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RESEARCH ARTICLE



Climate change and the water–energy–food nexus: insights from policy and practice in Tanzania

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ABSTRACT

The threat of climate change is emerging at a time of rapid growth for many economies in sub-Saharan Africa (SSA). Dominant narratives comprising ambitious development plans are common and often based around sectors with strong inter-dependencies that are highly exposed to climate variability. Using document analysis and key informant interviews, this article examines how climate change is addressed in policy, how it is being mainstreamed into water, energy and agriculture sector policies and the extent to which cross-sectoral linkages enable coordinated action. These questions are addressed through a case study of Tanzania, highlighting broader lessons for other developing countries, particularly those in SSA facing similar challenges. The article finds that, while the agriculture and water sectors are increasingly integrating climate change into policies and plans in Tanzania, practical coordination on adaptation remains relatively superficial. Publication of the Tanzania National Adaptation Plan of Action (NAPA) in 2007 marked a step change in the integration of climate change in sectoral policies and plans; however, it may have reinforced a sectoral approach to climate change. Examining the policies for coherence highlights overlaps and complementarities which lend themselves to a coordinated approach. Institutional constraints (particularly structures and resources) restrict opportunities for inter-sectoral action and thus collaboration is confined to ad hoc projects with mixed success to date. The results highlight the need for institutional frameworks that recognize and address these constraints to enable development goals to be pursued in a more sustainable and climate-resilient manner.

KEY POLICY INSIGHTS

- The NAPA has been successful at encouraging climate change mainstreaming into sectoral policies in Tanzania; however, the cross-sectoral collaboration crucial to implementing adaptation strategies remains limited due to institutional challenges such as power imbalances, budget constraints and an ingrained sectoral approach.
- Collaboration between nexus sectors in Tanzania is largely through ad hoc projects with limited progress on establishing deeper connections to enable collaboration as a process. Regular cross-sectoral planning meetings and consistent annual budgets could provide a platform to enhance cross-sectoral coordination.
- Plans to develop hydropower and agriculture are prevalent across sub-Saharan Africa. Insights from Tanzania highlight the importance of institutional and policy frameworks that enable cross-sectoral coordination.

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Introduction

The threat of climate change is emerging at a time of rapid growth for many economies in Sub-Saharan Africa (SSA). Dominant narratives comprising ambitious development plans are common and often based around sectors that are highly exposed to climate variability, notably agriculture, hydropower and infrastructure (African Development Bank, 2009; African Union, 2014). Tanzania epitomizes these challenges, with agriculture central to the Tanzania National Development vision 2025 (United Republic of Tanzania [URT], 1999), the Five Year Development Plans (URT, 2011a, 2016) and plans to develop the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). At the same time, other goals include increasing energy supply and access (URT, 2015a). Hydropower comprises 21% of electricity generation capacity in SSA, over 90% in, Ethiopia, Malawi, Mozambique, Namibia, Zambia, and roughly 39% in Tanzania (five-year averages from 2010 to 2014; World Bank, 2014). Agriculture and hydropower are dependent on rainfall yet climate change is likely to alter rainfall amounts, timing and intensity (Cook & Vizy, 2013; Shongwe, van Oldenborgh, van den Hurk, & van Aalst, 2011). The need to adapt to and plan for a future under changing rainfall conditions is complicated by ambiguous climate model projections for much of SSA (e.g. Cook & Vizy, 2013; Shongwe et al., 2011).

A coordinated approach to climate change across the three highly exposed sectors, often termed the water–energy–food (WEF) nexus, is crucial given that the impacts of and responses to climate change are generally cross-sectoral. The nexus perspective emphasizes interlinkages between different sectors and advocates for coordinated approaches that enable feedbacks, trade-offs and synergies across the sectors to be taken into account (Hoff, 2011; Kurian, 2017). This is not a new agenda: recognition of inter-dependencies pre-date the WEF nexus movement. Significant barriers to progress are known to exist, including factors of political economy and incompatibility of institutional structures (Leck, Conway, Bradshaw, & Rees, 2015), set against the wider context of governance challenges present in many developing countries. Yet, the rate of increasing demand for water, energy and food and the associated pressures emerging through rapidly converging inter-dependencies emphasize the need for cross-sectoral coordination to avoid significant stress points. In this regard, Tanzania exemplifies nexus issues facing many SSA countries and the potential for climate change to exacerbate existing resource management challenges.

Through an in-depth qualitative research approach, this article presents an analysis of policies across the three nexus sectors. Taking Tanzania as a case study, the article examines the extent to which an extensive policy framework addresses the sectors in a coordinated manner. Interviews build on this analysis to identify progress and barriers to implementing climate change adaptation in practice, within and across the three sectors. By identifying institutional barriers, the article draws lessons for other regions experiencing similar challenges and highlights the importance of an institutional framework that supports a coordinated approach across sectors. The article begins with relevant context on climate, the WEF nexus, institutions and policies in Tanzania. The methods are followed by results on integration of climate change policy by each sector, evidence of coordination across sectors and the role of power imbalances. The article ends with a discussion of the potential for a WEF nexus framing to develop a coordinated institutional approach to address climate change in Tanzania and more widely in SSA.

