Advancing Environmentally Sustainable Food and Water Security: Implementing Tanzanian National Policy at the Basin Scale

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1. Introduction

The Government of Tanzania has a range of contemporary development priorities, among which are enhancing food security, strengthening local and national economies, improving water services provision, and maintaining a spectrum of freshwater-dependent ecosystem goods and services. These national priorities align with several of the Sustainable Development Goals (SDGs; United Nations 2015), including Goals 1, 2, 3, and 6. Policies, legislation, and supporting initiatives are designed to advance these priorities, through specific objectives of increasing food production through expansion of irrigated agriculture and ensuring sustainable water resources management to maintain a diversity of other social, economic, and environmental benefits.

In support of these objectives, CDM Smith and partners implemented the "Technical Assistance to Support the Development of Irrigation and Rural Roads Infrastructure Project" (IRRIP2), funded by the U.S. Agency for International Development (USAID). The work involved a series of coordinated tasks that were carried out with particular focus on increasing irrigated food production, ensuring for the sustainability of water resources and associated ecosystem health and services, and developing a number of tools and practices for supporting adaptive long-term water resources management. Further, the Project was framed using integrated water resources management (IWRM) principles to advance methods, tools, and practices that are also applicable for achieving sustainability and resilience objectives during other water resource development efforts, such as those related to hydropower and industrial expansion. The project also involved work to improve rural roads for enhancing food-to-market transport, although these efforts are not described here.

This paper briefly summarizes a series of IRRIP2 tasks related to environmentally sustainable water resources management, drawing upon eight technical reports and a technical memorandum, as referenced. The sections below outline select key elements of Tanzania's national water and environmental policy, synthesize a specific 2,800-hectare irrigated agriculture project and associated work quantifying sustainability thresholds applied to the project's design and water allocation, and summarize associated tasks undertaken to similarly support environmentally sustainable water development projects at broader (basin and national) scales. The final section highlights key lessons learned

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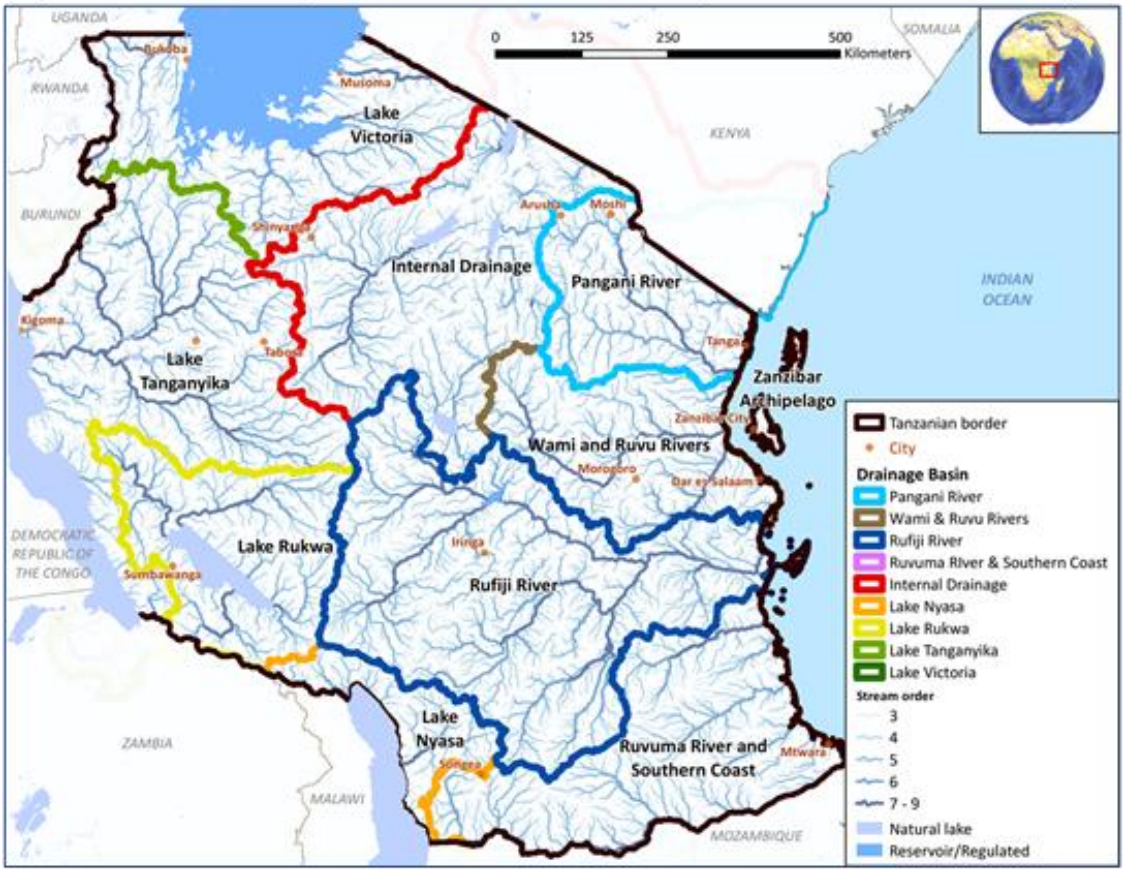
and select recommendations that have been offered for advancing sustainable water management in the Rufiji Basin and across Tanzania in support of achieving water and water-related security goals.

