pastoral systems discussed the importance of established agreements among the livestock keepers in safeguarding the use and management of pasture and water.

The differences show the importance of being able to assess the extent to which existing policies in strengthening the capacities of livestock keepers to adapt to climate change.

Table 4.4 Summary table comparing governmental and livestock keeper perspectives on factors influencing the capacity to adapt to climate change.

Actor group / Adaptive capacity	Ethiopia		Kenya			Uganda	
	Govt	**Livestock keepers (Highland MCL)**	**Govt**	**Livestock keepers (Lowland MCL)**	**Livestock keepers (Grazing-pastoral)**	**Govt**	**Livestock keepers (Grazing non-pastoral)**
Access to quality production inputs e.g., feed concentrates, treatment, breeding technologies	✓	✓	✓	✓	✓	✓	✓
Access to extension and veterinary services	✓	✓	✓	✓	✓	✓	✓
Financial resources	✓	✓	✓	✓	✓	✓	✓
Access to markets for livestock and livestock products	✓	✓	✓	✓	✓	✓	✓
Community-based marketing organizations e.g., cooperatives	✓	✓	✓	✓	✗	✓	✓

Support from the government	✓	✓	✓	✓	✓	✓	✓
Awareness and access to knowledge	✓	✓	✓	✓	✓	✓	✓
Infrastructure development and access	✓	✓	✓	✓	✓	✓	✓
Access to land	✗	✓	✓	✓	✓	✓	✓
Access to labor	✗	✓	✓	✓	✓	✗	✓
Informal/ local institutional capacity	✗	✗	✓	✗	✓	✓	✗
Formal institutional capacity	✓	✗	✓	✗	✗	✓	✗
Collaboration between state and non-state actors	✓	✗	✓	✗	✗	✓	✗
Research related to adaptation in livestock systems	✓	✗	✓	✗	✗	✓	✓
Social support networks	✗	✓	✗	✓	✓	✗	✓
Technology development, promotion, and use	✓	✗	✓	✓	✗	✓	✓
Cultural norms	✓	✗	✓	✗	✓	✓	✓

Similarities	53%	65%	65%	71%
Differences	47%	35%	35%	29%

Note: ✓indicates where the adaptive capacity factor was mentioned and ✗indicates where the adaptive capacity factor was not mentioned

4.3.5 Adaptation goals

In contrast to other dimensions where there are more similarities in the perspectives of livestock keepers and the government, in Kenya and Ethiopia, the differences are more prevalent under this dimension. In Kenya and Ethiopia, the two actor groups differ in 60% and 53% of the goals, respectively. In Uganda, the similarities are still dominant with differences occurring in only 33% of the themes. The differences show the need to conceptualize adaptation success broadly by linking adaptation outcomes with social and economic aspirations. Notably, social goals were given more recognition by livestock keepers. For instance, livestock keepers across the three countries mentioned that one of the objectives of investing in adaptation strategies is to improve their living conditions and well-being since incomes from livestock keeping enable them to access basic human needs such as housing and clothing. They also mentioned that successful adaptation in livestock systems is critical for self-dependence, particularly for women and young men:

> *As parents, we educate our children for them to become financially well off. But if I still have some livestock at home, even if my children are working, I will not become a burden to them, asking them for money, because I still have my own source of income. If I need soap or salt at home, I will not call my children to ask them for money. I can sell some chickens*. Livestock keeper, Grazing non-pastoral system, Uganda

Further, livestock keepers also mentioned the importance of successful adaptation in livestock systems in enabling them to sustain the diverse benefits from livestock, such as the provision of manure for their farms, having animals to use for cultural ceremonies such as dowry payment, and maintaining social standing. Livestock keepers also explained the connection between successful adaptation and access to education since revenue from selling livestock and livestock products enables parents to pay school fees for their children. Education was framed as a development agenda in the policies but the linkage with adaptation efforts in livestock systems was not explicitly made by the governments in the three countries.

While the livestock keepers focused on individual or household levels, governments included adaptation goals from a higher scale. For instance, the governments of the three countries mentioned that some of the adaptation goals include supporting the contribution of the livestock sector to national economic growth and development in general. We also see that policies link adaptation with the international discourses of climate action. For instance, the governments of the three countries mention the importance of ensuring that low-emissions pathways are pursued when implementing adaptation thus enabling national governments to fulfill their global commitment to reduce greenhouse gas emissions. Framing of adaptation goals using concepts such as resilience and adaptive capacity was common in the policies. However, livestock keepers point to practical elements that could be measured. For instance, livestock keepers in the grazing pastoral and non-pastoral systems talked about the importance of adaptation strategies enabling them to withstand climatic shocks and to emerge better off or at least not worse off in the event of a climatic disaster. This was framed in terms of the condition of the livestock herds and how well households can maintain robust sources of livelihood after climatic events such as droughts and disease outbreaks. This points to the importance of integrating multiple perspectives in linking national and international framings of adaptation with the aspirations of livestock keepers.

Nonetheless, as shown in Table 4.5, across the three countries, there are overlaps in the goals related to economic aspirations of livestock keepers and governments, such as increasing or

maintaining livestock production, increasing revenue from selling livestock and livestock products, building financial resources, and ensuring that the livestock sector contributes to poverty alleviation. Both groups also mentioned food security as an adaptation goal since animal-based foods such as meat and milk contribute to household diets and as a source of financial resources for buying other food items.

Table 4.5 Summary table comparing governmental and livestock keeper perspectives on adaptation goals

Actor group / Adaptation goal	Ethiopia		Kenya			Uganda	
	Govt	**Livestock keepers (Highland MCL)**	**Govt**	**Livestock keepers (Lowland MCL)**	**Livestock keepers (Grazing-pastoral)**	**Govt**	**Livestock keepers (Grazing non-pastoral)**
Increasing or maintaining livestock production	✓	✓	✓	✓	✓	✓	✓
Increasing revenue from livestock	✓	✓	✓	✓	✓	✓	✓
Building financial resources	✓	✓	✓	✓	✓	✓	✓
Poverty reduction	✓	✓	✓	✓	✓	✓	✓
Food security	✓	✓	✓	✓	✓	✓	✓
Improving living conditions and wellbeing	✗	✓	✗	✓	✓	✓	✓
Self-dependency	✗	✓	✗	✓	✓	✗	✓
Maximizing multiple livestock uses	✗	✗	✗	✓	✓	✗	✓
Access to education	✗	✓	✗	✓	✓	✗	✓
Provide source of employment	✓	✗	✓	✓	✗	✓	✓
Economic growth and development	✓	✗	✓	✗	✗	✓	✓
Adaptation co-benefits (emission reduction)	✓	✗	✓	✗	✗	✓	✗
Enhancing resilience and adaptative capacity	✓	✗	✓	✗	✗	✓	✗
Improving ecological conditions	✓	✗	✓	✗	✗	✓	✓
Better recovery from disasters	✗	✗	✓	✗	✓	✓	✓

Similarities	47%	40%	40%	67%
Differences	53%	60%	60%	33%

Note: ✓indicates where the goal was mentioned and ✕indicates where the goal was not mentioned

4.4 Discussion and way forward

Using FGDs and policies, we have compared how livestock keepers and governments discuss various aspects relevant to assessing climate risks and adaptation progress. The results foreground similarities and differences, with implications for adaptation tracking indicators. Here we reflect on the key findings, provide insights into how to develop appropriate adaptation tracking indicators, and explore directions for future work.

The prevalence of similarities indicates high levels of agreement among governments and livestock keepers about what is important to track. Livestock keepers and governments across the three countries recognize climatic hazards, such as prolonged dry seasons, changes in rainfall onset, cessation, and intensity, as well as an increase in temperatures. They also refer to similar impacts of these hazards on livestock systems, particularly on the availability of feed and water for livestock, the occurrence of livestock pests and diseases, livestock production, degradation of ecological resources, and changes in the contribution of livestock to livelihoods. These climatic hazards and impacts on livestock systems are widely recognized (Escarcha et al., 2018; Intergovernmental Panel on Climate Change (IPCC), 2022a; Rojas-Downing et al., 2017). To minimize these impacts and to achieve adaptation goals, such as food security and maintaining revenue from livestock, livestock keepers and governments mentioned common adaptation strategies related to veterinary care, investments in water infrastructure, feed production and management, and breeding. According to governments and livestock keepers, factors such as access to quality inputs, extension services, output markets, and knowledge determine people's ability to adapt. These findings suggest that creating a set of commonly agreed upon indicators that cut across the experiences and priorities of multiple stakeholder groups is possible.

Whilst there is general agreement on what could be tracked, the specific areas and extent of agreement differ between countries and production systems. For instance, while in Uganda the climatic hazards dimension had the highest number of themes mentioned by both governments and livestock keepers (83%), agreement about the adaptation strategies was much lower (53%). Further, in Kenya and Ethiopia, the government and livestock keepers differ in more than half of the themes related to adaptation goals. In Uganda, there are more similarities even under this dimension. In Kenya, where two production systems were sampled, there is variation in where

the alignment is found and the number of themes where government and livestock keepers refer to the same thing. The variation between countries and production systems could be attributed to differences in the level of advancement in adaptation planning across countries and disparity in the extent to which critical aspects of adaptation are addressed in national adaptation plans (Lesnikowski et al., 2016; Woodruff & Regan, 2019) and emphasizes the need for contextualized approaches to developing and applying indicators.

The observed differences in how governments and livestock keepers talk about the various dimensions provide an even stronger impetus for integrating multiple perspectives in the development of adaptation tracking indicators. While most climatic hazards are relevant across production systems and countries, we also note the uniqueness of highland MCL systems which are exposed to frost and cold extremes. Regional trends show that such hazards are expected to decrease with the increasingly warming temperatures (Intergovernmental Panel on Climate Change (IPCC), 2022a), but livestock remain sensitive to both cold and heat stress (Collier & Gebremedhin, 2015; Thornton et al., 2021). Similarly, although governments emphasize flooding and food insecurity, such hazards and impacts are not universally applicable, as their relative importance is contingent upon factors such as terrain and soil characteristics and the level of a household's reliance on livestock for food security (Megersa et al., 2014; Mubiru et al., 2018). Such differences point to the value of integrating the perspectives of local stakeholders in capturing the contextual variations of risks and vulnerability.

Given the need for adaptation tracking to capture adaptation efforts and outcomes across scale (Craft and Fisher, 2018; Leiter, 2015), our findings show the value of combining governmental and livestock keepers' perspectives to capture the variety of adaptation options and other relevant issues at national, subnational, and farm levels. Some strategies highlighted by livestock keepers, such as livestock mobility, are often overlooked and sometimes in conflict with government policies (Tonah, 2002). This again highlights the relevance of an integrated approach to adaptation tracking that could examine the compatibility of the adaptation pathways pursued by stakeholders at various scales (Lambert & Beilin, 2021). Furthermore, this integration can help evaluate the outcomes of governments' adaptation policies at the farm level as well as the contribution of other stakeholders towards national, regional, and global endeavors to adapt to the impacts of climate change.

The diversity of perspectives could also enrich the creation of holistic indicator sets and assessments (Reed et al., 2008). For instance, the increasing cost of production and the social

adaptation goals seem important to livestock keepers but were not always addressed by the governments. This also applies when capturing the adaptation strategies of the different stakeholders and their linkages. On one hand, governments are key in enacting adaptation policies and promoting emerging adaptation strategies, such as livestock insurance. They also draw attention to higher-level issues such as sectoral funding and investments in infrastructure relevant to adaptation. On the other hand, livestock keepers highlight contextual farm-level adaptation strategies such as the uptake of livestock fattening as a market-oriented enterprise. Further, integration can help capture other critical local-level aspects such as intrahousehold dynamics and 'soft' adaptation constraints such as access to labor as well as the identification of appropriate social and economic markers of progress. Capturing the varying adaptive capacities and the cross-scalar outcomes of adaptation efforts is needed for more robust assessments of progress in adaptation (United Nations Environment Progrmme (UNEP), 2022).

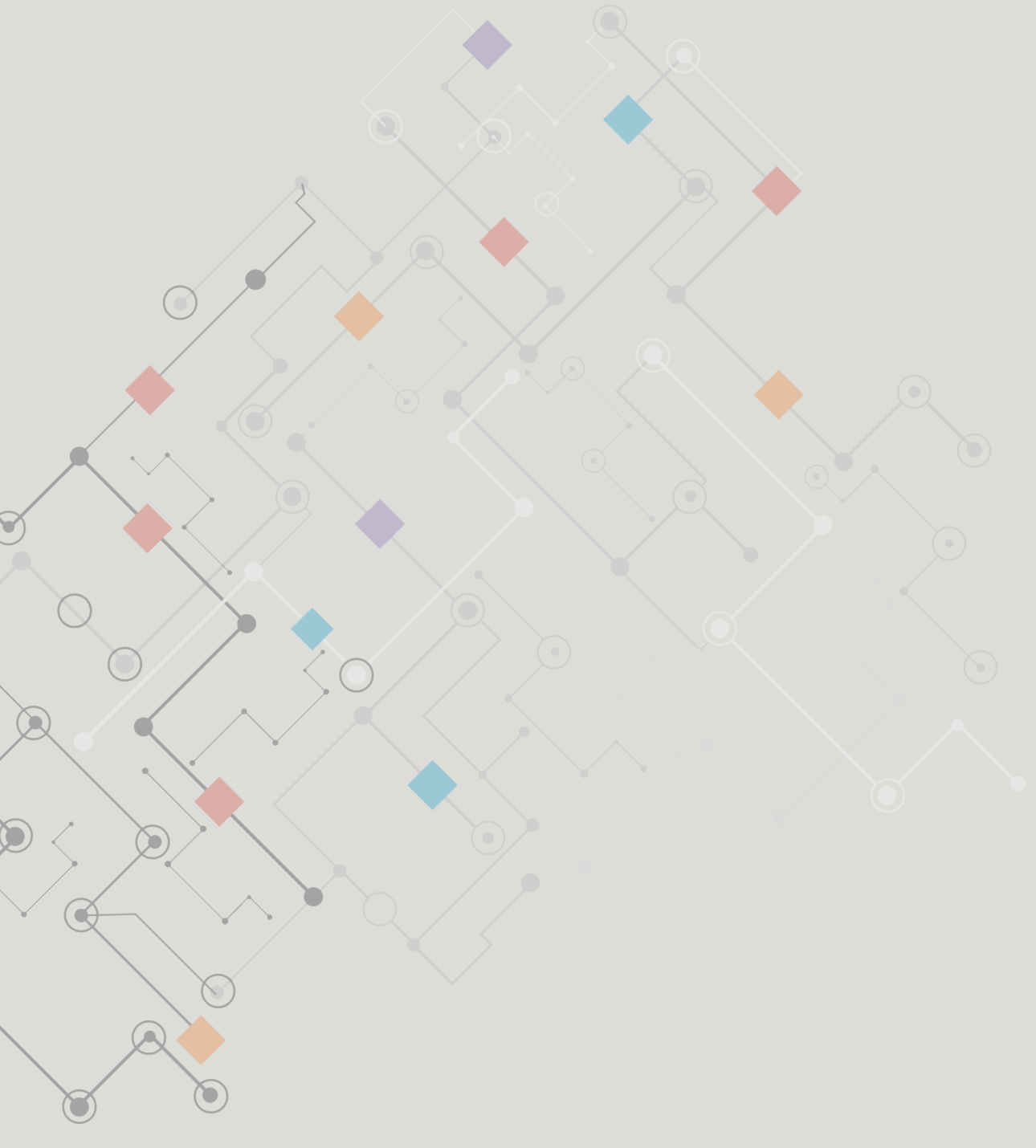
But how can this integration be done in practice? Defining indicators for abstract concepts like adaptation is inherently political considering the value-laden decisions and power relations that determine what is considered important to measure and the programmatic implications for measurement choices (Crane et al., 2011, 2016; Leiter et al., 2019). This makes it important to open up spaces for diverse stakeholders to influence the definition of indicators that are sensitive to their experiences and priorities (Dilling et al., 2019). By co-producing indicators, diverse areas of interest can be mapped, and corresponding indicators developed. Various techniques, such as iterative top-down and bottom-up analyses, can be used to ensure that indicators are not only aligned with stakeholder perspectives but also fit for purpose (Leiter et al., 2019; Reed et al., 2008). Given the context-specificity of some of the resulting indicators, modularized tools might be needed with core indicators – corresponding to the elements where stakeholder perspectives align – that can be tracked across production systems and countries. Another set of indicators whose applicability will depend on contextual relevance could complement the core indicators. This approach would allow for comparability and aggregation at national levels and beyond while maintaining sensitivity to context. This proposition is supported by others that advocate for the use of overarching global metrics while allowing the flexibility for additional indicators that can show the uniqueness of adaptation contexts (B. Craft & Fisher, 2018; Leiter et al., 2019; Olhoff et al., 2018).

Moving forward, scientific and policy debates on adaptation tracking could be enriched by studies that demonstrate the process and outputs from initiatives that support stakeholder engagement in the co-production of adaptation tracking indicators. Such works should provide

insights into how to strike a balance between capturing the priorities and experiences of the various actors and having practical tools for national and international reporting. It will also be crucial to reflect on how such initiatives are linked with the discussions and emerging ideas on how to track and report on adaptation under the UNFCCC. A more long-term research agenda is thus needed to examine the use of adaptation tracking indicators, including their effects on adaptation governance (Erkkilä, 2016; Persson, 2019). This research could also examine how adaptation tracking is institutionalized given data availability challenges and the uniqueness of government systems for producing and using data (Hammill & Dekens, 2014; Njuguna et al., 2022). Engaging with these issues will push the recognition of adaptation tracking, particularly, the development and application of indicators, not as a technical undertaking but as a political one where choices and tradeoffs need to be negotiated and contextualized.

4.5 Conclusion

This study supports growing evidence which shows that no single perspective can offer a full picture of adaptation and its progress (Mehta et al., 2019; Singh et al., 2021). Government plans remain important for highlighting progress in adaptation planning and the government's commitment to supporting adaptation as suggested in the first literature stream identified in this study (e.g., Ford et al., 2013; Moehner et al., 2021). However, conversations with livestock keepers highlight important contextual issues, underscoring the value of considering different perspectives in the development and application of adaptation tracking indicators. Such an approach can strategically align with the thinking in the Paris Agreement, which shifts from a government-centered framing to recognizing the multi-dimensional nature of adaptation, thus requiring collaboration between diverse actors (Lesnikowski et al., 2017). Besides mobilizing collective action, this collaboration can also support efforts to hold actors accountable to each other (Karlsson-Vinkhuyzen et al., 2018), but this necessitates the use of adaptation tracking indicators that are meaningful to the perspectives and priorities of those actors.



Chapter 5

Tracking climate change adaptation in the livestock sector: Insights from co-producing the Tracking Adaptation in Livestock Systems (TAiLS) tool

This Chapter is in preparation as: Njuguna, L., Crane, T., Tracking climate change adaptation in the livestock sector: insights from co-producing the Tracking Adaptation in Livestock Systems (TAiLS) tool.

Abstract

Tracking adaptation is essential for taking stock of progress in addressing climate change impacts and informing adaptation planning across scales. While politicians, researchers, and practitioners have been grappling with questions of how to track adaptation for some time, there is still no agreement on methodologies for tracking and reporting on adaptation at aggregated levels. In addition, empirical illustrations of how to design adaptation tracking tools still need to be explored, especially in the livestock sector. In this chapter, we showcase the co-production of a tool for tracking and reporting on adaptation in the livestock sectors of Eastern Africa. The tool, dubbed Tracking Adaptation in Livestock Systems (TAiLS), is a web-based tool that allows government officials to collate and analyze data and make statements on adaptation progress across spatial and temporal scales. This chapter's approach to developing the TAiLS tool, informed by the results of the previous chapters, accounts for crucial elements for adaptation tracking, including the plurality of experiences and the related need to integrate multiple perspectives as well as alignment with the institutional structures of producing and using knowledge relevant to adaptation tracking. By co-producing the TAiLS tool, I contribute to discussions on adaptation tracking by illustrating the components that can operationalize the measurement of adaptative capacity, resilience, and vulnerability in the livestock sector, the importance of integrating multiple indicator typologies, and the necessity to embed adaptation tracking within existing administrative processes and structures.

5.1 Introduction

Assessing progress in adapting to climate change across and within populations, sectors, and countries – also known as adaptation tracking – is crucial for effective decision-making and adaptation planning at local, sub-national, national, and global scales. Despite the growing number of proposed frameworks and tools, there is still no consensus on how to track and report on adaptation, more so in the livestock sector. The characteristics of the livestock sector pose challenges that typically impede adaptation tracking.