Climate variability and change

Across SSA, climate change will bring continued warming and disruption to rainfall patterns (Niang et al., 2014). However, the detail of rainfall change remains uncertain as climate models struggle to simulate observed climate variability and teleconnection patterns (Conway, 2011). In the case of Tanzania, the country encompasses a range of rainfall patterns, reflecting complex patterns of seasonality and inter-annual variability. Northern areas generally experience rainfall during the October–December (short rains) and March–May (long rains) seasons, whereas the southern areas experience a single rainy season from roughly October to April (Mapande & Reason, 2005). Warming trends are evident in the patchy observational records for most of Tanzania and across the region mean annual temperature increased 0.29°C per decade during the last 30 years (Climate Service Centre Germany, 2016). Evidence of change in rainfall is more complex. The long rains in the north show prolonged decline which is apparent in a range of datasets and no decreasing trend in the short rains (Rowell,

Booth, Nicholson, & Good, 2015). Observations suggest that traditional rainfall patterns in Tanzania are being disrupted with late onsets of the rains and wet seasons interspersed with prolonged dry spells (Sieber, Tschering, Graef, Uckert, & Paloma, 2015).

The effects of drought and flooding across nexus sectors have been extensive, with wide-scale drought in 2005 (Kijazi & Reason, 2009a) and major floods in 2006 (Kijazi & Reason, 2009b). Recurring droughts have been associated with reductions in hydropower generation leading to blackouts (Makoye, 2015). Detailed analysis of more recent trends and extremes and their socio-economic impacts on nexus sectors is lacking.

In terms of future climate change, consensus on warming is high. Climate model projections suggest a medium-strong warming in the range of 1.4°C to 4.2°C (above average conditions for 1971–2000) by the end of the century (Climate Service Centre Germany, 2016). For the wider region including Burundi, Malawi, Rwanda and Tanzania climate models do not produce a clear trend in future rainfall (Climate Service Centre Germany, 2016).

The water–energy–food nexus

The WEF nexus is concerned with the challenges surrounding the need to balance competing demands on water to address water, food and energy security under a changing climate (IWA, 2015; Mdee, 2017). Rising up the international agenda (Hussey & Pittock, 2012; Leck et al., 2015; Yumkella & Yillia, 2015), the WEF nexus promotes a systems perspective, emphasizing holistic and cross-sectoral approaches to decision making and planning (Cairns & Krzywoszyńska, 2016; Hussey & Pittock, 2012; Leck et al., 2015; Yumkella & Yillia, 2015). This approach is particularly relevant for sustainable development and climate change where the connections between water, energy and food are strong.

Within the broader governance literature, key challenges of different sector viewpoints and responsibilities are highlighted and calls for a better understanding of interconnections are raised (Koop et al., 2017; Weitz, Strambo, Kemp-Benedict, & Nilsson, 2017). The WEF nexus addresses these key gaps by highlighting the need to consider the impacts of policies and actions in one sector on other, inter-related, sectors in order to account for synergies and trade-offs, improving efficiency and reducing the potential for negative side-effects (Hussey & Pittock, 2012; Leck et al., 2015; Rasul & Sharma, 2016). This is an approach advocated by the post-2015 agenda and the Sustainable Development Goals (SDGs) (Stockholm Environment Institute, 2014; Weitz, Nilsson, & Davis, 2014). Increasingly, this perspective is also recognized within the climate change literature (Azhoni, Holman, & Jude, 2017; Conway et al., 2015; OECD, 2014) as it is clear that through changes in water availability, climate change will influence both agriculture and energy production, two sectors that are central to many SSA development agendas. At the World Economic Forum in 2008, it was particularly emphasized that the risks of climate change for WEF sectors could be worsened if contradictions in water and energy resource use are overlooked (Allan, Keulertz, & Woertz, 2015). In order to ensure that adaptation is effective, strategies need to be coherent and coordinated across water, energy and agriculture sectors (England et al., 2017; Mohtar & Lawford, 2016).

Whilst the nexus perspective addresses key challenges in climate change, water, energy and agriculture, criticisms have been made that the perspective takes a narrow focus on the three key sectors, overlooking other influences including wider political and cognitive factors (Weitz et al., 2017; Wichelns, 2017). Howarth and Monasterolo (2016) highlight the need to understand the governance arrangements through which a nexus approach may be applied.

Institutional and policy responses

Policy is an important tool for integrating issues of climate change adaptation (Giddens, 2008; OECD, 2014). Policy drives overall national and sectoral priorities as well as establishing the frameworks through which cross-sectoral collaborations may be facilitated. Rasul and Sharma (2016) highlight the value of a nexus perspective for climate change adaptation as encouraging more efficient resource use and ‘greater policy coherence’ (Rasul & Sharma, 2016, p. 22). They identify a need for policy approaches to shift from being sectoral in their focus in order to avoid competing and counterproductive actions. Gomar, Stringer, and Paavola (2014),

Di Gregorio et al. (2017) and Nilsson et al. (2012) all see a need for horizontal coordination in addition to vertical policy coherence, and OECD (2014) emphasizes the need for an effective institutional structure to facilitate this. Lafferty and Hovden (2003) and Di Gregorio et al. (2017) suggest that horizontal policy coherence on cross-cutting matters such as climate change can be facilitated if climate change is located in a ministry or department with established horizontal connections. Furthermore, this ministry or department should be a powerful and legitimate actor, which often is not the case if climate change is embedded within agencies only responsible for the environment (Allan et al., 2015; Cairns & Krzywoszynska, 2016; Jones et al., 2015; Verhoeven, 2015).