2. Tanzanian Water and Environmental Policy

Tanzania has set ambitious targets for its future development, in line with the Tanzania 2025 Development Vision (United Republic of Tanzania [URT] 1999), the Africa Water Vision of 2025 – the continental implications of which include a five-fold increase in water use for agriculture, industry and hydropower (McClain et al. 2013) – and the Sustainable Development Goals (World Bank 2018). In 2000. Tanzania also acceded to the Ramsar Convention on Wetlands, thereby committing to conserve and promote the wise use of its wetlands through local and national actions, and international cooperation, as contributions toward achieving sustainable development (Wilson et al. 2017).

Within this broader context, Tanzania has actively embraced IWRM as a foundation of its new and emerging water law and policy (URT 2002, 2009; The 2030 Water Resources Group, 2014; World Bank 2018) that govern water resources management across the nation's nine major river and lake basins (Figure 1). Through IWRM, water resources are developed and managed to maximize social and economic benefits for multiple users of

Figure 1: The Nine Major River Basins of Tanzania (source: CDM Smith 2018a).



the resource in an equitable and efficient manner, without degrading ecosystems (Global Water Partnership 2000). The allocation of sufficient water for environmental sustainability is a central theme. As part of the ongoing water sector reform, the heightened attention to the importance of water for the environment in meeting the needs of the Tanzanian people is reflected in the many national level laws and policies aimed at steering water and broader natural resource management towards sustainability.

The Tanzania National Water Policy (NAWAPO) of 2002 (URT 2002) offers a comprehensive framework for achieving the overarching goal of sustainability, and does so by addressing all cross-sectoral interests in and participatory approaches to water resources and catchment planning, development, and management. The NAWAPO provides national policy context, as well as more in-depth information pertaining to the main water use sectors, including domestic water supply; agriculture; livestock; industry; mining; energy, fisheries; forestry and beekeeping; navigation; wildlife and tourism; and – not least – the environment. The NAWAPO specifically states that "Water for the environment, in terms of quantity and quality, and levels, and for both surface and groundwater resource shall be determined on the best scientific information available considering both the temporal and spatial water requirements to maintain the health and viability of riverine and estuary ecosystems, and associated flora and fauna." (URT 2002).

The National Water Sector Development Strategy (URT 2008) helps guide the implementation of national water policy. It includes the goal of implementing a responsive, effective, and sustainable water resource utilization and allocation system based on social and economic priorities, inclusive of environmental protection and conservation measures to be achieved by managing to maintain a "reserve". The Water Resources Management Act No. 11 of 2009 (URT 2009) plays two crucial roles by defining the reserve and establishing legal priorities for water allocation in Tanzania. Specifically, the reserve is defined as: "the quantity and quality of water required for:

> (a) Satisfying basic human needs by securing a basic water supply for people who are now or who shall in the reasonably near future be:
>
> i) Relying upon,
>
> ii) Taking water from; or
>
> iii) Being supplied from the relevant water resources; and
>
> (b) Protecting aquatic ecosystem [*sic*] in order to secure ecologically sustainable development and use of the relevant water resources."

