Situation Analysis Report: Dodoma Transformation Lab

Climate Adaptation and Resilience In Tropical Drylands (CLARITY)

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Acknowledgements

We would like to express our gratitude to the CLARITY project's funders, the International Development Research Centre (IDRC, Canada) and the Foreign, Commonwealth and Development Office (FCDO, UK), which funded the project under the Climate Adaptation and Resilience (CLARE) programme.

We would also like to extend our thanks to all the contributors to this situation analysis report, including Richard Taylor, Japhet Kashaigili, Devotha Mosha, Joseph Kangile, Martin Todd, Hosea Sanga, Sekela Twisa, Johaiven Joel, Brenda Mndolwa, Ruth Emmanuel, Evarest Abraham, Vicky Ramadhan and Kaavya Pradeep Kumar.

Furthermore, we are grateful to all the stakeholders, particularly DUWASA, Wami Ruvu Water Basin Board and others, for validating most of the information and data contained in this report.

Finally, we would like to express our appreciation to all colleagues who have reviewed and provided feedback on the drafts of this report.

Suggested Citation: CLARITY Consortium (2024) *Situation Analysis Report: Dodoma Transformation Lab*. Sokoine University of Agriculture (SUA), Morogoro, Tanzania.

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List of Abbreviations

CBWSO	Community Based Water Supply Organizations
CLARE	Climate Adaptation and Resilience
CLARITY	CLimate Adaptation and Resilience In Tropical drYlands
DDCA	Drilling and Dam Construction Agency
DUWASA	Dodoma Urban Water Supply and Sanitation Authority
EWURA	Energy and Water Utilities Regulatory Authority
FCDO	Foreign, Commonwealth and Development Office
IDRC	International Development Research Centre
IRDP	Institute of Rural Development and Planning
JKT	*Jeshi la Kujenga Taifa*
LGA	Local Government Authority
MDA	Ministries, Departments and Agencies
MoW	Ministry of Water

MUST	Mbeya University of Science and Technology
NEMC	National Environmental Management Council
NGOs	Non-governmental Organization
PO-RALG	President’s Office Regional Administration and Local Government
RUWASA	Rural Water Supply and Sanitation Agency
SUA	Sokoine University of Agriculture
TANESCO	Tanzania Electric Supply Company Limited
TPDF	Tanzania Peoples Defense Force
TBS	Tanzania Bureau of Statistics
UDOM	University of Dodoma
UK	United Kingdom
WRCoE	Water Resource Centre of Excellence

Executive Summary

The Dodoma Transformation Lab (T-Lab) is situated in the Dodoma region of Tanzania's East African Central Plateau. It has a dryland climate and is home to low-income communities that are particularly vulnerable to the impacts of water scarcity resulting from unsustainable development pathways and climate change. Groundwater is a vital resource for these communities, playing a central role in supporting their water needs and livelihoods as well as their adaptation to the amplification of rainfall extremes.

The CLARITY (CLimate Adaptation and Resilience In Tropical drYlands) project aims to support transformational change in Dodoma City through the identification of equitable, sustainable, and climate-resilient water pathways, scaling these, and embedding them within wider policy processes and practice. This *Situation Analysis* provides baseline information on existing practices and drivers of change in the Dodoma region. The report draws on past research by the research team, a review of relevant literature and physical validation of information, which included a scoping study which was conducted in five districts of Dodoma region, namely Dodoma City, Bahi, Kongwa, Chamwino, and Chemba districts. Key stakeholders in and beyond the Dodoma region were consulted as part of the validation process.

The *Situation Analysis* provides insights into the current status of water supplies for drinking water, food security and industry in the Dodoma region, highlighting the challenges posed by water scarcity. Dodoma City is devoid of permanent surface water bodies and relies solely on groundwater for its perennial water source. Freshwater demand is nearly twice the available supply and it is anticipated that this demand will continue to rise as a consequence of population growth and development activities that include the expansion of irrigation to adapt to the impacts of climate change. This challenge has been compounded by the relocation over the last five years of government ministries, departments, agencies, some embassies, and other local and international offices from Dar es Salaam to Dodoma. Associated growth in population, manufacturing, agro-processing, services, and construction have additionally increased water demand. The rising imbalance between freshwater supply and demand has led to has led to an explosion in private boreholes (self-supply) and a search for additional sources of water that include additional wellfields around Dodoma's urban periphery, deep groundwater sources, and an inter-basin transfer of surface water from the proposed Farkwa Dam in Tanzania's Internal Drainage Basin.

The *Situation Analysis* serves as a foundation for understanding freshwater demand and groundwater availability in Dodoma City. It sets a baseline of understanding on to which assessments of equity and sustainability of groundwater withdrawals including their resilience to land-cover and climate change can be made. It also highlights the

disaggregated and socially stratified impacts of inhibited access to water, sanitation, and hygiene (WASH) services. The analysis reveals inequitable access to water, displacement of low-income households and concerns over water quality of water sources from (self-supply) shallow wells, used by some households. The report also considers the importance of a better understanding of gender equality and social inclusion (GESI) in groundwater development and management.

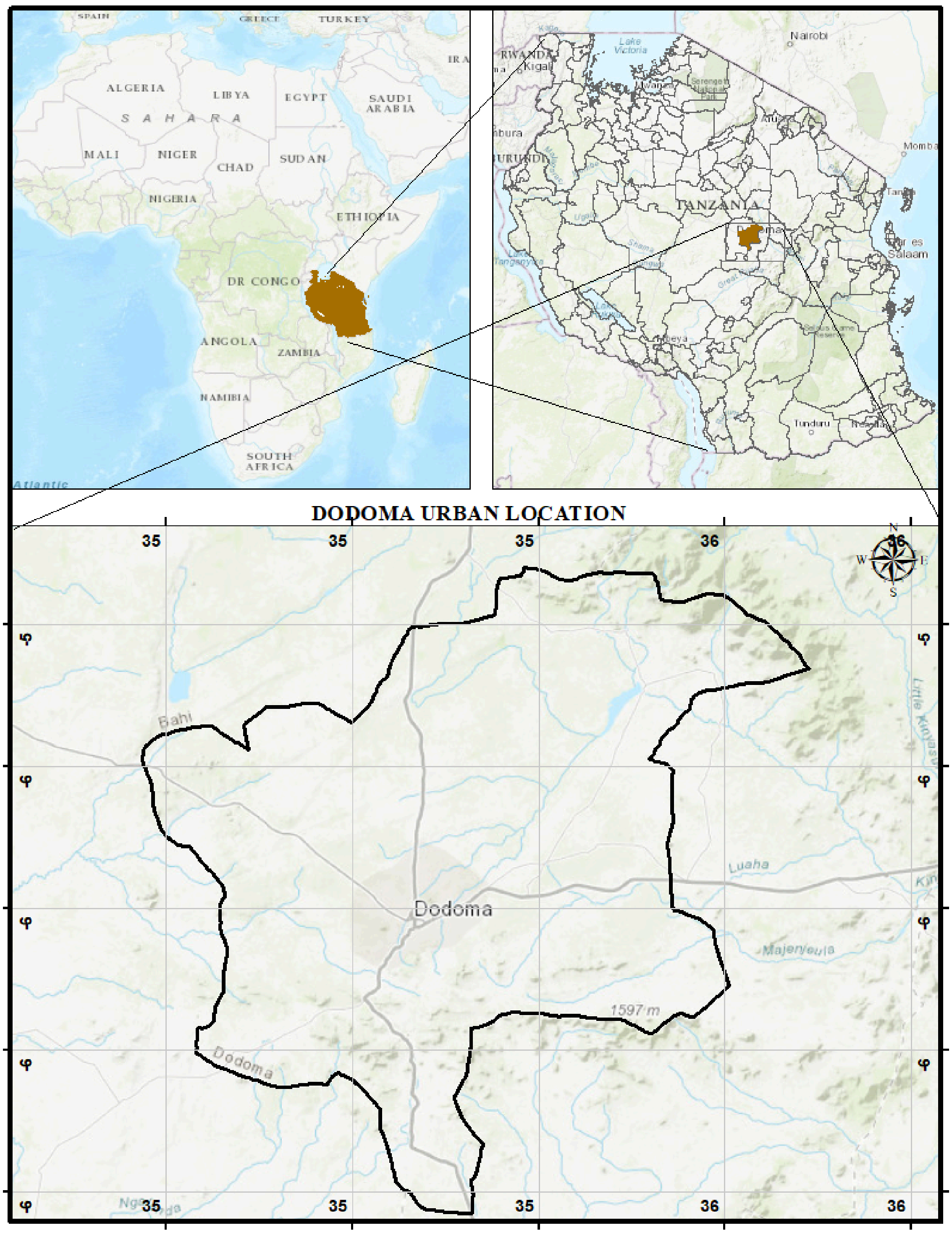

Figure 1: Location map (inset: Tanzania in Africa, Dodoma Region in Tanzania) of the Dodoma region and Dodoma City, Tanzania.

1. Introduction

1.1 Overview of the CLARITY Project in Tanzania

CLARITY (CLimate Adaptation and Resilience In Tropical drYlands)[1] is a 3.5-year project starting from May 2023, funded by the International Development Research Centre (IDRC, Canada) and Foreign, Commonwealth and Development Office (FCDO, UK) under the Climate Adaptation and Resilience (CLARE) programme[2]. The project aims to develop the scientific basis evidence, tools and participatory management processes that will lead to equitable, inclusive, and sustainable climate-resilient development pathways for groundwater resources in tropical drylands. CLARITY will create long-term assets (data, tools) and capacities to achieve transformational change. The Dodoma region is one of three regional foci that includes The Sahel of southeastern Niger and northern Nigeria.

The Dodoma region is home to impoverished communities that are acutely vulnerable to the risk of water scarcity amplified by climate change. Groundwater plays a vital role in supplying these communities' water needs and enabling adaptation to climate change. Renewable groundwater development can provide pathways towards sustainable growth and climate resilience. Mismanagement, however, can lead to resource depletion, unequal access, social exclusion and unsustainable development.

1.2 The Dodoma Transformation Lab

Transformation Labs (T-Labs) are inclusive spaces where stakeholders, practitioners and researchers come together to co-design and test ideas and innovations, co-produce new knowledge, and co-evaluate solutions. The Dodoma T-Lab is led by the Sokoine University of Agriculture (SUA) in collaboration with the Water Resources Center of Excellence (WRCoE) under the Ministry of Water (MoW). It began operations in May 2023 and was officially launched on October 31 (2023) by the Permanent Secretary of the Ministry of Water, Prof. Jamal A. Katundu (Fig. 2). The workshop was attended by 65 participants drawn from various private and public organizations, including Ministries, Departments and Agencies (MDAs), non-governmental organizations (NGOs), farmers, researchers (universities and others), media, local government authorities (LGAs), Wami Ruvu Water Basin Authority, and private sector institutions. International participants from Europe, USA, and India joined virtually.

[1] https://clareprogramme.org/project/climate-adaptation-and-resilience-in-tropical-drylands-clarity/
[2] https://clareprogramme.org/

Figure 2: Stakeholders at the Dodoma T-Lab Inception Workshop at the Nashera Hotel in Dodoma, 31 October 2023; Permanent Secretary of the Ministry of Water, Professor Jamal Katundu is seated central in first row.

SUA and WRCoE are working closely with the Dodoma Urban Water Supply and Sanitation Authority (DUWASA), which is responsible for the provision of water supply and sanitation services to residents of Dodoma City. In December 2019, DUWASA's mandate was extended to areas around Dodoma including Bahi, Kongwa, Chamwino, Kibaigwa and Mpwapwa.

The Dodoma T-Lab comprises public organizations including Ministries, Departments and Agencies (MDAs), community members (*e.g.* farmers, livestock keepers, food vendors, vulnerable groups, bricks making enterprises, etc.), private-sector stakeholders including NGOs, Water User Associations, Drilling Companies, Clean and wastewater service providers, commercial banks, media from the public and private sectors, research institutions, and development partners.

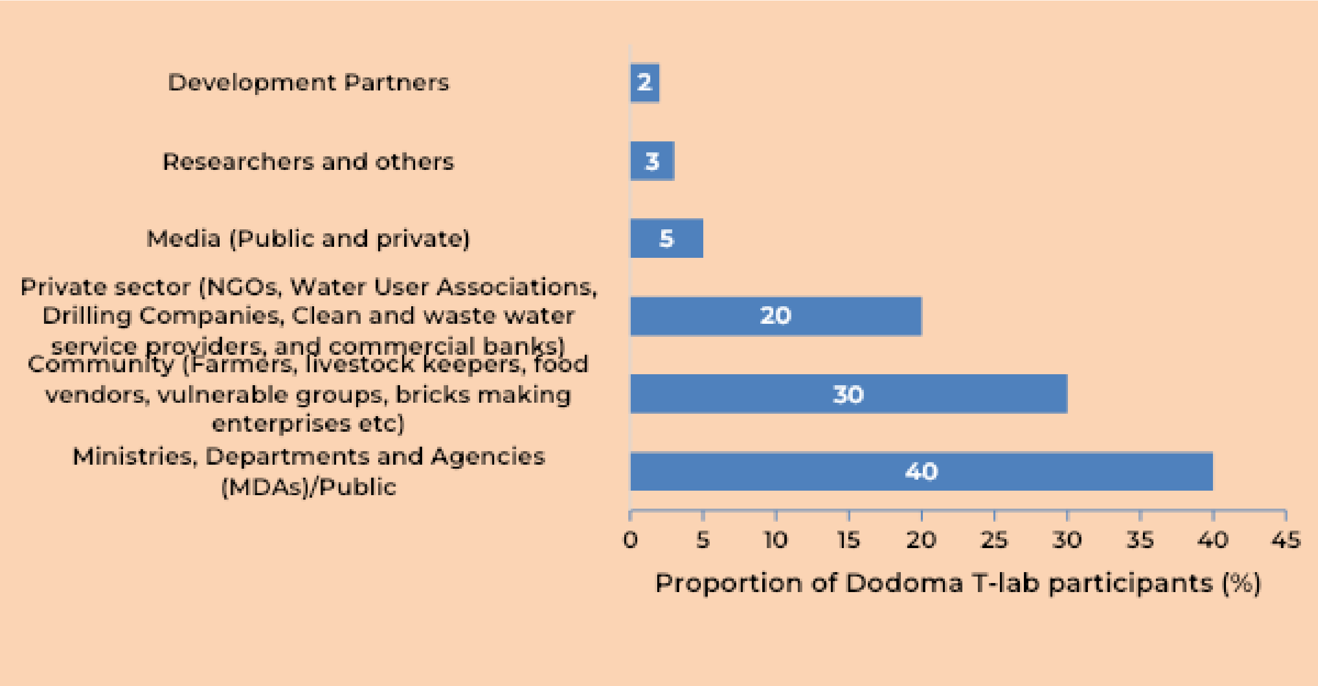

Figure 3: Composition of attendees attending the Dodoma T-Lab Inception Workshop on 31 October 2023.