First, climate change adaptation in the livestock sector involves actions at different scales, ranging from adjustments in technologies and practices at the farm level to policy reforms and investments by sub-national, national, and regional actors (Rivera-Ferre et al., 2016; Rojas-Downing et al., 2017; Thornton & Herrero, 2014). This necessitates the consideration of adaptation efforts and experiences across scales and the associated challenge of tracking adaptation in a manner that captures the diversity and still allows cross-scale comparisons. Secondly, the diversity within and across livestock production systems in Sub-Saharan Africa is linked to significant differences in vulnerability, adaptive capacities, and feasibility of adaptation options (Godde et al., 2020; Ng'ang'a & Crane, 2020). This suggests that adaptation outcomes can vary within and across livestock production systems, necessitating adaptation tracking approaches that accommodate this diversity in assessing adaptation progress. As such, it is unlikely that adaptation indicators will have universal relevance across systems. Thirdly, livestock systems entail complex interactions between economic, social, environmental, and political dimensions (Rust, 2019). Thus, adaptation tracking in livestock systems should capture these dimensions to get a complete picture of adaptation progress but still be practical. Fourth, tracking adaptation in the livestock sector must also address the gaps in the current data systems. In Africa, assessments dedicated to the livestock sector are rare since most surveys and censuses lump livestock with other farm activities, and most data collection methodologies do not effectively capture the uniqueness of pastoral systems (Krätli & Swift, 2014; Pica-Ciamarra et al., 2014). Therefore, it is paramount to identify tools and complementary data streams that can support a better understanding of adaptation progress in livestock systems. Fifth, although many countries have set up systems for tracking adaptation in the agriculture sector, the focus on assessing adaptation outcomes is limited (Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP), 2019), necessitating tools that can track different result types. For instance, frameworks such as Tracking Adaptation and Measuring Development (TAMD) (Brooks et al.,

2011) and tracking adaptation in agricultural systems (Food and Agriculture Organization of the United Nations (FAO), 2017) cover both process and outcome indicators of adaptation progress by incorporating measurements of adaptation policies and their local effects in reducing vulnerability. However, these tools only consider the adaptive actions of governments, leaving out the multitude of other actors that contribute to climate risk management and the linkages between different adaptation efforts.

Therefore, to bridge these gaps, the objectives of this chapter are three-fold. First, the chapter explores the use of a co-production approach to design adaptation tracking methodologies. It documents the steps towards consultative development of a tool for tracking and reporting on adaptation in livestock systems in Ethiopia, Kenya, and Uganda (dubbed Tracking Adaptation in Livestock Systems (TAiLS)). TAiLS is a web-based tool designed to enable government officials in the livestock sector to track and report on adaptation progress within the sector. The development of the tool was based on the premise that a sectoral approach to planning and tracking adaptation within countries could be better suited to capturing sector-specific priorities and actions (Ford et al., 2013). Reports from relevant sectors within the country can then be integrated to produce a national report. Secondly, this chapter advances knowledge in relation to linking multiple scales by empirically illustrating how tools that are fit for context can be developed, including how to consider existing institutional structures and variations in adaptation perspectives. In doing so, this chapter fulfills a third objective of demonstrating the value of the findings in Chapters 2, 3, and 4 in informing the design of adaptation tracking, as exemplified through the design of the TAiLS tool.

The chapter proceeds as follows: Section 5.2 describes the key decisions made as we embarked on developing the tool, which had implications for the process and the tool itself. In section 5.3, we explain the various steps followed in co-producing the TAiLS tool. In addition to the overarching decisions highlighted in section 5.2, in section 5.3, we provide the rationale behind the steps and highlight the inputs and outputs (see Fig 5.1). In section 5.4, we discuss our experience developing the tool, including the conceptual foundation of the tool, the value of using a co-production approach, the nature of the ensuing indicators, and the potential for aligning adaptation tracking within established government processes and structures.

5.2 Foundational decisions and guiding principles

First, the purpose for which adaptation is being tracked should match the selected adaptation tracking approach (Ford et al., 2013; Leiter, 2017). This dissertation focuses on adaptation

tracking at aggregated levels through the assessment and comparison of adaptation between and within populations and across space and time (Berrang-Ford et al., 2019). Therefore, the choices made in designing the TAiLS tool prioritize indicators that can be tracked over long durations, even in places without external interventions, and have a clear relationship with adaptation progress. Secondly, while choices need to be grounded in a sound conceptual understanding of the elements that constitute adaptation and the connections between them (Leiter et al., 2019), it is also important to consider what matters in practice. As such, a key step in designing the TAiLS tool was specifying a conceptual framework that unpacks critical components to be tracked. This framework was later used to guide the examination of contextual similarities and differences that needed to be captured by the tool. Thirdly, following the findings from Chapters 2 and 3, aligning TAiLS with existing government systems of producing and using knowledge was crucial. Therefore, the co-production of the TAiLS tool was done concurrently in each country to allow customization. Fourth, as shown in Chapter 3, it is important to consider diversity in experiences, understandings, and responses to climate change across actor groups. Therefore, we chose to integrate perspectives of livestock keepers from various livestock production systems and governments to identify indicators that capture adaptation in diverse contexts, including the social and geographical dimensions of differentiated adaptation experiences and outcomes. This entailed the use of a variety of methods to support the integration of the views of diverse stakeholders. Besides embracing diversity, participatory processes of designing and implementing adaptation tracking could support more robust assessments, enhance ownership, and generate information better suited for adaptation planning (Intergovernmental Panel on Climate Change (IPCC), 2022c).

5.3 Co-producing the Tracking Adaptation in Livestock Systems (TAiLS) tool

As Figure 5.1 shows, the co-production process comprised two phases: Phase A and Phase B. Phase A had two parallel components and laid the foundation for the design of the TAiLS tool in Phase B. Phase A corresponds with research elaborated in Chapters 3 and 4. Highlighting these steps is particularly important in showing how the insights in these chapters were used to inform the design of the TAiLS tool. Although the illustration implies a linear process with distinct steps, the process was iterative, and several steps took place simultaneously. The remainder of this section presents the various steps in co-producing the adaptation tracking tool.

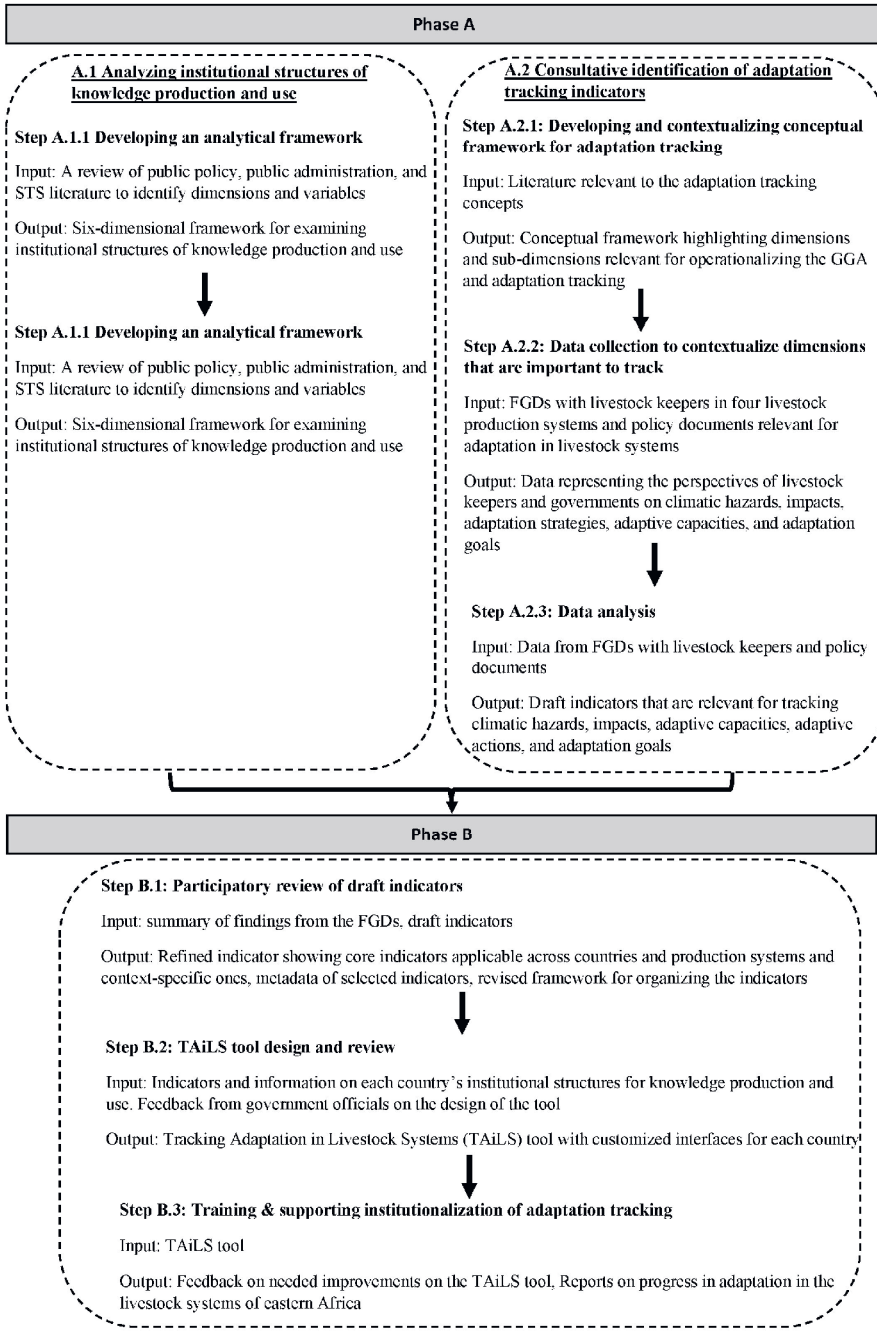


Figure 5.1 Overview of the process of co-producing an adaptation tracking tool

5.3.1 Step A.1: Analyzing institutional structures of knowledge production and use

The six-dimensional framework presented in Chapter 2 supports an understanding of the dynamics within government as well as relations between government and society in knowledge production and use. Intragovernmental dynamics consider aspects such as the influence of the political spheres of government on knowledge production and use, the flow of knowledge between various administrative units that produce knowledge, as well as the role of experts in influencing how the knowledge is produced. Capturing adaptation progress among various constituents is also necessary, making state-society relations and how they influence the participation of relevant stakeholders in knowledge production an important aspect to consider (see Chapter 2).

Therefore, a key step to developing the TAiLS tool was to apply the framework to characterize the rules and practices of producing and using knowledge relevant to tracking adaptation in livestock systems of Ethiopia, Kenya, and Uganda. To do this, the first author analyzed relevant government policies and qualitative data from interviews with selected government officials and livestock keepers Figure 5.1. The use of both policies and interviews allowed the analysis to capture the expected practices and structures as outlined in the formal documents as well as what is done and exists in reality. See Chapter 3 for an elaboration of this analysis and findings.

Based on this analysis, we mapped individuals and national and sub-national administrative units that would be crucial in the implementing adaptation tracking, hence their involvement in the subsequent steps. This analysis also highlighted differences across countries in how knowledge on livestock systems is produced and the need to customize the co-production process for each country. As such, all the steps were conducted in each country separately. However, synchronizing the steps across the countries allowed us to integrate feedback and validate the changes continuously. This means that after getting input from the first country, for instance, on the indicators, we integrated the input before conducting the same step in the second country to see if any further changes were needed.

5.3.2 Step A.2: Consultative identification of adaptation tracking indicators

Step A.2.1: Developing and operationalizing a conceptual framework for adaptation tracking

Based on how adaptation tracking is conceptualized in political and academic discussions, it is expected to show if and how actors' efforts are resulting in vulnerability reduction and enhancement of resilience and adaptive capacity (Ford et al., 2013; Intergovernmental Panel on Climate Change (IPCC), 2022c; United Nations Convention on Climate Change (UNFCCC), 2015). Adaptation tracking should also allow the assessment of progress in relation to achievement of the variety adaptation goals pursued by different actors and the synergies between the adaptation goals and relevant non-climate-related ambitions (Berrang-Ford et al., 2019; Intergovernmental Panel on Climate Change (IPCC), 2022c; Park et al., 2012). Therefore, five concepts are central to adaptation tracking: i) adaptation, ii) vulnerability, iii) adaptive capacity, iv) resilience, and v) adaptation goals. These concepts are not directly visible and thus have numerous and often competing ideas of how to define and measure them (Béné et al., 2012; Delaney et al., 2016; Levine, 2014; Schipper & Langston, 2015). Therefore, Step A.2.1 was necessary to unpack these five concepts and select suitable definitions for them from the diverse options that exist in the literature. In doing so, we developed a conceptual framework for adaptation tracking comprised of five dimensions that are important to track – highlighted in bold in this section. The conceptual framework was continuously refined based on insights from its application in organizing adaptation tracking indicators. The final conceptual framework is shown in Figure 5.2.

Adaptation refers to the process of adjustment to experienced or expected impacts of climate change (Intergovernmental Panel on Climate Change (IPCC), 2022f). This continuous adjustment includes a variety of **adaptive actions** aimed at reducing harm or exploiting beneficial opportunities associated with climate change. Within livestock systems, such actions may include technological changes such as improving livestock breeds, better farm management to enhance feed and water availability, livelihood diversification, integration of crop and livestock farming, as well as policy-related adjustments, including weather-based index insurance and the enactment of adaptation plans (Escarcha et al., 2018; Rivera-Ferre et al., 2016; Rojas-Downing et al., 2017; Thornton & Herrero, 2014). This implies that different actors undertake a variety of actions that should be considered when tracking adaptation.

Therefore, the TAiLS tool incorporates the adaptive actions of various actors at national, sub-national, and farm levels.

The second core concept is vulnerability. Vulnerability refers to the probability of human and natural systems being adversely affected by climate change and is constituted by *exposure* to *climatic hazards*, *sensitivity* to harm, and the *capacity* to adapt (Füssel & Klein, 2006; Intergovernmental Panel on Climate Change (IPCC), 2022f). Exposure considers the presence of people and economic, physical, cultural, or ecological assets in places likely to be adversely affected by climatic hazards (Intergovernmental Panel on Climate Change (IPCC), 2022f). **Climatic hazards** are climate-related events or changes that are likely to cause harm. For instance, in livestock systems, critical climatic hazards include precipitation anomalies such as excessive rainfall, which is associated with storms and flooding; inadequate rainfall, which may manifest as prolonged dry seasons and drought; as well as temperature extremes which lead to heat and cold stress in livestock (Escarcha et al., 2018). The context-specificity of exposure requires a consideration of the climate trends and events for specific areas as well as systems of parts of a system that are at risk. As such, in the TAiLS tool, we include a dimension for climatic hazard which is assessed at the sub-national level to capture local differences in exposure to climatic hazards.

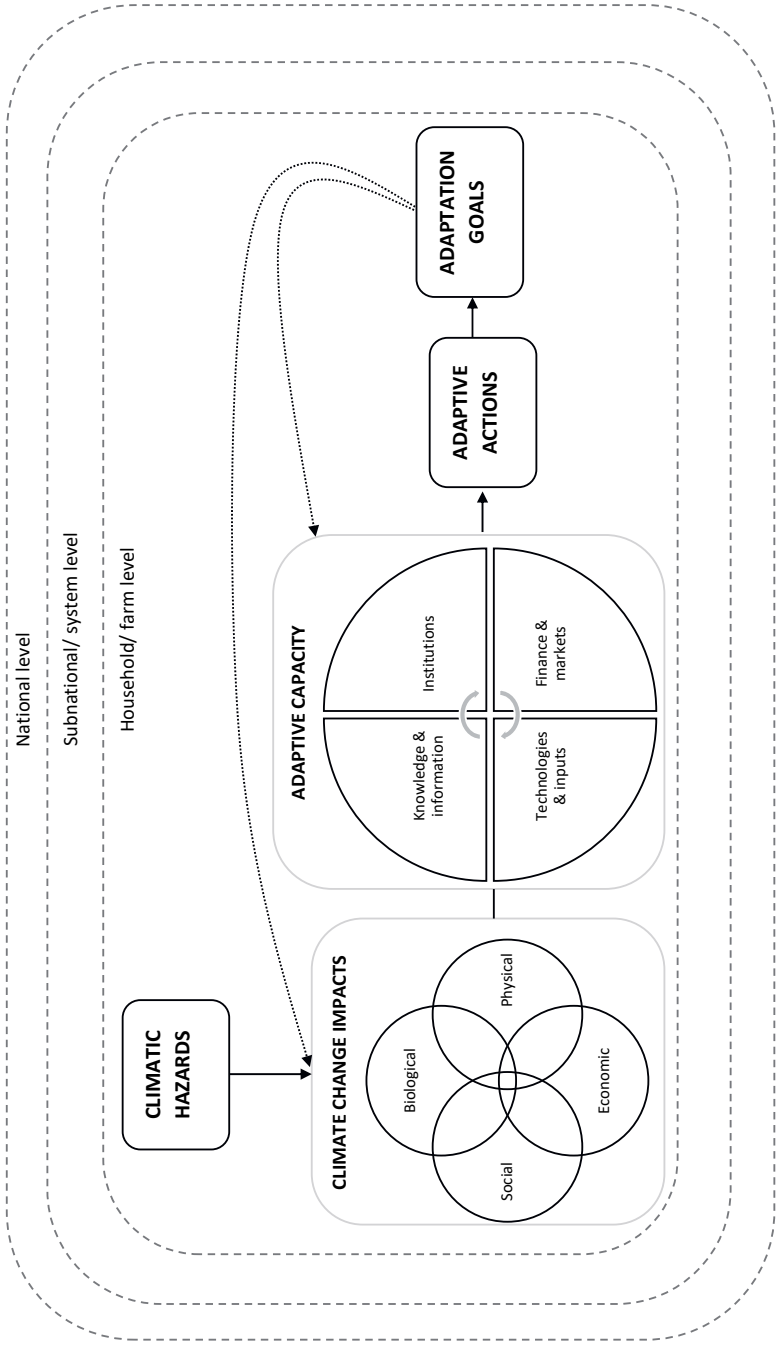


Figure 5.2 A conceptual framework for adaptation tracking

Sensitivity refers to the degree to which a system or parts of a system are positively and negatively affected by climatic hazards (Intergovernmental Panel on Climate Change (IPCC), 2014). Sensitivity can be attributed to the non-climatic social, economic, biological, and political characteristics of a system that determine the magnitude and direction of impacts (Smit & Wandel, 2006). In livestock systems, sensitivity can be linked to the types of livestock breeds reared, the characteristics of pastures and other sources of animal feeds, as well as the number and types of revenue streams an individual, household, or country depends on (Godde et al., 2020, 2021). For instance, some production systems, such as the rangelands, might be more sensitive to climatic hazards due to the harsh environmental conditions and low economic development (Godde et al., 2020).

Depending on the exposure and sensitivity of systems (and overall vulnerability), climatic hazards result in **impacts** – economic, social, biological, and physical consequences of climatic hazards on human and natural systems (Intergovernmental Panel on Climate Change (IPCC), 2022f). Economic impacts include aspects that are relevant to the local and national economies. In livestock systems, such impacts can directly be assessed by looking at changes in livestock production and incomes from livestock and livestock products. Social impacts include impacts on people's well-being and social relations, including food and nutrition security as well as peace and security. Biological impacts include direct and indirect impacts on livestock. Direct biological impacts include effects on livestock reproduction, health, and production, and indirect impacts include the availability and quality of feeds and water (Rojas-Downing et al., 2017). Lastly, physical impacts occur on the material components of the systems, including infrastructure.

The third core concept, also a determinant of vulnerability, is adaptive capacity. **Adaptive capacity** refers to the ability of people and systems to prepare and act in response to the experienced or expected impacts (Intergovernmental Panel on Climate Change (IPCC), 2022f). Adaptive capacity is constituted by context-specific material and social resources necessary for people and systems to respond to climate change impacts (Fuchs & Njuguna, 2019; Jones et al., 2010). The adaptive capacity dimension comprises four sub-dimensions based on the local adaptive capacity framework (Jones et al., 2010).

The first sub-dimension relates to *technologies and inputs*. In livestock systems, this category includes aspects such as access to extension and veterinary services, land, as well as livestock breeding and farm management technologies. The second sub-dimension is *knowledge and*

information, which is about generating and accessing knowledge and information relevant to adaptation, including the understanding of risks and viable adaptation options. This sub-dimension covers experiential endogenous knowledge gained through experience and exogenous knowledge generated elsewhere, e.g., through research. It is also concerned with the establishment of appropriate channels for disseminating knowledge and information, such as peer-to-peer learning, training, and print and electronic media.

The third sub-dimension is *institutions*, which encompass formal and informal social arrangements that shape access to and management of resources crucial for adaptation. The presence of relevant formal rules and plans, including the capacity of national and sub-national organizations to anticipate and plan for adaptation and the existence and recognition of informal arrangements that safeguard access to and management of resources, are examples of critical institutional aspects. Considering distinct social roles and unequal access to productive resources among livestock keepers (Marty et al., 2022; Ng'ang'a & Crane, 2020), here it is also essential to consider specific contextual aspects such as cultural norms and their influence on women's control over and access to assets relevant for their adaptative actions. The fourth sub-dimension is *finance and markets*. Financial resources, for instance, entail the establishment of adaptation funds at national and subnational levels, the availability of credit options for livestock keepers, and access to financial mechanisms for risk management, including livestock insurance. Input and output markets are important for ensuring that livestock keepers can access the necessary materials, such as feed additives and veterinary medicine, and favorable market options for livestock and livestock products.

Due to overlaps between empirical elements related to sensitivity and adaptive capacity (see also, Smit & Wandel, 2006), the sensitivity dimension was subsumed under the adaptive capacity dimension in the final conceptual framework. Therefore, under the adaptive capacity dimension, it is important to fully characterize the system under consideration to identify elements that determine the probability of the system experiencing climate change impacts and the capacity to adapt.

