TANZANIA

Policy Strategies to Augment Groundwater through Rainwater Harvesting

TANZANIA

Policy Strategies to Augment Groundwater through Rainwater Harvesting

Writers: Sushmita Sengupta and Swati Bhatia

Editor: Archana Shankar

Cover design: Ajit Bajaj

Layout: Kirpal Singh and Surender Singh

Production: Rakesh Shrivastava and Gundhar Das

Sida

Swedish International Development Cooperation Agency (SIDA)

Maps used in this document are not to scale.

Citation: Sushmita Sengupta and Swati Bhatia 2021, *Tanzania: Policy Strategies to Augment Groundwater through Rainwater Harvesting*, Centre for Science and Environment, New Delhi.

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: sales@cseinida.org
Website: www.cseindia.org

Contents

1. Introduction

- Water supply in Tanzania—both surface and groundwater—is rainwater based.
- More than 70 per cent of the population live in rural areas and depend to a large extent on groundwater reserves.
- The high rate of urbanization, loss of waterbodies and variability of rainfall have raised questions about the efficiency of natural recharge of groundwater in the country.
- To make the source sustainable, Tanzania needs policies that focus on groundwater recharge through technological interventions that are community-centric.
- Strong communication strategies should be formulated to make communities aware about water conservation.

The United Republic of Tanzania comprises the mainland and islands in the Indian Ocean. The country is bordered in the north by Kenya and Uganda and in the south by Mozambique. On the east lies the Indian Ocean and Rwanda, Burundi, the Democratic Republic of the Congo. Zambia borders Tanzania on the west (see ***Map 1: Tanzania—Political map***). The largest lake in Africa, Lake Victoria, and the deepest lake in the world, Lake Tanganyika, lie on the boundaries of Tanzania.

Nine major river basins form part of the country. The rivers are all rain-fed. Around 5.7 per cent of the country is covered by three large lakes—Lake Victoria, Lake Tanganyika and Lake Nyasa—that also form the boundary with neighbouring countries. There are also other smaller lakes in the country.

The country cannot be considered water stressed as the large lakes can cater to its population. But the domestic supply of water, especially the rural areas, depends heavily on groundwater.[1] Since 70 per cent of Tanzania's population lives in rural areas,[2] it is vital to ensure that the groundwater supply is clean and sustainable. In addition, groundwater is used for domestic purposes in peri-urban and the urban areas, where there is no distribution network. While urban areas depend on borewells, shallow wells are common in most of the country. Almost 65 per cent of the groundwater is used for domestic supplies.[3]

A 2016 government report[4] confirmed that urban areas have more access to safe drinking water in Tanzania than rural areas. The report said that in Tanzania, 61 per cent of households had access to an improved water source. This means that it takes 30 minutes or longer to obtain drinking water in only 40 per cent of Tanzanian households. Among urban mainland households, 86 per cent have access to an improved water source, compared to 48 per cent of rural mainland households. The report, however, said that island households had more access to an improved water source.

According to the 2021 WHO and UNICEF Joint Monitoring Progress (JMP) report,[5] even urban areas have no safely managed sources for drinking water on premises. The report confirms that the basic drinking water supply—UNICEF defines this as water "from an improved source provided collection time is not more than 30 minutes for a round trip including queuing"—is the best available supply in the country (61 per cent), with urban

Map 1: Tanzania—Political map

Source: Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC) (Tanzania Mainland), Ministry of Health (MoH) (Zanzibar), National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS), and ICF. 2016. Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015-16. Dar es Salaam, Tanzania, and Rockville, Maryland, USA: MoHCDGEC, MoH, NBS, OCGS, and ICF. https://dhsprogram.com/pubs/pdf/FR321/FR321.pdf, viewed on May 23, 2021.

areas accounting for 89 per cent of the supply and rural areas only 45 per cent. Unimproved sources account for the next best supply in rural and urban households. JMP data confirms the 2016 report of the government with regard to basic and unimproved water sources in the country.

An increase in population growth and industrial and agricultural activities has increased the demand for water. Studies also show that climate change is affecting rainfall patterns and Tanzania will be water stressed soon in spite of having several large waterbodies. Its fast-growing urbanization is directly linked to over-extraction of groundwater.[6] This will put yield and sustainability of groundwater abstraction in some parts of the country into question, especially in hard-rock areas where groundwater recharge is low. An example is the Dodoma region, where there are nonfunctional taps in many Local Government Areas and sustainability of the source is low.[7] The quality of groundwater is an added concern. High values of nitrate concentrations are observed in many urban and rural areas, with the highest—above 450 mg/l, around eight times higher than the permissible limit of nitrate in drinking water as per the World Health Organization—reported near Dar es Salaam.[8] The high concentration of nitrate in groundwater is due to unsafe sanitation practices and overuse of fertilizers.