In other words, the reserve consists of water for basic human needs and water for the environment. Moreover, water required for basic human needs – essentially domestic water supply – is currently estimated for rural communities at 25 liters per person per day and is to receive highest priority in water allocation, with water for the environment receiving second priority for protecting ecosystems and associated ecosystem services. Together as the reserve, these two requirements are to be met prior to allocating water for any other socio-economic objectives. In practice, the reserve is accompanied by a legally gazetted volume of water and associated pattern and timing of water flows and levels to be managed adaptively to fulfill the combined purpose of water for people and water for the environment.

Broadly, all water resources in mainland Tanzania are considered a public good and as such are vested in and governed by the President for the benefit of the people (URT 2009). The Ministry of Water and Irrigation (MoWI) is responsible for putting in place the

guidance, procedures and methods for allocating water, to include defining and ensuring implementation of environmental flows as part of the reserve for every water body in the water resource management system. Under national water law and policy, specific authority for managing water resources is assigned to Basin Water Boards (BWBs) established in each of the nine basins across the country (e.g., the Rufiji Basin Water Board [RBWB] for the Rufiji River Basin). BWB responsibilities encompass water planning, water allocation permitting, water user and stakeholder engagement, monitoring, reporting, and permit enforcement, to include ensuring that adequate reserves are defined and maintained across each basin.

3. Sustainable Irrigated Agriculture in the Kilombero River Sub-Basin

The focus of the USAID-funded IRRIP2 was to help strengthen food and water security within the Southern Agricultural Growth Corridor of Tanzania (SAGCOT, 2013), and specifically in the Kilombero Sub-Basin of the Rufiji River Basin. The Kilombero and its tributaries are considered to be high to very high in social and ecological importance and generally still retain natural patterns of flow, ecological function, and associated productivity of diverse socio-economic benefits (CDM Smith 2016a). However, the system is also considered potentially very sensitive to changes in flow conditions from growing water demands, land use changes, and other expanding impacts across the sub-basin. Other areas in the Rufiji Basin offer an instructive, yet concerning, backdrop of past and current degradation due to overallocation of water (Box 1).

The potential for expanding irrigated agriculture in the Kilombero Sub-Basin of the Rufiji Basin by developing four irrigation schemes of around 40,000 hectares for rice and other crops was evaluated in a feasibility study under IRRIP2 (CDM Smith, 2016b). One scheme considered included the development of two blocks (Kisegese 1 and 2) of irrigated rice and maize totaling 2,766 hectares and relying on water diversions from the Lwipa River, a tributary of the Kilombero River.

In parallel to design work on Kisegese 1 and 2, an environmental flow assessment (EFA) was conducted to quantify river flow requirements for maintaining ecosystem health and services for directly dependent local communities; that is, to function as sustainability boundaries for guiding project design, potential operational scenarios, and water diversions associated with the irrigation schemes. This EFA was comprehensive, giving consideration to the full range of natural river flow conditions – low flows to floods across seasons – and a diversity of ecological and socio-economic relationships dependent upon those flow conditions (CDM Smith 2016a). Flow recommendations also were given for climatically typical or normal conditions (“maintenance flow”), as well as for very dry years requiring drought management (“drought flow”):

- *Maintenance flow* – flow representative of a normal year and sufficient to support social and domestic uses, fish migration and breeding, riparian vegetation growth and recruitment, and sediment transport. The maintenance flow is expected to be equalled or exceeded 60 out of every 100 years.
- *Drought flow* – flow equivalent to a drought event, in which flows would be reduced as much as possible, without irreparably damaging the flow-related biophysical processes. For example, in a dry year, flow-sensitive species might miss a breeding season but would survive, perhaps in reduced numbers. The drought flow is expected to be equalled or exceeded 90 to 95 out of every 100 years.

Box 1. Overallocation of water in the Great Ruaha Sub-Basin of Tanzania's Rufiji River Basin and water management for restoring critical environmental low flows. Source: CDM Smith (2018a).

Water from the Great Ruaha River and many of its tributaries is already seriously overallocated for irrigated agriculture, including upstream on the Usangu Plain (Kashaigili et al. 2007, Kashaigili 2008). This overuse has led to the shrinkage of the Usangu Wetlands and drying up of the Great Ruaha River during the dry-season months in the Ruaha National Park, an annually recurring event since 1993 (URT 2014). The consequences have been particularly adverse within the National Park, among other impacts, affecting the life cycles, refuge habitats, condition, and survival of wildlife, riparian vegetation, and fish populations, and reducing water quality and critical ecological functions (WWF-TCO 2010).