The fourth concept is resilience, which refers to the ability of systems to withstand the impacts of climate change "… in ways that maintain their essential function, identity, and structure, …" as well as enhancing the ability to adapt, learn and transform (Intergovernmental Panel on Climate Change (IPCC), 2014, p. 1772). Based on this definition, there is considerable overlap between resilience and adaptive capacity. However, as opposed to only looking at systemic

properties in relation to material and social resources, the conceptualization of resilience as an outcome underscores the need to consider the adequacy of adaptive actions in minimizing the impacts and enabling the system to still perform or improve its functions despite the presence of climatic hazards. As such, the resilience concept also overlaps with the fifth concept of adaptation goals. **Adaptation goals** refer to the particular results that different actors aspire to achieve as they respond to climate change. For instance, at the global level, countries agreed on a collective goal of "… enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response …" (United Nations Convention on Climate Change (UNFCCC), 2015, Article 7.1). Nationally, countries also articulate adaptation goals and targets within their adaptation plans. Likewise, livestock keepers pursue various goals that can be linked to why they rear livestock and their aspirations as they invest in adaptation. For instance, livestock systems serve diverse functions, including contributing to food security, providing revenue streams for households and national economies, source of manure, and as a symbol of social prestige. Since adaptation is a never-ending process, identifying metrics to measure the adaptation goals pursued by different actors is fundamental to assessing the resilience of systems and as a reference point to evaluate the effectiveness of adaptation efforts.

Finally, a recurring theme in the operationalization on these concepts is the diversity of actors and scales that need to be considered. For instance, adaptive actions and adaptation goals are relevant to local, national, and global actors. Determinants of the capacity of systems to adapt to climate change also operate at these different scales. Therefore, as illustrated in the conceptual framework, it is important to consider how dimensions for tracking adaptation tracking are nested across scales. The TAilS tool captures the connections between adaptation efforts and outcomes at national, sub-national, and farm levels.

In sum, by unpacking concepts central to adaptation tracking, we identified five dimensions crucial to track: climatic hazards, impacts, adaptive actions, adaptive capacity, and adaptive goals. These dimensions highlight the specific themes for which indicators should be developed for a comprehensive assessment of adaptation progress. Therefore, in steps A.2.2 and A.2.3, we sought to establish adaptation tracking indicators that operationalize the above dimensions within the livestock sector across scales.

Step A.2.2: Data collection to contextualize dimensions that are important to track

Findings from comparing how different actors perceive the five dimensions show that although governments and livestock keepers perceive these issues similarly, fundamental differences underscore the importance of integrating multiple perspectives in the designing of adaptation tracking indicators (Chapter 4). Therefore, in this step, we used various data sources to get a comprehensive contextual understanding of the five dimensions of the conceptual framework and to capture the perspectives of governments and livestock keepers.

To contextualize adaptation in the diverse livestock systems and to capture the perspectives of livestock keepers, we selected four production systems: grazing-pastoral, grazing non-pastoral, highland mixed crop-livestock, and lowland mixed crop-livestock systems. These systems represent the main types of livestock production systems in Eastern Africa. Their inclusion allowed us to understand the five dimensions across diverse contexts. We used 48 Focus Group Discussions (FGDs) with livestock keepers in the selected production systems. FGDs allow a selected group of actors to discuss specific topics as guided by a facilitator, thus ensuring consistency in focus across groups (Morgan, 1996). In the study contexts, since adaptive capacities and adaptative options are influenced by age and gender (Marty et al., 2022; Ng'ang'a & Crane, 2020), data collection sought the representation of men and women of varied age groups to ensure the inclusion of diverse perspectives. Disaggregation of the FGDs by age and sex also helped create an environment where the respondents could interact freely. With the help of a discussion guide (Annex 4), the discussions focused on selected themes that helped us understand the climatic changes that the livestock keepers were experiencing, impacts, non-climatic drivers of impacts, their adaptation strategies, factors supporting or constraining adaptation, and adaptation goals.

Governmental perspectives in Ethiopia, Kenya, and Uganda were captured by analyzing policies relevant to adaptation in the livestock sector (Annex 5, see also Chapter 4). These included various sectoral and cross-sectoral plans such as the national development blueprints (e.g., Ethiopia's 10-year development plan and Kenya's agriculture sector transformation and growth strategy) and climate-specific plans (e.g., Uganda's national adaptation plan for the agricultural sector).

Instead of directly asking different stakeholders which indicators they would consider essential to track, using FGDs and policy analysis to contextualize the conceptual framework supported

the identification of broader issues for which indicators could be developed, thus creating a better linkage between the selected indicators and priorities.

Step A.2.3: Data analysis

The salient issues discussed by governments and livestock keepers were identified through a thematic analysis (Braun & Clarke, 2006) of the policy documents and the FGD transcripts. These salient issues were fundamental in informing the development of adaptation tracking indicators. First, data were coded deductively using the five dimensions of the conceptual framework developed in step A.2.1. Thereafter, the structured data were coded inductively using themes identified from the data. New codes were created to accommodate themes that did not fit the initial framework. For instance, a new code labeled 'non-climatic stress' was created, under which we placed any other factors contributing to changes in the livestock systems. Although using the conceptual framework to guide data collection and analysis did not allow us to capture an entire range of pressures driving practices and stakeholder priorities, the framework compelled us to focus on climate change issues, thus resulting in information relevant for adaptation tracking. Overall, this process generated more than 500 elements (considered as a first draft of adaptation tracking indicators), necessitating a refinement of the elements to a manageable number.

As illustrated in Figure 5.1, insights from the analysis of institutional structures and the draft indicators informed the design of the next phase of the co-production process. The findings on the rules and practices of producing knowledge informed the selection of national and sub-national administrative units to be involved in the rest of the process in each country. The nature of the indicators also underscored the importance of involving livestock keepers, researchers, and government officials in selecting the final indicators. A participatory review of the draft indicators helped ensure that the selected indicators were not only useful for adaptation tracking but also meaningful to diverse stakeholders.

5.3.3 Step B.1: Participatory review of draft indicators

As elaborated below, different approaches were used to elicit input from different stakeholder groups. After each stage of the review, ensuring that the input and evolution of the indicators captured the local nuances and could support adaptation tracking at aggregate levels was essential. This meant we regularly reviewed the suggestions and consulted on the best way to integrate the input. For instance, due to country-specificity in how extension services are

organized, government officials in each country provided divergent views of how to frame the indicator related to 'access to extension services by livestock keepers.' Considering all inputs, this indicator was broadly framed as the 'ratio of veterinary service providers to livestock-keeping households' to include the diverse types of providers such as public and private veterinarians, extension officers, and community-based livestock health workers. In Uganda and Ethiopia, there were strong suggestions to include indicators that measure livestock productivity instead of production, which aligned with the ambitions to increase productivity to reduce greenhouse gas emissions intensities from the livestock sector. In contrast, in Kenya, government officials emphasized that their priority was to focus on adaptation, hence their recommendation to remove indicators related to livestock numbers and breed types. Considering the complexity of factors influencing productivity and the tool's focus on assessing adaptation efforts, indicators of productivity and livestock population were excluded. The rationale provided by different actors toward including the indicators helped develop the metadata, which provides information on each indicator and its relevance. The metadata was a useful reference point during the review and was continuously enriched.

Step B.1.1: Review with livestock keepers

The main objective of this step was to allow livestock keepers to provide feedback on accuracy and completeness. To do this, the first author summarized the findings obtained through FGDs with livestock keepers and facilitated the discussions. For this process to be meaningful to livestock keepers and for us to get useful feedback, they were presented with findings specific to their production system. Therefore, besides supporting the assessment of the appropriateness of the draft indicators considering livestock keeper experiences and priorities, this step supported peer learning on climate change issues and adaptation options. Livestock keepers exchanged ideas on how they could enhance their adaptation strategies. Similar to the first round of data collection, the FGDs were distributed across four livestock production systems, were conducted using local languages, and allowed livestock keepers to discuss in small groups. In this round, we also included respondents that had not been engaged in the first round of data collection to increase the probability of collecting additional information on the perspectives of livestock keepers. Based on the feedback, we confirmed that the summaries adequately represented the main climate change issues within our study areas, as only minor additions were suggested. After this review, the draft indicators relevant to different livestock production systems and the different data sources were combined into one set, noting which ones were unique to a specific production system.

Step B.1.2: Review by technical experts

This step involved iterative review and revision of the indicators by the team leading the adaptation tracking work in consultation with other researchers. For instance, we reached out to researchers with different areas of expertise in the livestock sector, such as those specializing in animal health and breeding, to validate the scientific relevance and applicability of the identified indicators. The technical experts also assessed the indicators based on the clarity of their relationship to adaptation progress within the livestock sector, practicality of measurement, or uniqueness within the set. At this stage, some indicators were eliminated while others were reframed or subsumed into other indicators to ensure that all the important aspects were retained. For instance, interventions that support access to credit are sometimes framed as important for building adaptive capacities, but emerging research is showing how it might exacerbate vulnerability as farmers get trapped in debt (Guermond et al., 2022; Schipper & Langston, 2015). Therefore, although 'access to credit' was in the draft set of indicators, the final list focuses on the 'presence of credit options' and 'financial products that support adaptation in the livestock sector.' This framing amplifies establishing financial services that can be tapped into instead of equating increased access to credit with adaptation progress.

After the first technical review, only 86 indicators of the 500 were retained. These indicators included those that could be applied across countries and production systems and those whose relevance depends on adaptation context. The context specificity of the indicators was reflected in the weighting of the indicators (see step B.2.3).

Step B.1.3: Review with government officials

Since government officials have a core mandate of implementing adaptation tracking, involving them in the development stage was important for several reasons. First, this engagement helped build ownership of the process and outputs. Secondly, through this review process, government officials could confirm whether the indicators aligned with their priorities and whether any critical aspects were missing. This was important, considering that the analysis of governmental perspective was based on policy documents. Thirdly, this process enhanced the capacity of government officials by learning how to design adaptation tracking tools and through knowledge exchange among peers on various topics.

The review workshops brought together government officials from national and sub-national levels within each country. The selection of the participants was based on earlier findings that identified the administrative units that were relevant for producing data on livestock systems

(see step A.1.2). The participants were drawn from various administrative units responsible for livestock and climate change issues as well as those with a core mandate to produce national data such as the central statical agencies. Since not all participants were familiar with international climate governance processes and decisions, the workshops started with an introduction to adaptation tracking, its objectives, and requirements. The participants were divided into small groups where they discussed the indicators and suggested revisions to the indicators or new additions. These groups then presented their ideas to the rest of the participants for discussion and consideration.

The participants first agreed on indicator selection criteria (text box 1). These criteria guided the discussions with the groups and decisions of whether to accept or reject some of the suggestions during the plenary discussions. For instance, the participants rejected some proposed indicators, such as the 'proportion of community land under proper resource management,' due to the lack of clarity on how to measure 'proper management.' It was also considered that other indicators on the list, such as the 'Normalized Difference Vegetation Index (NDVI)' and 'access to mobility paths,' can provide insights into the management of communal lands. Applying the criteria ensured that the indicators were conceptually defensible, aligned with adaptation contexts, and fit for purpose. Standard criteria also ensured that the selection of the indicators was less shaped by a participant's biases, for instance, due to institutional affiliation or technical background. For instance, some government officials preferred or rejected particular indicators depending on their expertise and mandate.

Besides providing input on indicators, participants were free to add any missing sub-dimensions and categories. For instance, participants would suggest something they considered necessary, discuss whether the current draft adequately covered it, and how to include it if it was missing. The context-specificity of the indicators was also considered, strengthening the integrated nature of the indicators. The participants also mapped the administrative units producing data for each indicator, thus informing even better alignment with existing knowledge production and use systems. Presenting the findings from the analysis of institutional structures in each country at this stage provided an opportunity to validate the findings and for the government officials to discuss how best to implement adaptation tracking in light of prevailing gaps and opportunities in knowledge production and use within the sector.

Indicators review criteria

- Data availability and ease of measurement: checking whether the indicator is already being tracked through the existing data collection activities. Also considering the effort required to measure the indicator in light of methodological complexity and resource intensity.
- Representativeness of contextual diversity: considers the value of an indicator in relation to representing unique adaptation contexts and elements
- Conceptual clarity and specificity: relevance of the indicator to at least one of the five dimensions relevant for tracking adaptation progress and clarity of the relationship between the indicator and adaptation progress.
- Non-redundancy: uniqueness of the indicator within the set
- Providing information on multiple aspects: the ability of the indicator to show the progress of various aspects of adaptation, as a way of reducing overall number of indicators used.
- Relevance to adaptation tracking: the appropriateness of the indicator in showing adaptation progress at an appropriate level of detail.

After the iterative review with the three stakeholder groups, the final set of indicators consisted of three dimensions, six sub-dimensions, 31 categories, and 96 indicators (Annex 6). The indicators can assess adaptation progress at household, sub-national, and national scales. The set has indicators with diverse characteristics, thus covering multiple indicator typologies. For instance, there are indicators related to climate change impacts on human (e.g., Proportion of livestock keeping households classified as food insecure, revenue from livestock sector) and natural systems (e.g., Normalized Difference Vegetation Index, water levels in water sources critical for livestock). There are also indicators that can assess social (e.g., Number of inter/intracommunity conflict incidences, the extent of women's control over decision-making on productive assets e.g., livestock, livestock products, land, and incomes) and economic (quantity of milk produced, number of livestock deaths) impacts of climate change. The indicator set also incorporates indicators that measure different levels of adaptation progress. These include input (e.g., number of inputs suppliers available, the proportion of livestock sector budget allocated to adaptation in the sector), output (e.g., the proportion of livestock-keeping households accessing training on climate change adaptation, number of households with livestock insurance), process (e.g., existence of sub-national plans and strategies that are relevant to climate change adaptation in livestock systems, the existence of national plans, policies, and strategies that are supportive of climate change adaptation in livestock systems), and outcome (e.g., proportion of sub-national administration units undertaking emergency

livestock offtake programs, number of livestock keeping-households receiving emergency food aid) indicators[5].

5.3.4 Step B.2: TAiLS tool design and review

Once a satisfactory set of indicators was achieved, the process of co-developing an adaptation tracking index and tool commenced. This involved a series of iterative and consultative steps, described below.

Step B.2.1: Computing a composite index for tracking adaptation progress

In line with the conceptual framework, five dimensions are crucial for understanding adaptation progress or success: climatic hazards experienced in a particular area, the biophysical and socioeconomic impacts, relevant adaptive actions, adaptive capacities, and adaptation goals. However, as noted in the processes of developing indicators, there were overlaps in some of the dimensions. Therefore, the composite index for assessing adaptation progress was computed as follows:

$$Adaptation\ progress = Hazards + Impacts + Adaptive\ capacity\ \&\ adaptive\ actions$$

Equation 5.1

Using a composite index was necessary as an aggregation logic that would support the incorporation of multiple dimensions and scales.

Step B.2.2: Normalizing the indicator scores

Since the indicators have different units of measurement, another fundamental step was to develop a normalization logic. Following Xu et al. (2020), two normalization formulas were used to distinguish indicators that have a positive or negative contribution to the adaptation score. The use of an inversion formula allows for consistent interpretation of trends, that is, for both positive and negative indicators, an upward trend is interpreted as an increase. See Annex 6 for details on whether an indicator has a negative or positive contribution.

For indicators with a positive contribution:

[5] Building on Ford et al. (2013) and Mäkinen et al. (2018), this indicator typology measures progressive levels of results as follows: input indicators measure human, financial, and physical resources devoted to adaptation while process indicators measure progress related to the establishment of adaptation policies and systems. Output indicators measure direct results on adaptation without assessing whether those direct results lead to substantial results as measured by outcomes indicators.

$$NS = \frac{a - min(a_{rf})}{max(a_{rf}) - min(a_{rf})} \times 100$$ *Equation 5.2*

For indicators with a negative contribution:

$$NS = \frac{a - max(a_{rf})}{min(a_{rf}) - max(a_{rf})} \times 100$$ *Equation 5.3*

Where NS is the normalized score of an element an indicator, *a* is the unnormalized value of that indicator. The minimum and maximum values are the values of that indicator in the reference or baseline year for all sub-national administrative units.

Using a baseline year allows the tool to compare adaptation progress relative to a commonly defined reference point across countries. This can be defined based on when adaptation tracking and reporting started, providing a richer understanding that complements a comparison of consecutive years. This base year can be adjusted after some time to correspond to national and global political discussions, for instance, after every two cycles of NDCs (=10 years). Setting a base year could also help address the issue of lag between climatic events and impact or adaptive actions and results as one can visualize progress relative to the first year of reporting as well as in comparison to the preceding year. Also considering that reporting will be done biennially, this approach is better suited to show progress that would be difficult to detect after only two years.

An alternative approach to calculating the value of the indicators would have been to use a fixed reference value or threshold by setting the preferred maximum or minimum values, for instance, setting the ideal value for the proportion of food insecure households at 0% (e.g., see Chen et al., (2015)). However, for most indicators, this was not possible. Nonetheless, tracking the direction and magnitude of change is considered an adequate alternative to tracking progress toward a predefined target.

Step B.2.3: Weighting the elements within the index

Allocation of the weights followed a subjective approach based on expert knowledge of the livestock production systems and the governance systems of Ethiopia, Kenya, and Uganda. The weights of the indicators ranged from 0 to 2 (Annex 7), denoting the following:

- 2 – highest weight and aims to distinguish contexts where an element has high importance compared to other contexts.
- 1 – denotes where an element has relatively lower importance or where the elements have equal weight across the different contexts
- 0 – denotes where an indicator is not relevant given the context

A subjective approach was preferred because it allows someone to allocate weights to variables cognizant of the contextual issues and the purpose for which the index is designed (Xu et al., 2020).

Step B.2.4: Calculating weighted scores and aggregating

These weights were used to calculate the weighted scores of the indicators:

$$Weighted\ score\ of\ an\ indicator\ = \frac{w_a}{\underset{within\ category}{sum\ of\ weights\ of\ indicators}} \times NS_a \quad Equation\ 5.4$$

Aggregation of weighted scores starts from the indicators. This means that to get the adaptation progress score, the weighted averages of the various indicators are first calculated and then aggregated to get the score of a category. Thereafter, weighted normalized category scores are averaged to get sub-dimension and the sub-dimensions are aggregated to get dimension scores. The three dimensions are then normalized and averaged to get the overall adaptation progress score of that system. The adaptation progress score of each subnational administrative level is aggregated to obtain a national score. The aggregated scores of national-level indicators are also added at this point.

Step B.2.5: Programming, testing, and reviewing the TAiLS tool

The normalization and aggregation logics described above were then programmed to provide a ready-to-use tool that enables government officials to visualize the progress in adaptation across space and time. The tool has seven primary user interfaces. The first interface is the homepage with a description of the tool and its purpose. On the homepage, a user can access the login page or a form to register as a new user. A national administrator coordinating reporting within the livestock sector must approve a new user. This ensures that the use of the tool is limited to government officials who have the mandate to produce knowledge on the livestock sector. After approval, users can only access interfaces specific to their country. On the second interface, users can upload data for each indicator by first selecting the reporting level and the name of the administrative unit for which they are reporting. This allows the tool

to filter the indicators and apply specified weights. The national administrator has access to a validation interface to review submitted data and follow up with the relevant individuals in case any anomalies are observed. Once the data is validated, users can use the main dashboard and the comparison interfaces to visualize results. The dashboard shows trendlines that compare the adaptation progress score across the years with reference to the first year of reporting. Users can also zoom in to visualize progress within specific dimensions, sub-dimensions, categories, and indicators. The tool also offers other features, including the possibility of comparing adaptation progress across the various sub-national administrative units and between livestock production systems (Figure 5.3 and Figure 5.4). The disaggregation of results by sub-national administrative units is customized to each country in that the tool shows the results of the counties, districts, and zones in Kenya, Uganda, and Ethiopia, respectively.

Although the development of the indicators was centered around four production systems, this level of spatial resolution was not supported by the dataflows within which the tool was embedded. Visualizing trends was also more complicated as most sub-national administrative units had diverse livestock production systems. Therefore, the tool uses only two categories of production systems: grazing livestock-only and mixed crop-livestock systems. To do this, administrative boundaries and production systems data are layered to identify the dominant production system. If a subnational administrative unit had a mix of the two systems but a substantial proportion of the district had mixed crop-livestock systems, the whole unit was classified as a mixed crop-livestock system. This means that the calculation of the adaptation progress score for that administrative unit used the indicator weights related to mixed crop-livestock systems. This approach aligns with the current data flows and results in a user-friendly interface. However, it masks the diversity that characterizes livestock production systems at the local level. While this makes the tool unsuitable for decision support, especially in guiding localized interventions, the tool still serves its primary purpose of tracking and reporting on adaptation at aggregated levels while still capturing some level of spatial resolution. This is a novel aspect of the tool.

With the TAiLS tool, government officials can make detailed statements of adaptation progress and download graphs as evidence to support the statements. Governments can also show how adaptation efforts have helped minimize the impacts across scales and where further adaptation support is needed.