Recharge of groundwater improves both quality and quantity of reserves. Rural areas need to implement groundwater recharge structures efficiently as more than 90 per cent of Tanzania's rural water schemes are dependent on groundwater. Wherever groundwater quality is affected by poor quality of sanitation, insanitary toilets should be converted to sanitary ones and black and grey water should be treated.

Strong communication strategies should be designed to make households and communities aware about water conservation. Communities should be involved in such projects from the planning to the implementation stage. Traditional and small water-harvesting systems should be promoted. Reuse of treated wastewater for non-potable purposes should also be focused on.

Policies focusing on technological interventions to recharge groundwater need to be introduced to make the sources of groundwater—borewells and shallow wells—sustainable for the future.

2. Management of water sources in Tanzania: Overview

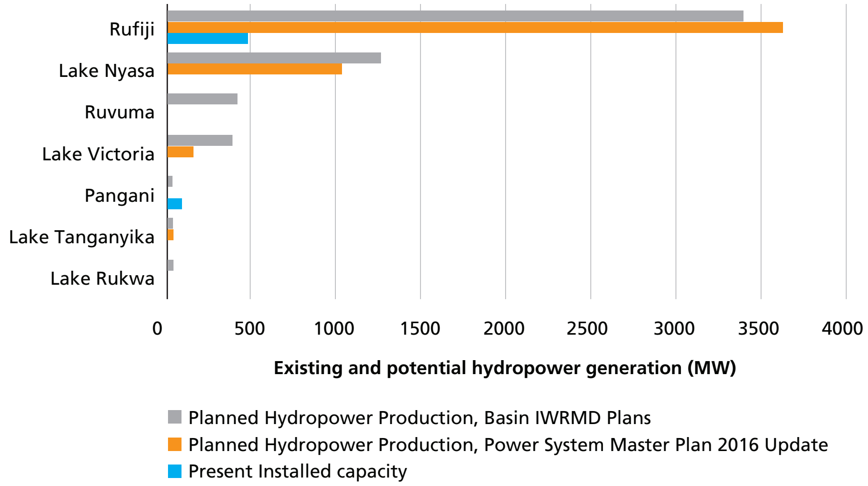
- Despite Tanzania being home to approximately 25 per cent of world's freshwater resources, it could see a water-stressed future. Its freshwater resources cater to its hydroelectric power needs.
- Although the country has abundant water resources, a large part of its rural population lacks access to water sources.
- Wetlands spread over 85,000 hectares support the economy and their degradation will lead to severe economic losses to the country.
- Monitoring stations and data needed for groundwater for efficient planning, utilization, recharge and conservation are lacking.
- Tanzania is largely an agrarian economy, heavily dependent on groundwater.
- Its irregular distribution of groundwater and rainfall is increasing due to climate change. Decreasing rainfall is increasing the burden on groundwater and surface water resources.
- Allocation of budget is skewed and inadequate and is decreasing.
- Other water-conservation measures along with conserving surface water and groundwater need to be looked into if a crisis is to be averted.
- Water resources in Tanzania have been managed by 20 ministries since 1961. Several reforms have been implemented under able leadership.
- Implementation remains a challenge on the ground. Better policy coordination and planning are required to manage the degrading wetlands.

Tanzania has an area of about 945,000 square kilometres (sq. km) of which 883,500 is land and 61,500 sq. km is covered by water.[9] The country manages its water demand through its rivers Pangani, Wami, Ruvu, Rufiji and Ruvuma; lakes Nyasa, Rukwa, Tanganyika and Victoria; and internal drainage basins of Lake Eyasi, Lake Manyara and the Bubu depression; and its southern coast.[10]

The rivers are largely perennial barring a few that are intermittent and ephemeral. Tanzania has approximately 25 per cent of the world's freshwater resources and stores about 29,425 km^3 of water. Of these two lakes—Nyasa and Rukwa—two rivers—Rufiji and Ruvuma—and the southern coast have abundant resources while the rest are already stressed. Despite this, Tanzania is not water stressed as the four lakes have much more than the required capacity.

Tanzania has approximately 600 dams of which 20 have a total capacity of 1,000,000 cubic metre (m^3). The dams produce electricity to the tune of 561 megawatt (MW). Most of them have operational water levels. A few dams are not operational due to preceding dry seasons (see *Figure 1: Planned versus installed hydropower potential in Tanzania*). A few basins such as Pangani are not able to run on full capacity due to lack of water. Although Tanzania has adequate potential to increase its hydropower, it is affected by underperformance due to limited availability of water.