Tanzania is typical of many countries in SSA in that policy is developed through a sectoral approach, driven internally and externally by a combination of domestic and international interests. Tanzania is party to various international agreements on climate change, including the Paris Agreement (which Tanzania signed but has, as of August 2017, not yet ratified), which have directed the integration of climate change into domestic policy. While the Division of Environment is responsible for national climate change policy, the emphasis from international processes has been on mainstreaming climate change into different sectors. The National Adaptation Plan of Action (NAPA) (URT, 2007) formed an important early phase of adaptation work across SSA, with 35 produced by November 2016 (UNFCCC, 2016). Rasul and Sharma (2016) argue that the NAPA approach to encouraging climate change integration in domestic policy has encouraged such sectoral mainstreaming but that this results in plans that are developed by individual sectors, often without coordination. Recognizing these shortcomings, the idea of mainstreaming adaptation into national policy is beginning to shift from sectoral (vertically integrated) approaches towards more horizontally integrated approaches which is seen as a positive step towards more effective implementation with risks of maladaptation reduced (Barnett & O'Neill, 2010; Chasek, 2010; Kalaba, Quinn, & Dougill, 2014; Nunan, Campbell, & Foster, 2012; Rasul & Sharma, 2016). This article considers the extent to which water, energy and agriculture policies and plans have integrated climate change and cross-sectoral planning in a coherent and coordinated manner. Through the in-depth case study analysis, lessons are drawn for other developing SSA countries.

Methods

Case studies provide in-depth insights from a particular context to facilitate deep understanding of complex phenomena (Yin, 1984). The lessons drawn from these insights may be applicable or at least informative to other places with similar contexts. Tanzania is used here as a case study to aid understanding and inform approaches in other developing countries facing similar climate change and development challenges.

This research applied in-depth qualitative methods of document analysis of policies, plans and strategies and semi-structured interviews with individuals in relevant ministries and other organizations. As far as possible, the document analysis followed a systematic procedure (Bowen, 2009; Prior, 2003), designed to examine the extent to which climate change has been integrated into key sector policies, plans and strategies and to look at how this has evolved over the last 15 years, a period when climate change has risen in prominence on the international agenda. Interviews were used to complement this analysis by providing insights into the practical application of the policies and strategies for climate change adaptation (Gill, Stewart, Treasure, & Chadwick, 2008).

The document analysis was carried out by initially identifying key policies, plans and strategies for each of the nexus sectors (29 documents). Sectoral policies were complemented by analysis of national growth and development strategies which provide the general policy direction of the country and the overarching frame for the sectoral policies. National climate and environment policies were also consulted to guide the consideration and integration of climate change in the relevant sectors. In total, 44 policy documents were reviewed, including detailed analysis of the 29 WEF nexus sector documents (see Table 1 and Supplementary Information 1).

The sector documents were analysed systematically through keyword searches to identify and isolate passages relating to climate change and/or inter-sectoral coordination. Each document was searched for the keywords 'climate/climatic change', 'flood', 'drought' and 'variability' to help identify passages relating to climate change. For passages relating to inter-sectoral coordination and collaboration, key word searches were 'sector', 'coordination/coordinate', 'collaboration/collaborate', 'integration', 'interlinkages'. The keyword searches were supplemented by a more detailed read of the documents to identify any additional relevant sections and details.

Table 1. List of WEF nexus sector documents analysed in detail.

Document Title	Publication Date	Sector
Food and Nutrition Policy	1992	Agriculture
National Energy Policy	1992	Energy
Agricultural Sector Development Strategy	2001	Agriculture
National Water Policy	2002	Water
National Energy Policy	2003	Energy
National Irrigation Master Plan	2003	Water
Agricultural Sector Development Programme	2006	Agriculture
National Water Sector Development Strategy	2006	Water
Electricity Act	2008	Energy
National Irrigation Policy Draft	2009	Water
Water Resources Management Act	2009	Water
Livestock Sector Development Programme	2011	Agriculture
SAGCOT Investment Blueprint	2011	Agriculture
Tanzania Agriculture and Food Security Investment Plan	2011	Agriculture
Energy Strategic Plan	2011	Energy
EIA Guidelines for Energy Sector	2012	Energy
Power System Master Plan	2012	Energy
National Agriculture Policy	2013	Agriculture
Big Results Now - Agriculture	2013	Agriculture
Natural Gas Policy	2013	Energy
National Irrigation Act	2013	Water
Water Resources Management Strategic Interventions and Action Plan for Climate Change Adaptation	2013	Water
Agriculture Climate Smart Resilience Plan	2014	Agriculture
Electricity Supply Reform Strategy Roadmap	2014	Energy
Water Sector Development Programme Phase II	2014	Water
Climate Smart Agriculture Programme	2015	Agriculture
Draft Energy Policy	2015	Energy
National Energy Policy	2015	Energy
Agriculture Sector Development Programme Phase II	2016	Agriculture

Identified passages then underwent a content analysis process whereby they were coded based on whether they (a) mentioned the keywords climate/climatic change, (b) suggested actions specifically in order to adapt to climate change and (c) mentioned a desire or efforts to coordinate and collaborate with other sectors, in particular any of the other nexus sectors. The results of the document analysis were used to map the integration of climate change, the inclusion of specific climate change adaptation plans and references to inter-sectoral coordination and collaboration in each nexus sector over time (see [Figure 1](#)).