1.3 Scope and Structure of the Report

The Dodoma T-Lab *Situation Analysis* draws on past research by the research team, a review of relevant literature and physical validation of information, which included a scoping study which was conducted in five districts of Dodoma region, namely Dodoma City, Bahi, Kongwa, Chamwino, and Chemba districts. Key stakeholders in and beyond the Dodoma region were consulted as part of the validation process. The report is divided into four main parts. The first part introduces Dodoma City and the concept of T-Lab. The second part describes the current situation in Dodoma City, including complex, adaptive, socio-hydrologic systems, hydrogeological conditions, and socioeconomic stratification. The third part details the existing policy framework in the water sector in Tanzania, and the final part of the report presents potential stakeholders of the water sector and those specific to the Dodoma T-Lab.

2. Dodoma T-Lab Context

2.1 Dodoma's Water Challenge

The water supply of Dodoma City, Tanzania's national capital, derives primarily from the Makutupora Wellfield that is located within the adjacent tributary of the Kinyasungwe Catchment in central Tanzania (Fig. 4), the headwater catchment of the Wami-Ruvu Basin. Freshwater demand, currently estimated at ~134 000 m^3/day (ADF, 2022), greatly exceeds the installed transmission capacity of the Makutapora (~61,600 m^3/day) and Mzakwe Wellfields (~7,000 m^3/day). The maximum pumping capacity of the wellfield has been estimated to be ~72,000 m^3/day (ADF, 2022). As freshwater demand is projected to triple in the Dodoma region by 2051 (ADF, 2022) due to population growth and rising standards of living, fundamental concerns of the MoW and DUWASA are the sustainability of not only current groundwater withdrawals but also that of additional, requisite freshwater sources under climate change.

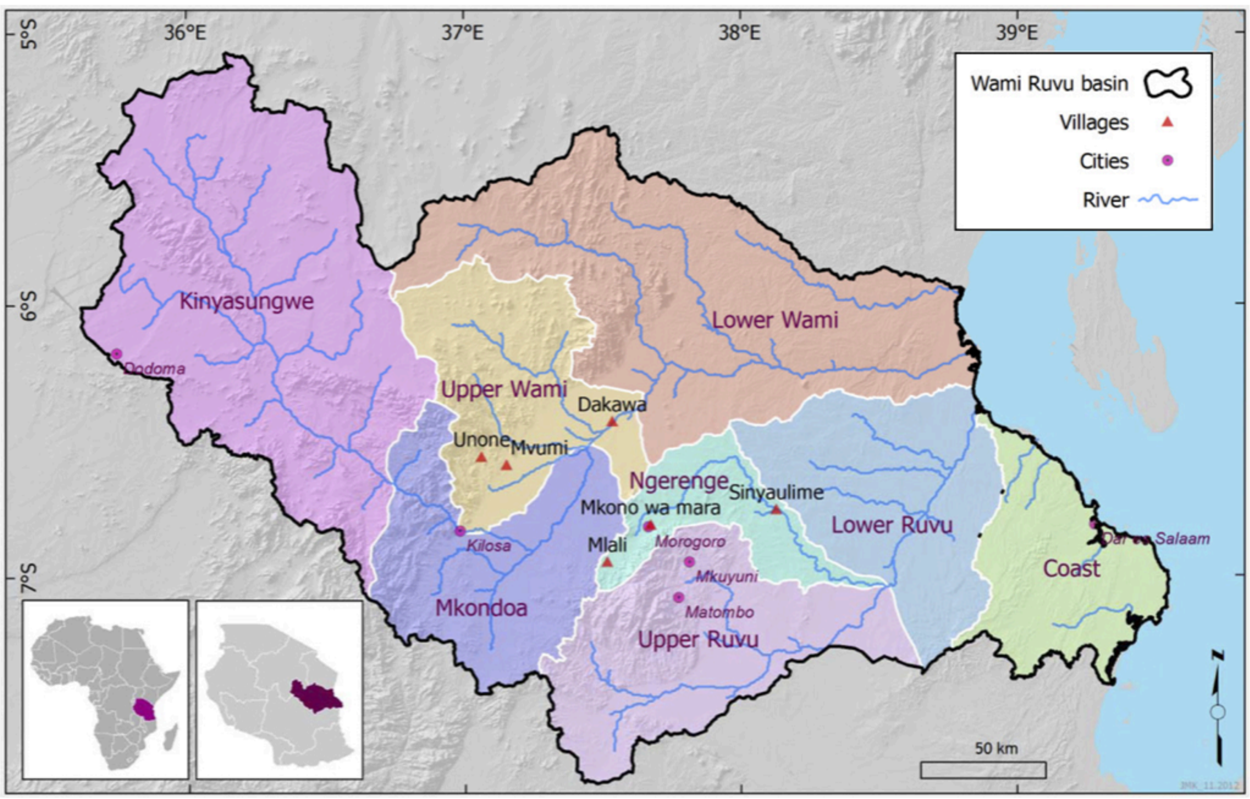

Figure 4: Location map showing the Dodoma and the Kinyasungwe headwater catchment of the River Wami Basin (Ojoyi and Kahinda, 2014).

Population growth in the Dodoma region is accelerating for a range of reasons that include the relocation in 2016 of government Ministries, Departments, and Agencies (MDAs), some embassies, and other local and international offices from Dar es Salaam.

More pervasively in cities across Tanzania is growth from rural-urban migration (Christopher, 2021). The Dodoma region is divided into seven districts, Kondoa, Chemba, Bahi, Dodoma, Chamwino, Kongwa and Mpwapwa; each is administered by a council. Kondoa district has both a Town Council and a District Council.

Available statistics indicate that the population of the Dodoma region by 2022 has risen to over 3 million, with ~765,000 people in Dodoma City alone. Mean annual population growth from 2002 to 2012 was 2.1% but increased to 3.9% from 2012 to 2022 (URT, 2023). Based on this latter rate of growth, the population of Dodoma City is projected to be ~2.4 million by 2052.

Commensurate with population rises is an increase in population densities in the Dodoma region. Mean population densities in the region rose from 50 persons per km^2 in 2012 to 74 in 2022. Table 1 indicates that while population densities have grown in all districts over this period, the rise is most acute in Dodoma City where densities nearly doubled from 158 to 294 persons per km^2.

Table 1: Populations and population densities by council in the Dodoma region

Council	Area (km^2)	Population 2012	Population 2022	Pop. density 2012	Pop. density 2022
Kondoa DC	4,640	214,265	244,854	46	53
Kondoa TC	917	55,439	80,443	60	88
Mpwapwa DC	7,479	305,056	403,247	39	52
Kongwa DC	4,041	309,973	443,867	77	110
Chamwino DC	8,056	330,543	486,176	41	60
Dodoma CC	2,576	410,956	765,179	158	294
Bahi DC	5,949	221,645	322,526	36	52
Chemba DC	7,653	235,711	339,333	31	44
Total	**41,311**	**2,083,588**	**3,085,625**	**50**	**74**

Source: *National Bureau of Statistics; 2012 and 2022 Population Census Reports*

The Dodoma Resilient and Sustainable Water Development and Sanitation Program (DRSWDSP) was created to address rising water shortages associated with urban population growth. The program seeks to expand access to safe water to about 2 million people in Dodoma City as well as Bahi Chemba and Chamwino towns (ADF, 2022). There are, however, other demands for freshwater that include irrigation for viticulture (grapes) and horticultural crops, implemented under the Building Better Tomorrow (BBT) youth program in Dodoma region.

In addition to agriculture, the number of service workers as well as shop and stall sales workers has also increased in Dodoma City. Agricultural activities in and around Dodoma City have decreased due to increased construction activities, which have doubled in recent years. Manufacturing, agro-processing, and service sectors have also grown substantially in Dodoma City.

2.2 Water Resources in the Dodoma T-Lab

Dodoma lies within and adjacent to the River Kinyasungwe sub-catchment (16,538 km^2), headwaters of the River Wami (Fig. 4). River discharge in this dryland environment is ephemeral, flowing episodically between November and May. Surface drainage to the north and east of Dodoma includes the Rivers Little Kinyasungwe, Great Kinyasungwe and Lumuna, flowing in a southeastern direction where these tributaries combine before joining the River Mkondoa River downstream (Fig. 4). The Makutupora Wellfield lies within the Little Kinyasungwe Catchment, ~20 km north of Dodoma City (Figs. 4, 5). This area lies at the southern end of the eastern branch of the East African Rift System (EARS).

The Little Kinyasungwe River drains an area of 698 km^2 from the Chenene Hills downstream to the Chihanga stream gauge (Fig. 5) from which it then flows to Lake Hombolo, a controlled reservoir (Shindo, 1989). Tectonic activity associated with the on-going development of the EARS has strongly influenced surface and sub-surface drainage in the basin and surrounding areas. Linear drainage features including lakes, rivers and swamps, which generally trend NE-SW and NW-SE, reflect extensive, tectonically induced faulting (Nkotagu, 1996a; Taylor *et al.*, 2013a; Zarate *et al.*, 2021). Major lineaments within the Little Kinyasungwe catchment include the Mlemu and Kitope faults (Fig. 5). River flow is ephemeral and varies substantially from one rainy season to the next (Table 2).

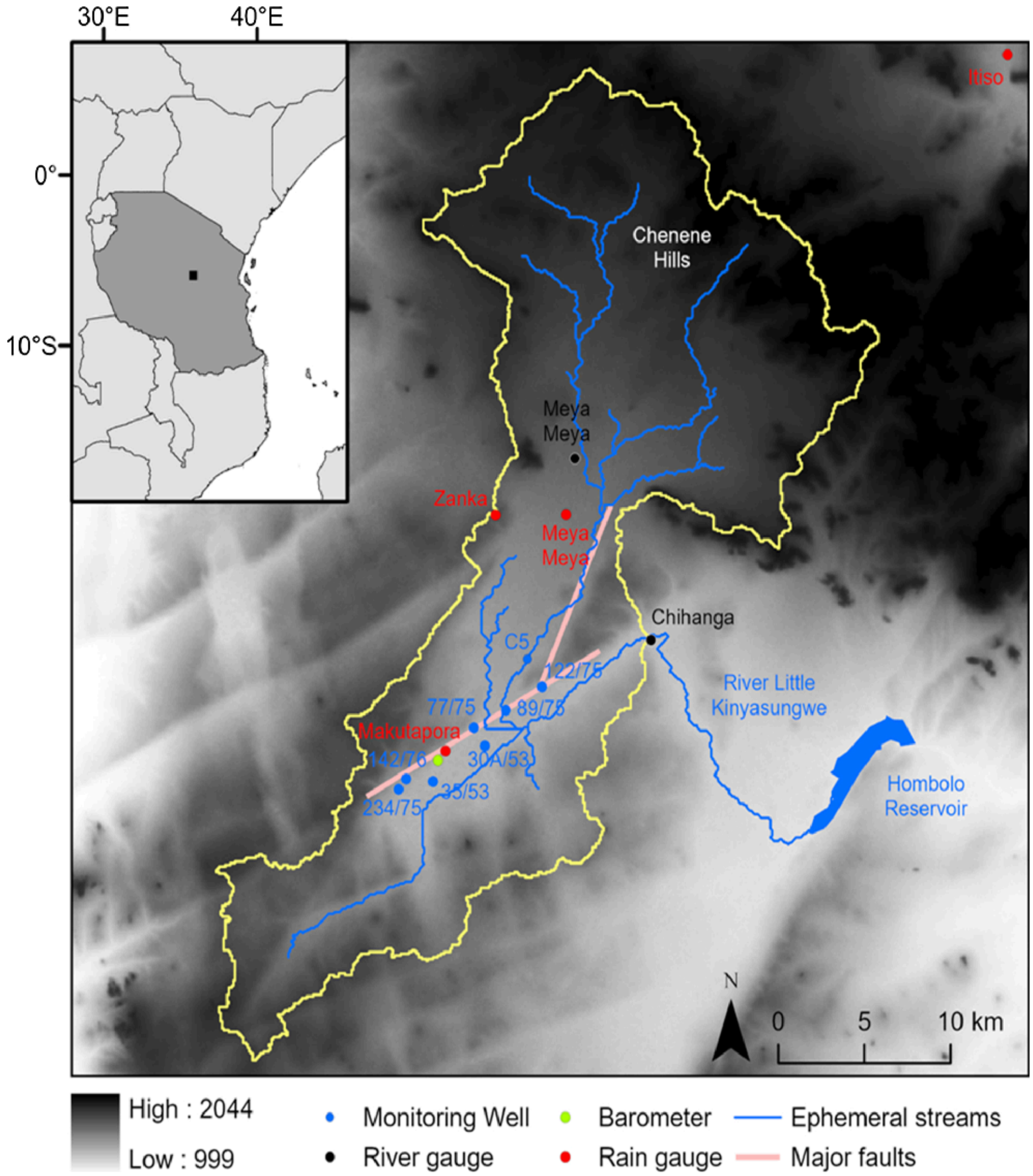

Figure 5: Inset – catchment location in East Africa; Main - Map of the Little Kinyasungwe Catchment delineated using NASA Shuttle Radar Topography Mission (SRTM) data (90 m resolution) with ArcSWAT, depicting locations of surface water, comprising the ephemeral River Little Kinyasungwe and its main tributaries, Hombolo Reservoir, major faults in the Little Kinyasungwe Catchment, and groundwater monitoring wells (blue dots: 89/75, 122/75, C5), rain gauges (red dots), barometric pressure datalogger (green dot), and Meya Meya and Chihanga stream gauges (black dots) (Seddon, Kashaigili et al., 2021).