In response, an initial (2003-2005) estimate was made of the low flows necessary to maintain the river as perennial and connected. This estimate was generated using a rapid, semi-holistic EFA applying the DRM (CDM Smith 2018c) and Flow Duration Curve analysis to combine hydrological data with limited ecological information from the Msembe Ferry site on the Great Ruaha River inside the park (McClain et al. 2013). In cooperation with RBWB, a more in-depth EFA was subsequently undertaken using the BBM, with the objective "to reinstate sufficient dry-season flows in the reaches of the river passing through Ruaha National Park" (McClain et al. 2013). Maintenance flow recommendations were quantified for two sites on the Great Ruaha mainstem and three sites in the Ihefu Wetland, based on hydrology, hydraulics, riparian vegetation, fish and invertebrates (WWF-TCO 2010).

For a discharge of at least 1 m^3/s to be maintained in the park, an estimated 65 to 90 percent reduction in water allocations for agriculture would be necessary on the Usangu Plains; stakeholders considered this unrealistic in the short-term (McClain et al. 2013). While different options for restoring dry season flows have been considered with some ongoing implementation – such as partial irrigation canal closures during the dry season, water efficiency measures, controls on illegal withdrawals, and alternative livelihoods and water sources – significant reaches of the mainstem river continue to go dry during the dry season (McClain et al. 2013). These conditions were observed in October 2017 (photos below: Great Ruaha National Park, including dry bed of the Great Ruaha River [left] and example of hippopotamus mortality in small and isolated river pools [right]).

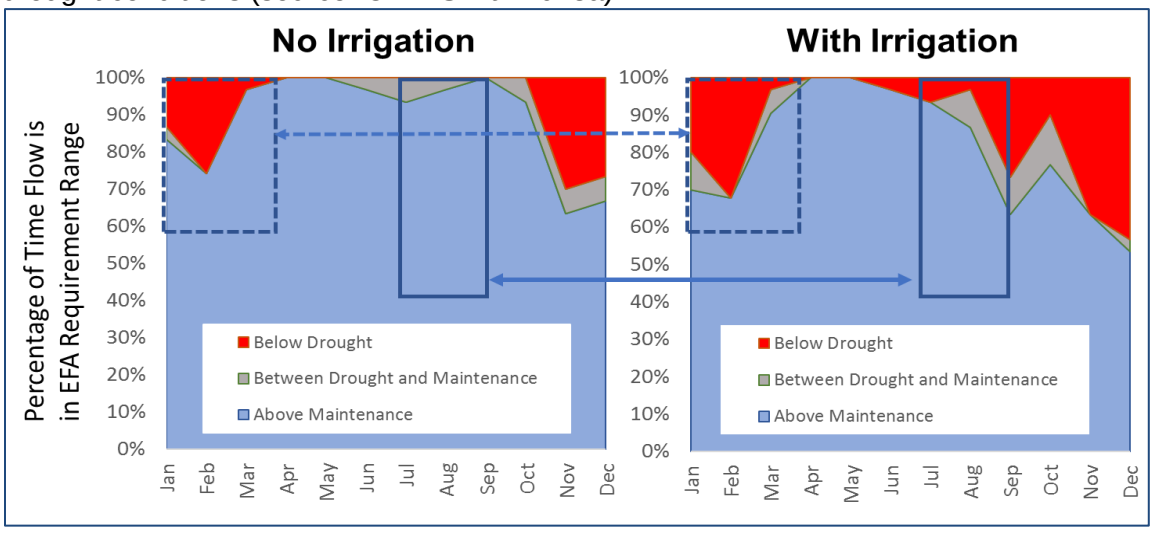
Photo credits: Andrew Warner

Subsequent integration of the EFA recommendations into the irrigation design in part involved a re-design of the schemes to account for the quantity of available water in the system during the dry season (June to October; Figure 2). This involved exploring potential trade-offs and alternatives for meeting ecosystem health and service needs based on the EFA results (CDM Smith 2016a).