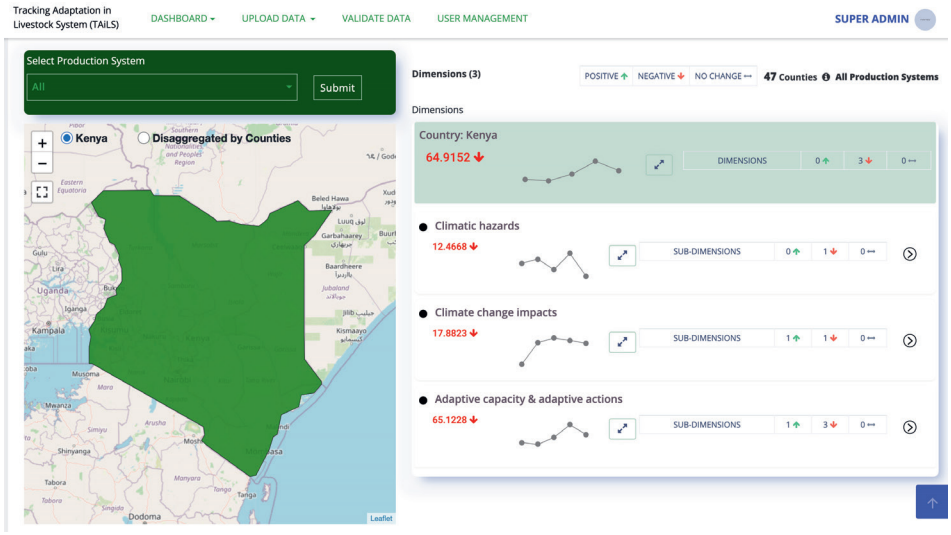


Figure 5.3 Dashboard showing aggregated national scores and trends in Kenya

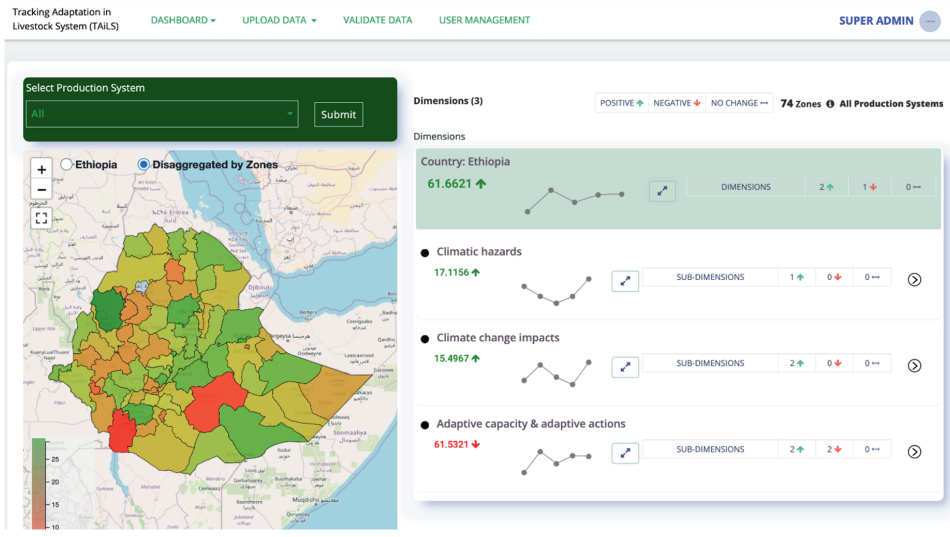


Figure 5.4 dashboard showing the varying adaptation progress in the Zones in Ethiopia

After creating the prototype and running initial tests, the tool was presented to government officials in each country for feedback. The discussions focused on the design, including the structural and aesthetic changes that would make the tool user-friendly as well as the appropriateness of the envisioned dataflows and the procedural aspects that needed to be integrated to ensure continued use of the tool in tracking and reporting on adaptation.

5.3.5 Step B.3: Training government officials and supporting the institutionalization of adaptation tracking

To support the use of the tool in adaptation tracking and reporting, there is ongoing work with a focus on training government officials on how to use the tool and supporting initiatives that support regular data flows that support its use in meeting international reporting obligations.

5.4 Reflections and discussion

Tracking and reporting on adaptation is a necessary step towards taking stock of progress in adapting to the impacts of climate change across scales. The work highlighted in this chapter makes a novel contribution by showcasing the development of a fit-for-context tool for tracking adaptation in the livestock sector, focusing on Ethiopia, Kenya, and Uganda. In doing this, we also illustrate how research findings highlighted in the preceding chapters of this dissertation could inform the design of the TAiLS tool. This section discusses key insights emerging from this work, covering both the approach used and the tool itself.

In a step towards clarifying what to track, we highlight five dimensions for assessing adaptation success in relation to enhancing resilience and adaptive capacities and reducing vulnerability in the livestock sector. The five dimensions are: climatic hazards, impacts, adaptive actions, adaptive capacities, and adaptation goals. Climatic hazards and impacts dimensions illuminate the adaptation context by capturing the climate risks and the context-specific ways impacts are manifested. The adaptive capacities dimension looks inward to examine characteristics of systems that crucially determine a system's sensitivity and ability to respond to the impacts of climate change. Lastly, the adaptation goals dimension is concerned with the results emanating from adaptive actions, which can be defined based on people's aspirations as well as careful consideration of any unexpected results. Therefore, the effectiveness and adequacy of adaptation can be evaluated based the extent to which set adaptation goals are achieved and progress in limiting context-specific impacts and enhancing adaptive capacities. The overlap in the literature discussing the measurement of adaptation, vulnerability, resilience, and adaptive capacity (e.g., Carr & Nalau (2023); Füssel & Klein, (2006); Intergovernmental Panel on Climate Change (IPCC), (1994, 2022b); Smit & Wandel, (2006); Turner et al., (2003)), suggests the high relevance of dimensions to adaptation tracking. These dimensions are also covered to varying extents by other literature that documents frameworks for assessing adaptation (e.g., Berrang-Ford et al., 2019; Park et al., 2012). In developing the TAiLS tool, we have demonstrated how these dimensions were further disaggregated into sub-dimensions,

categories, and indicators that capture context-specific and cross-cutting elements that are important to track in the livestock sector.

In contextualizing these dimensions, this chapter exemplifies the value of co-production in supporting sensitivity to diverse adaptation experiences and priorities. By adopting a design process grounded in a co-production approach, the TAiLS tool integrates the perspectives of various actors, including livestock keepers, governments, and researchers. Therefore, the tool mirrors the context-specificity and cross-scalar linkages integral to adaptation tracking in the livestock sector. For instance, with this approach, we were able to understand the varying importance of climatic hazards, impacts, actions, adaptive capacities, and goals across livestock production systems (see Chapter 4), which was addressed in the selection of indicators and the weights allocated to them (see step B.2.3.2). Considering the tradeoffs between aggregation and sensitivity to the diverse adaptation contexts (Ford & Berrang-Ford, 2016), integrating context-specific indicators to complement cross-cutting ones ensures that contextual issues are considered in the assessment of adaptation progress at aggregated scales. Furthermore, the TAiLS tool maintains a level of resolution that allows government officials to visualize and compare adaptation progress across sub-national administrative units and different livestock production systems, thus avoiding generalizing assessments at the national level.

Given the need to assess whether adaptation is taking place and its effects (Intergovernmental Panel on Climate Change (IPCC), 2022c; United Nations Environment Programme (UNEP), 2022), there is an imperative to integrate indicators that perform complementary functions (Lesnikowski et al., 2016). Moreover, diversifying the indicators used in tracking complex phenomena is not only strategic for covering all the critical issues but also reducing the risk of those indicators incentivizing actions that have a narrow focus (Kim, 2023). For instance, focusing on indicators that are suited for tracking adaptation over extended spatial and temporal scales, the indicators incorporated in the tool cover a wide range of indicator typologies and characteristics (Annex 6). First, in contrast to tools that prioritize process indicators with a focus on adaptation planning (e.g., Moehner et al., 2021), the TAiLS tool integrates input, process, output, and outcome indicators. Typically, process indicators are related to policy and institutional efforts, and input indicators assess the human and financial resources devoted to adaptation, output indicators look at the immediate and direct results of adaptive actions, while outcome indicators are concerned with the long-term effects of adaptive actions (Ford et al., 2013; Mäkinen et al., 2018). Secondly, these indicators reflect the multiple dimensions of adaptation in the livestock sector by including human, biophysical, economic, and social

aspects. Thirdly, cognizant of the nested scales within which adaptation occurs, the TAiLS tool incorporates indicators that can track adaptation at household, sub-national, and national scales. This is necessary considering the need to capture the efforts of different actors and their linkages (Berrang-Ford et al., 2021). For instance, adaptation in livestock systems entails diverse actions, from shifts in farming practices by livestock keepers to institutional reforms by governments (Rivera-Ferre et al., 2016; Rojas-Downing et al., 2017), hence the need to represent this richness of actions in the selection of indicators.

Uncertainty about data availability and quality is another challenge for tracking adaptation in livestock systems. Building on growing evidence of the role of national contexts in the implementation of global initiatives (e.g., Hickmann et al., 2022; Pillai & Dubash, 2021) and the findings from our analysis of government structures of producing knowledge that is relevant for tracking adaptation in livestock systems (Chapter 3), the TAiLS tool is designed to be embedded within existing government rules and practices. Identifying administrative units and individuals crucial to the implementation of adaptation tracking within the livestock sector of each country had many advantages. It informed the selection of government actors to be involved in the co-production of the tool, the identification of datasets that could support adaptation tracking in the sector, as well as supporting the establishment of targeted and continued engagement with specific individuals, thus increasing the ownership of the tool by the governments and gradual strengthening of their capacity to track adaptation. Similar advantages are discussed in Hammill & Dekens (2014). Besides, the characterization of institutional structures and presentation of the findings to government officials catalyzed conversations about how to improve current knowledge production practices to sustain adaptation tracking.

Along with its novelty and strengths the TAiLS tool has some limitations. The first set of limitations is associated with the tool's use of a composite index and spatial mapping. While these are powerful communication instruments since they can distill information on multiple variables into summaries that can quickly be understood, the level of aggregation and abstraction makes them inadequate for decision-making (Baptista, 2014; de Sherbinin, 2014). This is justified since the TAiLS tool was primarily designed for adaptation tracking and reporting. Nonetheless, since such tools by default influence policy decisions, the indicators used in the tool were carefully selected to ensure that they have a clear link to adaptation progress and to minimize the risk of misinterpretation. Related to this, we also acknowledge that the level of resolution provided by the tool makes it unsuitable for supporting targeted

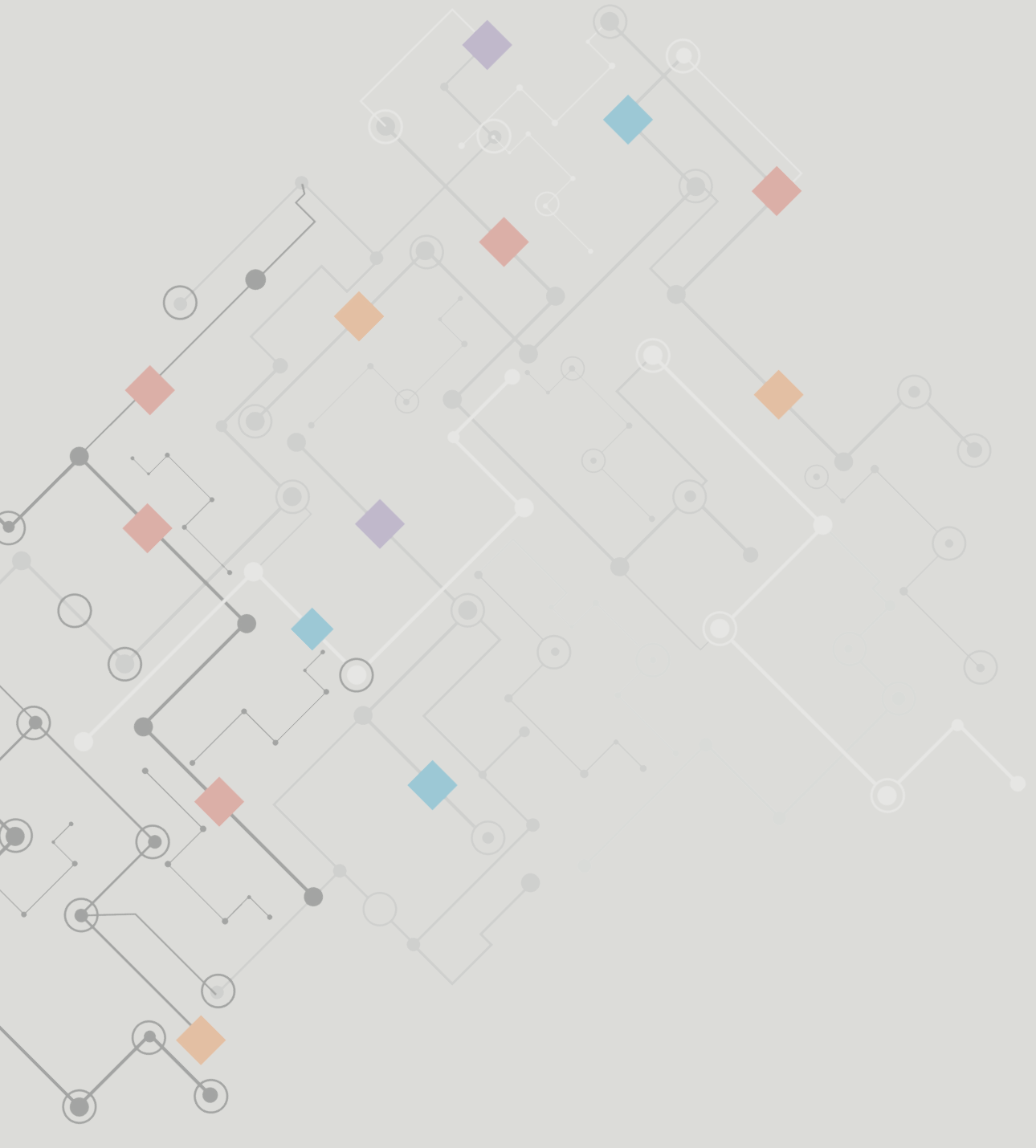
adaptation. For instance, with the focus on aggregating data at a sub-national administrative unit, the tool does not show the inter and intra-household variability in adaption progress or the distinctions between different livestock production systems within the administrative unit. Similarly, the maps imply distinct progress along administrative boundaries (de Sherbinin, 2014). Given these limitations, in relation to decision making, the tool can only highlight key areas that need to be considered. However, additional investigations would need to be undertaken to identify the appropriate adaptive actions.

The co-production of the TAiLS tool is only the beginning, and several steps could advance this work. First, it would be necessary to validate the tool further. For instance, the expert-driven allocation of indicator weights could be compared with other approaches, such as the use of systematic approaches that allow more diverse actors to rank the indicators. Secondly, while the inclusion of a limited number of stakeholder groups in the co-production of the TAiLS tool was a useful starting point in exploring the value of this approach, it could be useful in the future to validate the tool with other relevant stakeholders, such as the business community along the livestock value chain, to see if there are additional elements to be added. Thirdly, continuous capacity-building efforts are needed to support tracking and reporting on adaptation. Besides developing tools and training government officials on how to use them, follow-up is needed to consider how the insights from such sectoral assessments are integrated into national reports and the global stocktake. This could be further strengthened by availing the additional human and financial resources needed to support adaptation tracking in the sector. Fourth, we recognize that the evolution of the tool is contingent upon users' feedback as well as national and global discussions on adaptation tracking. Therefore, it is paramount to ensure that the tool is continuously refined to suit user needs and align with national and global discussions on adaptation tracking.

5.5 **Conclusion**

With the multitude of challenges that must be overcome to assess progress in the livestock sector, there is a need for tools that are tailored to capture diversity within the sector and are aligned with the existing institutional structures. This chapter takes the discussions on adaptation tracking a step forward by showcasing the development of a tool for tracking adaptation in livestock systems (TAiLS). Focusing on Ethiopia, Kenya, and Uganda, we demonstrate how the conceptual, methodological, and empirical challenges that hamper adaptation tracking can be addressed through the co-production of adaptation tracking tool. Involving livestock keepers, governments, and researchers in designing the TAiLS tool was

valuable in not only ensuring fit for purpose but also alignment with diverse experiences and priorities across scale as well as the established government systems of producing and using knowledge. Despite the focus on livestock systems of Eastern Africa, the insights from this work could be of relevance to other regions and inform the development of methodologies and guidelines for adaptation tracking under the Paris Agreement.



Chapter 6

Discussion, reflection, and conclusion

6.1 Introduction

The livestock sector is increasingly experiencing the impacts of climate change, but there is limited understanding of how the sector is adapting, as well as of the adequacy and effectiveness of adaptation efforts (Intergovernmental Panel on Climate Change (IPCC), 2022d). Therefore, the departure point for this dissertation was the acknowledgment of the pressing need for methodologies and guidelines for tracking progress in adaptation to climate change in the livestock sector. Adaptation tracking is important for assessing *if* adaptation is taking place, where, and the outcomes of adaptation (Berrang-Ford et al., 2019; Intergovernmental Panel on Climate Change (IPCC), 2022c; United Nations Environment Programme (UNEP), 2022). Yet, conceptual, methodological, and empirical challenges make adaptation tracking difficult. Focusing on the livestock sectors of Ethiopia, Kenya, and Uganda, this dissertation foregrounds the importance of tailoring adaptation tracking tools to match the diverse adaptation perspectives and the country-specific systems of producing and using knowledge relevant to adaptation tracking. Such an approach is needed to track adaptation across scales effectively and sustainably. In this concluding Chapter, I draw together the research findings to discuss and reflect on the design of adaptation tracking within the livestock sector and beyond.

The central research question of this dissertation was: ***How does the design of adaptation tracking benefit from considering existing institutional structures, plural perspectives on adaptation, and adopting a co-production approach?***

First, regarding institutional structures, this dissertation has conceptualized and demonstrated the differences that exist within and across countries in how they produce and use knowledge relevant to tracking adaptation in livestock systems. This finding underscores the importance of alignment between the design of novel adaptation tracking tools and the prevailing rules and practices to leverage the existing data streams, mandates, and processes within a country. Alignment promises better chances of continuity in adaptation tracking over time and meaningfulness for those involved in adaptation tracking. Furthermore, building on sub-national and national processes of knowledge production and use is important in catalyzing cross-scalar linkages, thus ensuring that assessments of adaptation progress at the global level not only capture local experiences but that the knowledge is relevant for domestic adaptation planning and decision-making. Therefore, it is paramount to consider how adaptation tracking can be directly embedded within country-specific rules and practices while planning for

contextually appropriate adjustments and strengthening the capacity of governments to track adaptation.

Second, this dissertation has provided evidence of how governments and livestock keepers perceive components that need to be tracked. The differences in perspectives, in particular, provide a rationale for considering diverse actors' perspectives in the adaptation tracking design. The inclusion of multiple perspectives starts from identifying the relevant actors involved in climate change adaptation in the different scales of the livestock sector, their experiences and priorities, and strategically accounting for the similarities and differences in the design and application of adaptation tracking tools. This is particularly relevant in capturing the linkages between the adaptation efforts of livestock keepers and governments and adaptation outcomes and needs at the farm, sub-national, and national scales.

Third, and finally, given the breadth of topics and the contextual knowledge required to understand institutional structures and diversity inherent in adaptation, this dissertation has shown how the co-production of adaptation tracking tools supports sensitivity to the uniqueness of national contexts and the plurality of adaptation perspectives. Co-producing the TAiLS tool was valuable in achieving the balance between capturing the contextual nuances of adaptation and developing a tool that is suited for tracking and reporting on adaptation at broad temporal and spatial scales. It also allowed the tool to be situated within the prevailing institutional structures by considering the uniqueness of rules and practices of producing knowledge in each country. Thus, this dissertation substantiates arguments for designing adaptation tracking methodologies through participatory approaches to capture local and national realities.

The remainder of this chapter proceeds as follows: in Section 6.2, I elaborate on the three aspects described above by synthesizing the findings from the previous chapters to answer the specific research questions. In this section, I also present the theoretical, empirical, and practical contributions made in addressing the research questions. In Section 6.3, I elaborate on the contributions of the dissertation as a whole, particularly on the theoretical advances for adaptation tracking. Section 6.4 reflects on the methodology of this dissertation, including the research approach, its strengths and limitations, and directions for further research. In this section, I also discuss my role as a researcher in shaping the process and output of the dissertation. Section 6.5 discusses the implications of the dissertation's findings for adaptation tracking more widely before concluding.

6.2 Synthesis of research findings and contributions to the existing literature

6.2.1 RQ1: How relevant are similarities and differences in countries' institutional structures of knowledge production and use for the design of adaptation tracking?

Placing adaptation tracking in the livestock sector in an institutional context

Countries have distinct policy styles, which are reflected in the institutional structures in place, that is, the rules and practices that influence how the government is organized and conducts its business (Howlett, 2002; Howlett & Tosun, 2019). Moreover, path dependency in policy processes implies that the institutionalization of new mandates, such as adaptation tracking follows, the established policy styles (Brendler & Thomann, 2023; Hickmann et al., 2022; Pierson, 2000; Pillai & Dubash, 2021). To situate adaptation tracking within an institutional context required creating a theoretical framework to examine how existing rules and practices shape the production and use of knowledge pertinent to adaptation tracking. As elaborated in Chapter 2, developing this framework involved drawing on diverse literature streams to identify key dimensions that help characterize institutional structures of knowledge production and use and how to operationalize them. One literature stream stemmed from the concept of civic epistemology which is concerned with the country-specific relations between the government and society and how they shape knowledge production and use (Jasanoff, 2005). For state-led adaptation tracking, state-society relations are important in determining the extent to which the experiences of non-state actors are considered and their role in validating knowledge and holding governments accountable. Additionally, intra-governmental dynamics influence the linkages between different administrative units within the government and government support towards knowledge production and use (Jamil et al., 2013; Painter & Peters, 2010a), hence the consideration of public administration literature in developing the framework. The framework I developed in Chapter 2 is constituted of six dimensions: 1) stakeholder participation, 2) transparency, 3) bureaucratic accountability, 4) engagement with experts, 5) politico-administrative relations, and 6) coordination within the administration. Further, I synthesized literature covering different geographical contexts and domains to identify variables that support an empirical examination of each dimension. The six dimensions and their respective variables support a comprehensive characterization of how governments are organized and the institutionalized styles of producing and using knowledge relevant to adaptation tracking.