Key informant interviews supplement the document analysis and provide detailed insights into climate change adaptation actions and cross-sectoral coordination in practice (Arksey & Knight, 1999). The semi-structured interviews asked about the integration of climate change as a sector objective, climate change adaptation activities, coordination and collaboration on climate change with other sectors, generally, and the WEF sectors, more specifically. Interviewees were asked about opportunities and barriers to deeper coordination. Interviews were held with representatives from a range of organisations including sectoral ministries (e.g. Ministry of Water and Irrigation; Ministry of Energy and Minerals), NGOs, research organisations and private companies ([Table 2](#)). Interviews were completed initially in April–May 2016 ($n=45$) with further follow-up interviews in October 2016 ($n=10$). The interviews were audio recorded ($n=32$) and transcribed or captured through handwritten notes ($n=23$).

Climate change policy in Tanzania

In SSA, climate change is often located within a Ministry or Department dedicated to environmental issues. In Tanzania, climate change is currently the responsibility of the Vice President's Office (VPO). The VPO encompasses two key agencies central to managing environmental issues and climate change; Division of Environment (DoE) and the National Environment Management Council (NEMC). Specifically, the DoE is primarily responsible for guiding the integration of climate change into domestic policies and plans, while NEMC is responsible for enforcement through their mandate under the Environmental Management Act (URT, 2004).

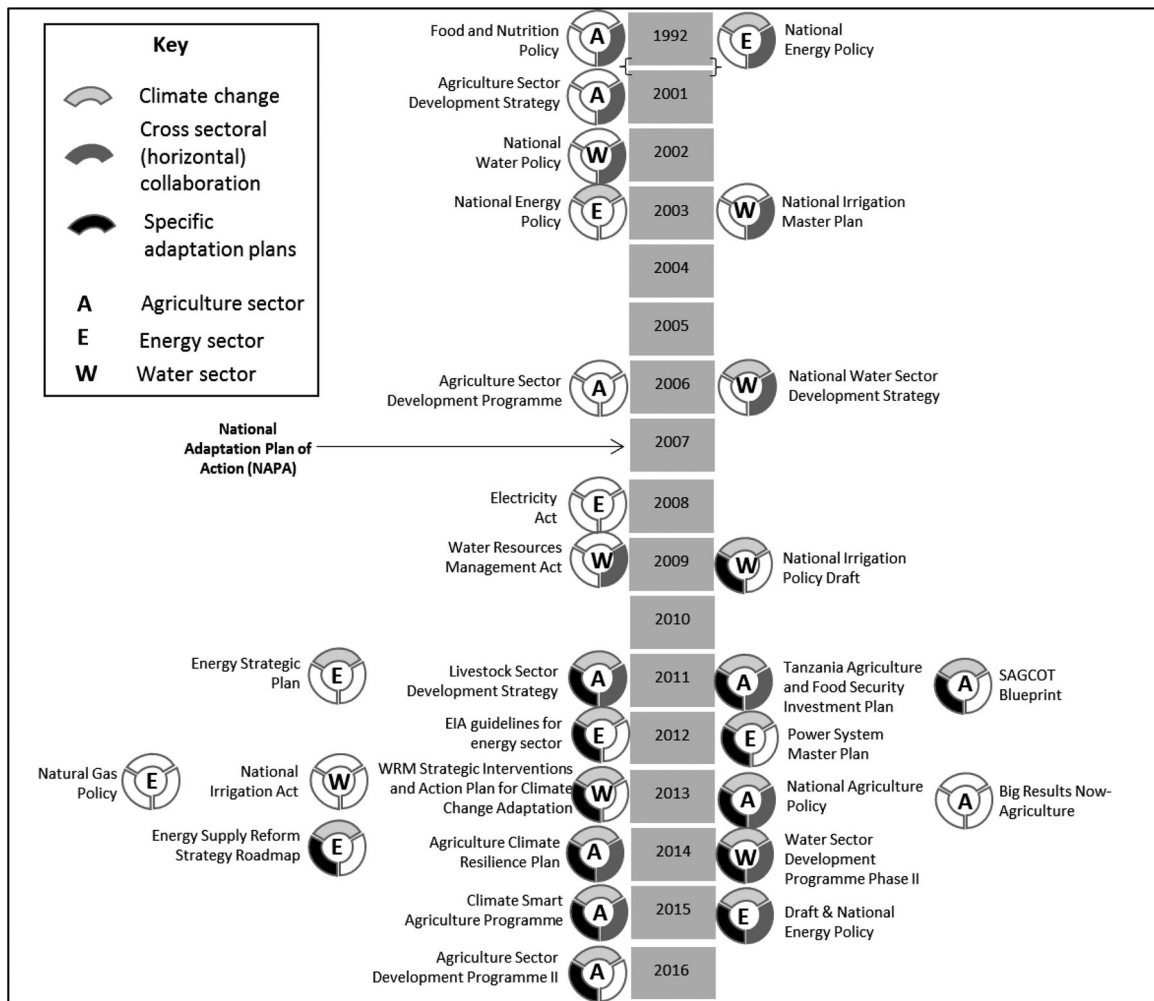


Figure 1. Integration of climate change, adaptation plans and reference to cross-sectoral collaboration in Tanzania's water, energy and agriculture policies over time.