Figure 1: Planned versus installed hydropower potential in Tanzania



Source: World Bank, 2017, Tanzania Economic Water Update, Managing water wisely-the urgent need to Improve Water resources management in Tanzania, https://documents1.worldbank.org/curated/en/673961509974154698/pdf/120954-NWP-PUBLIC-p156957-p164469-86p-WorldBankNovFR.pdf

Most of these rivers are within two arms of the Great Rift Valley, which are marked by long, narrow and deep wetlands. Approximately 7 per cent of the area of Tanzania is covered by wetlands. The Rufiji–Ruaha river system has the largest coverage area of wetlands, extending up to 695,500 hectares. Tanzania has approximately 85,000 hectares of manmade wetlands of which the Mtera Dam (61,000 hectares [150,734. 283 acre]), Lake Nyumba ya Mungu (18,000 hectares [44,478.969 acre]) and Mindu Dam are the most important. Coastal wetlands are covered by mangroves (see ***Table 1: Mangrove forests of Tanzania***).

Table 1: Mangrove forests of Tanzania

District/Region	Area (ha)
Muheza and Tanga	9,403
Pangani	1,755
Bagamoyo	5,636
Dar es Salaam	2,168
Kisarawe	3,858
Rufiji	53,255
Mafia	3,473
Kilwa	22,439
Lindi	4,564
Mtwara	8,942

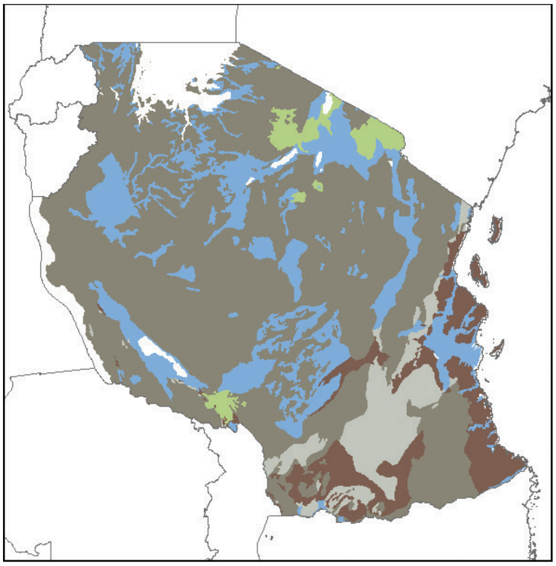
Source: Bakobi, B.L.M, n.d., "Conservation of Wetlands of Tanzania", https://legacy.oceandocs.org/ bitstream/handle/1834/522/ Wetlands1526.pdf?sequence=1 (viewed on July 31, 2021).

Wetlands have long supported Tanzania's economy as along with high production capacity, they control floods, recharge groundwater, prevent eutrophication of rivers, contribute to sediment retention and support wide and specific varieties of biota. They have also been found to have traditional uses in for example the social and cultural fabric and in supply of food, fibres, medicine, etc. Disruption of these wetlands due to urbanization can have disastrous consequences to the economy of Tanzania.[11] Hence they need special attention.

Groundwater data information is also scarce. Data collection stations and monitoring stations are few, inadequately maintained and do not function properly to collect data. Due to variations in geography, groundwater potential in Tanzania also varies.

Roughly only 25 per cent of the area in Tanzania is said to have high groundwater recharge potential due to weathered, fractured, volcanic rocks and unconsolidated sediments and the remaining 75 per cent is barren and thus lower aquifer potential (see ***Map 2: Types of aquifers in Tanzania and their productivity***).[12]