In applying this framework in a comparative study of the rules and practices of producing and using knowledge in the livestock sectors of Ethiopia, Kenya, and Uganda, this dissertation demonstrates the need to pay attention to institutional structures in designing adaptation tracking. Chapter 3 has shown how the country-specificity of institutional structures shapes knowledge production and use. Institutional structures influence processes and organizational setup through the codification of knowledge production procedures in government plans and laws and their enforcement in everyday practices. Consequently, I find substantial and salient variations within and between the three countries along the six dimensions. For instance, basic structural differences in the government system in the three countries underscore the need for contextually appropriate strategies for leveraging the vertical and horizontal flow of knowledge. While the hierarchical structure in Ethiopia would allow adaptation tracking to be embedded within existing reporting processes, in Kenya, the self-determination of county governments in the devolved government systems requires a more strategic approach to incentivize the vertical flow of data. Similarly, the distinct knowledge production standards within and across countries necessitate country-specific discussions on the data streams to be used for adaptation tracking and reporting. Domestic transparency and accountability measures are essential in complementing global climate governance arrangements, especially since these are often based on soft law and voluntary reporting mechanisms (Karlsson-Vinkhuyzen et al., 2018). However, the practicality of these measures will depend on the rules and practices of individual countries. Also, calls for stakeholder involvement in adaptation tracking (e.g., Dilling et al., 2019) must be positioned within each country's institutional context since *if* and *how* such a participatory approach will unfold is contingent upon prevailing relations between the government and society within that country. In countries such as Ethiopia, the existing knowledge production systems could support livestock keepers' participation in adaptation tracking. However, given the limited involvement of livestock keepers in knowledge production and use in Uganda and Kenya, more innovative strategies for capturing the perspectives of livestock keepers are needed. These differences point to the value of anticipating variations in how countries will track and report on adaptation progress by understanding the existing systems of knowledge production and use within countries and designing adaptation tracking in a manner that aligns with these systems. This way the design of adaptation tracking can deliberately enhance linkages between national and sub-national scales and global reporting mandates.

In summary, the examination of the role of national contexts in shaping knowledge production and use has revealed how the design of adaptation tracking could build on existing rules and practices, noting the common strengths and differences in styles of producing and using knowledge on livestock within and across Ethiopia, Kenya, and Uganda. As opposed to seeing differences as an impediment, this dissertation underscores the need for alignment between global reporting guidelines and methodologies and existing institutional structures. Through this alignment, adaptation tracking can be meaningful to actors at local, sub-national, national, and global scales and sustained over time.

Theoretical contribution: Towards an integrated framework for characterizing institutional context for adaptation tracking

In addressing the first research question, this dissertation makes an important theoretical contribution to the adaptation tracking literature by developing an integrated framework that situates calls for the engagement of state and non-state actors in adaptation tracking within existing government rules and practices. There is an emergent literature that characterizes national contexts (e.g., Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP), 2023; Hammill & Dekens, 2014; Klostermann et al., 2018; Price-Kelly et al., 2015). While these works provide evidence of variations between countries, the theoretical grounding of their analysis is seldom explicit, and government-centric analyses overlook important dimensions, such as the participation of non-state actors as technical or non-technical experts. It is also notable that the literature highlighting the need for local non-state actors' participation in adaptation tracking (e.g., Dilling et al., 2019) does so with little consideration of the institutional context within which adaptation tracking will take place. To bridge these gaps in the literature, Chapters 2 and 3 provide a tested framework for examining institutional structures for knowledge production and use, drawing on civic epistemology, public policy, and public administration literature streams. In doing so, this dissertation demonstrates the value of combining these literature streams in supporting the consideration of the relations between the government and society in knowledge production and use and their relevance for adaptation tracking. Furthermore, drawing on public administration literature allows the framework to consider the dynamics within government by considering the politico-administrative linkages and coordination across national and sub-national administrative units. This enabled this framework and its application to go beyond depictions of government as a homogenous unit of analysis (e.g., Jasanoff, 2005) by paying attention to differences and relations within the government.

Empirical contribution: Demonstrating differences in knowledge production and use within and across countries

Based on a comparative study of the rules and practices of knowledge production and use in the livestock sectors of Ethiopia, Kenya, and Uganda, Chapter 3 provides empirical evidence of differences within and across countries, which have important implications for adaptation tracking. While similar analyses exist in the literature (e.g., Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP), 2019, 2023; Hammill & Dekens, 2014; Klostermann et al., 2018), Chapter 3 characterizes Ethiopia which was not covered in these cross-country assessments. Chapter 3 also expands the scope of such analyses by considering the value of other relevant data streams for adaptation tracking, thus advancing previous assessments of national contexts that focus on monitoring processes tied to adaptation plans and strategies (Hammill & Dekens, 2014; Klostermann et al., 2018; Leiter, 2021).

6.2.2 RQ2: What differences exist in how actors perceive climate risks, adaptative capacities, adaptation options, and goals, and how are these differences important for the design of adaptation tracking?

Accounting for similarities and differences in governmental and livestock keeper perspectives

To answer this question, I compared how livestock keepers and governments discuss dimensions that are important to track to understand adaptation progress: climate hazards, impacts, adaptation options, adaptive capacities, and adaptation goals. A thematic analysis of these dimensions revealed that, despite the overlaps in governmental and livestock keeper perspectives, notable differences underscore the importance of integrating different perspectives in the design of adaptation tracking.

Chapter 4 shows that both livestock keepers and governments recognize the importance of climatic hazards such as prolonged dry seasons, changes in rainfall patterns, and increased temperatures in livestock systems. Both groups also referred to similar impacts of these hazards, including changes in the availability of feeds and water for livestock, the prevalence of pests and diseases as well as fluctuations in livestock production and related impacts on the contribution of livestock to livelihoods. To minimize these impacts and to achieve adaptation goals, such as food security and maintaining revenue from livestock, livestock keepers and

governments mentioned common adaptation strategies related to veterinary care, investments in water infrastructure, feed production and management, and breeding. Similarly, access to quality inputs, extension services, markets, and knowledge to support adaptation is critical in relation to adaptive capacities. Agreement on these themes indicates the possibility of developing adaptation tracking indicators that are meaningful to the livestock keepers' and governments' perspectives and priorities. It also highlights elements for which corresponding indicators can be used to compare adaptation progress across geographical contexts.

However, differences in governmental and livestock keeper perspectives and the variations in the extent of agreement across countries are also important to note. The findings in Chapter 4 highlight several advantages of integrating livestock keepers and governmental perspectives. First, considering the themes that were exclusively discussed by livestock keepers, it was evident that integrating livestock keeper perspectives in the development and application of adaptation tracking tools is crucial for capturing the context-specificity of climatic hazards, impacts, adaptive capacities, adaptation options and goals. Since national policies tend to be generic, discussions with livestock keepers revealed differences in experiences and priorities across the sampled livestock production systems. Secondly, integrating the perspectives of livestock keepers and governments could also be useful in capturing adaptation progress across scales. For instance, while livestock keeper perspectives highlighted the adaptation efforts at the farm level, government policies captured the efforts at national and sub-national levels. Highlighted adaptation efforts by governments included the development of adaptation plans and programs, government investments in critical areas such as water infrastructure, and enacting policies that create an enabling environment for state and non-state actors to adapt. Thirdly, integrating governmental and livestock keeper perspectives could support the evaluation of adaptation outcomes at the farm, sub-national and national levels, and eventually at the global level, thus a better consideration of the linkages and variations across spatial scales. Capturing cross-scalar variation in adaptation progress is a prerequisite for understanding how adaptation impacts systems with varying vulnerability levels. Besides linking autonomous and public adaptation, integrating multiple perspectives could also help in alleviating the risk of adaptation tracking obscuring the experiences of local stakeholders who are often excluded from high-level adaptation discussions (Ayanlade et al., 2023; Dilling et al., 2019; Eriksen et al., 2021; Rahman & Hickey, 2019).

In sum, granting the results reported here, integrating governmental and livestock keeper perspectives is an effective strategy for ensuring that adaptation tracking is meaningful.

Integration is important in identifying metrics that support the comparison of adaptation progress across diverse contexts and in reflecting the diversity of adaptation actions, needs, and priorities across farm, sub-national, and national scales.

Empirical contribution: Advancing the understanding of the relevance of multiple perspectives for adaptation tracking

As illustrated in Chapter 4, there are divergent ideas on what constitutes adaptation and how to measure it. While many approaches focus on planned adaptation by governments, with policy documents and government reports being the main reference points in defining and evaluating adaptation (e.g., Berrang-Ford et al., 2019; Brooks et al., 2011; Food and Agriculture Organization of the United Nations (FAO, 2017; Moehner et al., 2021), others argue for the need to integrate multiple perspectives in adaptation tracking (e.g., Dilling et al., 2019). However, this literature does not discuss what will be gained by integrating multiple perspectives. This dissertation addresses this gap by empirically showing the themes discussed by livestock keepers and policy documents and the advantages of combining them. In doing so, this dissertation demonstrates the value of integration by developing adaptation tracking metrics that correspond with the diversity of adaptation experiences and priorities at various scales and contexts.

6.2.3 RQ3: How does the co-production of the TAiLS tool shape its sensitivity to existing institutional structures of knowledge production and use and diversity of stakeholder perspectives?

Insights from the co-production of the Tracking Adaptation in Livestock Systems (TAiLS) tool

Findings for RQ1 show variations in how governments produce and use knowledge relevant for tracking adaptation in livestock systems, while RQ2 demonstrates differences in governmental and livestock keeper perspectives on adaptation. In this dissertation, I also practically demonstrated how the insights from RQ1 and RQ2 can be considered when designing an adaptation tracking tool. Therefore, in Chapter 5, I document the process of developing the TAiLS tool through extensive consultations with livestock keepers, governments, and researchers. Chapter 5 presents an opportunity to reflect on the value of an instrumental co-production approach in designing adaptation tracking tools that align with prevailing institutional structures and diverse adaptation experiences and priorities. In the

context of this dissertation, instrumental co-production refers to the iterative process through which diverse individuals and groups contribute to the design of adaptation tracking using a mix of activities (Bremer & Meisch, 2017; Brix et al., 2020; Miller & Wyborn, 2018; Turnhout et al., 2020).

Building on a study of the institutional structures of producing and using knowledge on livestock systems (Chapter 3) and the involvement of relevant government officials (Chapter 5), the TAiLS tool aligns not only with existing rules and practices but also with the preferences of government officials on how best to institutionalize adaptation tracking. As a result, the TAiLS tool was tailored to each country to draw on contextually appropriate data streams and represent adaptation results. Organizing the process in each country simultaneously also created opportunities for government officials to discuss reforms and support needed to make adaptation tracking feasible, including how to capture the experiences of livestock keepers. This way, co-production was useful in situating adaptation tracking within the existing rules and practices of knowledge production and use. Moreover, a co-production approach allowed multiple perspectives to shape the choice of adaptation tracking metrics. The selection of the metrics used in the TAiLS tool was informed by a consideration of the perspectives of diverse stakeholders, including livestock keepers, governments, and researchers, on key components fundamental to adaptation tracking. As a result, as shown in Annex 6, the tool brings together a rich mix of indicators that capture the uniqueness of adaptation contexts, including the diversity of livestock production systems and the governance arrangements. The tool also brings together metrics that can assess adaptation at farm, sub-national, and national levels. The selection of the indicators also considered if they could be feasibly tracked considering prevailing intra-governmental dynamics and state-society relations. The value of a co-production approach was thus in supporting a process of designing adaptation tracking that considered diverse perspectives and country-specific institutional structures.

While sensitivity to the existing structures and the diversity of perspectives is crucial, ensuring that the tool can be practically used to track and report on adaptation is also important. In being an active participant and facilitator of the process of developing the TAiLS tool, the co-production approach allowed me to strategically draw on diverse sources of input to ensure that the priorities of different actors were incorporated in the best way possible while optimizing the utility of the TAiLS tool for tracking and reporting on adaptation across space and time. For instance, while numerous metrics were initially identified to correspond with the diverse

issues raised by each stakeholder group, iterative and systematic refinement of these metrics supported the development of a lean but rich set of metrics included in the TAiLS tool.

Furthermore, stakeholder engagement in developing the TAiLS tool supported the exchange of knowledge among peers. This was particularly important for the livestock keepers. By framing the adaptation tracking process in a manner that was meaningful for them, in addition to sharing their experiences with government processes, livestock keepers used the FGDs to share knowledge on adaptation to climate change. It also facilitated a bottom-up approach through which the priorities and needs of livestock keepers were made visible to the government. Similarly, national and sub-national government officials shared their experiences with national and global processes of monitoring and reporting as well as the implementation of adaptation policies, which informed discussions on how best to institutionalize adaptation tracking.

Methodological contribution: Demonstrating *why* and *how* to co-produce an adaptation tracking tool

In documenting the co-production of the TAiLS tool (Chapter 5) and reflecting on the value of a co-production approach, this dissertation provides evidence for and rationale for co-producing adaptation tracking tools. While many works focus on developing adaptation tracking tools with indicators that can directly be applied across countries (e.g., Ford 2019), few document the process of developing the tools. As such, there is limited knowledge of how to establish compatibility between top-down approaches that privilege external viewpoints and exclude contextual heterogeneity (Dilling et al., 2019) and bottom-up approaches that capture local nuances but have little potential for scaling (Berrang-Ford, 2017). Besides, as previously noted, parallel literature streams discussing the country-specificity of knowledge systems (Food and Agriculture Organization of the United Nations (FAO) & United Nations Development Programme (UNDP), 2023; Hammill & Dekens, 2014) or are concerned with the integration of diverse experiences and priorities in adaptation tracking (e.g., Dilling et al., 2019). Therefore, Chapter 5 of this dissertation makes a novel contribution to adaptation tracking by demonstrating the value of co-production in addressing these issues: involving people with diverse perspectives, striking a balance between capturing local nuances and adaptation elements that can be tracked across extended spatial and temporal scales, while also considering the institutional structures.

Practical contribution: Developing a tool that is tailored to track adaptation in the livestock sectors of Ethiopia, Kenya, and Uganda

Chapter 5 also highlights the applied research element of this research whereby I facilitate the development of a tool that is tailored to support tracking and reporting on adaptation progress in the livestock sectors of Ethiopia, Kenya, and Uganda. The TAiLS tool has notable differences from existing tools. First, so far, no adaptation tracking tools focus on the livestock sector. There are notable examples of tools specific to the agriculture sector that include a few indicators relevant to livestock systems (e.g., Food and Agriculture Organization of the United Nations (FAO), 2017). Yet, their scope limits the consideration of the wide range of elements that need to be tracked in the livestock sector. Second, cognizant of the inability of existing tools to support a comparison of adaptation progress across space and time (Berrang-Ford et al., 2017), TAiLS tool is specially designed to allow government officials to make statements of adaptation progress across national and sub-national scales and across the years. Third, the TAiLS tool captures input, processes, and outcomes of adaptation at farm, sub-national, and national scales (see Annex 6). This makes the design of TAiLS an important addition to the adaptation tracking literature and practice where there is a proliferation of frameworks that have a narrow view of adaptation progress, for example, by only focusing on the adaptation efforts of governments (e.g., Ford 2019).

6.3 Theoretical reflections

This dissertation uses STS, public administration, and public policy literature streams to build a theoretical basis for the research. These literature streams are compatible, given their common concern with power relations and how their configuration is contingent upon context-specific rules and structures (Jasanoff, 2004, 2005; Wyborn et al., 2019). However, the specific contributions possible from each literature stream and their compatibility provided the rationale for combining them. While STS literature is generally concerned with the mutual relationship between knowledge and governance, public administration and public policy literature offers insights into government relations and how they shape knowledge production and use. Therefore, in combining these literature streams, this dissertation advances political and academic discussions on adaptation tracking by addressing issues previously discussed in parallel. For instance, advocates of participatory design and application of adaptation tracking methodologies do not consider the role of national contexts. Analyses of adaptation tracking systems of governments also do not adequately show variations within governments, and the role of non-state actors is not extensively discussed. Therefore, complementing the three

literature streams allowed the research to situate co-production within existing rules and structures, an approach that is better suited for a more pragmatic consideration of how current systems shape knowledge production and use (Wyborn et al., 2019). Furthermore, compared to previous works on adaptation tracking that do not elaborate on their theoretical underpinning, being explicit on the theoretical approach was central to being transparent on the choice of elements foregrounded in the research and their relationship, which can be the basis for further examination these elements elsewhere (Nilsen, 2015).

6.3.1 Towards a conceptual framework for adaptation tracking

As discussed in section 1.2.1, the ambiguity of concepts central to adaptation tracking and divergent ideas on how to operationalize them is a significant challenge to developing appropriate adaptation tracking methodologies. A major theoretical contribution of this dissertation is providing a framework for operationalizing the concepts. Chapters 4 and 5 highlight important dimensions for tracking adaptation progress across scales: climatic hazards, impacts, adaptive capacities, adaptive actions, and adaptation goals. These dimensions resonate with those proposed by other scholars who use the adaptation cycle as the foundation for contextualized assessment of adaptation (e.g., Berrang-Ford et al., 2019; Park et al., 2012). Furthermore, the overlap in the literature discussing the measurement of adaptation, vulnerability, resilience, and adaptive capacity (e.g., Carr & Nalau (2023); Füssel & Klein, (2006); Intergovernmental Panel on Climate Change (IPCC), (1994, 2022b); Smit & Wandel, (2006); Turner et al., (2003)) suggests the high relevance of these components for adaptation tracking. In developing and applying this conceptual framework, I advance discussions on how to address conceptual issues in adaptation tracking in two ways. First, I show how concepts such as adaptation success, adequacy, and effectiveness can be operationalized to support cross-scalar comparisons and capture variations across geographical contexts. In doing so, I advance suggestions to assess adaptation success in a manner that captures the contribution of diverse actors in addressing climate risks and other societal objectives (e.g., Dilling et al., 2019; Intergovernmental Panel on Climate Change (IPCC), 2022b). These suggestions are typically theoretical and untested, but I show how these ideas can be used to design an adaptation tracking tool. Secondly, Chapter 5 demonstrates how the dimensions can be broken down into indicators for tracking adaptation in the livestock sector. Using this conceptual framework to guide the selection of adaptation tracking indicators, the TAiLS tool incorporated indicators that cover diverse aspects, thus supporting a more comprehensive understanding of adaptation progress. This way, the conceptual framework highlighted in this dissertation goes beyond

frameworks that single out aspects such as progress in adaptation planning (process indicators) or changes in adaptive capacities (outcome indicators) (e.g., Dilling et al., 2019; Moehner et al., 2021).

6.3.2 Integrating constitutive and instrumental co-production lenses

In applying a co-production approach to design the TAiLS tool, this dissertation contributes to the literature on co-production by showcasing the value of integrating constitutive and instrumental co-production lenses. Constitutive co-production is concerned with the mutual relationship between knowledge and social order and is commonly applied as a normative analytical lens to examine the pitfalls of exclusionary ways of knowing in the governance of societal problems (Bremer & Meisch, 2017; Jasanoff, 2004). In contrast, instrumental co-production entails creating actionable knowledge through collaboration between different actor groups (Bremer & Meisch, 2017; Glass et al., 2013; Wyborn et al., 2019). These definitions result in limitations in their application. On one hand, applications of the constitutive lens seldom provide practical demonstrations of how alternative knowledge can be created. On the other hand, instrumental co-production projects often do not critically reflect the social order that is (re)created through the co-production of knowledge, with the de-politicization of co-production running the risk of reinforcing unequal power relations (Bell & Pahl, 2018; Turnhout et al., 2020). As such, scholars posit that there is value in combining multiple co-production lenses (e.g., Bremer & Meisch, 2017), yet there is limited literature demonstrating this combination.

As elaborated in section 1.3, this dissertation was motivated by the awareness of how the design of adaptation tracking mirrors the normative choices of those involved in deciding what counts as adaptation progress and how to measure it, which in turn, could determine adaptation priorities moving forward (constitutive co-production). This compelled the dissertation, including the design of the TAiLS tool, to pay attention to how to integrate multiple experiences and perspectives through the collaboration of livestock keepers, governments, and researchers (instrumental co-production). The combination of the two lenses was instrumental in supporting a reflexive approach (Stirling, 2006), meaning the design of the TAiLS tool entailed critically reflecting on the process and output and making changes accordingly. I use two examples to demonstrate this.