Although Tanzania, in common with most countries in SSA, lacks a national climate change policy, it does have a National Climate Change Strategy (NCCS) (URT, 2012a), which guides the integration of climate change in sectoral policies and plans. This is supplemented by the National Climate Change Communication Strategy (NCCCS) (URT, 2012b) and Guidelines for Integrating Climate Change Adaptation into National Sectoral Policies, Plans and Programmes of Tanzania (URT, 2012c). The NCCS draws heavily on Tanzania National Adaptation Plan of Action (URT, 2007), which includes plans for climate change adaptation for various sectors, including strategies for the water, agriculture and energy sectors. The NAPA, NCCS, NCCCS and Guidelines are the key documents intended to guide climate change integration into sectoral policy.

The documents presented by the VPO-DoE also reflect the sectoral approach of the NAPA. The NCCS, in particular, details the potential impacts of climate change by sector before presenting the adaptation strategies identified for each sector (URT, 2012a). On cross-sectoral (horizontal) integration, the NCCS states that the strategy responds to gaps 'by ensuring that there is more coordination and complementarity between key economic sectors in implementing climate change activities' (URT, 2012b, vi), however, the strategy provides no details on how this would be achieved beyond forming technical and steering committees. The policy also notes that 'Government objectives relevant to the environment are enjoined to coordinate their activities and synchronize their

Table 2. Summary of interview respondents by sector of expertise and type of organization.

	Government	Private Sector	Non-Governmental Organisation
Agriculture	Ministry of Agriculture, Livestock and Fisheries	United Nations Food and Agriculture Organisation	Kilombero Plantations Limited
	Rufiji Basin Development Authority (RUBADA)	National Networks of Farmers' Groups in Tanzania	Muongano Outgrowers Association
	Southern Agricultural Growth Corridor of Tanzania	Mbeya Youth Development Organisation	Msolwa Outgrowers Association
	Agricultural Research Institute - Uyole	Alliance for a Green Revolution in Africa Mbeya	Techno Serve
	Mbeya Irrigation Office	Embassy of Finland Catholic Relief Services	Illovo
Energy	Ministry of Energy and Minerals Tanzania Electricity Supply Company Limited		
Water	Ministry of Water and Irrigation	Association of Tanzanian Water Suppliers	
	Rufiji Basin Water Board	Japan International Cooperation Agency World Bank Deutsche Gesellschaft für Internationale Zusammenarbeit Water Resources Group Worldwide Fund for Nature	City Engineering
Environment and other/ multiple sectors	Ministry of Natural Resources and Tourism	Tanzania Natural Resource Forum	
	Tanzania Meteorological Agency	International Union for Conservation of Nature	
	National Environment Management Council	Tanzania Association of Foresters	
	Vice President's – Division of Environment	The Community Forest Conservation Network of Tanzania	
	Prime Minister's Office – Disaster Management Department	Forum CC	
	President's Delivery Bureau	Belgian Development Agency	
	Ardhi University Sokoine University of Agriculture	SNV Netherlands Development Organisation Embassy of Norway Policy Forum	
	University of Dar es Salaam		

rules and regulations' (URT, 1997, p. 38). However, water, energy and agriculture are divided into separate government ministries in Tanzania (the Ministry of Water and Irrigation (MoWI), the Ministry of Energy and Minerals (MEM) and the Ministry of Agriculture, Livestock and Fisheries (MALF)). Potential connections between these Ministries could have been enhanced by previous configurations that placed water within for example, the Ministry of Water and Livestock Development. Irrigation has formerly been located within the Ministry of Agriculture and Irrigation. Such shifts in configurations could aid efforts to coordinate between Ministries; however, this was not found to be the case.

Integration of climate change in water, energy and agriculture policies and plans

Figure 1 shows that Tanzania's NAPA marked a step change in the integration of climate change in sectoral policies and plans over time. However, the extent of climate change integration into policies, plans and strategies and the development of stand-alone sectoral climate policies varied from sector to sector. Energy was the first of the three to include a reference to climate change, briefly in the 1992 National Energy Policy; 'destructive activities of man destroy the balance in the ecosystem leading to such effects as climatic changes' (URT, 1992, p. 21). In contrast, the first mention of climate change in water sector policy was in the 2006 National Water Sector Development Strategy (URT, 2006a), which was published just before the NAPA. The agriculture sector first mentioned climate change in the Livestock Sector Development Programme (URT, 2011b). Despite the late start, agriculture was the first of the three sectors to develop climate change specific plans such as the Agriculture

Climate Resilience Plan (ACRP) 2014-2020 (Ministry for Agriculture Food Security and Cooperatives, 2014) and the Tanzania Climate Smart Agriculture Programme 2015-2025 (URT, 2015b).