The Makutupora Wellfield experiences a 'hot semi-arid' climate that is characterized by distinct wet and dry seasons and perennially high temperatures (mean of 27◦C from in situ observations: 2017–2019). Mean annual rainfall of 527 mm (2006–2018) falls during a unimodal wet season between November and April (Fig. 6); mean annual potential evapotranspiration is estimated to be 2120 mm. Rainfall is dominated, however, by substantial interannual variability (Fig. 7). Indeed, Tanzania and the wider EA region have experienced dramatic extreme dry (2020-22) and wet conditions (2019, 2023-24) seasons in recent years, with significant drought and flooding. The main drivers of this variability, during the first half of the season (Nov-Jan), are the Indian Ocean Dipole (IOD) mode and less strongly ENSO (El Niño Southern Oscillation).

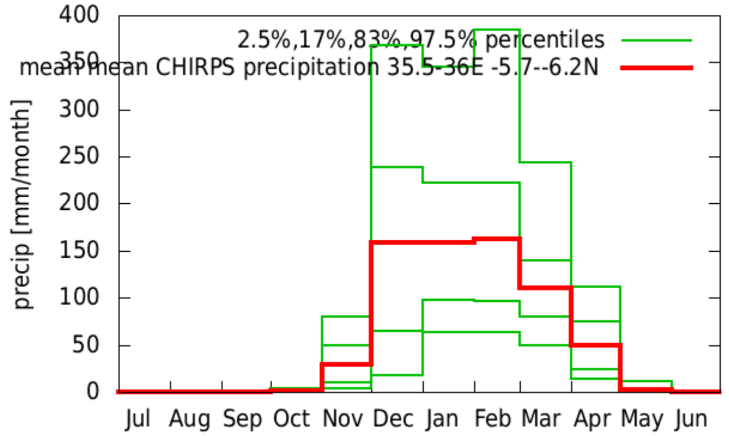

Figure 6: Annual cycle of mean monthly rainfall in the Dodoma T-Lab (CHIRPS 1981-2024).

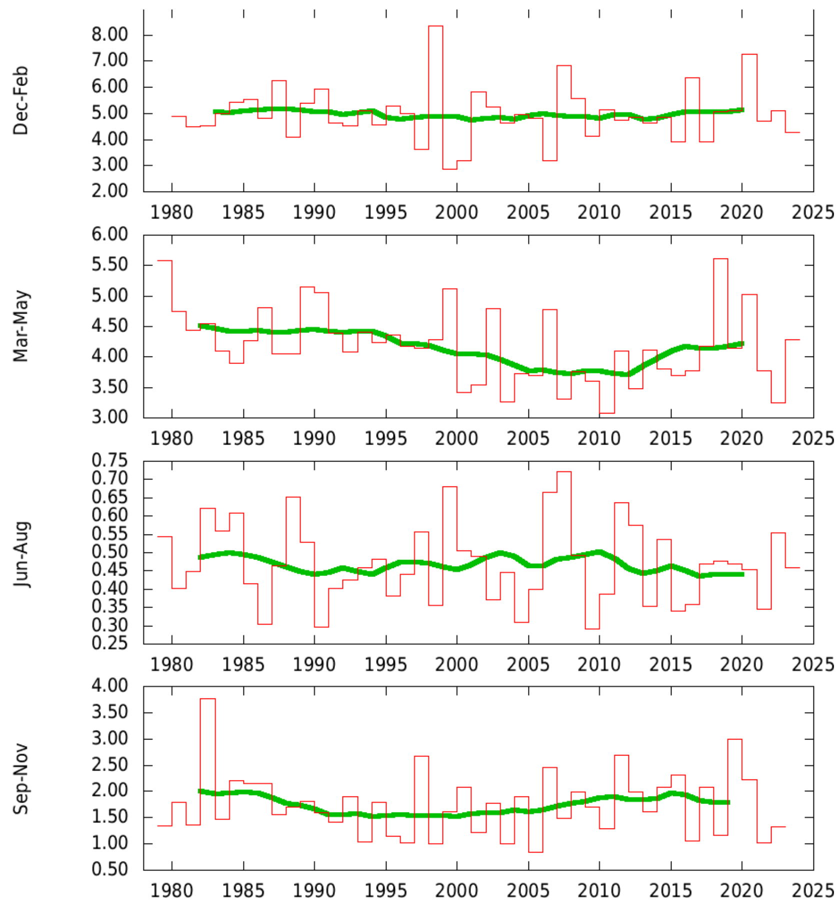

Figure 7: Substantial inter-annual variability in mean seasonal (quarterly) rainfall across Tanzania (CHIRPS 1981-2023).

The physical mechanisms of the influences of IOD and ENSO involve reorganizations of the Walker Circulation across the Indo-Pacific basins (Fig. 8). During positive IOD/ENSO events the positive (negative) SST anomalies in the Western Indian Ocean (Eastern Indian Ocean and West Pacific) serve to weaken the Indian Ocean Walker circulation (Nicholson, 2017; Jiang et al., 2021) favouring a rising branch over Eastern Africa associated with elevated rainfall (Fig. 8a) Conversely, during the negative phases of IOD and ENSO, including the warm 'Western V' events the Walker circulation over the Indian Ocean in enhanced with strengthened upper-level easterlies, increase subsidence over Eastern Africa, and reduce rainfall (Fig 8b) (see also Funk et al., 2023).

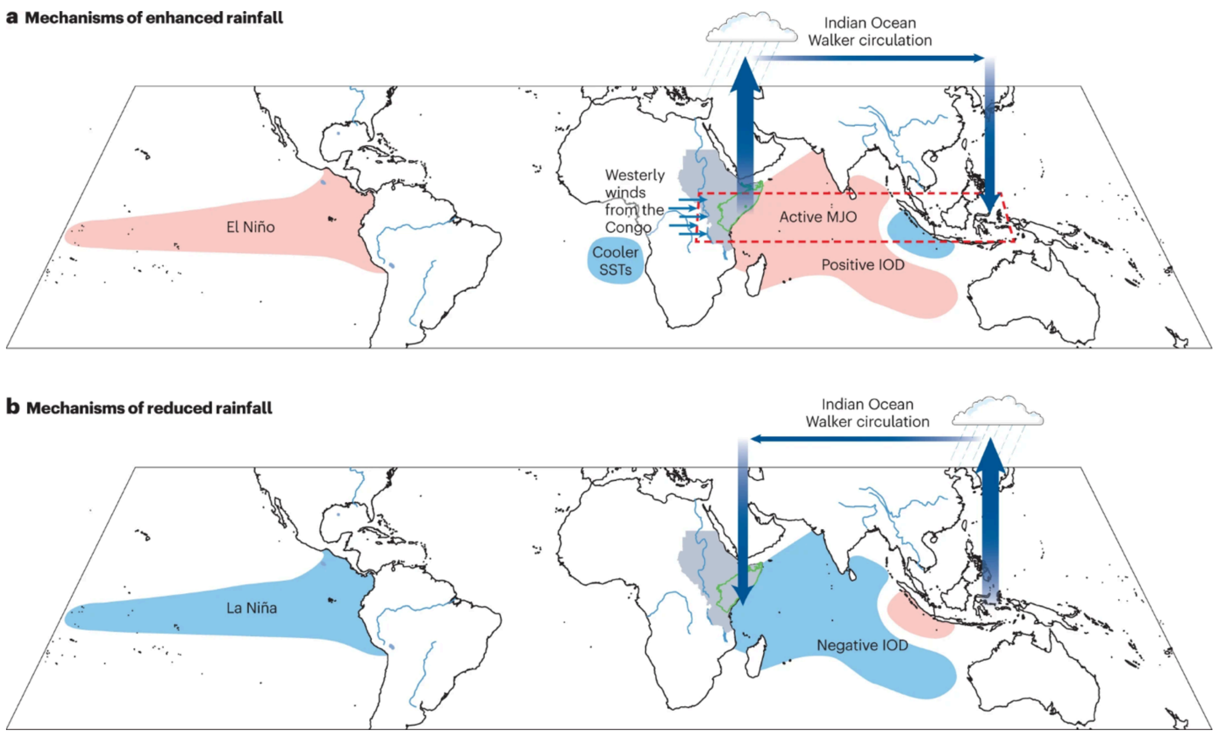

Figure 8: Teleconnection mechanisms that lead to enhanced rainfall over Eastern Africa (marked by grey shading); green contour marks the region within Eastern Africa that experiences two wet seasons per year; orange and blue shading represent warm and cool sea surface temperatures (SSTs), respectively. b, as in a, but for mechanisms that lead to reduced rainfall over Eastern Africa (Palmer et al., 2023).

Lowland land cover is dominated by grassland and dwarf shrubs (Taylor et al., 2013a) whereas catchment uplands are mostly covered by thick shrubland and forest (De Pauw et al., 1983). Agriculture is restricted due to the importance of the wellfield, a nearby military base, and a soil preservation policy (Kangalawe, 2009). In contrast to much of the surrounding areas, recent land-cover change is limited (Taylor et al., 2013a).

Table 2 presents coarse estimates of the water balance for the Little Kinyasungwe catchment over an 11-year period from 2006 to 2017 that derive from Seddon, Kashaigili et al. (2021). Streamflow discharge was estimated from a river gauging station at Meya Meya

(Fig. 5) and scaled up to the Little Kinyasungwe catchment. Annual (hydrological year: October-September) streamflow varies substantially from 1 to 76 million m^3 with a mean from 2006 to 2017 of 16 million m^3. Observed streamflow at Chihanga is considerably lower, varying from 0 to 21 million m^3 with a mean from 2006 to 2017 of 5.1 million m^3; these values include transmission losses to the atmosphere through evaporation and subsurface through leakage from surface waters (i.e. focused groundwater recharge). These fluxes calculated over 11 years (2006 to 2017) suggest that the maximum capacity of the Little Kinyasungwe catchment to sustain wellfield pumpage is 16 million m^3 per year, equivalent to 45 000 m^3 per day. This estimate excludes potential contributions to wellfield replenishment from diffuse recharge (*i.e.* direct infiltration of rainfall) within the catchment and groundwater inflow via fault networks outside of the catchment. Extreme inter-annual variability in stream discharge and recharge recorded from groundwater-level observations complicates the quantification of the long-term renewability of pumped groundwater.

Table 2: Annual comparison of computed volumes of ephemeral stream discharge at Meya Meya (drainage area: 167 km²) and Chihanga (drainage area: 698 km²) with wellfield abstraction, and estimated recharge; catchment river flow was estimated by scaling specific discharge at Meya Meya to the catchment area gauged at Chihanga.

Hydrological Year (Oct-Sept)	Meya Meya streamflow (10^6 m^3)	Catchment streamflow (10^6 m^3)	wellfield pumpage (10^6 m^3)	Chihanga streamflow (10^6 m^3)	wellfield recharge (mm)
2006-07	18.2	76	7.3	21	307
2007-08	2.1	8.8	9.6	0.0	68
2008-09	0.4	1.7	10.4	0.0	55
2009-10	7.8	32	10.3	12	188
2010-11	1.0	4.2	10.4	0.8	0
2011-12	3.3	14	11.2	6.4	105
2012-13	0.7	2.9	12.6	0.0	0
2013-14	0.2	1.0	11.8	0.6	0
2014-15	0.4	1.8	14.5	0.2	0
2015-16	7.6	32	17.8	16	302
2016-17	1.2	5.0	18.0	0.0	0
mean	3.9	16	12.2	5.1	93

Source: *Seddon, Kashaigili et al. (2021)*

The Makutapora Wellfield features one of the longest near-continuous time series of groundwater-level observations in tropical Africa (Fig. 9). Observed multi-annual declines in groundwater levels are interrupted by episodic groundwater replenishment, often associated with El Niño - Indian Ocean Dipole (IOD) events (Taylor *et al.*, 2013a). Perceptions regarding the predominant process by which groundwater in the Makutupora Wellfield is replenished have changed over time. Groundwater recharge was initially considered to be primarily diffuse (Shindo, 1989; Nkotagu, 1996b) with soil macropores transmitting the majority of infiltrating water through the unsaturated zone (Shindo, 1989). Recent observations (Fig. 10) and research (Seddon, Kashaigili *et al.,* 2021, Zarate et al., 2021) supports the hypothesis of Taylor *et al.* (2013a) that focused recharge via leakage from ephemeral streams features centrally during heavy extreme daily and seasonal rainfall.