First, the increasingly complex dynamics that come into play as different actors come together to co-produce knowledge are important to consider (Turnhout et al., 2020; Wyborn et al.,

2019). For instance, as opposed to presuming that co-production unfolds seamlessly, it is important to consider dynamics between actors and make a deliberate effort to create a conducive space for actors to express themselves freely and to empower those who might be marginalized to participate in co-production processes (Bell & Pahl, 2018; Wittmayer & Schäpke, 2014). Therefore, in anticipation of the hierarchical power dynamics that might hinder interactions between government representatives and livestock keepers, I chose to engage with the government officials and livestock keepers separately. Sociocultural power asymmetries among livestock keepers would have silenced certain perspectives. This led to the decision to disaggregate the FGDs by age and sex, as highlighted in Chapter 4. Also as highlighted in Chapter 5 (section 5.3.3), the framing of indicators that corresponded with the elements that the different stakeholders recognized as important to track was carefully done in recognition of the unintended consequences the indicators might have in shaping adaptation priorities.

Second, while instrumental co-production is presented as an unproblematic process, another major issue revealed by considering the constitutive lens is the restricted scope within which co-production takes place. Akin to undertaking co-production within pre-negotiated constructs such as sustainability (Pohl et al., 2010), I recognize that this research also took place within a domain where some of the elements had already been pre-defined. For instance, I focus on governments as the primary actor group that oversees and facilitates adaptation tracking and reporting. Besides, the focus on climate change adaptation also places less emphasis on non-climatic drivers of change to which governments and livestock keepers respond. Such predefinition of scope is criticized for "pressurizing non-elite participants to stay within … sanctioned reality" (Turnhout et al., 2020, p. 16) and the associated use of co-production to rubber stamp ideas that maintain the status quo (Bell & Pahl, 2018). Such trade-offs are inevitable due to the need to track adaptation at national and global scales. Nonetheless, the value of this dissertation remains in advancing academic knowledge and providing practical insights into how to design adaptation tracking in a manner that is meaningful to local, sub-national, national, and global scales.

In sum, this dissertation provides evidence of how combining constitutive and instrumental co-production lenses helps a practical exploration of alternative ways of designing adaptation tracking while supporting a reflexive stance needed to make those alternatives meaningful and effective.

6.3.3 The importance of linkages between local, sub-national, national, and global scales in adaptation tracking

By empirically showing the variations within and across countries in how they produce and use knowledge (Chapter 3) and in governmental and livestock keeper perspectives (Chapter 4), this dissertation provides an imperative for cross-scalar linkages in adaptation tracking. In addition, Chapter 5 provides evidence of how paying attention to these variations can be particularly useful in informing the design of adaptation tracking tools that meaningfully capture adaptation priorities and experiences across scales while ensuring adaptation tracking can be sustained over time by aligning with existing institutional structures.

Establishing linkages between local, sub-national, national, and global scales could be valuable in pragmatically addressing the challenges hampering adaptation tracking. For instance, one of the major challenges in tracking adaptation discussed in Chapter 1 is the lack of data to assess adaptation progress over extended spatial and temporal scales (Ford et al., 2013; Olhoff et al., 2018). As Chapter 3 demonstrates, the three countries have data streams that could support adaptation tracking in the livestock sector. The metrics captured by these data streams, such as livestock diseases and measures to control them, uptake of improved livestock production technologies, and socioeconomic situations, can support the assessment of the efforts of livestock keepers and governments and adaptation outcomes at farm, sub-national, and national scales. As these data are produced by designated administrative units at national and sub-national levels, placing them at the core of adaptation tracking and reporting underscores an opportunity for capitalizing on linkages between sub-national and national processes of producing knowledge to avail the data that is urgently needed to track adaptation. Similar noteworthy accountability mechanisms, coordination rules, and structures exist in these countries and may be useful for adaptation tracking. This dissertation advances literature that highlights the importance of linking adaptation tracking at the global level with national processes (e.g., Beauchamp, 2023; Hammill & Dekens, 2014; Karlsson-Vinkhuyzen et al., 2018; Leiter, 2021) by providing empirical evidence of key issues that need to be addressed and further demonstrating how linkages across scales can be optimized in the design of an adaptation tracking tool.

6.4 Methodological reflections

6.4.1 Accounting for the role of the researcher

Given the role of the researcher in qualitative research, the researcher is a fundamental part of the research design (England, 1994; Merriam & Tisdell, 2016). Therefore, in reflecting on the research methods, I focus on my positionality to highlight some of the primary ways I observed my biography shaping the research process and output.

I have an academic background in both natural and social sciences, which explains my engagement with diverse topics within the study, from the technical aspects of adaptation to the political nature of adaptation tracking. Drawing on this background, this study uniquely led to the development of the TAiLS tool, which accounts for dynamics within social, economic, and biophysical systems. As a social scientist interested in climate governance and the nationalization of global agreements, I was inclined to consider the politics of measurement by foregrounding the plurality of perspectives and the need to align with government systems. Other personal characteristics such as outward markers of a researcher's "belonging" or identity can also influence the willingness of research participants to engage in research, especially during interviews (England, 1994). As I did data collection in Kenya, Uganda, and Ethiopia, in interactions with both government officials and livestock keepers, what was striking was that my identity was often debated as my complexion and facial features did not give clear clues of my nationality or tribe. As this discussion was often put forward on a light note, over time, I learned to ride on it as an icebreaker, thus creating rapport with the respondents. Moreover, data collection took place when there were travel restrictions due to the Covid-19 pandemic and political unrest in the region. Consequently, I had to devise innovative ways of engaging with various stakeholders through research assistants who were based in the field sites and virtual meetings. While this limited my direct influence during data collection, it was still possible to influence the study during the analysis and interpretation of findings. To mitigate this, I validated the study findings with various research participants after data analysis.

While facilitating co-production processes, researchers play a key role in knowledge brokering as they mediate different interests and thought styles (Pohl et al., 2010; Wittmayer & Schäpke, 2014). Within this process, it is important to account for the interests and thought styles of the researchers as they shape the process and outcomes of co-production. This dissertation was motivated by the need to pay attention to local realities and priorities when designing

adaptation tracking. Nonetheless, it was also partially shaped by externally driven priorities based on the desire to align with ongoing national and global discussions on adaptation tracking. To do this, I had to ensure that the diverse perspectives of livestock keepers, governments, and researchers were captured in the TAiLS tool by first framing adaptation tracking in a way that was relatable to each stakeholder group and further translating their views into usable input for adaptation tracking. This means that process facilitation occurred in a restricted scope predetermined by the set research topic, its context, and expected output. Additionally, as noted in Chapter 1, my affiliation with PCSL and the International Livestock Research Institute (ILRI) had implications for the research design. This affiliation was valuable to the research as it provided access to human and financial resources, information, and networks that were valuable to the success of this research. However, it led me to focus exclusively on the livestock sector to align with programmatic and institutional mandates. While focusing on the livestock sector allowed me to build on a sectoral approach to adaptation tracking, this narrow focus precludes complex cross-sectoral interactions. In the next section, I will further reflect on the study limitations related to this point.

6.4.2 Study limitations and areas for further research

Along with contributions, this research also had limitations. Since I discuss specific limitations related to each of the previous chapters, in this section, I reflect on the overarching limitations of the dissertation and propose areas for future research.

First, the dissertation addresses both institutional and technical aspects of adaptation tracking. Although this allowed the research to address a wide range of issues, this came at the cost of an in-depth study of each aspect. For instance, in relation to the involvement of non-state actors within the livestock value chain in adaptation tracking (Chapters 3 and 4), this dissertation focuses on livestock keepers. However, to make adaptation tracking even more inclusive, other actors should be involved. For instance, the private sector plays a vital role in complementing the efforts of governments and citizens through the mobilization of financial resources and the development of innovative adaptation technologies and services while also adapting their operations to climate change impacts (Biagini & Miller, 2013; Godde et al., 2021; Pauw & Pegels, 2013). In the livestock sector, the private sector includes consumers, financial institutions, agribusinesses, private companies, and many other entities involved in processing and distributing livestock and livestock products. Future research should investigate the priorities of these actors and how they can be actively involved in the design and application

of adaptation tracking methodologies. Inversely, the research focused on the livestock sector. While this demarcation allowed the research to have an in-depth understanding of government systems of producing knowledge relevant to the livestock sector as well as bringing out cross-scalar nuances that are often neglected when the livestock sector is lumped with other agricultural sectors (Pica-Ciamarra et al., 2014), this research did not account for the interactions across sectors. For instance, crop and livestock production are widely integrated as an adaptation strategy as well as shifts to alternative economic activities (Thornton & Herrero, 2014). A sectoral approach will be useful in tracking and comparing sectoral priorities, needs, and progress (Ford et al., 2013). However, future studies could consider how sectoral tracking and reporting will be consolidated to account for interconnections across sectors.

Second, transboundary climate risks and the related need for cross-country cooperation in addressing such risks and assessing the effectiveness of efforts are crucial. For instance, in Africa, regional efforts are required to deal with issues such as sharing water and pasture, the spread of human and livestock diseases, and cross-country movement of livestock in search of pasture (Intergovernmental Panel on Climate Change (IPCC), 2022b; Opitz-Stapleton, 2023). However, with the focus on developing a country-specific tool for tracking adaptation, this study does not extensively capture efforts to address transboundary climate risks. Therefore, further work is needed to strategize how to capture these cross-country adaptation efforts and results without double counting.

Third, with adaptation tracking being a continuous process that takes place in dynamic institutional, environmental, and political contexts, there is an imperative for a research agenda that goes beyond the time scale allowed by this research project. One, in line with this dissertation's main argument for aligning adaptation tracking with government systems to ensure its sustained tracking and reporting, it would be insightful to examine if and how adaptation tracking is situated within evolving institutional contexts. For instance, as noted in Chapter 3, some administrative adjustments were underway at the time of the study, implying that the engagement with institutional aspects of adaptation tracking will be a continuous process. Two, evaluating the suitability of the selected adaptation tracking metrics in cognizance of shifts in climate risks and adaptation priorities across space and time could be valuable. Three, research is also needed on how the development of adaptation tracking guidelines at the global level evolves and the extent to which the political discussions accommodate evidence of local and national realities. This research could also trace how adaptation tracking and reporting will shape adaptation governance and action across scales.

Fourth, adaptation tracking straddles many domains with persistent debates such as contention over the definition and measurement of vulnerability and resilience concepts (e.g., Béné et al., 2012; Delaney et al., 2016; Levine, 2014) as well as the construction and utility of composite indices and maps in decision-making (e.g., Baptista, 2014; de Sherbinin, 2014; Hallegatte & Engle, 2019; Hinkel, 2011). While the process of designing adaptation tracking methodologies may offer useful insights, providing a consensus on these debates is beyond the scope of any project focused on designing adaptation tracking. Therefore, the research community within these domains needs to provide a practical way forward for adaptation tracking to build upon.

6.5 Recommendations for policy and practice

Throughout the dissertation, I have made practical recommendations that I believe could be useful in advancing adaptation tracking. In this section, I consider these recommendations in the context of adaptation tracking more broadly, focusing on the policy discussions and practices for advancing adaptation tracking: definition of adaptation tracking methodologies and guidelines, capacity building for adaptation tracking, and science-policy engagements. Although presented separately, these three issues are interconnected.

6.5.1 Designing methodologies and guidelines for adaptation tracking and reporting

The global and national politics that come into play in governance-by-disclosure mechanisms and the intricate link between transparency and action is a central issue in the design of global reporting systems (Dooley & Gupta, 2017; Gupta, 2008; Gupta & Mason, 2016; Hickmann et al., 2022; Mol, 2014). Normatively, adaptation tracking should make information on adaptation progress available to state and non-state actors, thus nudging them to engage in more ambitious and effective adaptation efforts. However, the link between disclosure and transformative outcomes is contingent upon information quality, reliability, legitimacy, and utility for holding actors accountable and decision-making (Karlsson-Vinkhuyzen et al., 2018; Mol, 2014; Weikmans et al., 2020). For instance, to address information gaps in the GST, discussions in the political and scientific arena suggest the use of multiple sources of evidence, including comparable government reports, subjective expert assessments, scientific synthesis, as well as reports from non-state actors, such as civil society (Christiansen et al., 2020; Magnan & Chalastani, 2019; Tompkins et al., 2018). Integrating diverse information sources could greatly improve the understanding of adaptation progress at the global level. However, such an approach raises concerns over how the insights from the GST will inform adaptation planning and decision-making at national and sub-national scales. In developing adaptation tracking

methodologies and tools, this dissertation echoes Beauchamp (2023), by recommending linkages across local, sub-national, national, and global scales for adaptation tracking to be meaningful. This implies adopting a country-driven approach that integrates adaptation tracking and reporting within government systems, promoting adaptation tracking methodologies that capture diverse adaptation experiences and priorities, and empowering diverse stakeholders to engage in the design and implementation of adaptation tracking. This would help enhance ownership of information and its integration into decision-making and planning in a manner that addresses the context-specificity of adaptation needs, capacities, and aspirations. Furthermore, given that there are no 'hard' consequences for inadequacies in climate action at the global level, such an approach is well aligned with the suggestion by Karlsson-Vinkhuyzen et al. (2018) for the use of domestic mechanisms to enhance accountability.

At the national level, countries could identify adaptation tracking tools and systems that allow them to capture national, sub-national, and local priorities and are aligned with existing institutional structures. This necessitates collaboration between governments and non-state actors (e.g., researchers, practitioners, farmers, private sector) in developing methodologies that are fit for context, thus enabling countries to meet their international reporting obligations while producing information needed to guide policy decisions that address locally situated adaptation priorities. At the global level, countries could define a tracking and reporting framework that provides clarity on procedural matters as well as overarching themes that can be used to synthesize evidence on adaptation progress at the global level, thus allowing countries to align with these themes cognizant of their adaptation priorities and contexts (Beauchamp, 2023; Leiter, 2022). Paying attention to the role of adaptation tracking in evaluating adaptation progress and informing adaptation planning is crucial for the design of effective adaptation tracking.

6.5.2 Supporting adaptation tracking and reporting within countries

How the discussions on the design of adaptation tracking methodologies and guidelines evolve and the subsequent capacity-building programs will be crucial in determining the effectiveness of adaptation tracking and reporting (Konrad et al., 2022; Leiter, 2022). This is particularly important in allowing adaptation tracking to build on existing systems and processes while addressing country-specific capacity needs to make adaptation tracking useful nationally and globally. Actors within the adaptation tracking domain could learn from other more established

domains, like mitigation, MDGs, and SDGs, where scholars are increasingly showing how technocratization through standardized methodologies and downplaying the role of power dynamics undermine the trickling down of globally agreed goals to national and local actors (Gupta & Mason, 2016; Hickmann et al., 2022). This means that contrary to scholars that conceptualize parallel roles of the international community and domestic actors in terms of technical capacity building in relation to defining standard reporting guidelines and institutional reforms, respectively (e.g., Wang & Gao, 2018), it is necessary for technical and institutional capacity building to take place in tandem.

As opposed to deficit models that focus on what is not aligned with externally driven expectations, it is important to engage with countries to identify local processes and structures that could support adaptation tracking and the country-specific capacity needs. Strengthening the capacity of countries to track and report on adaptation may come in the form of supporting dialogue within countries and learning across countries to identify and work on institutional reforms that can make adaptation tracking effective. In line with this dissertation's emphasis on the importance of a country-driven approach in enhancing cross-scalar linkages in adaptation tracking, capacity-building programs should also be continuously customized to match each country's tracking and reporting needs. This would ensure relevance and allow adaptation tracking to build on what is already working well within countries and gain root as a process that is useful across local, subnational, national, and global scales. This way adaptation tracking will be both meaningful to actors involved in tracking and sustained over time.

6.5.3 Science-policy engagement in designing and implementing adaptation tracking

The daunting task of designing adaptation tracking necessitates a reflection on the role of science. Ambiguity in concepts central to climate governance, the lack of scientific agreement on assessment methodologies, and the persistent need for evidence to inform policy decisions have led to divergent opinions about the role of science in supporting a political consensus. On one extreme, there are those who believe that scientists should leave the decisions on methods to assess and compare countries to politicians. For example, Klein (2009) argues that due to the failure of science to provide one "true and objective" method for assessing and ranking the vulnerability of countries, the selection of the best method out of the many scientists put forward should be left to negotiators who can discuss and arrive at a "... compromise of different and biased interpretations of vulnerability" (p. 291). But how can we ensure that the

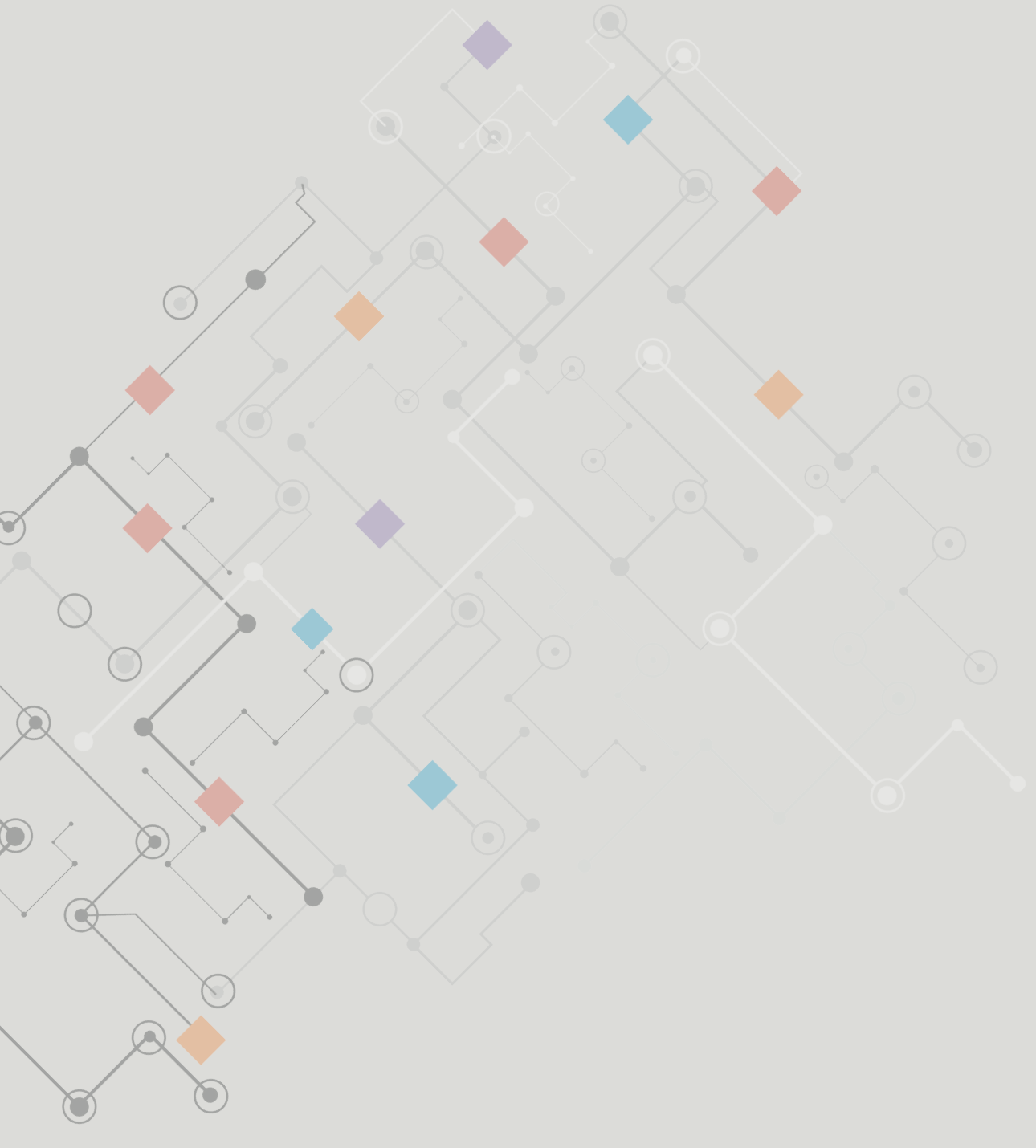
politicians' normative choice is sensible? On the other extreme, others center the role of scientists. For instance, Magnan & Chalastani (2019) propose the disentanglement of adaptation tracking from national and global politics through the design and application of an adaptation tracking methodology that uses a universal set of indicators that experts can assess centrally. I recommend a middle ground where scientists can engage with policymakers in designing and implementing adaptation tracking. For instance, science still has a vital role in highlighting the wide range of aspects that policymakers need to consider when defining adaptation tracking guidelines (Briggs et al., 2015; Hinkel, 2011; Leiter, 2022). Policymakers also need to point out the knowledge gaps that must be addressed to arrive at a political consensus, and perhaps co-create knowledge with scientists. However, it is important for "science" to be conceptualized more broadly to include non-scientific ways of knowing. This implies the relevance of co-production approaches that allow a two-way relationship between new ways of knowledge production and decision-making (Wyborn et al., 2019).

This way, science-policy engagements can pave the way for researchers, practitioners, local actors, and negotiators to influence the design of adaptation tracking. This dissertation has demonstrated how collaboration between researchers, livestock keepers, and governments can be instrumental in developing an adaptation tracking tool that accounts for government systems and adaptation priorities across scales. Insights from these national-level engagements can be useful in informing the design of adaptation tracking guidelines at the global level. For instance, at the global level, the GGA workshops organized in the run-up to COP28 could be useful avenues for science-policy engagement and should endeavor to open up the space for debate that embraces diverse approaches and pushes discussions towards making adaptation tracking and reporting a process that will be useful for decision-making and planning across scales. Other processes such as the syntheses by the adaptation committee on the state of the art of adaptation tracking are also important entry points for non-state actors to contribute to the process.