Map 2: Types of aquifers in Tanzania and their productivity



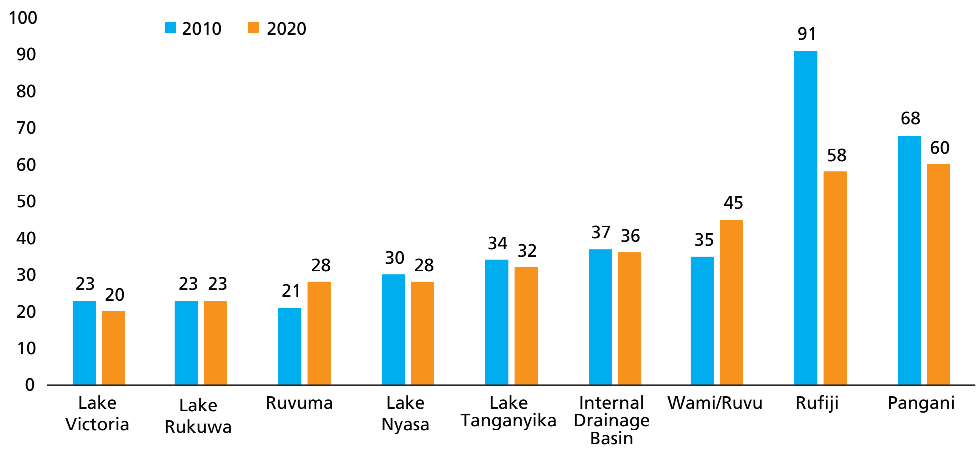
Tanzania—Aquifer type and productivity

- Unconsolidated—Low to high
- Volcanic—Low to moderate
- Sedimentary Intergranular/fracture—Low to high
- Sedimentary Intergranular/fracture—Low to moderate (sometimes high)
- Basement—Low to moderate

Source: https://upgro.org/country-profiles/tanzania/

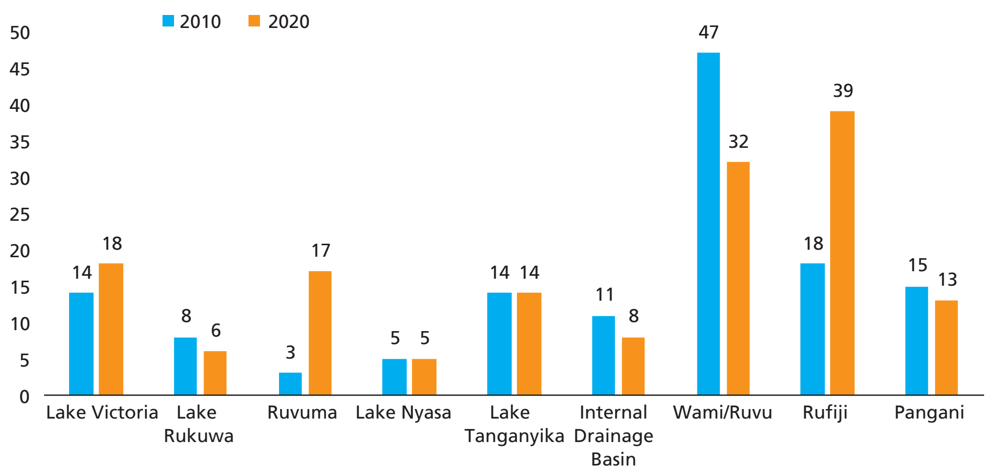
Tanzania currently has 794 hydrometric monitoring stations (see ***Figure 2: Number of hydrometric stations in Tanzania***). The status hasn't changed much over a decade—only the number of weather monitoring stations, hydrometric stations and groundwater monitoring stations has fallen since 2010 probably due to faulty stations where no action has been taken to repair them. Efforts have been limited to increase the weather monitoring stations in the country. Several basins do not have groundwater monitoring stations and no effort has been made to rehabilitate them (see ***Figure 3: Status of weather monitoring stations in Tanzania***).

Figure 2: Number of hydrometric stations in Tanzania



Source: Water Sector Status Report: 2015-20, United Republic of Tanzania, Ministry of Water, 2020, https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf

Figure 3: Number of weather stations in Tanzania



Source: Water Sector Status Report: 2015-20, United Republic of Tanzania, Ministry of Water, 2020, https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf

While data to understand the recharge potential is lacking and needs intervention, a few older studies estimate an annual recharge of 4–10 mm per year (i.e. approximately 0.4–1.3 per cent of the annual average precipitation).[13] A 2015 study indicates that Dar es Salaam has quaternary sediment aquifers and a recharge flux capacity of 0–570 mm per year.[14]

The temporal and geographical distribution of water in Tanzania is not well distributed. Several areas do not have sufficient water supply despite abundant freshwater reserves. Rainfall distribution is also highly variable; southern Tanzania gets most of its rainfall in two to three months of the year and for the remainder depend heavily on groundwater, which is difficult to access.

Rainfall pattern is also highly variable. The highlands in southwest Tanzania receive 1,200 mm per year of rainfall while the internal drainage basin receives less than 600 mm per year of rainfall.[15]

As per a recent study, Tanzania is witnessing declining rainfall and irregular rainfall patterns due to increasing average sea surface temperatures in the Indian Ocean, suggesting climate change is affecting rainfall patterns in Tanzania.[16] The country is also highly susceptible to floods and droughts, greatly affecting its GDP. These events are now increasing due to climate change. The country needs to develop resilient water systems and structures to avoid incidences in the future and also cope up better with the disasters.