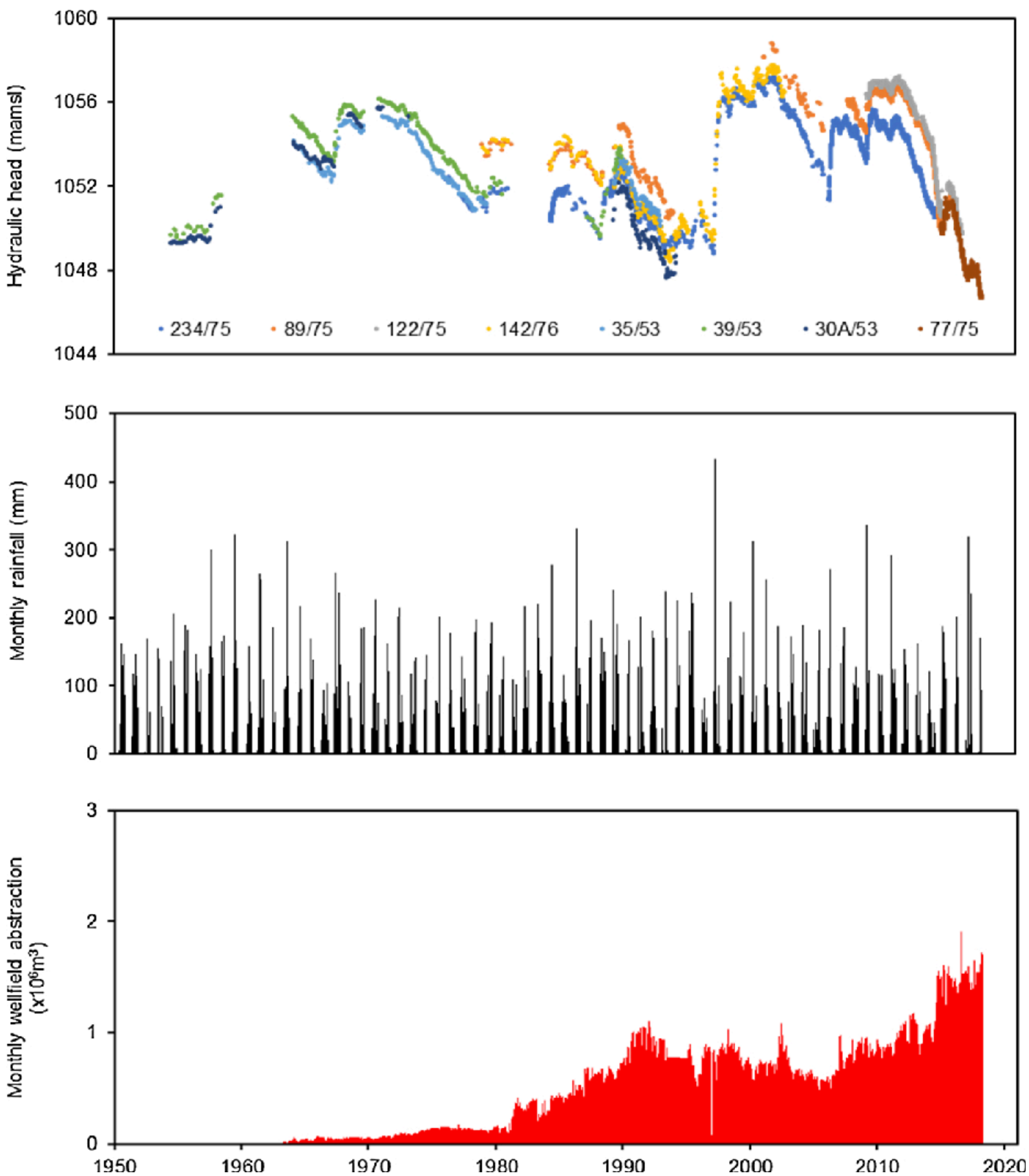

Figure 9: 63-year observational record of groundwater-levels, rainfall and groundwater abstraction from the Makutupora Wellfield: (a) time series of groundwater-level observations from 8 monitoring wells (Fig. 5); (b) monthly rainfall at Dodoma Airport (6◦10.182′S, 35◦44.964′E) (Fig. 1); and (c) monthly groundwater abstraction recorded at the Makutupora Pump House from 1954 to 2017.

Figure 10: Monitoring groundwater levels in the Makutupora Wellfield via telemetry.

Depths to groundwater in the Makutapora Wellfield range from 25 to 35 m below ground level (Fig. 9). Water-bearing formations include fracture networks within the faulted crystalline bedrock of the Dodoma System (saprock) and the overlying unconsolidated and deeply weathered regolith (saprolite). The crystalline basement comprises migmatite granite and disconnected fragments of older, more basic basement rocks such as amphibolite, schist and gneiss (Fig. 11). In the seasonally inundated lowland depression in the vicinity of the wellfield, the regolith is covered by a generally thick (> 10 m) layer of Mbuga clay, a black clayey deposit (Fig. 11). This surface clay layer locally restricts diffuse recharge and promotes ponding of ephemeral stream discharges. Detailed geophysical studies (Zarate *et al.*, 2021) have identified potential pathways of focused recharge that include overbank flood discharges that leak via slow piston flow or preferential pathways such as vertical fractures (Figure. 12).

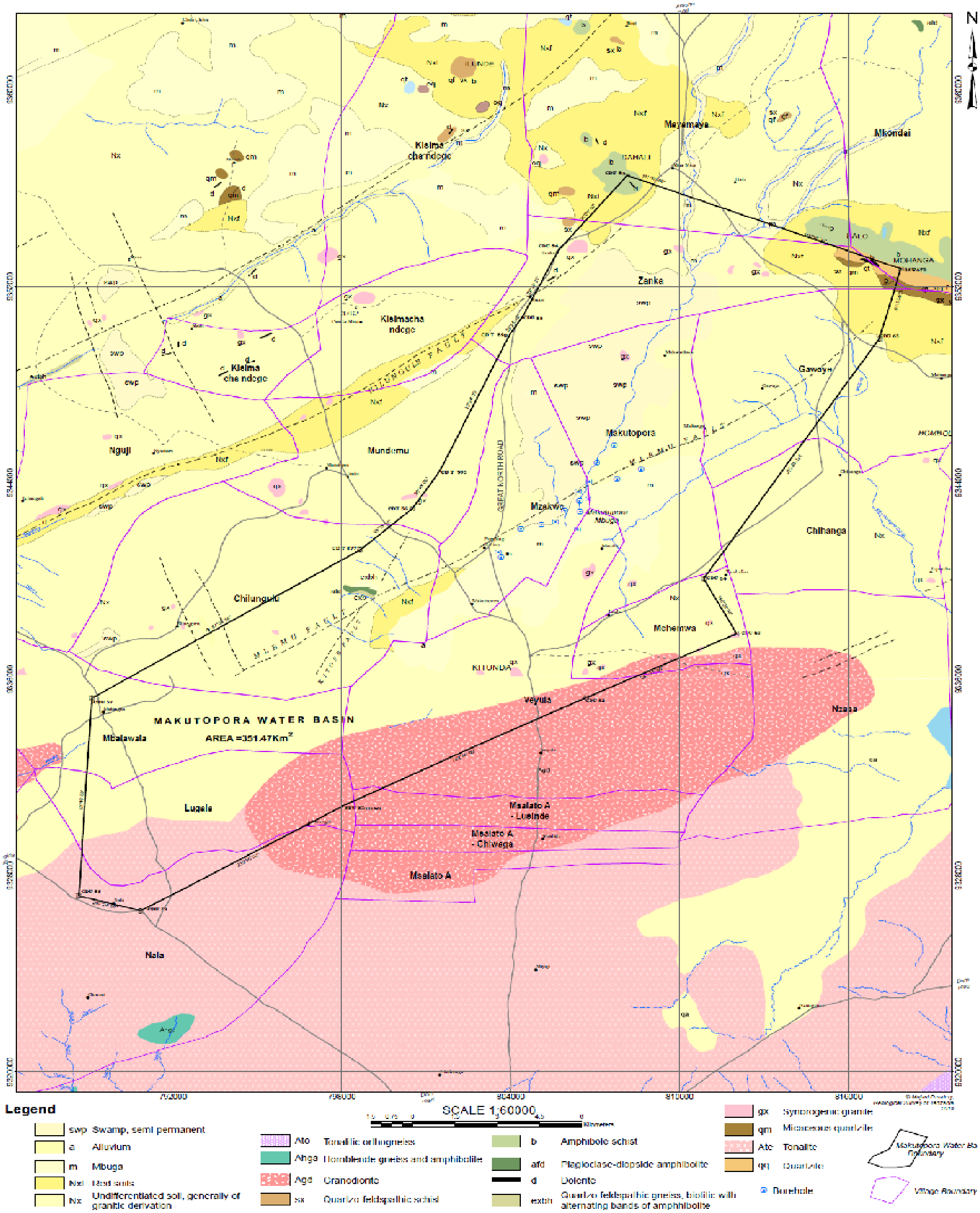

Figure 11: Geological map of the Makutapora Basin (Wami Ruvu Water Basin Board).

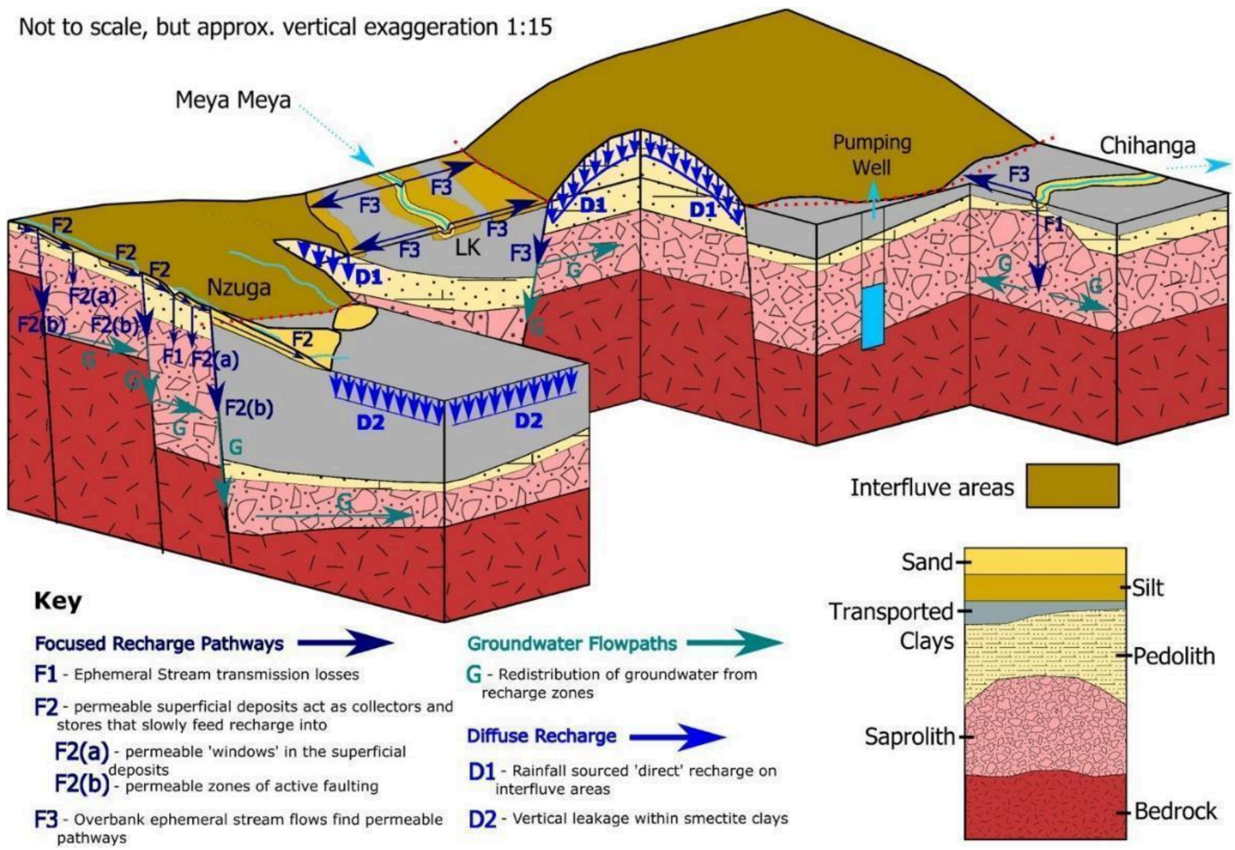

Figure 12: Conceptual model of the Makutupora Wellfield showing configuration of superficial deposits and highlighting permeable pathways; saprock and saprolite horizons have been grouped into 'saprolith' layer (Zarate et al., 2021).

Pumping tests in the Makutapora Wellfield indicate that transmissivities range from 400 to 4000 m^2/d (Maurice et al., 2019). These are considerably greater than those typically observed in deeply weathered and fractured crystalline rock aquifer systems (Taylor and Howard, 2000; Bianchi et al., 2020). The anomalously high transmissivities enable high-yielding wells that are aligned to major faults, conducive to groundwater flow and enhanced weathering in the saturated zone (Maurice et al., 2019; Taylor et al., 2013a). The wellfield currently comprises 19 production wells. Since groundwater was first pumped from the wellfield in the 1940s, groundwater abstraction increased substantially during the 1980s and then again abruptly in 2015 with the completion of a new transmission line to Dodoma City (Fig. 9c).

The search for additional wellfields in the Dodoma region has focused on fault zones in Precambrian crystalline rocks, similar to those in the Makutapora Wellfield in Bahi and Chamwino districts. Small supplies of groundwater have also been accessed by shallow aquifers in Quaternary alluvium along ephemeral watercourses.

2.3 Water Supply and Demand in Dodoma

2.3.1 Water sources

Most households in Dodoma City (68%) have in-house piped water connections for domestic purposes supplied by DUWASA. 12% of households are supplied water by public tap or standpipe and 10% obtain water from private/shared boreholes; 10% oif households do not have access to safe water (i.e. an improved water source). Use of private boreholes is positively perceived as self-supply adds to Dodoma's water supply capacity and, for these households, provides water supply control in the face of uncertain water availability.