6.6 Concluding remarks

The overall objective of this dissertation was to build knowledge on how to design adaptation tracking. Conceptual ambiguity, lack of appropriate tools for tracking adaptation across scales, and inadequacies in available data hamper the assessment of if adaptation is taking place and its effects. Based on research on the livestock sectors of Ethiopia, Kenya, and Uganda, this dissertation has provided new insights into the importance of considering existing institutional

structures of knowledge production and use, the plurality of adaptation experiences and priorities, and the potential for collaborative approaches in designing adaptation tracking. Aligning adaptation tracking within country-specific rules and practices of producing and using knowledge is paramount in building on existing systems and resources. This creates better chances of ensuring continuity and making adaptation tracking meaningful within countries for the long term. Regarding adaptation plurality, recognizing variations in adaptation experiences and priorities across scales and geographical contexts in the design of adaptation tracking is crucial as it helps capture the adaptation efforts of state and non-state actors as well as adaptation results across scales. As such, co-producing adaptation tracking tools becomes necessary to ensure that various issues are adequately considered in the design and application of adaptation tracking tools. Addressing these three aspects in the design and application of adaptation tracking looks promising in ensuring that adaptation tracking offers an opportunity to tailor methodologies that fit national contexts and catalyzing the cross-scalar linkages required to make adaptation tracking meaningful.



Appendix

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Annexes

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Annexes

Annex 1: List of policy documents analyzed to characterize rules and practices of knowledge production and use (Chapter 3)

Country	Title	Year/ period
Ethiopia	Proclamation Number 4 – a proclamation to provide for the definition of powers and duties of the executive organs of the Federal Republic of Ethiopia	1995
	Proclamation Number 449 – a proclamation to provide for the re-establishment of the census commission	2005
	Proclamation Number 442 – A proclamation to establish the Central Statistics Authority	2005
	Ethiopia's Climate Resilient Green Economy Strategy	2011
	Ethiopia's updated NDC	2021
Kenya	Statistics Act	2006 (revised in 2019)
	Climate Change Act	2016
	Kenya National Bureau of Statistics Data Access and Data Dissemination Policy	2012
	Kenya National Adaptation Plan	2015 – 2030
Uganda	Climate Change Act	2021
	Uganda Bureau of Statistics Act	1998
	National Adaptation Plan for the Agriculture Sector	2018

Annex 2: List of government officials interviewed to characterize rules and practices of knowledge production and use (Chapter 3)

Country	Affiliation	Code
Ethiopia	Ministry of Agriculture – Environment and climate change coordination directorate	ET_191125_1132_Fe_MoA_Env & CC directorate
	Ministry of Agriculture – Markets development directorate	ET_191125_1324_Fe_MoA_markets development directorate
	National Animal Genetics Improvement Institute	ET_191125_1722_Fe_MoA_NAGII
	Ministry of Finance and Economic Development – CRGE facility	ET_191126_0927_Fe_MoFED_CRGE
	Environment Forestry and Climate Change Commission	ET_191126_1401_Fe_EFCCC/ EPA

	Ministry of Agriculture – Feeds Development Directorate	ET_191126_1619_Fe_MoA _feeds development directorate
	Ministry of Agriculture – Dairy Directorate	ET_191125_1000_Fe_MoA_Dairy Directorate
	Central Statistics Authority	ET_191126_Fe_CSA_
	Amhara Region Livestock office (Zone)	ET_191127_1035_Zo_livestock office
	Amhara Region Livestock Office (Zone)	ET_191127_1408_Zo_ livestock office
	Amhara Region Livestock Office (Kebele)	ET_191127_1535_Ke_ livestock office
	Amhara Region Livestock Office (Kebele)	ET_191128_1252_Ke_livestock office
	Amhara Region Livestock Office (Woreda)	ET_191128-1028_Wo
Kenya	Ministry of Agriculture Livestock Fisheries and Cooperatives – State Department of Livestock	KE_200218_1314_Na_MoALF_SDL
	Ministry of Agriculture Livestock Fisheries and Cooperatives – Climate Change Unit	KE_200218_1421_Na_MALFC_CCU
	Ministry of Environment and Forestry – Climate Change adaptation Directorate	KE_22112019_Na_MoE_Adp Dir_
	Kenya National Bureau of Statistics	KE_KNBS
	County Government of Bomet – Department of Agriculture	KE_200304_0946_Co_Bomet
	County Government of Kajiado – Department of Agriculture	KE_201026_1135_Co_Kajiado
	County Government of Bomet – Department of Agriculture	KE_200304_1142_Co_Bomet
Uganda	Uganda Bureau of Statistics – Agriculture and Environment Statistics	UG_200214_1147_Na_UBOS
	Uganda Bureau of Statistics – Environment Department	UG_Na_UBOS_Env dept
	Uganda Bureau of Statistics – Livestock Department	UG_Na_UBOS_Livestock dept
	Ministry of Agriculture Animal Industry and Fisheries – Dairy Development Authority	UG_200214_1441_Na_MAAIF_DDA
	Ministry of Agriculture Animal Industry and Fisheries – Statistics Unit	UG_200210_1011_Na_MAAIF_statistics unit
	Ministry of Agriculture Animal Industry and Fisheries	UG_200210_1431_Na_MAAIF
	Ministry of Agriculture Animal Industry and Fisheries – Statistics Unit	UG_200211_1430_Na_MAAIF_statistics unit

	Ministry of Water and Environment – Climate Change Department	UG_200211_1549_Na_MWE_CCD
	Ministry of Agriculture Animal Industry and Fisheries	UG_200212_1350_MoA_Sub-county
	Ministry of Agriculture Animal Industry and Fisheries	UG_200213_0903_MoA_District
	Ministry of Agriculture Animal Industry and Fisheries	UG_200213_1054_District
	Ministry of Agriculture Animal Industry and Fisheries	UG_200212_1206_District

Annex 3: Details of Focus Group Discussions (FGDs) held with livestock keepers to study their involvement in knowledge production and use (Chapter 3). These FGDs were also used to examine livestock keeper perspectives on adaptation climatic hazards, impacts, adaptation options, adaptation capacities, and adaptation goals (Chapters 4 and 5).

Country	**Type of livestock production system**	**Number of FGDs**	**Number of participants**			
			Female elders (35 years and above)	**Male elders (35 years and above)**	**Female youths (18 – 34 years)**	**Male youths (18 – 34 years)**
Ethiopia	Highland Mixed Crop-Livestock	8	14	14	12	12
Kenya	Lowland Mixed Crop-Livestock	12	22	20	20	19
	Grazing-pastoral	12	21	20	21	22
Uganda	Grazing non-pastoral	16	32	33	27	28
Total		48	89	87	80	81

Annex 4: FGD guide (Chapters 3 and 4)

Thank you all for attending this meeting. My name is ……. I work with the International Livestock Research Institute (ILRI). ILRI is implementing a project called the Program for Climate Smart Livestock Systems in Ethiopia, Kenya, and Uganda. Within that project, this part of the research aims at developing protocols for long-term tracking of adaptation to climate change in the livestock sector by integrating the perspectives of the government and livestock keepers.

Our discussion today aims at understanding the changes that you have observed in your locality in relation to climate change and livestock production, if and how you are responding to these changes, as well as your preferences for monitoring the outcomes of these strategies. This meeting is a significant component of the research, and your active involvement will help us to develop protocols that capture the interests and priorities of livestock keepers. We plan to share preliminary research findings with the relevant stakeholders early next year, where we will have more rounds of discussions.

This meeting will take approximately 1.5 hours, and I have a list of questions to guide the discussions.

We will treat the information with the utmost confidentiality, and we shall ensure that the data cannot be traced back to you. Feel free to point out if there are questions you are not comfortable discussing or where you need further clarification. There are no right or wrong answers.

Please note that your participation in this meeting is voluntary. There will be no financial compensation, apart from the reimbursement for transport costs incurred coming to the meeting.

I will be taking notes from the discussions, which will be used as data in the research. I would like to audio record the conversation for later reference with your permission. I would also like to take photographs during the discussions.

Are there any questions so far?

Is there anyone with objections or concerns?

Do you consent that we carry on with the discussions?

****

1. Climate risks and impacts on livestock systems
    a. Compared to the conditions that were there 30 years ago, have you observed any changes in climate and weather patterns in the area? *Or Based on your knowledge of the history of the area what changes in climate and weather have been observed?*
    b. If yes, what are those changes? (*Examples of possible observed changes in weather elements such as temperature, rainfall, wind: comparing the amount of*

rainfall between rainy seasons, changes in amount of rainfall received over the years, changes in the onset of wet and dry season, frequency and intensity of droughts or floods etc).

c. Have these changes affected livestock production? How? (*Probe for changes related to the prevalence of diseases, changes in quality and/or quantity of fodder/pasture and water, changes in livestock productivity, changes in livestock numbers, conflicts, and migration trends)*

d. What non-climatic factors do you think contribute to these impacts*? (e.g., land shortage, population increase, shifts in land use, etc)*

2. Individual and collective adaptation strategies at the household and community levels:

a. Are there strategies that you have put in place to respond to the impacts of climate change on livestock systems? If yes, what are some of those strategies? (*examples: strategies and technologies for water and fodder/pasture management, treating and/or mitigating diseases, improved livestock breeds, livelihood diversification, insurance, destocking etc)*

b. As a community, are there collective strategies have you put in place to deal with these changes? If yes, what are some of those strategies? (*see 2a above for some examples. Others may include institutional reforms, for example, in resource management, cooperatives for marketing agricultural produce, etc)*

3. What are the immediate, intermediate, and long-term goals of these adaptation strategies you have mentioned? (for example, increasing or maintaining livestock stocks, productivity, or incomes)
4. What shows the success of these strategies in helping you deal with climate stress at household and community levels? (*categories of indicators to include: social, economic, biophysical)*
5. What factors support or enable you to adopt these strategies? (*Examples of factors: infrastructure, access to markets, availability of technical support, for instance, Artificial Insemination in the adoption of improved animal breeds, financial support, changes in institutional arrangements)*
6. Are there actors who are supporting you in the adoption of these strategies? How are they supporting you? (*support from the government, projects from development partners, private entities, community investments*)
7. What else do you wish you could be doing to respond to these changes? Why are you not engaged in these additional/alternative strategies?

Farmer preferences for long-term assessment of adaptation

8. Do you think there is a need for the government to regularly be collecting information on how you are adapting to climate change? What information should be collected?
9. What processes of collecting this information would best represent your perspective as a livestock keeper?
10. What would this information be used for?
11. Are you aware of any activities undertaken to collect information on livestock by the government? Are farmers involved in these activities? How?

12. Are there activities for information gathering that take place within the community that would help you to monitor and understand issues around livestock production and adaptation to climate change? (E.g., *directive from the government, community initiative, or a key actor in the area who collects and shares the information with the community).* What is this information used for?

(Thank the participants for their responses and reiterate what this information will be used for. Then open the discussion to questions and additional comments before closing.)

Annex 5: List of policy documents analyzed to characterize governmental perspectives on adaptation climatic hazards, impacts, adaptation options, adaptation capacities, and adaptation goals (Chapters 4 and 5)

Country	Title	Year/ period	Rationale for inclusion
Ethiopia	Climate-Resilient Green Economy Green Economy (CRGE) Strategy	2011 – 2021	Provides a 10-year plan for climate action and development across the sectors
	Growth and Transformation Plan II (GTP II)	2015/16 – 2019/20	Provides 5-year development priorities for the country
	Livestock master plan	2015 – 2020	Highlights the pathways for addressing the challenges facing the livestock sector and identifies the contribution of the plan to the GTP II
	National Adaptation Plan	2019	Identifies vulnerable sectors, including the livestock sector, and outlines the country's adaptation vision and strategic priorities
	NDC	2015	Communicates Ethiopia's climate action commitments and needs in line with the Paris Agreement. It highlights the key climate risks and response options
	Updated NDC	2022	Updates Ethiopia's commitments under the Paris Agreement and highlights the mandates for each sector towards adaptation and mitigation
	Ten Years Development Plan	2021 – 2030	Articulates the country's development priorities including addressing challenges such as climate change
	National Adaptation Programme of Action (NAPA)	2007	Outlines adaptation needs and identifies twenty priority project ideas to support adaptation in various sectors
Kenya	Agricultural Sector Transformation and Growth Strategy	2019 – 2029	Defines pathways for achieving sustainable growth within the agriculture sector and achieving food security
	Climate Smart Agriculture Strategy	2017 – 2026	Describes the vulnerability of the crops, livestock, and fisheries sectors to climate change and measures towards climate adaptation and mitigation
	Climate Smart Agriculture Implementation Framework	2018 – 2027	Elaborates on the plan for implementing the Climate Smart Agriculture Strategy

	National Agriculture Investment Plan (NAIP)	2019 – 2024	Identifies strategic initiatives and the budgetary needs for implementing the transformation and growth strategy of the agriculture sector which includes livestock
	Nationally Determined Contribution (NDC)	2015	Communicates Kenya's commitments under the Paris Agreement including the sectoral priority actions for climate change adaptation
	Updated Nationally Determined Contribution	2020	Communicates updated commitments and builds on the first NDC
	National Livestock Policy	2008	Outlines the key issues affecting the livestock sector and the priority policy measures
	National Spatial Plan	2015 - 2045	Supports physical and economic planning integration by demarcating the land use needs of the various sectors and the strategies for optimizing the use and management of land and natural resources.
	National Climate Change Response Strategy	2010	Articulates the country's long-term plan to address climate change, including sector-specific interventions
	National Climate Change Action Plan	2018 - 2022	Articulates the road map for climate action and outlines the sectoral priority climate actions
	National Policy for the Sustainable Development of Northern Kenya and other Arid Lands	2012	Aims to close the development gap in the Arid and Semi-Arid parts of the country, including supporting responses to climate change. Approximately 70% of livestock in Kenya are found in arid and semi-arid lands
	Range management and pastoralism strategy	2021 – 2031	Sets out the plan to address degradation of the rangelands and low productivity for the benefit of pastoral communities and the economy
	Vision 2030 Development Strategy for Northern Kenya and other Arid Lands	2012	Outlines a long-term vision for developing the arid and semi-arid parts of the country, including strategies for drought management
	Vision 2030 third medium-term plan	2018 – 2022	Provides a five-year development plan for implementing Kenya's vision 2030, including highlighting the priorities for livestock sector
	County Integrated Development Plan – Kajiado County	2018 – 2022	Articulates the County's development priorities, including projects for the livestock sector and their alignment with the national policies

	County Integrated Development Plan - Bomet County	2018 – 2022	Outlines the development priorities for Bomet County including projects for the livestock sector and their alignment with the national policies
Uganda	National Climate Change Policy	2015	Outlines sectoral policy priorities and defines the mandate for various actors at national and subnational levels to contribute to climate change mitigation and adaptation
	National Adaptation Programmes of Action	2007	Maps the climate risks affecting sectors such as agriculture and identifies priority interventions
	National Land Policy	2013	Considers the role of land in national development and outlines policy priorities "to ensure efficient, equitable and optimal utilization and management of Uganda's land resources for poverty reduction, wealth creation and overall socio-economic development"
	National Agriculture Sector for the Agriculture sector	2018	Identifies the sector's vulnerabilities, priority adaptation actions and adaptation goals for the agriculture sector
	National Agriculture policy	2013	Sets out the strategic objectives for the agriculture sector, the key issues affecting the sector and the strategies for addressing them
	Animal Feeds Policy	2005	Sets out the government's priorities and policy objectives for developing the livestock feeds industry and supporting livestock nutrition
	Green Growth Development Strategy	2017/2018 – 2030/31	Identifies challenges for green growth including issues of climate change and sets out actions for addressing the challenges while ensuring economic development

Annex 6: Indicators for tracking adaptation in livestock systems (Chapter 5)

Dimension 1: Climatic hazards

Category	Indicator	Contribution to adaptation progress index	Result level *(input, process, output, outcome)*	Level of measurement *(national, sub-national, household)*
Rainfall patterns	Delay in rainfall onset	-	N/A	Sub-national
	Amount of rainfall received	-	N/A	Sub-national
Temperature patterns	Average temperatures	-	N/A	Sub-national
	Number of extremely hot days	-	N/A	Sub-national
	Number of extremely cold days	-	N/A	Sub-national
	Incidences of frost	-	N/A	Sub-national

Dimension 2: Climate change impacts

Sub-dimension: Biophysical impacts				
Category	**Indicator**	**Contribution to adaptation progress index**	**Result level** *(input, process, output, outcome)*	**Level of measurement** *(national, sub-national, household)*
Pasture & feed availability	Distance to the main sources of livestock feeds	-	Outcome	Household
	Cost of livestock feeds e.g., a bale of fodder	-	Outcome	Household
	Normalized Difference Vegetation Index (NDVI)	+	Outcome	Sub-national
Pasture & feed quality	Variety of feeds in use	+	Outcome	Household
	Distance to main water points	-	Outcome	Household

Water availability	Cost of water for livestock	-	Outcome	Household
	Water levels in water sources that are critical for livestock	+	Outcome	Sub-national
Livestock health	Prevalence of pests that are linked to climatic hazards	-	Outcome	Sub-national
	Number of TLUs affected by pests that are linked to climatic hazards	-	Outcome	Sub-national
	Prevalence of diseases that are linked to climatic hazards	-	Outcome	Sub-national
	Number of TLUs affected by diseases that are linked to climatic hazards	-	Outcome	Sub-national

Sub-dimension: Socioeconomic impacts				
Category	**Indicator**	**Contribution to adaptation progress index**	**Result level** *(input, process, output, outcome)*	**Level of measurement** *(national, sub-national, household)*
Livestock production	Quantity of milk produced	+	Outcome	Sub-national
	Quantity of meat produced	+	Outcome	Sub-national
	Number of livestock deaths related to climatic hazards	-	Outcome	Sub-national
	Revenue from livestock sector	+	Outcome	Sub-national
Food security	Proportion of livestock-keeping households classified as food insecure	-	Outcome	Sub-national
	Number of livestock-keeping households receiving emergency food aid	-	Outcome	Sub-national

Livestock-related resource conflicts	Number of inter/intra- community conflict incidences	-	Outcome	Sub-national

Dimension 3: Adaptive capacity and adaptive actions

Sub-dimension: Technologies and inputs				
Category	**Indicator**	**Contribution to adaptation progress index**	**Result level** *(input, process, output, outcome)*	**Level of measurement** *(national, sub-national, household)*
Extension & veterinary services	Ratio of veterinary service providers to livestock keeping-households	+	Input	Sub-national
Land management and access	Average land ownership/certification per livestock-keeping household	+	Process	Sub-national
	Land access per livestock-keeping household	+	Input	Sub-national
	Share of community land available for livestock-keeping activities	+	Input	Sub-national
Water management and access	Proportion of livestock-keeping households engaging in water harvesting & storage	+	Output	Household
	Proportion of functional water sources	+	Output	Sub-national
	System-level investments in water infrastructure development	+	Input	Subnational
	National-level investments in water infrastructure development in livestock systems	+	Input	National
Livestock care technologies and practices	Proportion of livestock-keeping households engaging in heat & cold stress reduction interventions on livestock	+	Output	Household

	Proportion of livestock-keeping households engaging in control of diseases and pests that are linked to climate risks e.g., vaccination, treatment, deworming, spraying	+	Output	Household
	Number of vaccination campaigns carried out on diseases related to climate change	+	Output	Sub-national
	Number of TLUs covered by the vaccination campaigns	+	Output	Sub-national
Livestock breeding	Existence of a sub-national livestock breeding program	+	Process	Sub-national
	Existence of sub-national breeding programs/ schemes that are focused on improving the adaptability of livestock to climate change	+	Process	Sub-national
	Establishment & implementation of national livestock breeding programs	+	Process	National
	Establishment & implementation of national breeding programs/ schemes that are focused on improving the adaptability of livestock to climate change	+	Process	National
Feed management	Proportion of livestock-keeping households growing adaptive fodder varieties	+	Output	Household
	Number of livestock-keeping households adopting improved livestock feeding technologies	+	Output	Household
	Proportion of livestock-keeping households engaging in feed preservation practices	+	Output	Household
	Proportion of livestock-keeping households engaging in pasture management practices	+	Output	Household
	Proportion of livestock-keeping households engaging in collective feed production &/or storage	+	Output	Household
	Proportion of communal lands with grazing plans	+	Output	Household

Sub-dimension: Knowledge and information				
Category	**Indicator**	**Contribution to adaptation progress index**	**Result level** *(input, process, output, outcome)*	**Level of measurement** *(national, sub-national, household)*
Capacity building on adaptation	Proportion of livestock-keeping households accessing training on climate change adaptation	+	Output	Household
	Number of state & non-state actors capacity built to support adaptation	+	Output	Sub-national
	Number of livestock keepers trained on climate change adaptation	+	Output	Sub-national
Climate information services	Proportion of livestock-keeping households accessing agro-weather information	+	Output	Household
	Utility of agro-weather information	+	Output	Household
	Existence of a sub-national system offering climate information services	+	Process	Sub-national
	Existence of a functional national-level system for generating and disseminating climate information	+	Process	National
Surveillance & disease information systems	Proportion of livestock-keeping households accessing information on livestock pests and diseases	+	Output	Household
	Utility of information on livestock diseases	+	Output	Household
	Existence of a sub-national livestock disease surveillance system	+	Process	Sub-national
	Existence of a functional national livestock disease surveillance system	+	Process	National
	Proportion of livestock keeping households accessing information on livestock and products markets	+	Output	Household