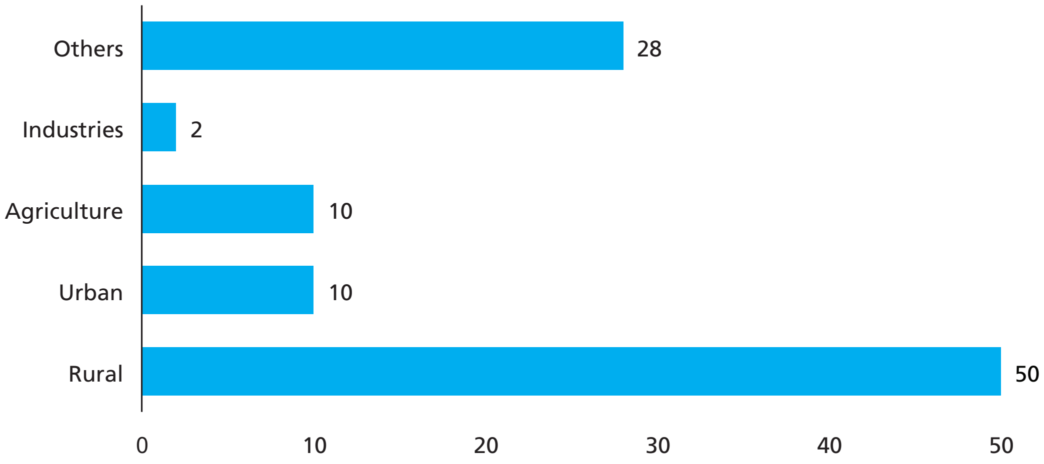
Land-cover classification is done mainly to study the type of physical land. By comparing land-cover data, land-use changes and their effect on coastal water resources management are studied. A study on the Wami-Ruvu Basin[17] that evaluated land-use and land-cover changes found that over the last three decades water and wetland areas have decreased by 0.3 per cent, forest areas by 15.4 per cent, and grassland by 6.7 per cent, while agricultural lands, bush lands, bare soil and built-up areas have increased by 11.6 per cent, 8.2 per cent, 1.6 per cent and 0.8 per cent, respectively. According to the study, precipitation has decreased, temperature has risen by 1°C, population has increased and water discharge has decreased by 4,130 m^3.

Thus despite Tanzania's numerous waterbodies, it is expected to be water stressed by 2035. Some of its rivers are already water stressed. Increasing population will further impact its groundwater resources. Further, its terrain distribution poses a challenge as there are few studies regarding natural recharge and approximately 75 per cent of land area is estimated to be a tough recharge zone.

A recent study[18] on land cover changes in the components of water balance of the Kikafu-Weruweru-Karanga (KWK) watershed suggests that expansion in cultivation land and built-up area are the main attributes in changes in water yield, surface runoff, evapotranspiration and groundwater flow and will have negative impacts on the water balance. It suggests that improving vegetation cover on hillsides and abandoned land area could help reduce direct surface runoff in the watershed and recurring flooding of the area.

Approximately 80 per cent of Tanzania's population is dependent on agriculture, and it contributes approximately 25.8 per cent of GDP of the country. A large proportion of groundwater is used for domestic and agrarian purposes.[19] It is estimated that approximately 12 per cent of groundwater of the total water available is used for domestic, agriculture and industrial use. Several rural schemes are based on groundwater.[20]

Figure 4: Percentage share of groundwater usage in different sectors

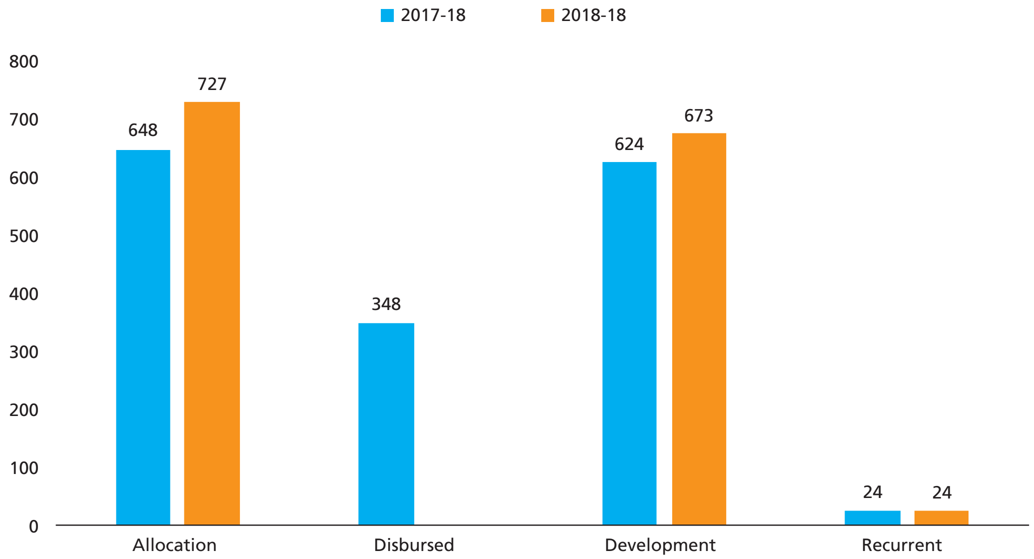


Source: https://www.maji.go.tz/uploads/publications/sw1556197668-GROUNDWATER%20STATUS%20IN%20TANZANIA.pdf