Climate change integration in the agriculture sector

Interviews gave the impression that, despite being the latest of the three nexus sectors to include a mention of climate change in sectoral policy or plans, agriculture had since taken a lead in mainstreaming climate change (environmental and agriculture NGO interviews). This was particularly evident in the recent development of plans dedicated to climate change. The ACRP (Ministry for Agriculture Food Security and Cooperatives, 2014) and the Climate Smart Agriculture Programme (URT, 2015b) both specifically focus on climate change adaptation. This was a marked development from the initial inclusion of climate change in the Livestock Sector Development Strategy where it was suggested that climate change would not be a significant challenge for the sector, arguing that 'shocks from climate change will not significantly increase' (URT, 2011b, p. 44)

The SAGCOT Investment Blueprint (SAGCOT, 2011) went further than the Livestock Sector Development Strategy, recognizing the potential for climate change to exacerbate competition for water. Climate change is then included as one of five areas of environmental focus for SAGCOT with the Blueprint calling for the development of irrigation in order to adapt to climate change (SAGCOT, 2011). Irrigation now forms the basis of adaptation strategies in the agriculture sector, reiterated in the National Agriculture Policy (URT, 2013a), the ACRP (Ministry for Agriculture Food Security and Cooperatives, 2014) and the Climate Smart Agriculture Programme (URT, 2015b). The Climate Resilience Plan was described by one government interviewee in the agriculture sector as the 'mother document' which stems from the VPO 'father document', and, therefore, represents the agriculture sector's mainstreamed climate change strategy.

Respondents from two environmental NGOs both commented that the recent rise in prominence of climate change in agriculture is also reflected in actions, primarily in the implementation of Climate Smart Agriculture (CSA). Interviewees provided examples of CSA practices being implemented at the local level and linked these directly to the 2014 ACRP which backs up the CSA approach as an example of a specific strategy to address climate change (environmental NGO interviews).

Climate change integration in the water sector

The water sector is recognized as another lead sector for addressing climate change (environmental NGO interview) with water sector policies, plans and strategies increasingly integrating climate change, particularly over the last ten years and following introduction of the NAPA. For example, the National Water Policy (NAWAPO) published in 2002 (URT, 2002) did not mention climate change but since then, the National Water Sector Development Strategy (URT, 2006a), the National Irrigation Policy draft of 2009 (URT, 2009) and the Water Sector Development Programme (URT, 2014a) all mention the need to consider and address climate change. Produced following the publication of the 2007 NAPA, both present specific plans and strategies to adapt to climate change. Actions include irrigation, awareness raising and the construction of 'strategic dams' for water security and flood control.

Whilst climate change is integrated into these general water sector policies and strategies, the sector still lacks a suite of climate change specific plans. Instead, the Water Resources Management (WRM) Strategic Interventions and Action Plan for Climate Change (URT, 2013b) was identified as the single climate change specific plan. It includes specific strategies to adapt to climate change, including water conservation, efficiency and flood defence and risk management strategies, however, the document does not mention coordination with other sectors in implementing such plans.

Climate change integration in the energy sector

Whilst the energy sector was the first of the three sectors to mention climate change, subsequent National Energy Policies (NEPs) of 2003 and 2015 show less coverage (URT, 2003, 2015c). This is in contrast to the water and agriculture sectors which have given increasing attention to climate change. The 2003 NEP mentions

only ‘minimizing threats on climate change’ (URT, 2003, p. 25) and the 2015 NEP mentions the vulnerability of hydropower to climate change. In contrast, the draft NEP for 2015 also included mention of the need to ‘mitigate climate change’ (URT, 2015a, p. 1), a statement that was removed for the final version. Unlike the agriculture and water sectors, the energy sector still lacks a dedicated climate change strategy or plan. Discussions with interviewees in the energy sector tended to focus on mitigation rather than adaptation and highlighted Tanzania’s capacity as a net carbon sink (government environment sector, government energy sector and environment NGO interviews). When pushed to consider adaptation, diversification was given as the key strategy to cope with the main climate change impacts on energy which were identified to be on hydropower generation as a result of insufficient water availability (government energy and environment sector interviews).

The effects of drought on recurring electricity blackouts is highlighted in the Electricity Supply Reform Strategy (URT, 2014b, p. 7) as a key driver behind the push to diversify away from hydropower, potentially overlooking adaptation opportunities to manage hydropower in line with a changing climate. While the 2015 NEP (URT, 2015b) does mention diversification of energy sources to include renewable energy, the 2003 NEP (URT, 2003) notes that ‘the dissemination of renewable energy technologies have been limited’ and therefore, ‘initiatives to increase utilization of coal for electricity generation are being explored’ (URT, 2003, p. 6). This was reiterated in interviewees with government energy sector representatives who stressed a need to shift to coal and natural gas, potentially undermining mitigation goals (government energy interviewees; Makoye, 2015).