As illustrated (Figure 2), the degree to which potential irrigation water could be supplied for the Kisegese scheme with the environmental flows maintained in the Lwipa River (as a reserve) was examined in three categories for the annual hydrograph, based on monthly average discharges: i) above the maintenance environmental flows; ii) between drought and maintenance flows; and, iii) below drought flow. Note that the 'No Irrigation' scenario contains months during which river flows decline below drought flow levels (as frequently as 30% of the time in November). With irrigation, the percentage of time below the drought flow is shown to increase, with the increase greatest during dry periods when the river is already under stress. The amount of time flow is above maintenance levels decreases, even during the wetter periods of the year (notably March). Allowable water withdrawal can be limited by irrigation scheme managers to avoid additional years where flow is projected to fall below the recommended drought flows.

Many other scenarios exist, reflecting the balance between irrigation and the environmental flow recommendations of the reserve, informed by the societal values of different water users and stakeholders, as well as technical alternatives such as methods for improving irrigation efficiency. In this way, the environmental flow recommendations are used to help guide decisions on water resource allocation and associated engineering design and operations. While uncertainties in potential impacts often remain, monitoring of flow, ecological, and related socio-economic conditions around the river can improve understanding and guide adaptive management to improve sustainability and resilience.

Figure 1: Exploring trade-offs for meeting EFA recommendations and potential irrigation allocations of a development scenario for the Lwipa River under maintenance and drought conditions (source: CDM Smith 2018a).



4. Advancing Sustainability at the Basin and National Scales

The initial localized water-related work described above focused on assessing the feasibility of specific irrigation schemes, collecting and understanding local community priorities related to water allocation, defining (quantifying) associated sustainability boundaries, and designing and constructing select irrigation schemes aligned with those priorities. Based on the collection of experience from this work, a series of additional tasks was identified to further support and expand capacity of the RBWB for carrying out its responsibilities across the Rufiji Basin, as well as support similar efforts by other BWBs and nationally by the Ministry of Water and Irrigation. This section provides a brief overview of these tasks.

River Classification System (CDM Smith 2018b): This desktop river classification system is designed to support water resource and broader natural resource management in Tanzania. It provides a constructive framework for guiding planning, monitoring design, scientific investigation, and decision making, including the siting, design, and operation of water development projects (e.g., hydropower dams, and irrigation or industrial supply). This system includes a national classification of rivers, as well as a nested and more detailed Rufiji Basin classification of river types.

Desktop Reserve Model (Tz-DRM; CDM Smith 2018c): This science-based, desktop tool for defining the reserve, first developed in South Africa, continues to be customized for use in Tanzania (CDM Smith 2016a). The Tz-DRM offers a rapid precautionary approach for defining the reserve for river systems throughout Tanzania and was used to generate quantified reserves to supplement other flow assessments across the Rufiji Basin and elsewhere. Training in the tool's application was conducted for RBWB and other Government of Tanzania representatives, academic experts, and NGO staff. Water management and water infrastructure operations that adaptively maintain these defined reserves will help protect ecosystem health and services and strengthen future system resilience.

Simplified Water Allocation Model (CDM Smith 2018d, 2018e): A Simplified Water Allocation Model (SWAM) was developed for both the Great Ruaha and Kilombero Sub-Basins to support the RBWB's water permitting program and broader water resource planning and management activities. These SWAMs are designed to enhance sustainability and resilience across the basin by helping to evaluate the individual and collective impacts on water security of small and large water users, define water requirements for maintaining or restoring quantified reserves, and assess trade-offs in various long-term water use demands such as agricultural irrigation, industrial expansion, and hydropower generation. Hands-on training in applications of the SWAM was conducted in June 2018 as part of an Adaptive Water Resource Management workshop (below).

Adaptive Water Resource Management (CDM Smith 2018f): A Monitoring Program and Adaptive Management Plan was developed for the Rufiji Basin, a priority monitoring network was established, and associated gauging stations were rehabilitated or new monitoring equipment installed, as appropriate. The Plan comprises a three-level program tiered to accommodate monitoring and evaluation at low, moderate and high levels of data collection, funding, and institutional capacity. An Adaptive Water Resource Management

workshop was conducted in June 2018 to advance implementation in support of environmentally sustainable and resilient water resources management across the Rufiji Basin.