The Makutupora Wellfield is estimated to provide ~91% of freshwater supply to the Dodoma City with the remainder supplied by wellfields in other areas. DUWASA manages 61 production boreholes in Makutupora/Mzakwe (19), Ihumwa (15), Chamwino (11), Nzuguni (3), Lyumbu (5), Kongwa (4), Nala (2), Bahi (2) and 1 spring at Sagara (Fig. 13). The total length of the water supply network is 393 km; the main transmission line is 48 km whereas the length of the distribution network is 345 km.

The recent rapid rise in development activities including irrigated agriculture has raised concerns over the risk of contamination to water supplies derived from wellfields. The imposition of wellhead protection areas, restricting human activities around the Makutupora Wellfield, helped to address an emerging problem of high nitrate concentrations. Efforts are underway to improve household sanitation and support tree planting to reduce the risk of contaminating water supplies from wellfields.

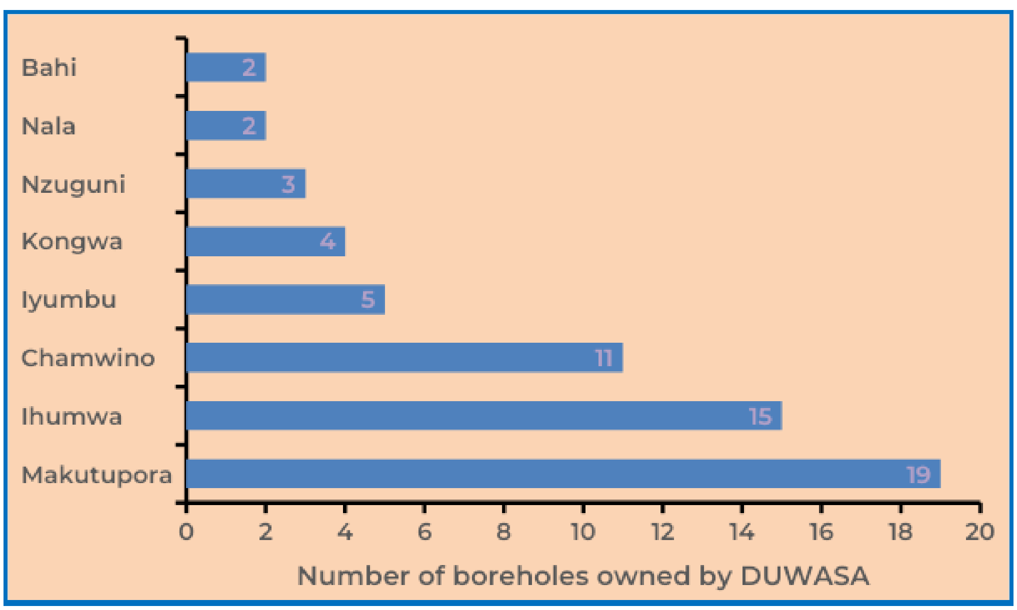

Figure 13: Number of boreholes owned and managed by DUWASA in the Dodoma region.

2.3.2 Water demand exceeds water supply

In Dodoma City, the transmission capacity of water drawn from the Makutupora and Mzakwe wellfields was upgraded in 2015 and remains 69,000 m^3/day. Additional wellfields in the Dodoma region at Ihumwa, Lyumbu, Chamwino, and Kongwa have installed capacities of 3,906, 2,400, 3,740 and 1,673 m^3/day, respectively. The Ihumwa Wellfield serves the Government City at Mtumba, Njedengwa, parts of Iyumbu, Nyumba 300, Mwangaza, Nzughuni and Ihumwa village. The Lyumbu Wellfield supplies Lyumbu village, parts of The University of Dodoma, Nghong'onha village and Benjamin Mkapa Hospital (BMH). The Chamwino Wellfield serves Chamwino, Chinangali, Msanga, Mwegamile, and Buigiri areas. Kongwa, 4 boreholes and 1 spring operate Kongwa and Ugogoni wards.

Current water production and transmission capacity to supply Dodoma City is ~69,000 m^3/day (Fig. 14), which is approximately half (51%) of the currently estimated demand of 133,845 m^3/day (Norplan-GIBB JV, 2019). Note that Khatibu and Alami (2023) estimate total water demand for Dodoma City to be slightly lower, 125,461 m^3/day based on the 2022 population census (Khatibu and Alami, 2023).

To augment the water supply to Dodoma City, the MoW has considered several inter-basin water transfers that include waters from the Mtera Dam within the Rufiji Basin about 140 km south of Dodoma and Lake Victoria to the north. Current efforts are focused on the proposed Farkwa Dam at Chemba on the River Bubu catchment (area: 6,565 km^2) that is situated about 130 km north of Dodoma City. There is also renewed interest in increasing groundwater abstraction from the Makutapora Wellfield and additional wellfields in the Dodoma region, though concerns persist over the renewability of increased pumpage under climate change. Lastly, there is also speculation around the possibility of abstracting deep groundwater at depths of ~300 m within the Precambrian crystalline basement rocks underlying Dodoma City.

2.3.3 Water quality

Groundwater quality across much of Tanzania is generally considered good and acceptable for most uses. There are, however, incidents of high salinity, hardness, and acidity as well as concentrations of fluoride, nitrate and iron exceeding drinking-water guideline values of the World Health Organization (Mato and Mujwahuzi, 2018). Banyikwa (2023) recently mapped the spatial distribution of the major ions in groundwater sampled across the Dodoma region (Fig. 15); Kongwa was found to have the highest salinity. Most sampled groundwater in the Dodoma region is considered to be suitable for irrigation purposes (Banyikwa 2023).

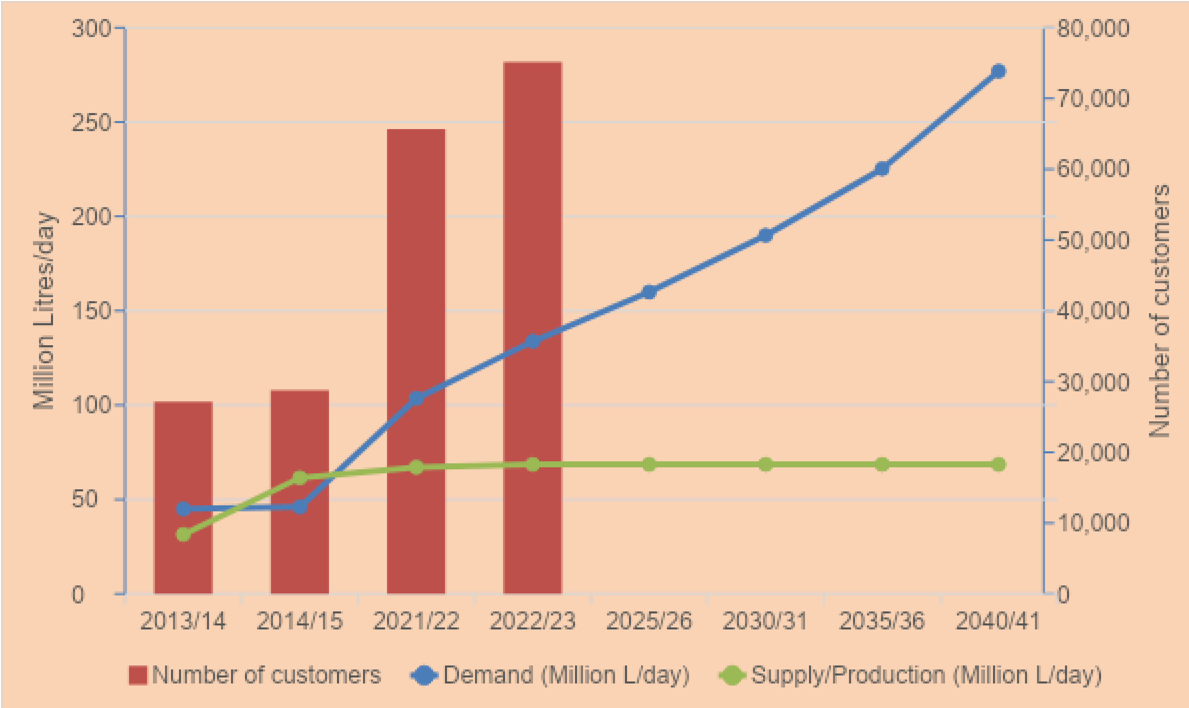

Figure 14: Current and projected freshwater demand in Dodoma City (DUWASA); note 1 million L is equivalent to 1000 m^3.

The quality of groundwater abstracted from the Makutupora Wellfield has consistently been good. A field study conducted by the Ministry of Water in 2008 reviewed the case of elevated nitrate concentrations in the vicinity of the wellfield indicative of pollution from human settlements. This necessitated the involuntary resettlement of 2048 families between 1997 and 2003 to protect the quality of groundwater abstracted from the wellfield. The government employed the Land Acquisition Act of 1967, which granted the President of the United Republic of Tanzania authority to acquire land for public interest purposes, without compensation. The MoW reported that the affected individuals were compensated and resettled in neighboring villages.

Notwithstanding the imposition of a Wellhead Protection Area (WHPA) around the Makutapora Wellfield (Fig. 16), recent evidence cited above that groundwater recharge to the wellfield depends upon catchment-wide responses to rainfall in the generation of flood discharges leaking to the subsurface via pathways that include overbank flows, entails that the wellfield may be vulnerable pollutant fluxes outside of the WHPA. Population growth and increased agricultural activities exacerbate the risk of groundwater contamination from human and animal waste in wellfields and private boreholes. Further data on the sources and pathways of nitrate pollution are required to develop management strategies to sustain groundwater quality.

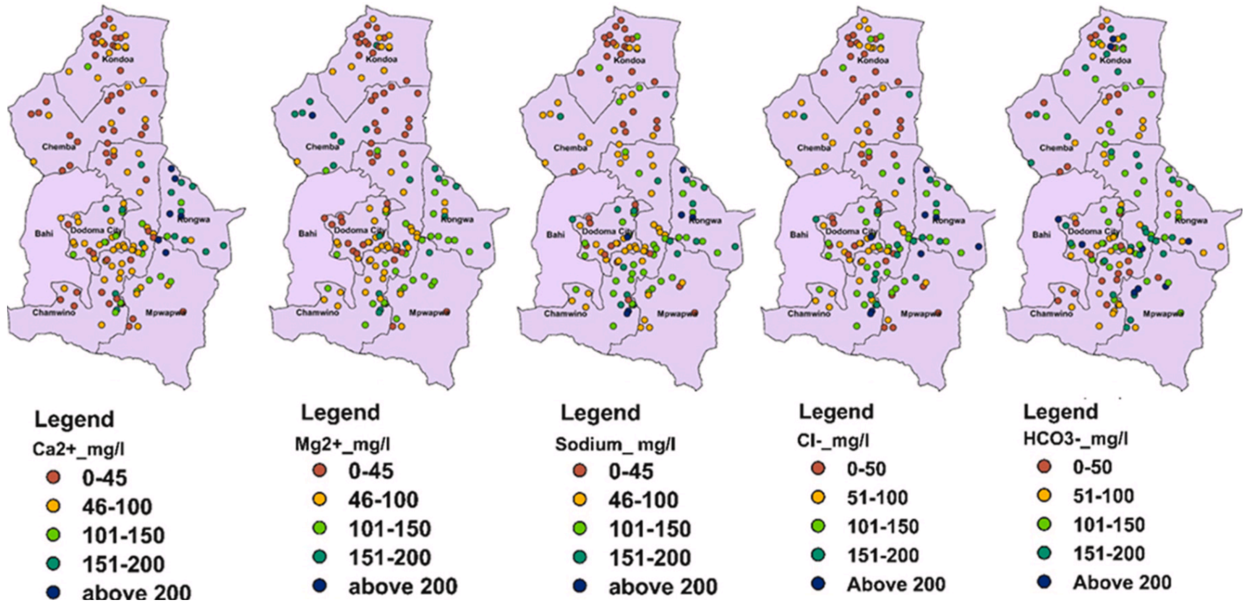

Figure 15: Spatial distribution of major ions in Dodoma region (Banyikwa, 2023).

Figure 16: Public noticeboard outlining the imposition of a Wellhead Protection Area in the vicinity of the Makutapora Wellfield (photo: Taylor).

2.3.4 Water sanitation and hygiene (WASH)

Water, Sanitation, and Hygiene (WASH) provision is central to improving community health and livelihoods. Evidence from WHO and UNICEF (2024) indicates that about ~6% of urban residents in Tanzania lack access to handwashing facilities, ~3% are without access to safe water, and ~10% lack access to improved sanitation (Fig. 17). Data from 2022 indicates this improved sanitation coverage in urban areas of Tanzania comprises improved latrines (66.7%), sewerage (21.5%) and septic tanks (1.4%). Access to safe water in urban areas is enabled via piped water supplies (63.4%) and on-site systems comprising wells and springs (33.4%). These statistics speak to constructed infrastructure and do not reflect the operational access, a particularly important point given the water supply challenges affecting Dodoma City. Further, this access to infrastructure for on-site water supply systems does not reflect the risk of contamination (i.e. safety of the source). A recent study in Dodoma City by Kwikima (2024) found widespread bacterial contamination of self-supply wells that exceeded the WHO guidelines. These findings highlight the importance of community-level hygiene, adequate source construction, and availability of treatment, where necessary, to ensure access to safe water (Twinomucunguzi et al., 2020).