Market information systems	Utility of livestock market information services	+	Output	Household
	Existence of sub-national market information systems for livestock and livestock products	+	Process	Sub-national
	Existence of a functional national market information system for livestock & livestock products	+	Process	National
	Presence of national market information systems linked to regional livestock & livestock products market information systems	+	Process	National
Research and development	Existence of a knowledge management systems	+	Process	Sub-national

Sub-dimension: Institutions				
Category	**Indicator**	**Contribution to adaptation progress index**	**Result level** *(input, process, output, outcome)*	**Level of measurement** *(national, sub-national, household)*
Plans and rules for securing access to & sound management of land, water & pasture	Proportion of livestock-keeping households with access to livestock mobility paths/ migratory routes	+	Output	Household
	Existence of sub-national/ landscape-level land use plans that address climate change adaptation needs of livestock keepers	+	Process	Sub-national
	Existence of a national land-use plan that recognizes climate change adaptation needs of livestock keepers	+	Process	National
	Presence of designated and recognized livestock mobility paths	+	Process	Sub-national
	Existence of water management institutions and plans	+	Process	Sub-national
	Existence of policies for defining land tenure	+	Process	National

Cultural norms that are relevant for socially differentiated adaptative capacity	Extent of women's control over decision-making on productive assets e.g., livestock, livestock products, land, and incomes	+	Outcome	Household
Policies & economic environment and its impact on socially differentiated adaptive capacity	Existence of socially and economically inclusive programs and interventions, particularly with a focus on supporting the youth to engage in adaptive actions	+	Process	Sub-national
Social support groups & networks	Proportion of livestock-keeping households with membership in social support groups & networks	+	Output	Household
	Number of registered social groups & networks existing within the landscape	+	Output	Sub-national
	Number of livestock keepers that are members of social support groups and networks disaggregated by gender	+	Output	Sub-national
Forward-looking governance & decision making	Existence of sub-national plans and strategies that are relevant to climate change adaptation in livestock systems	+	Process	Sub-national
	Existence of sub-national institutional frameworks and programs for the implementation of plans, policies, and strategies that are relevant to climate change adaptation in livestock systems	+	Process	Sub-national
	Existence of national plans, policies, and strategies that are supportive of climate change adaptation in livestock systems	+	Process	National
	Existence of national institutional frameworks for the implementation of plans, policies, and strategies that are relevant to climate change adaptation in livestock systems	+	Process	National

Sub-dimension: Finance & markets				
Category	**Indicator**	**Contribution to adaptation progress index**	**Result level** *(input, process, output, outcome)*	**Level of measurement** *(national, sub-national, household)*
Market dynamics	Ratio of average farmgate to retail price for milk	+	Outcome	Sub-national
Inputs market	Number of inputs suppliers available	+	Input	Sub-national
	Distance to the nearest livestock inputs supplier	-	Output	Household
	Livestock keepers' satisfaction with the quality of the inputs	+	Output	Household
Marketing organizations & associations	Proportion of livestock-keeping households with active membership in functional livestock and livestock products marketing group	+	Output	Household
	Number of functional marketing groups for livestock and livestock products within the subnational administrative units	+	Output	Sub-national
Livestock insurance	Number of households with livestock insurance	+	Output	Sub-national
	Proportion of TLUs in the sub-national administrative units covered by livestock insurance	+	Output	Sub-national
Livestock offtake programs	Number of TLUs in a sub-national administrative units undergoing emergency livestock offtake programs	-	Outcome	Sub-national
	Proportion of sub-national administration units undertaking emergency livestock offtake programs	-	Outcome	Sub-national

Financial investment toward adaptation	Proportion of national budgetary allocation to the livestock sub-sector from the total budgetary allocation	+	Input	National
	Proportion of livestock sector budget allocated to adaptation in the sector	+	Input	National
	Amount of resources from non-state actors invested towards adaptation in livestock systems	+	Input	National
	Resources allocated to research in livestock systems	+	Input	National
	Resources allocated to research relevant to climate change adaptation in livestock systems, including research on feeds	+	Input	National
	Number of credit options available to livestock keepers	+	Input	Sub-national
	Number of financial products supporting livestock sub-sector adaptation	+	Input	Sub-national
	Number of livestock keepers taking up financial products	+	Output	Sub-national

Annex 7 Weight of indicators (Chapter 5)

	By production system		By governance system		
	Livestock only/ grazing system	**Mixed crop-livestock system**	**Federal (Ethiopia)**	**Devolved (Kenya)**	**Deconcentrated (Uganda)**
Delay in rainfall onset	1	1			
Amount of rainfall received	1	1			
Average temperatures	1	1			
Number of extremely hot days	1	1			
Number of extremely cold days	1	1			
Incidences of frost	0	1			
Distance to the main sources of livestock feeds	2	2			
Cost of livestock feeds e.g., a bale of fodder	2	2			
Normalized Difference Vegetation Index (NDVI)	2	1			
Variety of feeds in use	1	1			
Distance to main water points	2	2			
Cost of water for livestock	1	2			
Water levels in water sources that are critical for livestock	2	2			
Prevalence of pests that are linked to climatic hazards	1	1			
Number of TLUs affected by pests that are linked to climatic hazards	1	1			
Prevalence of diseases that are linked to climatic hazards	1	1			

Number of TLUs affected by diseases that are linked to climatic hazards	1	1			
Quantity of milk produced	1	1			
Quantity of meat produced	1	1			
Number of livestock deaths related to climatic hazards	1	1			
Revenue from livestock sector	1	1			
Proportion of livestock keeping households classified as food insecure	2	1			
Proportion of livestock keeping households receiving emergency food aid	2	1			
Number of inter/intra- community conflict incidences	1	1			
Ratio of veterinary service providers to livestock keeping households	1	1			
Average land ownership/certification per livestock-keeping household	1	1			
Land access per livestock-keeping household	1	1			
Share of community land available for livestock-keeping activities	1	0			
Proportion of livestock-keeping households engaging in water harvesting & storage	1	1			
Proportion of functional water sources	1	1			
System-level investments in water infrastructure development			1	2	1
National-level investments in water infrastructure development in livestock systems			2	2	2

Proportion of livestock-keeping households engaging in heat & cold stress reduction interventions on livestock	1	1			
Proportion of livestock-keeping households engaging in control of diseases and pests that are linked to climate risks e.g., vaccination, treatment, deworming, spraying	1	1			
Number of vaccination campaigns carried out on diseases related to climate change	1	1			
Number of TLUs covered by the vaccination campaigns	1	1			
Existence of a sub-national livestock breeding program			1	2	1
Existence of sub-national breeding programs/ schemes that are focused on improving the adaptability of livestock to climate change			1	2	1
Establishment & implementation of national livestock breeding programs			2	2	2
Establishment & implementation of national breeding programs/ schemes that are focused on improving the adaptability of livestock to climate change			2	2	2
Proportion of livestock-keeping households growing adaptive fodder varieties	1	1			
Number of livestock-keeping households adopting improved livestock feeding technologies	1	1			
Proportion of livestock-keeping households engaging in feed preservation practices	1	1			

Proportion of livestock-keeping households engaging in pasture management practices	1	1			
Proportion of livestock-keeping households engaging in collective feed production &/or storage	1	1			
Proportion of communal lands with grazing plans (Extensive systems)	1	0			
Proportion of livestock-keeping households accessing training on climate change adaptation	1	1			
Number of state & non-state actors capacity built to support adaptation	1	1			
Number of livestock keepers trained on climate change adaptation	1	1			
Proportion of livestock-keeping households accessing agro-weather information	1	1			
Utility of agro-weather information	1	1			
Existence of a sub-national system offering climate information services			1	2	1
Existence of a functional national-level system for generating and disseminating climate information			2	2	2
Proportion of livestock keeping-households accessing information on livestock pests and diseases	1	1			
Utility of information on livestock diseases	1	1			
Existence of a sub-national livestock disease surveillance system			1	2	1
Existence of a functional national livestock disease surveillance system			2	2	2

Proportion of livestock-keeping households accessing information on livestock and products markets	1	1			
Utility of livestock market information services	1	1			
Existence of sub-national market information systems for livestock and livestock products			1	2	1
Existence of a functional national market information system for livestock & livestock products			2	2	2
Presence of national market information systems linked to regional livestock & livestock products market information systems			2	2	2
Existence of a knowledge management systems			1	1	1
Proportion of livestock-keeping households with access to livestock mobility paths/ migratory routes	1	0			
Existence of sub-national/ landscape-level land use plans that address climate change adaptation needs of livestock keepers			1	2	1
Existence of a national land-use plan that recognizes climate change adaptation needs of livestock keepers			2	2	2
Presence of designated and recognized livestock mobility paths	1	0			
Existence of water management institutions and plans	1	1			

Existence of policies for defining land tenure			2	2	2
Extent of women's control over decision-making on productive assets e.g., livestock, livestock products, land, and incomes	1	1			
Existence of socially and economically inclusive programs and interventions, particularly with a focus on supporting the youth to engage in adaptive actions	1	1			
Proportion of livestock-keeping households with membership in social support groups & networks	1	1			
Number of registered social groups & networks existing within the landscape	1	1			
Number of livestock keepers that are members of social support groups and networks disaggregated by gender	1	1			
Existence of sub-national plans and strategies that are relevant to climate change adaptation in livestock systems			1	2	1
Existence of sub-national institutional frameworks and programs for the implementation of plans, policies, and strategies that are relevant to climate change adaptation in livestock systems			1	2	1
Existence of national plans, policies, and strategies that are supportive of climate change adaptation in livestock systems			2	2	2
Existence of national institutional frameworks for the implementation of plans, policies, and strategies that are			2	2	2

relevant to climate change adaptation in livestock systems					
Ratio of average farmgate to retail price for milk					
Number of inputs suppliers available			1	2	2
Distance to the nearest livestock inputs supplier			1	2	2
Livestock keepers' satisfaction with the quality of the inputs			2	2	2
Proportion of livestock-keeping households with active membership in functional livestock and livestock products marketing group	1	1			
Number of functional marketing groups for livestock and livestock products within the subnational administrative units	1	1			
Number of households with livestock insurance	1	1			
Proportion of Tropical Livestock Units in the sub-national administrative units covered by livestock insurance	1	1			
Number of Tropical Livestock Units in a sub-national administrative units undergoing emergency livestock offtake programs			2	2	1
Proportion sub-national administration units undertaking emergency livestock offtake programs			1	2	1
Proportion of national budgetary allocation to the livestock sub-sector from the total budgetary allocation			1	1	1

Proportion of livestock sector budget allocated to adaptation in the sector			1	1	1
Amount of resources from non-state actors invested towards adaptation in livestock systems			1	1	1
Resources allocated to research in livestock systems			1	1	1
Resources allocated to research relevant to climate change adaptation in livestock systems, including research on feeds			1	1	1
Number of credit options available to livestock keepers	1	1			
Number of financial products supporting livestock sub-sector adaptation	1	1			
Number of livestock keepers taking up financial products	1	1			

Summary

Summary

The impacts of climate change are increasingly evident around the world, including in the livestock sector. As a result of more intense and frequent droughts, livelihoods and economies dependent on livestock are under increasing threat. Whilst state and non-state actors are responding to climate change impacts, limitations in available information make it difficult to evaluate and compare adaptation progress across space and time. The systematic assessment of progress on adaptation efforts over time and space, and across and within sectors and populations, is referred to as adaptation tracking. Adaptation tracking typically aims at documenting the state of adaptation and sharing lessons, enhancing accountability among state and non-state actors, and informing adaptation planning and decision-making across sub-national, national, and global scales. However, ambiguity in concepts central to adaptation tracking and the lack of appropriate methodologies and data that can support the assessment of adaptation hamper progress in adaptation tracking in practice. Therefore, there is a pressing need for tailored methodologies and guidelines that can support adaptation tracking and reporting across scales.

To contribute to the rapidly evolving political and scientific debates on adaptation tracking, this dissertation builds on science and technology studies, public administration, and public policy literature streams to examine the benefits of considering existing institutional structures, diverse perspectives on adaptation, and adopting a co-production approach in designing adaptation tracking. To do this, this dissertation answers three research questions:

- How relevant are similarities and differences in countries' institutional structures of knowledge production and use for the design of adaptation tracking?
- What differences exist in how actors perceive climate risks, adaptative capacities, adaptation options, and goals, and how are these differences important for the design of adaptation tracking?
- How does the co-production of the TAiLS tool shape its sensitivity to existing institutional structures of knowledge production and use and the diversity of stakeholder perspectives?

These questions are addressed through a comparative case study approach and qualitative research design. The dissertation consists of four research chapters that address the research aims and questions.

Chapter 2 develops a framework for analyzing institutional structures of knowledge production and use. Established institutional structures, that is, the rules and practices that shape how the government is organized and conducts its business, are fundamental to the country-specific styles of knowledge production and use and the implementation of new policy mandates such as adaptation tracking. Through a review of academic literature concerned with state-society relations and intragovernmental dynamics, the chapter presents a framework constituted of six dimensions and corresponding variables: 1) stakeholder participation, 2) transparency, 3) bureaucratic accountability, 4) engagement with experts, 5) politico-administrative relations, and 6) coordination within the administration. Besides providing an integrated framework for examining institutional structures, this chapter calls for moving beyond conceptualizations of adaptation tracking as a technical process requiring standardized methodologies to also consider the alignment of those methodologies with existing systems of producing and using knowledge.

Chapter 3 uses the framework developed in Chapter 2 to analyze and compare rules and practices of producing and using knowledge relevant to adaptation tracking in the livestock sectors of Ethiopia, Kenya, and Uganda. To do this, I review policy documents to identify the formal rules, conduct interviews with selected government officials to understand practices, and facilitate Focus Group Discussions (FGDs) with livestock keepers to examine their involvement in knowledge production processes that are similar to those required in adaptation tracking. The results show that there are relevant resources, government structures, and processes within which adaptation tracking can be embedded. These include leveraging the existing data streams, mandates, and decision-making processes. However, variations exist within and between countries in how they produce and use knowledge. For instance, the three countries vary in the extent to which coordination is codified and coordination practices between administrative units at national and sub-national levels of government. These differences are crucial in determining the compatibility of knowledge streams, the flow of knowledge within government, and consequently, the need for contextually appropriate coordination mechanisms that can feasibly support adaptation tracking. Similarly, the role of experts, clarity of knowledge production standards, accountability arrangements, and accessibility of produced knowledge also vary within and across countries, with implications on the quality of produced knowledge and its use. This chapter concludes by emphasizing the importance of considering national contexts when designing adaptation tracking

by examining how methodologies and guidelines for adaptation tracking and reporting can feasibly and sustainably be implemented within existing government systems.

To complement the focus on institutional structures in Chapters 2 and 3, Chapter 4 investigates the diversity that exists in how different actors perceive dimensions that are relevant to track. A thematic analysis of data from discussions with livestock keepers and policy documents relevant to adaptation reveals similarities and differences in governmental and livestock keeper perspectives with implications for how to assess adaptation in the livestock sector. While the similarities indicate the possibility of having indicators that could align with livestock keeper and governmental perspectives as well as capture adaptation progress across scales, the differences underscore the value of integrating multiple perspectives. On one hand, livestock keeper perspectives highlight the context specificity of climate hazards, impacts, adaptative capacities, and adaptation options. They also show the variety of adaptation efforts and outcomes at the farm level. Governmental perspectives, on the other hand, help bring out the adaptation efforts of governments and the linkages to high-level policy priorities and discourses. This chapter provides evidence of how the integration of multiple perspectives is not only necessary for capturing adaptation progress across scales but also for ensuring robustness and richness in adaptation tracking. Chapter 4 ends with an elaboration of how this integration could be done in practice through the development of an integrated adaptation tracking framework that captures local nuances while providing metrics that can be assessed across different scales and contexts.

Chapter 5 builds on Chapters 2, 3, and 4 by demonstrating the development of a tool for tracking adaptation in livestock systems (TAiLS). TAiLS is a web-based tool that is designed to fit the uniqueness of institutional structures of Ethiopia, Kenya, and Uganda. It also captures diversity across spatial contexts, multiple levels of adaptation results, and changes in adaptation progress across a temporal scale. Various steps were followed to develop the tool. These steps included analyzing the institutional structures of knowledge production and use in the three countries, consultative identification of adaptation tracking indicators, and iterative review and design of the TAiLS tool. Analyzing the institutional structures and involving government officials in the co-development of the tool informed the customization of the tool to each country. In addition, considering the adaptation experiences and priorities across different livestock production systems as well as those articulated in policy documents allowed the tool to link adaptation efforts and

outcomes across the farm, sub-national and national scales. Besides explaining the steps to developing the tool, Chapter 5 provides an opportunity to reflect on the value of a co-production approach to designing adaptation tracking.

In Chapter 6, I synthesize the results of the research chapters to answer the research questions, reflect on the research, and discuss the implications of findings for the design of adaptation tracking within the livestock sector and beyond. Chapter 6 also elaborates on the theoretical, empirical, and practical contributions of the dissertation. Regarding theoretical contributions, this dissertation advances the literature by developing an integrated framework for analyzing institutional structures, a conceptual framework for adaptation tracking, and demonstrating the integration of constitutive and instrumental co-production lenses. Empirically, this dissertation strengthens evidence of country-specificity of systems for producing and using knowledge relevant to adaptation tracking and the need to tailor adaptation tracking methodologies to countries. It also provides evidence of what can be gained by integrating multiple perspectives in adaptation tracking design, more so using a co-production approach. In terms of practical contribution, this research led to the development of a tool that is tailored to support tracking and reporting on adaptation in the livestock sectors of Ethiopia, Kenya, and Uganda. In combining analytical questions with the application of research findings to inform the development of the TAiLS tool, this dissertation advances knowledge of adaptation tracking by providing contextualized insights while also generating a tool that can practically be used to track and report on adaptation in the livestock sector. Overall, this dissertation emphasizes the need for linkages across local, sub-national, national, and global linkages in adaptation tracking for it to be meaningful and effective.

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While managing four supervisors was not easy, I also see it as a privilege to learn from four great minds. We made a great team and I look forward to further opportunities to collaborate with you.

It is difficult to conduct research in multiple sites across three countries. Not to mention the additional difficulty of conducting fieldwork during the Covid-19 pandemic. Each country had elections during the research period, adding another layer of logistical challenges due to security concerns. Your assistance during fieldwork, Leah (Kenya), Tigist (Ethiopia), Roland (Uganda), and the field assistants you helped me recruit, was invaluable to the success of my PhD. I am also grateful to the livestock keepers and government officials who provided great insights into my study.

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About the author

Lucy Njuguna acquired a Bachelor of Science degree in Environmental Conservation and Natural Resource Management from the University of Nairobi in Kenya (2009-2013). She then pursued a Master of Science in Environmental Governance at Albert Ludwig University in Freiburg, Germany (2015-2017). Her Master's thesis demonstrated the role of community-based governance structures in the management of natural resources that are critical to farmers and livestock keepers' climate change adaptation strategies using a case study of a Water Resource User Association. Following that, she worked as a research fellow, synthesizing findings generated by various researchers in the Local Governance and Adaptation to Climate Change (LGACC) project to inform the design of a decision-support tool.

Lucy Njuguna began her PhD studies at the Public Administration and Policy Group in 2019. During this time, she has also been working at the International Livestock Research Institute (ILRI), where she leads research activities and stakeholder engagements to increase governments' capacity to track and report on climate change adaptation. The focus of her PhD has allowed her to continue investigating the connections between governance processes and priorities at the local, sub-national, national, and global levels. She has taken an active role in both scientific and policy discussions about climate change adaptation, particularly in the agricultural sector.

Lucy Wanjiku Njuguna
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project-related competencies			
A1 Managing a research project			
WASS Introduction Course	WASS	2021	1
Research data management	Wageningen University Library	2021	0.45
Working on your PhD research in times of crisis	PE&RC and WIMEK	2020	0.6
Writing a research proposal	WUR/ ILRI	2019	6
'Qualitative study comparing policy implementation: Insights from adaptation tracking in eastern Africa livestock systems'	5th International Conference of Public Policy, Barcelona	2021	1
'Adaptation tracking as a cross-scalar policy process'	6th International Conference of Public Policy, Toronto	2023	1
A2 Integrating research in the corresponding discipline			
Research methodology: from topic to proposal	WASS	2019	4
Advanced qualitative research design & data collection methods, GEO 56806	WUR	2021	6
Qualitative data analysis, MAT 50806	WUR	2020	6
B) General research-related competencies			
B1 Placing research in a broader scientific context			
Qualitative research: epistemology and methods	ILRI	2020	6
'Understanding the institutional structures for effective tracking of climate change adaption'	ILRI Capacity Development Unit interdisciplinary seminars	2019, 2021	1
STEPS summer school	STEPS Centre/ Institute of Development Studies	2021	1
B2 Placing research in a societal context			

Presenting research outputs to policymakers and climate change negotiators	ILRI/AGNES	2021, 2022	2
Preparing a submission to the UNFCCC Adaptation Committee on the development and application of adaptation M&E systems at national and subnational levels	ILRI	2022	1
C) Career-related competencies/personal development			
C1 Employing transferable skills in different domains/careers			
Climate governance, diplomacy, and negotiation leadership	African Group of Negotiators Expert Support (AGNES)	2021	3
Total			**40.05**

*One credit according to ECTS is on average equivalent to 28 hours of study load

Colophon

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