Recommend Enhancements to the Guidelines for Environmental Water Requirements Assessment (CDM Smith 2018g): To assist Basin Water Boards in managing for the reserve, the Government of Tanzania has drafted Environmental Water Requirements Assessment Guidelines for the country. This draft was reviewed, and recommendations for strengthening the Guidelines submitted to and accepted by the Ministry of Water and Irrigation. While these recommendations were informed by international best practice, they strongly reflect the collective experience gained while implementing the above Rufiji Basin work. Application of the finalized Guidelines can constructively steer siting, design, and operation of current and future water development projects, to include energy generation and municipal, industrial, and agricultural supply, thereby strengthening water management in river basins across Tanzania.

5. Conclusions

This project generated a series of technical, institutional, and capacity-based recommendations for advancing sustainable water management in the Rufiji River Basin and across Tanzania in support of achieving water and water-related human security goals, aligned with several SDGs (CDM Smith 2018a). These recommendations were derived in large part from the experiences and lessons learned from the collection of work summarized previously, including identified challenges and constraints, innovations, and ultimate outcomes and results. Those recommendations are not fully revisited here, but select recommendations specific to the Rufiji Basin and national scales are outlined below.

At the basin scale, a primary recommendation is to ensure adequate funding for and capacity within the RBWB (and other BWBs) to carry out its responsibilities as called for under Tanzania's national water policies. These responsibilities encompass a wide range of adaptive management actions across water planning, allocation and permitting, and monitoring (including rapid biological assessments and other screening level evaluations), reporting, reserve compliance, and enforcement of regulations. While important investments are being made in staff education and training, funding is generally insufficient to support broad stakeholder engagement, guarantee long-term monitoring including equipment maintenance, and enable enforcement activities. These capacity challenges are exacerbated by the vastness of the Rufiji Basin and difficulty of travel, especially during the rainy season.

However, there are innovations emerging that should be further encouraged and supported for their ability to help alleviate such resource constraints. For example, water user associations (WUAs) – locally-established groups typically operating at the tributary or sub-tributary scale – have been established at select locations within the Rufiji and other basins. WUAs are and have been active in a range of critically-important activities such as organizing water user and stakeholder engagement, processes to partition water allocations, monitoring, and self-regulating water use among members. By playing any or all of these roles in coordination with a BWB, a WUA can effectively and efficiently fill critical gaps in otherwise resource-limited basin water governance, contribute to monitoring and adaptive management, and enhance the sustainability and resilience of water resource management.

Pressures on water resources in the Rufiji Basin continue to increase, for example from expanding irrigated agriculture and planned hydropower dams. These expanding demands raise the urgency not only to conduct environmental flow assessments for other areas of the basin but also to implement and adaptively manage environmental flow recommendations to help guide decisions toward sustainable water resource allocation and management. The most pressing need is for an EFA for the Lower Rufiji River System – including the social and ecological flow-linked needs of the river-floodplain, lakes, and delta – to help inform decisions related to the design, construction, and future operation of Stiegler's Gorge Dam. Further, it is important that action be taken to formally gazette and initiate implementation of reserves across the basin as soon as they are developed.

At the national scale, much can be learned from the collective work to date by each of the nine BWBs, including work in the Rufiji Basin through the IRRIP2 project. An outreach effort should be initiated on the reserve to inform officials in other ministries with environmental and water-related responsibilities, to include identifying options for improving cross-institutional collaboration and water governance. The Policy Brief (CDM Smith 2018a) and other resources can act as a foundation for this outreach. In parallel, this collection of work should be used to update and finalize the *2016 Draft National Environmental Flow Guidelines for Tanzania*, to include the recommendations provided in the memorandum to the MoWI (CDM Smith 2018g; Memorandum from CDM Smith to the Permanent Secretary, Ministry of Water and Irrigation. March 28, 2018). Similarly, benefits could be realized by MoWI finalizing the *Draft Environmental Water Requirements Assessment Guidelines for Tanzania* and expanding efforts to transfer methods and tools described above and lessons learned across the nine basins. If further supported, efforts to date to establish and advance a national center of excellence for water resources management could significantly benefit the nation by developing best practices, encouraging common approaches and systems across the basins, establishing and maintaining a national water resources information system, and/or acting as a forum for exchange and source of experts accessible to BWBs and Ministries.

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