



Do government knowledge production and use systems matter for global climate change adaptation tracking? 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 the livestock sectors 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.

Keywords Livestock · Climate change adaptation · Adaptation tracking · Adaptation monitoring · Knowledge production

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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 and 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 and 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 and 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 (Ford et al. 2013; Berrang-Ford et al. 2019). 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 (Ford et al. 2013, 2015; Bours et al. 2014; Delaney et al. 2016). 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 comparable and aggregable of information across countries and over the years (Ford and Berrang-Ford 2016). Consequently, divergent proposals for advancing adaptation tracking have emerged. On the 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 (Hammill and Dekens 2014; European Environment Agency 2015; Leiter 2021). This literature recognizes that for adaptation tracking to be meaningful to countries and sustained over time, 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 and Whitford 2017; Boräng et al. 2018).¹ Variations within and across these systems can reasonably be expected to shape 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 from 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 that are relevant for other structurally similar domains such as monitoring and reporting on SDGs.

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 this 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 (Painter and Peters 2010; Jamil et al. 2013). The framework has been developed and

¹ 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, and 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, and impact of livestock diseases.

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 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 (Jasanoff 2005; Painter and Peters 2010; Jamil et al. 2013; Njuguna et al. 2022). 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 (Leiter 2015; Klostermann et al. 2018). Similarly, adaptation tracking requires contribution from both state and non-state actors to capture diverse adaptation priorities, actions, and outcomes (Dilling et al. 2019; Bartelet et al. 2022) making state-society relations an essential element to consider. Second, 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 and Tosun 2019). Third, 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.

Methodology

Study context

The livestock sector is an integral part of the livelihoods and the economies of the three study countries, as shown in Table 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 (Thornton and Herrero 2014; Rojas-Downing et al. 2017) 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 (Republic of Uganda 2015; Republic of Kenya 2020; Federal Democratic Republic of Ethiopia 2021). 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 2), making them suitable for comparison.

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 and 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 (Table 4 in 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 and 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 (Table 5 in 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 (Table 6 in Annex 3). We engaged livestock keepers as they are critical for knowledge production on livestock systems.

Table 1 Framework for analyzing institutional structures of knowledge production, relevance, and operationalization

Dimension	Definition	Relevance	Variables	Data sources and 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 Administrative structure	Reviewing government documents to identify the established guidelines on how coordination in knowledge production should be achieved Using government documents and interviews to map the relevant administrative units at national and sub-national 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 and Pilbeam 2017)	Established knowledge production standards and procedures Accountability forums	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 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 knowledge production and use	The nature of politico-administrative linkages influences data availability and quality, for instance, considering politicization of knowledge which might incentivize non-disclosure or manipulation of knowledge (Ford et al. 2013; Boräng et al. 2018; Aragão and Linsi 2020)	Bureaucratic autonomy	Using interviews to identify how bureaucrats perceive politics to be influencing their knowledge production activities
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 Characteristics of accessible knowledge	Reviewing government documents to identify provisions related to access to knowledge on livestock that is held by the government 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 (Gupta et al. 2012; Green and Lund 2015)	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

Table 1 (continued)

Dimension	Definition	Relevance	Variables	Data sources and analysis
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

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 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 three workshops with government officials for critical discussion. The 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.

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 within the livestock sector 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. Second, 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. Third, 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 in achieving their objectives (Gupta and Mason 2016; Weikmans et al. 2020) which we do not extensively address in this paper.

Table 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, <i>woredas</i> (district), and <i>kebeles</i>	Devolved governance system with subnational administrative structure comprised of 47 county governments which are further broken down into subcounties and wards	Deconcentrated governance system with subnational administrative structure comprised of 135 districts which are further divided into subcounties and parishes

Table 3 Summary of institutional structures of knowledge production in the livestock sectors of Ethiopia, Kenya, and Uganda

	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 production. Externalized engagement with experts at county level	Collaboration between government agencies to capitalize on the available 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, livestock keepers are represented in designing knowledge production. Sampling criteria based on agricultural production activities and agroecological zones

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

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 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.

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 Service²) 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 10-year development plan, the Planning and Development Commission will oversee the production of national statistics and monitor the 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, thus, 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

² 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.

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.

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 similar 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 *woreda* (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 how bureaucrats produce 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 for 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.

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, elected officials in the county governments focus on projects that give them political mileage, which often do 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. As one county official explained,

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 atten-

tion 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 counties change every 5 to 10 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, though 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.

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 they 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 and promptly knowledge that meets the needs of various users. The policy further outlines the various channels for disseminating available knowledge, including seminars, 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.

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 (NAGII) 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.

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 *woreda* 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 viewed 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.

Discussion and conclusions

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 designing and implementing adaptation tracking programs. 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 (Price-Kelly et al. 2015; Klostermann et al. 2018). 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 have 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 and 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). This further highlights 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 a country's 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. Since 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 and 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 the “Transparency” section, 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 and 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 to be considered 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 and 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 rationales of knowledge production are important as 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 (Painter and Peters 2010; Biesbroek et al. 2018). 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 and 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.

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Data availability The data analyzed during this study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare no competing interests.

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