Policy coherence and conflicts

Although there is a difference in the degree to which climate change is integrated and prioritized in the three sectors, there are some similarities, particularly in approaches to address climate change in the water and agriculture sectors. Both sectors advocate irrigation for adaptation to climate change (e.g. National Agriculture Policy, URT, 2013a; National Irrigation Policy draft, URT, 2009; Water Sector Development Programme Phase II, URT, 2014a). The agriculture sector has been keen to increase irrigation long before concerns about climate change, based on a desire to utilize the perceived abundant supply of surface water (government agriculture sector interview; URT, 2006b). With climate change threatening rainfall, irrigation is now packaged as an adaptation strategy for both sectors to help manage rainfall variability. In addition, the water sector has also identified ‘strategic dams’ which could combine irrigation with hydropower generation (Water Sector Development Programme Phase II, URT, 2014a). Clearly, these strategies should be coordinated with the agriculture and energy sectors to maximize efficient use of resources and ensure environmental flows, however, in water sector documents, references to coordination and collaboration have tended to focus predominantly on vertical (sectoral) coordination, with only a few vague statements on a need for horizontal (cross-sectoral) coordination (see Supplementary Information 2).

Although the specific plans of the water and agriculture sectors to adapt to climate change reflect a degree of coherence, the agriculture sector remains in pursuit of greater utilization of land resources to increase productivity. This is at odds with water sector concerns about rising water demand. In contrast to the water and agriculture sectors, the energy sector is focused on diversification away from hydropower as the main strategy for adaptation. Yet, further hydropower dams are planned and indeed, both the water and agriculture sectors expect such dams to form part of the irrigation network to help manage flood and drought conditions (government agriculture, water and energy sector interviews).

Coordination and collaboration

Coordination and collaboration in policy

Policies, strategies and plans, not only guide the activities of the ministries but also provide the framework for practical coordination between the ministries. However, without an overarching climate change policy to direct collaboration, climate change policy integration and practical collaboration depends on the initiatives of the sectors. Figure 1 shows a timeline of policies and their inclusion of climate change and nexus sector issues. This demonstrates that many of the policy documents and strategies have included reference to a need and

desire to collaborate and coordinate with other ministries. The importance of coordinated approaches is highlighted in policies and strategies such as the National Water Sector Development Strategy (URT, 2006a) which highlights that conflicts have occurred between the water and energy sector as a result of a lack of coordination. The National Agriculture Policy (URT, 2013a) also mentions challenges in developing the irrigation system as a result of a 'lack of holistic integrated planning in water utilization' (URT, 2013a, p. 15). However, most of the statements on cross-sectoral collaboration are nebulous calls for greater collaboration (see Supplementary Information 2). The persistence of these calls in policies and strategies over time suggests there is an ongoing recognized gap in collaborative and coordinated efforts in practice. This is reinforced by the emphasis that the NAPA places on vertical integration.

Coordination and collaboration in practice

Although the policy setting for the WEF nexus sectors does not provide a strong framework for coordination and collaboration, the nature of the climate change adaptation strategies and approaches clearly calls for cross-sectoral efforts in practice. Interviews with key stakeholders reveal how collaboration and coordination are taking place in practice to implement the climate change objectives of the policies and plans.

Collaboration in the nexus sectors regarding climate change was most evident between the water and agriculture sectors (based on the number of mentions/projects). There was also mention of one project between MEM and MOWI (government energy sector interview) and collaboration between the MEM, TANESCO (electricity supplier) and local Basin Water Boards on managing upstream activities (government energy, water and environment sector interviews). However, collaboration between the agriculture and energy sectors was not mentioned in interviews. One interviewee commented that energy and agriculture 'are not connected' and that 'we don't know each other or what we are doing' (government agriculture sector interview).

The interviews noted only two means for interaction: specific projects on an ad hoc basis and, formal communications such as requests for data. Informal interaction through personal contacts was explicitly highlighted as not being present with interviewees stressing formal channels as the means to inter-sectoral communication, for example:

we are two different entities but since we are all government institutions, let's say, if you come, you are demanding to get some information on water data, it is easy for me to write a letter requesting the water office there, they will respond ... we communicate as government institutions but we don't have a straight link because they are [a] different ministry (government agriculture sector interview)

The emphasis on formal modes of contact may dis-incentivize regular collaboration; however, this is not the only barrier to cross-sectoral coordination and collaboration that was revealed in the interviews.

Budget and financing arrangements are also strongly sector based. Interviews repeatedly highlighted that limited budgets restrict opportunities to implement a range of strategies. They restrict contributions to cross-sectoral projects owing to concerns of free-riding and a need to recover costs. This was exemplified during an interview with the coordinators of a project that involves MOWI and the Tanzania Meteorological Agency (TMA) sharing hydroclimatic data with each other and MALF. Both MOWI and TMA incur costs to collect the data and whilst MOWI would usually provide this freely, TMA normally charge fees. As a result of this disparity, MOWI and TMA have not been able to agree on provision of the data to each other and MALF. This highlights what could be a very concrete example of coordination (data sharing) if an agreement could be reached.