In urban areas (especially Dar es Salaam, where 80 per cent of industries are located), industries are also highly dependent on groundwater utilization. Many industries are now opting for private wells to augment surface water as water supplies are inadequate.

The 2020–21 water sector budget for Tanzania has earmarked Tanzanian shilling (TSh) 680.3 billion for the Ministry of Water out of which TSh 646.6 will be spent on developmental projects and rest on recurrent expenditure. It is evident that more than 95 per cent of the budget is directed towards development of rural and urban infrastructure. This budget will be spent on approximately 1,527 rural projects worth TSh 366 billion and 114 urban water projects worth TSh 195 billion. In the recurrent budget also more than half will be spent on government expenses. Only TSh 15.2 billion is allocated for direct and indirect support activities, of which the actual release is much lower, which poses the problem of delivery of projects[21] (see ***Figure 5: Skewed allocation and disbursement of water budget***). Only 56 per cent of fund allocated was released in financial year 2017–18.

Figure 5: Skewed allocation and disbursement of water budget



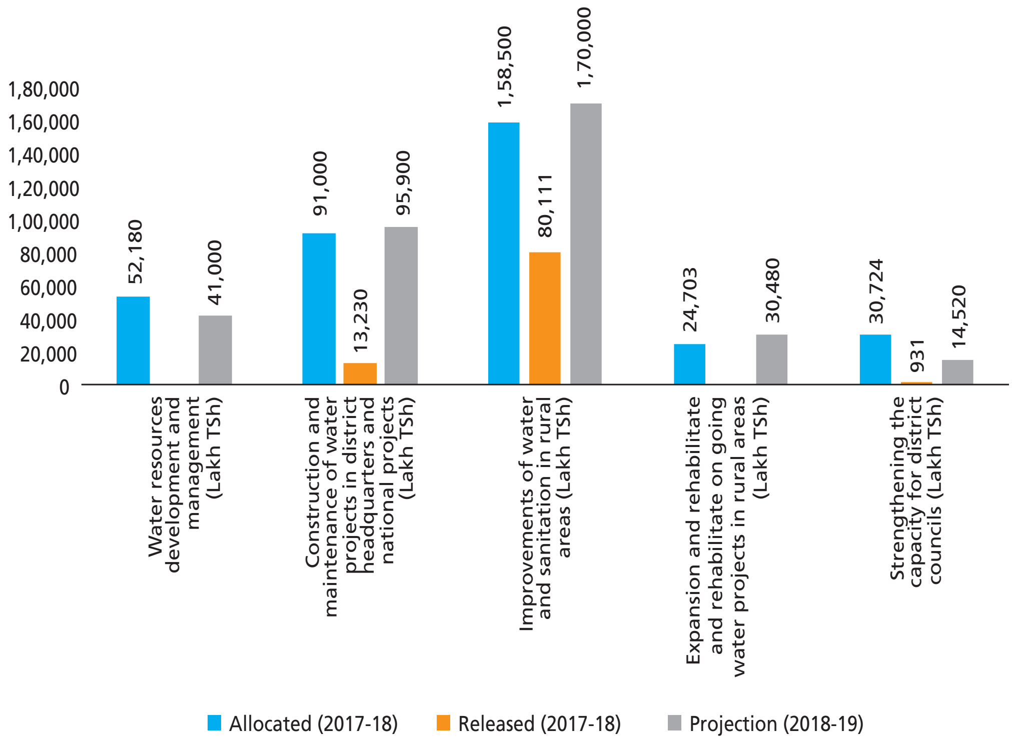
Source: Policy Forum, n.d, " Water Summary Budget Analysis-TGNP Brief", https://www.policyforum-tz.org/sites/default/files/Policy%20Forum%20-%20Water%20Summary%20Budget%20 Analysis-TGNP%20BRIEF.pdf (viewed on July 31, 2021).