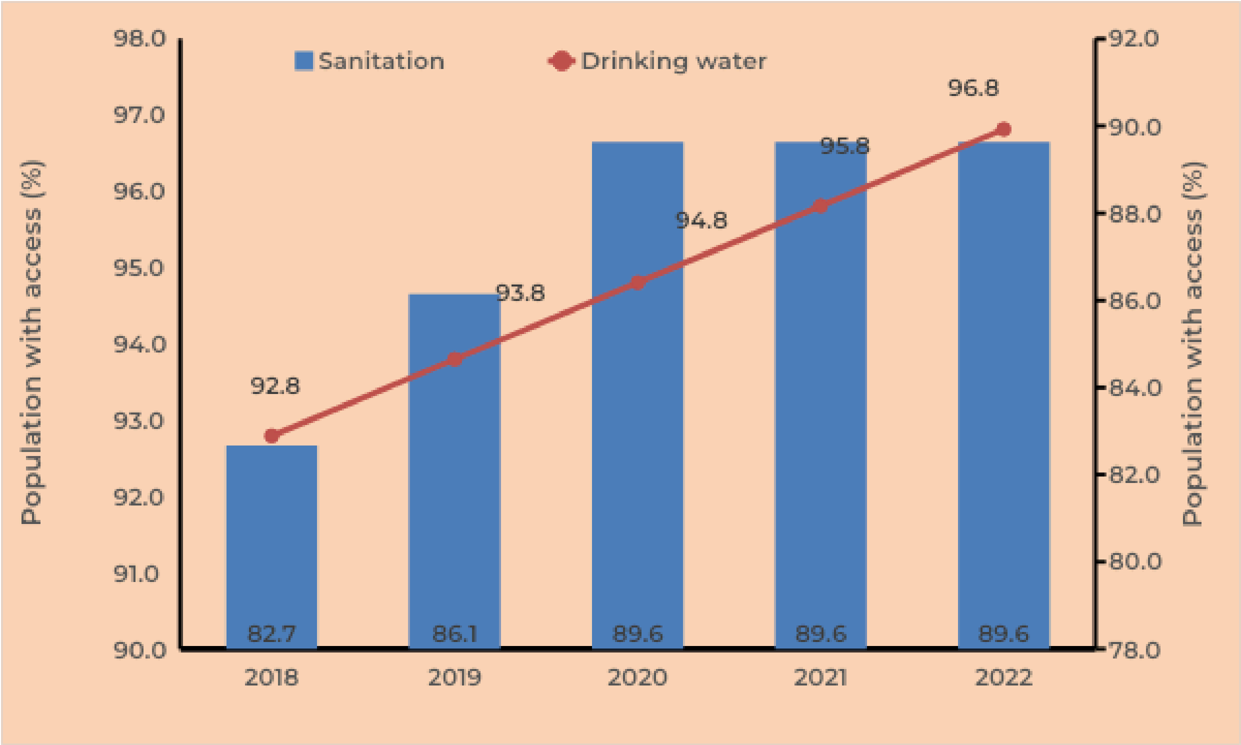

Figure 17: Access to basic water services and improved sanitation services in the urban areas of Tanzania (WHO and UNICEF, 2024).

Dodoma's sewerage system comprises wastewater collection, transport, treatment and disposal. The treatment facility manages two main wastewater categories: the central sewerage system developed under the Dodoma Trunk Service Project I and II between 1977 and 1979 and hauling wastewater from the septic tanks. On-site sanitation comprises both pit latrines and septic tanks with associated soak pits and infiltration trenches. The sewer line has a total length of 24.3 km and was designed to serve 423,000 people. The wards in Dodoma City where the trunk mains were installed include Kizota, Kikuyu North, Kikuyu South, Hazina, Chamwino, Tambukareli, Kiwanja cha Ndege, Madukani, Uhuru, Kilimani, Majengo, Viwandani. Among them however, only four areas are currently served with a comprehensive reticulation sewers network, namely Mlimwa West (Area C), Mlimwa East (Area D), Central Business Park (CBP) and Hazina. The existing wastewater treatment facility is located northeast of Mlimwa at Swaswa in Ipagala Ward (Fig. 18). It comprises two series of ponds in parallel, each with two 200 m × 200 m square ponds and an average depth of 1.5 m, covering an area of 16 ha. The size of the ponds was fixed on the assumption that critical flow would not exceed 90 L per day for an estimated population of 68,000 people, that is, an average wastewater flow of 6,120 m^3/d. It receives wastewater through the pipe network and septage brought by tankers. Demand for sanitation services including sewerage is growing rapidly and exceeds current sewerage capacity. Households in areas of urban growth increasingly rely on on-site sanitation technologies such as septic tanks and soak-away pits with uncertain and largely unmonitored impacts on the quality of groundwater from private wells.

Significant differences exist in the types and quality of water sources and sanitation available and used by households in rural and urban areas as well as between households in rural and urban areas. In the urban areas, piped water and sewerage services are available but in rural areas, people rely on on-site water supply solutions such as private wells and springs whose quality is much less frequently monitored. Coverage rates for (self-supplied) sanitation in rural areas also tend to be lower.

Efforts to improve coverage via piped water-supplies and sewerage are hampered by high capital costs of infrastructure such extension, operation and maintenance of piped networks and sewerage lines. The government of Tanzania is currently implementing the Dodoma Resilient and Sustainable Water Development and Sanitation Program (DRSWDSP) under African Development Fund financing. The program aims by 2051 to improve water supply for domestic and industrial use, sanitation services, and food and nutrition security by harnessing water resources and developing infrastructure and water and sanitation systems for Dodoma City, Bahi, Chemba and Chamwino Towns. This is expected to involve, among other initiatives, construction of the Farkwa Dam, a Water Treatment Plant, conveyance systems, and a water supply distribution network and sanitation management systems for Dodoma City and the two neighboring towns of Bahi and Chamwino.

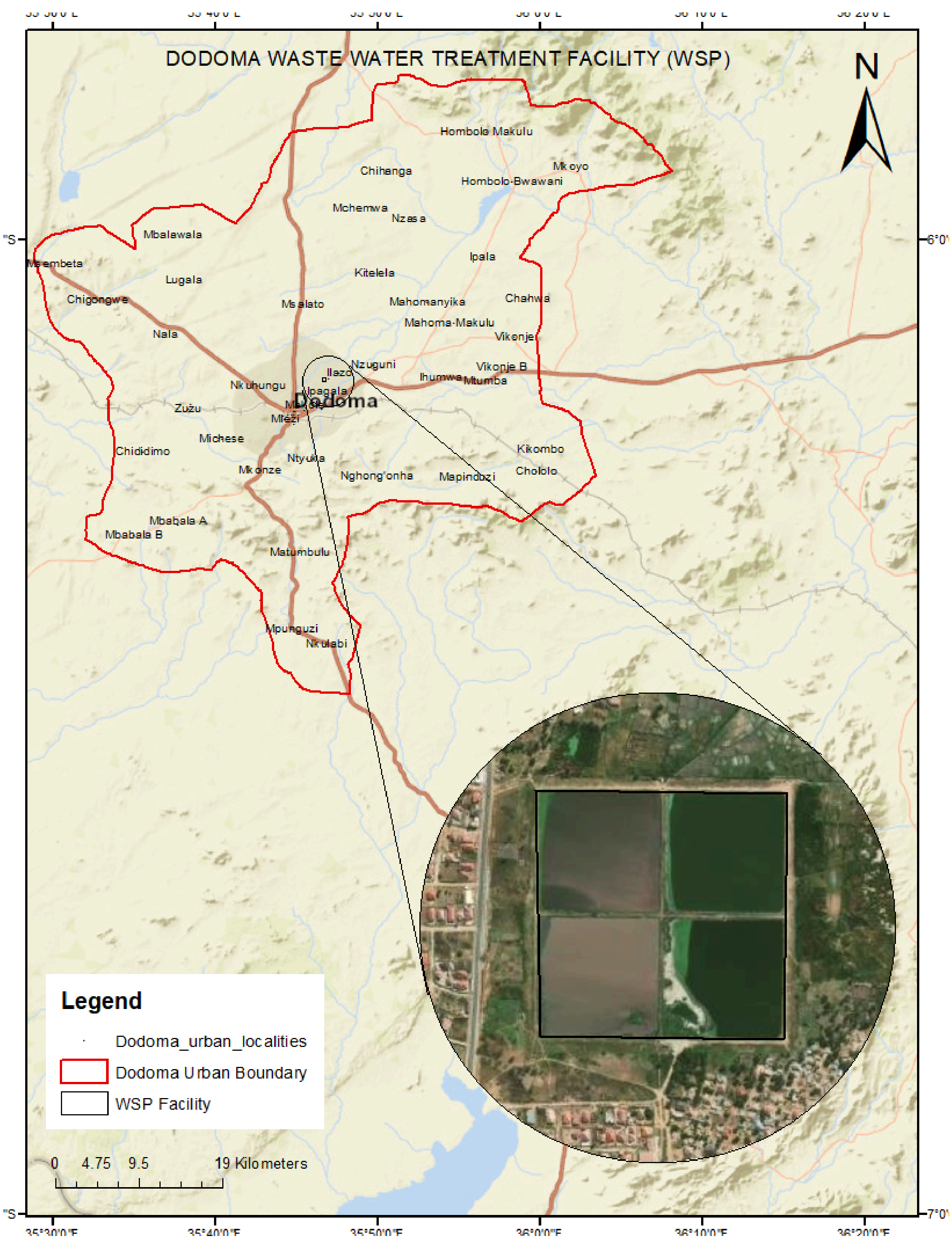

Figure 18: Location of the wastewater treatment facility in Dodoma City.

2.4 Climate and Land-Cover Change in Dodoma

2.4.1 Land-Cover Change

Urban growth exacerbated by the relocation of the national government to Dodoma City has led to substantial changes in land cover that include loss of vegetative cover and a proliferation of impermeable surfaces (e.g. roads, roofs) (Kabanda, 2019). Due also to regional rural-urban transition, the number of households in Dodoma City increased from 2012 to 2022 by 67% (NBS, 2022), reflecting a substantial increase in housing development. According to Kabanda & Whata (2022), built-up areas in Dodoma City increased by ~47 km^2 between 2014-2021, impacting land, water and other natural resources. Mubako *et al.* (2022) project that the urban area of Dodoma City will have expanded by 435% from 1992 to 2029.

Changes in the natural environment are closely related to urban development activities. In Dodoma City, forests and grasslands are essential components of local ecosystems and they play a significant role in the landscape and ecological balance. The decrease in vegetative land-cover is associated with an increase in surface air temperature as a result of the growth in built up areas (Sumari *et al.*, 2022). An increase in water demand associated with construction and the operation of hotels has reduced water availability for household water supplies and urban farming. Initiatives to increase water supplies include the use of gray water generated from households and industries. For example, wastewater treatment is currently used to support some farming activities in Dodoma City (Wawa, 2020).

The Dodoma regional government and stakeholder communities have taken some steps to improve land and catchment management (e.g. planting trees) in the Dodoma region. Tree planting has been intensively promoted both at household and institutional levels. In Dodoma City, especially in the period between 2018-2022, fruit and shade trees have been planted in Dodoma City and surrounding villages under a regional initiative, Greening Dodoma. A study by Gayo (2023) estimated that ~24 trees have been planted per household, which, if scaled, is equivalent to ~4.5 million new trees in Dodoma City (assuming a mean household size of 4 and a population of ~765,000). Water scarcity and the availability of tree seedlings that are adaptive to the area significantly influence the number of trees planted.

2.4.2 Climate change and variability

Projections of future climate under various scenarios of future anthropogenic radiative forcing (from GHG and aerosols) have been made by a number of global modelling centres. This enterprise is coordinated by the IPCC (Inter-governmental Panel on Climate Change) under the Coupled Model Intercomparison Projects (CMIP), which provide updated forcing scenarios and climate model simulations for each iteration of the IPCC reports. For IPCC AR6 2021-22, the CMIP6 included multiple models forced with emissions consistent with a set of contrasting but 'plausible' Shared Socioeconomic Pathway (SSPs). Output from these models represents the primary source of information for climate change impact assessment from the global scales to national climate change risk assessments, and adaptation planning (*e.g.* National Adaptation Plans).

The latest (CMIP6) multi-model mean indicates an increase in mean precipitation over the Dodoma and wider East African region (Fig. 19) but with high uncertainty. By the mid-21st century, under the SSP4.5 emissions scenario, regional precipitation is projected to increase by ~6% on average compared to the pre-industrial baseline, with an Inter-Quartile Range (IQR) across the models of ~3 to 10% and 5 to 95th percentile range of –3% to ~18%. Intense rainfall (maximum annual 1-day precipitation) is projected to increase by a greater proportion of ~15% (IQR of 4 to 24%), 5 to 95th percentile range of ~4 to 34%).

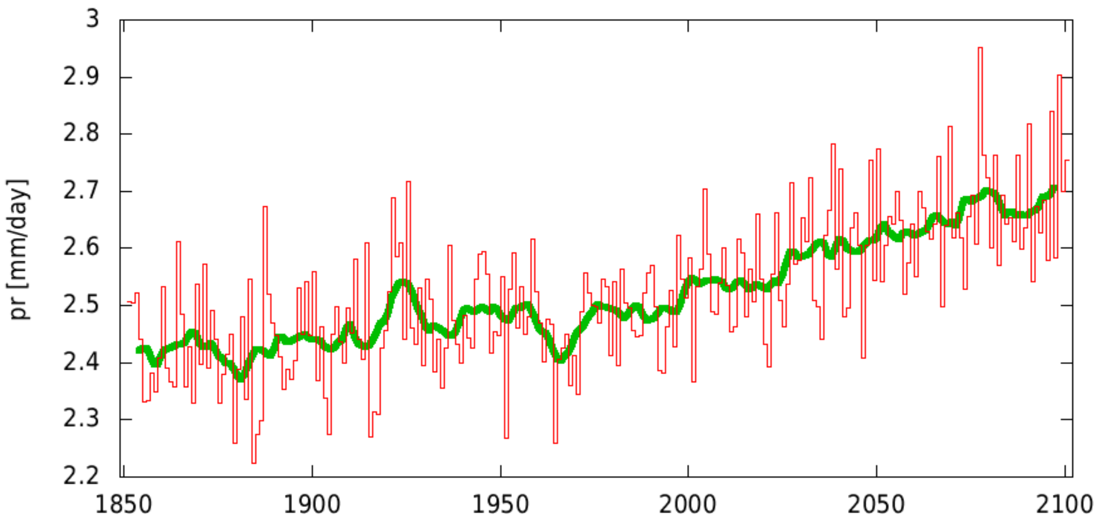

***Figure 19**: Historic and future mean annual precipitation under the CMIP6 SSP4.5 emissions scenario, as represented by the multi-model mean centered on the Dodoma T-Lab.*

Uncertainties in precipitation projections related to ENSO and IOD and the teleconnections to the T-Lab region depend on internal variability associated with the mode. Whilst many studies have assessed future changes by distinguishing 'good' and 'bad' climate models in terms of their representation of the mode in question, there is need to consider model's ability to represent the teleconnection patterns to regions of interest (*e.g.* Nworgu et al., 2024).