Power imbalances

The document analysis reveals that a key driving force for the integration of climate change in Tanzania has been the development of Tanzania's NAPA which is required to conform with an international process. As a result, Tanzania has been supported by external agents such as the Global Environment Facility and the United Nations Environment Programme in the development of its NAPA. However, such processes have been criticized as being prone to a lack of domestic buy-in (Kalaba et al., 2014; Nunan et al., 2012). Comments from several interviewees highlighted climate change as an externally derived priority. For example, one interviewee from the government energy sector

commented that 'it is something that people talk about as though it has come from outside' and another from an environmental NGO commented that work on climate change is related to funding for projects: 'there could be a call for a proposal so ... that's the thing we will be following ... it's not from our heart, it's just because we are implementing the project'. These interviewees felt that climate change would become a priority as the impacts began to materialize at the local level and were seen to be more pressing than other development priorities. Until that point, climate change might be integrated into policies but the allocation of limited resources to practical actions on adaptation would require a stronger internally derived imperative.

In Tanzania, the impetus to integrate climate change into domestic policy is led by the VPO-DoE. Whilst the DoE has the mandate to oversee climate change integration across the different sectors, it has tended to take a reactive rather than proactive approach to encouraging greater action on climate change. This may reflect a power imbalance, whereby sectoral interests override the DoE climate change agenda. Indeed, interviewees (private sector agriculture and government water sector) commented on situations where dam releases have been made despite the implications of this for downstream agriculture and longer term water availability as a result of the pressure on the energy sector to ensure a stable electricity supply. This imbalance, whereby the energy sector is pressured to consider immediate power needs over longer term sustainability, is reflected in the energy sector's integration of climate change in policy documents whereby coal and gas are promoted to serve more immediate needs.

As Cairns and Krzywoszynska (2016) highlight, power is an important, yet often neglected, factor in understanding coordination and collaboration opportunities and constraints in the WEF nexus. From interviews, it appears that coordination and collaboration, particularly in relation to climate change in Tanzania remains limited across all three sectors by a power imbalance between the energy sector, and agriculture and water. An institutional framework that places climate change under a powerful and proactive overarching agency could help to overcome some of these challenges. However, development goals remain central and thus, climate change adaptation will need to be aligned with the development agenda in order to garner necessary support (Shemdoe, 2013; Smucker et al., 2015)

Conclusions and policy implications

The WEF nexus framing draws on holistic, systems perspectives that recognize the value of coordinated approaches. Climate change is a cross-cutting issue as adaptation strategies often require efforts of more than one sector. This is certainly the case in Tanzania where adaptation strategies include irrigation which may involve the use and development of multi-purpose dams, cutting across the responsibilities of all WEF nexus sectors with strong potential for synergies and trade-offs.

The integration of climate change into national-level policies, plans and strategies is an important means through which to encourage action on climate change. Studies in policy coherence emphasize the value of policies that are coordinated across sectors so as to avoid maladaptation or conflicts between sectors (e.g. England et al., 2017). This article contributes to the literature on the nexus and climate policy integration through an illustration of the progress but also the barriers to effective integration and cross-sectoral coordination and collaboration in Tanzania.

The findings have shown that, in Tanzania, publication of the NAPA was followed by greater integration of climate change and specific adaptation strategies into policies and planning documents. The agriculture and water sectors have demonstrated progress integrating climate change and specific plans for adaptation into policy and planning documents. In contrast, although the energy sector has integrated climate change it has tended to focus on diversification through increased coal and natural gas-powered electricity. This reflects the different priorities and pressures placed on the energy sector compared to water and agriculture and effectively undermines the efforts of water and agriculture sectors on climate change.

Cross-sectoral collaboration, which is crucial to effective implementation, has not been as evident. Policies and plans continue to call for cross-sectoral working yet in practice collaboration is limited and largely confined to ad hoc projects and activities. The findings have identified key barriers relating to institutional structures. Resource constraints also dis-incentivise collaboration due to issues around cost recovery, free-riders and a need to protect

roles and responsibilities to ensure future budgets. Like climate change, a nexus agenda needs to achieve internal recognition and ownership by relevant agencies to become legitimate and move to implementation.

For effective action on adaptation strategies, cross-sectoral coordination needs to be recognized internally as important, and fostered through suitable institutional structures. Besides situating climate change within a more powerful ministry or department, coordination and collaboration could be fostered through budgets allocated specifically to cross-sectoral projects or simply providing greater annual budget consistency for sectors would also increase confidence to work together on longer term projects and plans. Interviews also emphasized that data sharing is a crucial part of the collaborative process. A platform for sharing data among government departments would help foster collaboration and promote efficiency. However, it must be acknowledged that these changes will require political will and trade-offs may need to be addressed on a broader scale.

The lessons from this case study are relevant for many other countries in SSA, particularly those pursuing agricultural intensification and hydropower development in the face of an uncertain future climate (for example, as proposed in the Programme for Infrastructure Development in Africa which provides an outlook for the development of African infrastructure (2011–2040) (African Development Bank, 2009)). Of the 51 countries in SSA, 35 have submitted NAPAs which this research and others such as Rasul and Sharma (2016) have found to further entrench sectoral approaches, overlooking the need to coordinate between WEF nexus sectors. As the SDGs become a new focal point for development planning, it is anticipated that this will increase recognition of the need for greater collaboration and coordination. In Tanzania, this is beginning to appear in policy design but the barriers of unsupportive institutional structures will remain a challenge that many developing countries will need to overcome for successful implementation of these interconnected goals.

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