The government budget is skewed towards expansion and construction of new projects and renovation of infrastructure and water supply issues remain neglected.[22] Despite the fact that Tanzania is home to 25 per cent of the world's freshwater resources, a large part of the population still struggles with improved access to water. Increase in population and intensification of agriculture are adding to the woes. The release of budgetary allocations is also an issue. They have been seen to delay developmental projects beyond the recommended time and hamper implementation in both phases of the Water Sector Development plan due to delayed payments and accrued interest costs on these payments.[23] This delay will pose challenges such as increasing poverty and gender disparities in Tanzania.

Budgetary allocations to the water sector have also decreased. The allocated budget is also not properly released (see ***Figure 6: Tanzania water sector budget allocation versus release***), i.e. allocated budget in different sectors of investments are not released despite availability of budget.[24]

The National Water Fund (NWF), established in 2015–16 under the Water Supply and Sanitation Act, 2009, and revived later by the Water Supply and Sanitation Act 2019, is the only source of local financing in the sector. As per a blog report,[25] between financial years 2018–19 and 2020–21, the government released TSh 1.2 trillion to support water developmental activities, out of which 30 per cent was contributed by NWF whose share is increasing and it has thus emerged as a resource mobilizer. The fund board is always on the lookout for new funding.

Figure 6: Tanzania water sector budget allocation versus release

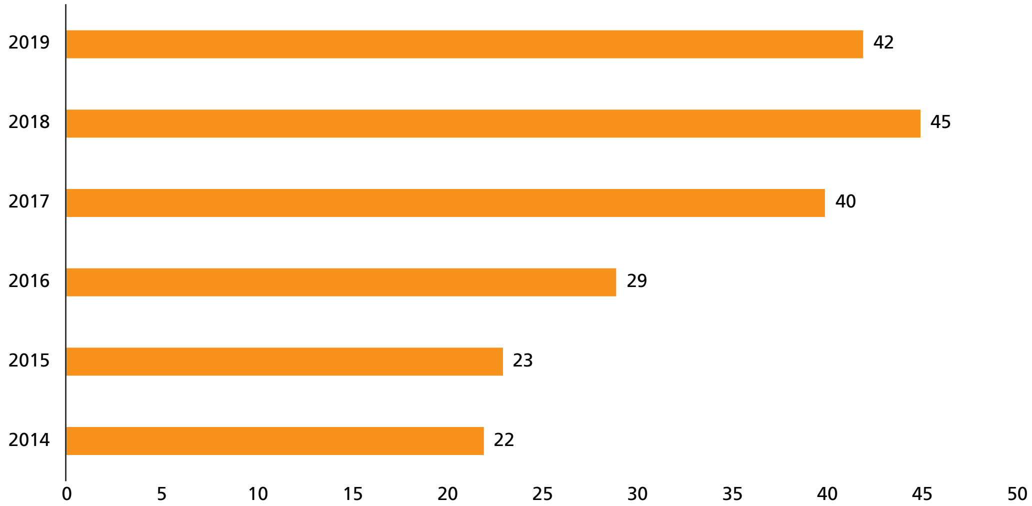


Source: Policy Forum, n.d, " Water Summary Budget Analysis-TGNP Brief", https://www.policyforum-tz.org/sites/default/files/Policy%20Forum%20-%20Water%20Summary%20Budget%20 Analysis-TGNP%20BRIEF.pdf (viewed on July 31, 2021).

Data shows that Tanzania has adequate resources for now, but a large part of the population still doesn't have water access. Also as the population increases, the burden on resources will increase. The fund allocation is skewed, which makes policy implementation tough. Tanzania needs to revisit its financing sector and allocate properly to each activity in the water sector. Also, policies related to release of funds need to be revisited. Tanzania has decreased its budget for water sector investments over the years.[26] This will eventually create issues. As per a 2021 Water AID report, countries need to spend more on water and sanitation if they intend to fuel economic growth.[27] It is obvious that when a populations spends a large fraction of time accessing water, it will not be able to contribute to the country's economy.

Another important aspect is conservation of water. According to a study[28] that identifies non-revenue water loss due to leakages caused by high pressure in pipes—due to pipes of large diameter and resultant pipe bursts—faulty network topology, etc., leakages need to be minimized and network topology and demand-driven supply improved to ensure that larger parts of the country have increased access to water supply. Sustainability of existing water

Figure 7: Cumulative data—Number of non-functioning water points in Tanzania in 2014–19



Source: Water Sector Status Report: 2015-20, United Republic of Tanzania, Ministry of Water, 2020, https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf

infrastructure needs to be increased. Non-functional water points need to be revived and made functional.[29] Local authorities have been found to not have funds for such maintenance work. It is estimated that if such non-functional water points are revived, approximately 5.3 million people in sub-Saharan Africa can be provided with improved water sources[30] (see ***Figure 7: Cumulative data—Number of non-functioning water points in Tanzania in 2014–19***). As per the data from the status report of the water sector[31] only 70 per cent of water points were fully functional at the end of December 2019.