Climate change impacts socio-economic activities and livelihoods across the Dodoma region. The intensification of precipitation has led to prolonged droughts and shortened growing seasons; inter-annual variability has led to increased frequency of seasons (years) of low rainfall affecting the renewability of water sources, including groundwater. Reduced water availability due to the increased frequency and duration of droughts inhibits livestock watering, agricultural yields, and stability in crop choice and planting regimes (Mayaya *et al.*, 2015). Inter-annual variability on seasonal rainfall is extreme in the Dodoma region and influenced by the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). Heavy rainfall and flood discharges associated with positive phases in ENSO and IOD can damage infrastructure (e.g. roads, homes) and crops but are also associated with enhanced groundwater recharge observed through sharp rises in groundwater levels in the Makutapora Wellfield (Fig. 20; Taylor, Todd, Kongola *et al.*, 2013). Such events are critical to the security of continued groundwater abstraction from this wellfield.

Figure 20: River Little Kinyasungwe at the Chihanga gauging station in overbank flood discharge conditions during the 2015-16 El Niño Event on 1 April 2016 (photo: R. Taylor).

Groundwater resources are considered more resilient to the amplification of rainfall extremes under climate change (Taylor *et al.,* 2013b; Cuthbert *et al.,* 2019) but such resilience can be exceeded if pumping rates exceed the renewability of pumped groundwater. Some communities in Dodoma have responded to the constraints on water availability in Dodoma City posed by global change by planting drought-tolerant crops such as sorghum, millet, cassava, and sunflower and digging wells (Banyikwa, 2023). Livestock farming, especially for indigenous cattle, is being practiced. Inadequate investment capital makes many farming communities fail to venture into capital-intensive climate change coping mechanisms such as irrigation (Banyikwa, 2023). This implies that not all communities are coping and adapting equally to the climate and demographic changes in Dodoma City.

2.5 Socio-economic Stratification

Cities across Africa are experiencing fast urbanization with growing demand for basic services. Dodoma City is one of the fastest-growing cities in Tanzania and the Sub-Saharan Africa region and is likely to guide the economic development of Tanzania. The population of Dodoma comprises various social groups, categorized based on demographic characteristics such as age, sex, marital status, gender and relationship to the household members and education (literacy). Social groups can also be categorized based on ethnicity and wealth categories, and power structures.

In the Dodoma region, the main economic activities are farming (crop production), livestock keeping, and retail businesses. Maize, sunflower, sorghum, paddy, and groundnuts are common food crops, while grapes are mostly grown as cash crops. Due to agricultural transformation and commercialization in Dodoma since the 1980s, the sunflower and groundnut value chains have been improved and transformed from subsistence to food and cash crops. In addition, the residents of Dodoma keep different livestock, including cattle, goats, sheep, donkeys, chickens, and ducks (DUWASA, 2018).

A study by Msuya *et al.* (2020) categorized sock-economic neighborhoods within Dodoma City into five neighborhood types based on the pre-defined wealth indicators. The categories are: (i) low-income (11%), mixed and medium income (6%), medium income (15%), mixed medium and high income (35%) and high income (38%). According to Msuya *et al.* (2020) page 4, "… *Low-income and mixed low- and medium-income populations largely comprise individuals who live in rural and peri-urban areas. With respect to social demographic characteristics, low-income neighbourhood residents are illiterate, with low rates for secondary and university education and low coverage for social security and civil and vital registration. Medium-income, mixed medium- and high-income populations largely comprise individuals who live in CBD, near CBD and rural wards. Residents from these neighbourhoods have high secondary and university education rates, high coverage for social security and civil and vital registration, and low illiteracy rates*".

Dodoma City is endowed with the cultural practices displayed by a number of ethnic groups. The main ethnic groups are Gogo, Rangi, Sandawe, Taturu, and Kimbu. Other less-prominent ethnic groups include the Sangu, Hadzabe, hehe, nyaturu, and Wasukuma. The most common languages spoken in Dodoma are Kiswahili, gogo, sandawe, and rangi. Polygenism, extended families, and male-dominating decision-making are among the common features of these societies (DUWASA, 2018). Traditional foods are stiff porridge, commonly known as “Ugali”, served with dried green vegetables (plus milk in some families). Mlenda (green vegetable) is common for the Gogo and Sandawe people, and they are normally collected during the wet season and dried and stored for future use (DUWASA, 2018).

Housing in Dodoma City is generally fair and expanding horizontally. Houses are typically made of cement block walls with corrugated iron roofs and big or moderate-sized screened and unscreened windows (Msuya *et al.*, 2020). Scoping study findings revealed there is a wide disparity between rural and urban wards in access to and provision of quality services (e.g. transport, health, education, communication, retail). Urban wards benefit from better service coverage. Msuya *et al.* (2020) assert that residents from low-income and urban villages face deprivations in income, health, and education.

Common with other parts of Tanzania, the rights bundle of land use and ownership is claimed by either statutory or customary rights. Statutory rights are described in legal frameworks such as the National Land Policy (1999) and Village Land Act (1999). They guide laws on how land in Tanzania should be allocated, used, controlled and managed. The Land Act of 1999 governs general land whereas the Village Land Act of 1999 governs village land. Customary rights, which are traditionally held in trust by elders, community committees or kin groups, govern rights inherited either from parents, village government allocation or buying and self-allocation. The residents of the Dodoma City comprise Christians, Muslims and others with their own beliefs; the majority or residents are Christians (Dodoma Municipal Council, 2016).

According to the 2022 census, the population of the Dodoma Region (3 085 625) is 50.9% female and 49.9% male or comprises 97 males for every 100 females. Despite comprising a slim majority of residents, studies show women are disadvantaged in terms of education and economic opportunities compared to men (Mason *et al.*, 2015; Bonatti *et al.,* 2019). There is a need to empower women with equal opportunities in order to alleviate poverty and improve social and economic welfare (NBS, 2022).

The population of Dodoma Region has been categorized using several demographic characteristics such as age, sex, marital status, and education level. Table 3 presents the age and gender profile, which shows a slight bias to women outlined above. It also shows the number of school-going children in the city (children 4–14 years - 28% and children 15-24 years - 19%). The number of households is 757,821, with a mean household size of 4.1; household size has decreased from 4.6 in the 2012 census.

Table 3: Population by key age groups in Dodoma Region (Tanzania 2022 Population and Housing Census, National Bureau of Statistics).

Age categories	Total population		Male		Female	
	Number	%	Number	%	Number	%
Total population	3,085,625	100	1,512,760	49.1	1,572,865	50.9
Children (0-4 years)	456,823	15	228020	7.5	228,803	7.5
Children (4–14 years)	850,968	28	427839	14.3	423,129	13.7
Youth (15– 24 years)	592,154	19	291841	9.3	300,313	9.7
Youth (25–34 years)	405,521	13	197598	6.3	207,923	6.7
Age (35– 44 years)	287,441	9	137186	4.3	150,255	4.7
Age (45–54 years)	212,426	7	101535	3.3	110,891	3.6
Age (55– 64 years)	131,634	4	63917	2.1	67,717	2.2
Elderly (65 – 74 years)	75,511	2	35011	0.9	40,500	1.2
Elderly Age 75+	73,147	2	29813	0.8	43,334	1.2

Rural-to-Urban Migration: Rural-to-urban migration is a key factor contributing to population growth in Tanzanian cities. Scholars argued this type of migration is reflected in social stratifications within the households, where the prevalence of nuclear families is sparse as compared to extended families. The presence of extended families and the nature of their relationships are signs of a high rate of rural-to-urban migration to Dodoma City. This is reflected by the high proportion of youth - the bulge in the age range from 14 to 34. Such migration creates pressures on natural resource use, including GW resources, subsequently affecting land use and development of the City.

Rapid urban growth in Dodoma City has had positive and negative outcomes for different communities. The city's population increase has accelerated economic activities of some communities that have benefited from the multiplier effects of different economic activities. The expansion of economic activities has increased employment and business opportunities, including the demand for goods and services for many people, thereby opening and expanding new business centers, markets, and farms, which has led to increased incomes and other livelihood outcomes. Collectively, these have contributed to improved food security and living standards, such as housing conditions. However, it has increased the demand for utilities such as electricity, water and other forms of energy.

There are negative impacts of rapid population growth including the displacement of smallholder farmers out of the city. DUWASA (2018) reported almost 90% of Dodoma inhabitants depend on GW sources for livelihood and economic development. The inability of the community to access water to meet the demand for basic uses creates a specific burden on poor households, especially women, who must ensure water is available for the households but have fewer resources, for example, to employ household water storage.

Banyikwa (2023) asserts that some communities have responded to water shortages brought about by demographic and climate change in Dodoma City by planting drought-tolerant crops and digging wells. Although groundwater sources may be more climate-resilient sources of freshwater, the faster rate of observed declines in groundwater levels in the Makutupora Wellfield in response to increase pumpage rates over the last two decades highlight the vulnerability of groundwater sources to groundwater depletion, especially given the episodic nature of their replenishment in drylands (Taylor *et al.*, 2013a; Seddon *et al.*, 2021; Kisiki *et al.*, 2023). Through improved and expanded groundwater and surface water monitoring, opportunities to increase the renewability of pumped groundwater pumping from the Makutupora Wellfield can be considered through options such as Managed Aquifer Recharge (MAR).

Some communities, especially those that practice agricultural farming, have begun to plant drought-resistant crops such as sorghum, millet, cassava, and sunflower. However, inadequate investment capital prevents many farming communities from pursuing capital-intensive climate change coping mechanisms such as irrigation (Brüssow *et al.*, 2019). This implies that not all communities are coping and adapting equally to the climate and demographic changes in the city.

3. The Water Sector Policy Framework

The Constitution of the Republic of Tanzania of 1977 places much emphasis on preserving and protecting human rights and perceives water as a basic human right. Tanzania understands that the right to water is an important point in realizing other human rights, including the right to life, the right to food, the right to education, and the right to health. With this understanding, there are institutional and legal frameworks governing the water supply and water resources management. The Tanzania Development Vision (TDV) 2025 and its National Five-Year Development Plan (FYDP III, 2021/22-2025/26) recognize water as a driver for achieving economic and social transformation. The FYDP III (2021/22-2025/26) plan focuses on improving the availability and distribution of water supplies and sanitation services in urban and rural areas, and the protection of water sources and resource environment (URT, 2020). These policy frameworks contribute to the continental and global policy framework.

The National Water Policy (2002) and Water Resource Management Act No. 11 (2009) are the principal institutional frameworks for Tanzania's water sector (Mosha, 2024). This institutional landscape for water governance in Tanzania clearly states access to water is a human right and strives to fulfill this goal. It provides a comprehensive framework that emphasizes equitable access, appropriate exploitation, sustainable development, control, and management of both surface and groundwater resources for the benefit of the present and future generations. It has been argued that insufficient effort has been put forward to manage groundwater (Komakech and de Bont, 2018). Policy frameworks are implemented through the Water Sector Development Programme's goal to achieve universal access to water and sanitation by 2025, which is now in the third phase. However, strategic frameworks such as the National Climate Change Response Strategy (NCCRS) 2021-2026 and the National Determined Contribution (NDC) Report 2021 are currently being integrated in the implementation of the program.

The NCCRS recognizes the likely impacts of climate change on water resources, including a decline in river flows that lead to a reduction in water levels in Lakes and hydropower dams. Moreover, extreme weather events are reported to destroy water infrastructure and cause water contamination. The strategy calls for investment in government plans and budgets to respond to such disasters. Several interventions have been put forward in response to climate change impacts on water resources, including supporting rainwater harvesting technologies and sustainable development and exploitation of groundwater resources to enhance water resilience in a changing climate. Furthermore, it recognizes the importance of monitoring water resources in water basins; the approach is also highlighted in the water sector development programme (2006-2025).

The NDC report provides a set of interventions on adaptation and mitigation to build resilience to the impacts of climate in the country. The report reveals the intention of the Government to develop and manage sustainable exploitation of groundwater resources, promote climate resilience investment, suitable water supply technologies, and monitoring of water and wastewater quality.

Enactment of the Water Supply and Sanitation Act, No. 5 of 2019, establishes the water supply and sanitation legislative framework. The Act came with significant structural reform to promote and ensure every Tanzanian has access to efficient, effective and sustainable water supply and sanitation services (URT, 2022). Reaching the set target in service provision was in line with the establishment of the Rural Water Supply and Sanitation Agency (RUWASA), which is responsible for the development of water infrastructure and supervising their operations and maintenance in rural areas. The Act outlines the responsibilities of government authorities involved in the water sector and establishes Water Supply and Sanitation Authorities (WSSA) as commercial entities. It also provides for registering and operating Community Owned Water Supply Organizations.

The National Water Quality Management and Pollution Control Strategy of 2010 targets to improve the quality of life and social well-being through safeguarding the welfare of current and future generations, protecting biological diversity and maintaining ecological processes. To achieve this attainment, the strategy outlines principles, threats, priorities and sectoral recommendations for water quality protection and surface and groundwater monitoring.

A better understanding of water governance in Tanzania requires awareness of the policy and legal landscape of water resources, as presented in Figure 21. It is recognized that some policy and legal frameworks in the water sector are in need of reform. For example, the Water Supply and Sanitation Act (2019) is the only recently developed legal framework for water. Other supporting policies and legal framework are in need of revision and include the National Environmental Policy (1997), National Water Policy (2002), National Land Policy (1997), National Health Policy (2007), Community Development Policy (1996), and Water Resources Management Act (2009) among others. Reconciling policies related to water use in the Dodoma region across ministerial jurisdictions (e.g. water for drinking versus water for food supply) is also needed.

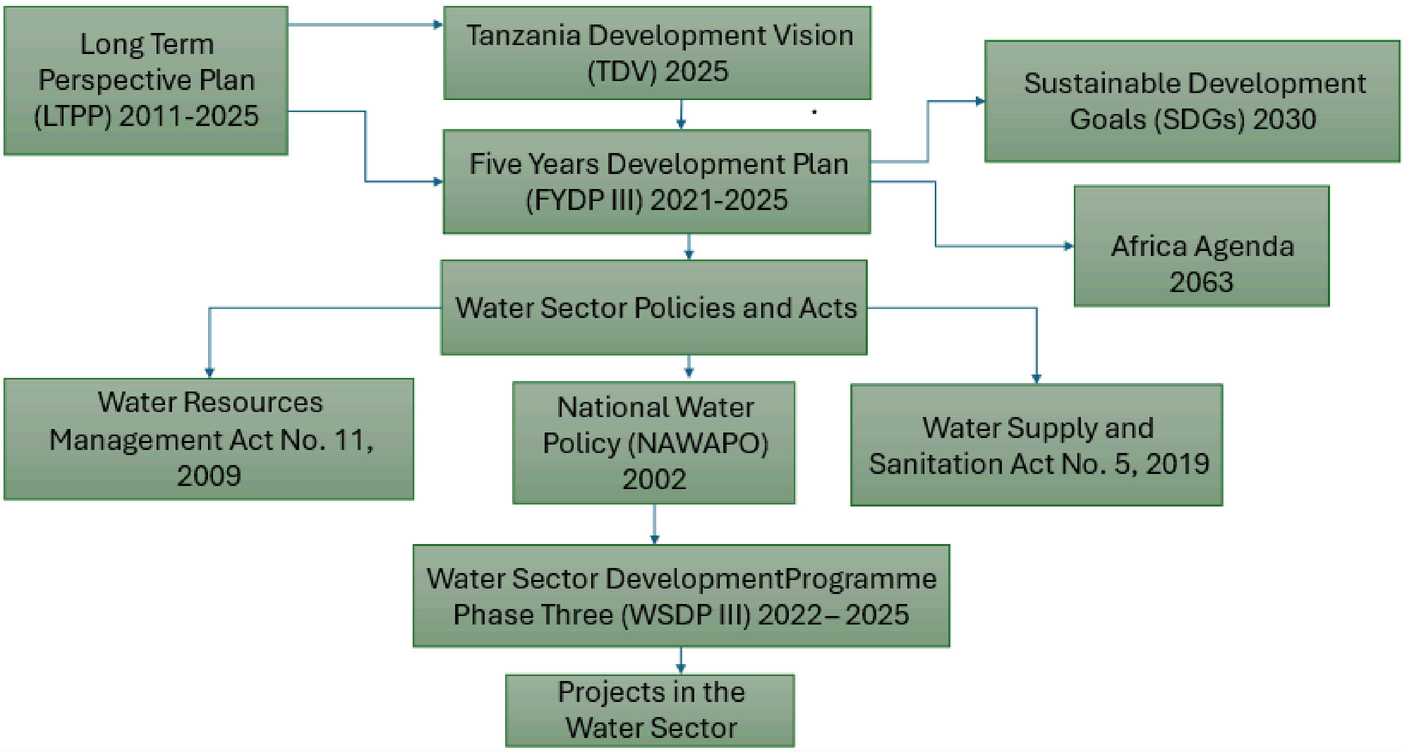

Figure 21: Policy and legal landscape of water resources in Tanzania.

4. Stakeholders of the Water Sector and Dodoma T-Lab

Key stakeholders in the Dodoma region's water sector can be divided into those in the public and non-public sectors (Tables 4 and 5). Public-sector stakeholders include Ministries of Water and Agriculture, which are responsible for domestic water supply and irrigation, respectively. DUWASA is the primary operational stakeholder accountable for producing and distributing water in urban areas of Dodoma. In contrast, rural areas are supplied water through the Rural Water Supply and Sanitation Agency (RUWASA) in collaboration with non-public community-based water supply organizations (CBWSOs).

Other key public stakeholders include the Drilling and Dam Construction Agency (DDCA), policymakers such as councillors and parliamentarians, and supportive ministries such as the Ministry of Energy through TANESCO, which provides the necessary power supply for water pumping. The Ministry of Land is also an important stakeholder in the process. Additionally, non-governmental organizations (NGOs) such as *Water for People* work in the area to ensure the availability and accessibility of water in the Dodoma region.

Generally, the water sector stakeholders are categorized into Ministries, Departments, and Agencies (MDAs)/Public, the Private sector (Drilling Companies, Clean and wastewater service providers, water vendors, and commercial banks), Civil society organizations, Community civil societies, Development Partners, and Researchers and training institutions (Table 4 and 5).

Table 4: Key water supply stakeholders from the public sector in the Dodoma region.

Public sector stakeholders
1. **Ministries** (Ministry of Water, Ministry of Agriculture, President's Office Regional Administration and Local Government (PO-RALG), Vice President Office-Environmental Department, Ministry of Health, Ministry of Community Development, youth, elders and Disabled, Ministry of Livestock and Fisheries, Ministry of Energy, Ministry of Land and Housing and Human Settlement, Ministry of Minerals, Ministry of Natural Resources and Tourism, Ministry of education science and technology 2. **Departments/Agencies** a. RUWASA b. DUWASA c. NEMC d. EWURA e. TANESCO f. TBS

Public sector stakeholders
g. DDCA **3. Makutupora TPDF and JKT** **4. City and district councils** a. Dodoma City Council b. Bahi, Chemba, Kongwa and Chamwino district councils **5. Basin water boards** a. Wami Ruvu Basin Water Board b. Rufiji Basin Water Board c. Internal Drainage Water Board 6. **Media** (SUA media and TBC) **7. Researcher and training institutions** a. Universities (SUA, UDOM, Nelson Mandela African Institute of Science and Technology, Ardhi University, MUST, UDSM) b. Water Institute c. Institute of Rural Development Planning (IRDP)

Table 5: Key water supply stakeholders from the non-public sector in the Dodoma region.

Category	Stakeholders
1. Private sector	a) Drilling Companies b) Clean and wastewater service providers c) Water vendors d) Commercial banks
2. Civil society organizations	i) Non-governmental organization (specifically *ShahidiwaMaji*) and International Non-Governmental Organizations (*WaterAid*) ii) Community-Based Organizations
3. Community civil societies	i) Water User Associations ii) Community Based Water Supply organizations-(CBWSO) iii) Faith-Based Organizations)
4. Media	AZAM media and ITV media

Category	Stakeholders
5. Community	i) Farmers and livestock keepers ii) Food vendors iii) vulnerable groups iv) bricks making enterprises
6. Development Partners	UNICEF, FCDO, IDRC, GIZ, WWF, UNEP, UNDP

Some stakeholders hold a greater level of influence compared to others. For instance, DUWASA, RUWASA, and the MoW (as represented in Figure 21) have a strong alignment and influence in the water sector. Some policymakers, such as politicians, parliamentarians, and councilors, also have a significant impact despite having weak alignments with the water sector. On the other hand, water users, such as farmers, pastoralists, and domestic water users, strongly align with the water sector but are generally considered to have limited (weak) influence.

Stakeholders can be categorized into champions and gatekeepers based on their level of influence and alignment. The Ministry of Water (MoW), particularly through the Water Resources Centre of Excellence (WRCoE), serves as a champion by driving the research agenda forward and integrating solutions into the government planning process. Government agencies such as DUWASA and Wami Ruvu Basin Water Board act as gatekeepers, overseeing water resources management, allocation, and regulation.

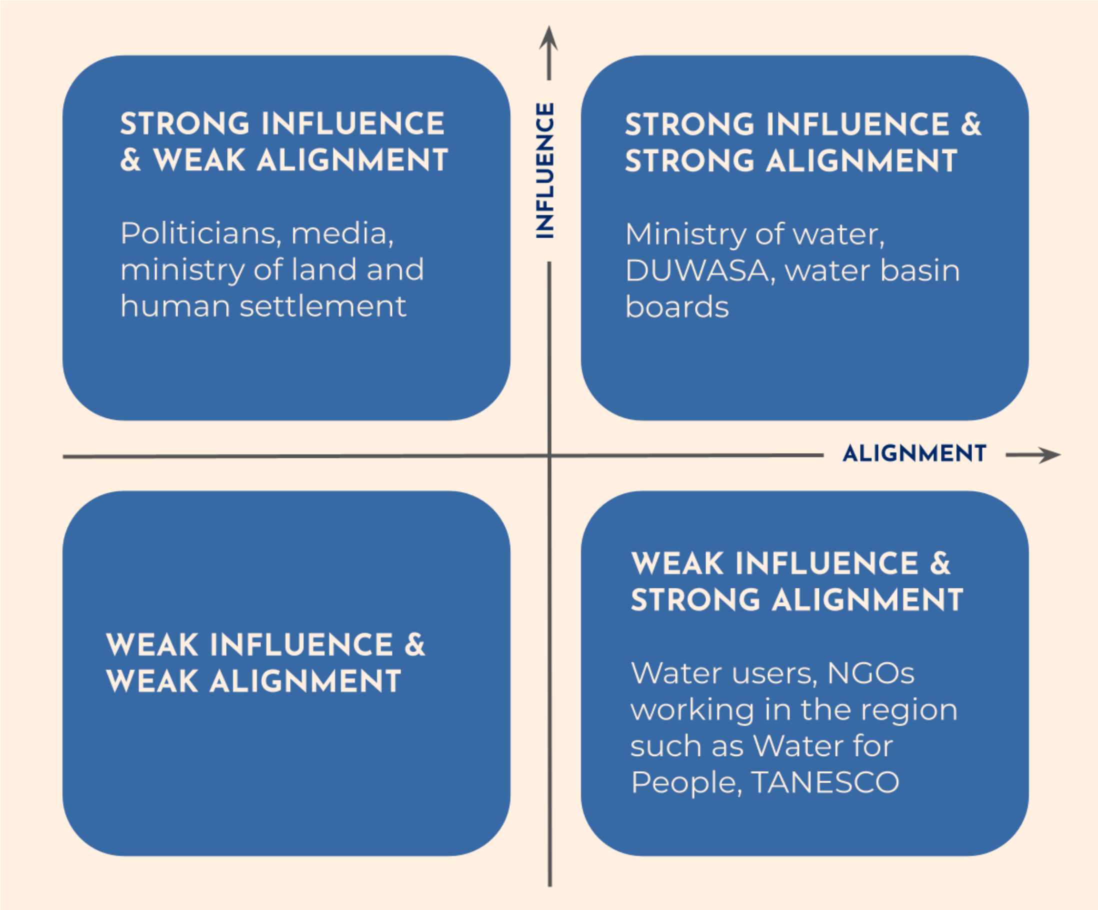

Figure 22: Examples of stakeholders in the alignment and influence quadrant.

5. Conclusion

The *Situation Analysis* provides insights into the current status of the Dodoma T-Lab in Dodoma City. Dodoma City lies within a dryland environment on the East African Plateau of central Tanzania that is challenged by access to freshwater. This region has no permanent surface water bodies and depends solely on groundwater for a perennial source of water. Freshwater demand is approximately double the current supply and expected to rise even further in the coming years and decades. The *Situation Analysis* notes further that demand for freshwater in Dodoma City and the surrounding areas has increased substantially. Current efforts to close the gap between supply and demand are primarily supply-driven and include: (1) an inter-basin water transfer of surface water from the proposed Farkwa Dam on the River Bubu in the Tanzania's Internal Drainage Basin; (2) an expansion in wellfields around Dodoma City including potentially increased abstraction from the Makutapora Wellfield; and (3) promotion of self-supply options (private boreholes and shallow wells) in Dodoma City. Environmental conservation, particularly conservation and protection of water sources, is being implemented, including the tree planting initiative.

Rainfall in the Dodoma T-Lab and Dodoma region more widely is dominated by interannual variability driven by known modes of large-scale ocean-atmosphere patterns of IOD and ENSO. Observed episodic groundwater recharge is associated with major positive IOD/ENSO events. Surface water resources are likely similarly sensitive to such variability. Such events have some predictability at seasonal lead times, providing potential utility in water resource management. Trends in precipitation are generally weak. Future behavior of these IOD/ENSO is likely important for water resource planning but is poorly understood both in terms of natural decadal variability and forced changes from anthropogenic climate change

The *Situation Analysis* provides a baseline assessment of freshwater demand and supply to Dodoma City. It seeks to provide further a benchmark on what needs to be done to understand the sustainability of current and future groundwater abstraction, and the resilience of groundwater use to climate change. The *Situation Analysis* also indicates that understanding social stratification in water supply, sanitation, and hygiene practices is essential. Inequitable access to water exists and considerable concern persists over the safety of shallow groundwater sources in Dodoma City. Poorer households, for example, may be less able to adapt to interruptions in piped water supplies through household water storage and access to safe drinking water through the purchase of bottled water. A better understanding of gender dynamics and social inclusion over water supply decisions and access is required in Dodoma City.

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