Also, institutional reforms need to be looked into as several institutions still work in accordance with traditional rules.[32] The reforms consider inclusion of all the stakeholders, but, as per a recent study, community inclusion on the ground remains a challenge. Small investments at the household level as well as in behavioural change in communities can boost water conservation measures.[33] Studies in evaluating feasibility of recharge for low recharge potential aquifers should be taken up.

Overall, Tanzania needs to focus on proper allocation of funding, better accountability, maintaining existing infrastructure, establishing monitoring routines, funding studies for more accurate data and modifying institutional framework for better on-ground implementation.

State of groundwater in rural areas: Existing policies, strategies and actions

Tanzania's water governance has been under various ministries. The transformational journey of its water sector can be broadly divided into the pre- and the post-Independence eras.

The pre-Independence era, or colonial period, i.e. before 1961, saw a focus on improvement of indigenous systems and some large-scale irrigation projects.[34]

Tanzania did not focus on domestic and agricultural water supply until 1930. During 1930–45, water supply systems were constructed for townships, large estates, trading centres and minor settlements, and the Public Works Department became involved.

The Water Development Department was developed in 1946. It took over construction works of townships, administrative setups and development of water resources for rural areas, while the Public Works Department was left only responsible for water supply in townships and major settlements.

Post 1950s the construction of several water resources started. The government bore 70 per cent of the capital cost and remaining 30 per cent was borne by local authorities and project owners.

There was substantial shuffling in the department in 1959–60. The department changed its ministry thrice.

The post-Independence era saw good work in the water sector under able leadership. Trained staff worked on the ground and more regional offices that facilitated equal work distribution were opened. Emphasis was laid on betterment of rural water supplies and the second five-year development plan was laid out.

From 1967 to the 1970s—known as high modernist period—water was considered a public good and the state made high capital investment in the water sector. There was substantial donor funding and access to water sources increased but community participation was lacking.[35] States and donors offered services together only after the 1980s,[36] the transition period. Access to water supply did not improve much though.

The cost of operation and maintenance was shared between government and beneficiary. In 1990–2000, known as the liberalization period—or the period of polycentric governance—the state acted as a facilitator and regulator, and access to protected water supplies increased further[37] (see ***Table 2: Developments in policy reforms in the water sector in Tanzania***).

Table 2: Developments in policy reforms in the water sector in Tanzania

Year	**Developments**
1959–60	• Water Department was shifted to the Ministry of Natural Resources and then to the new Ministry of Lands, Surveys and Water, where it accomplished some water development projects among which was the construction of a Provincial Water Division office in Bukoba. The Department was again shifted to the Ministry of Agriculture, where it became a Division, with five main responsibilities, including provision of domestic water for humans and animals in rural areas, conservation of water to improve river flows and prevention of floods, execution of irrigation schemes, hydrological investigations and long-term planning of major water development works.
1964	• The Water Development and Irrigation Department was again shifted to the Ministry of Lands, Settlement and Water Development.
1969	• Division again shifted to the Ministry of Agriculture, Food and Cooperatives
1970	• Historic year for the Water Development and Irrigation Division. • Ministry of Water Development and Power was created. • The four Divisions of Water and Drainage, Water Supply, National Water Resources Council and Water Development and Irrigation were brought together to form this new ministry. • The ministry became responsible for all aspects of management of water resources and development in rural and urban areas as well as for the development of hydropower for the whole country.
1971	• A programme for provision of piped water supply to rural areas by 1991 was launched in accordance with the primary development objective of rising rural standard of living as per directives of the Arusha Declaration.
1971	• The Water Supply Development Programme (WSDP) introduced other aspects such as planning, construction, operation and maintenance, and financing of the 1971 agenda of provision of domestic water supply by 1991.
1974	• Introduction of Water Utilization Act (Control and Regulation)
1961–74	• Colonial Water Ordinances of 1959 continue being used for water resources management, and Water Works Ordinances of 1949 were in use even after independence for water supply service provision.
1975	• Separation of Water Department and Irrigation Department.
1976	• Review of Water Supply Development Programme 1971 addressed gaps and challenges in WSDP
1979	• Review of Water Supply Development Programme 1971
1981–2001	• Amendments of Water Utilization Act (Control and Regulation) Act No. 10-1987, No. 8 of 1997, No. 1 of 1999 and No. 20 of 2001. • Act No. 10 of 1981 amended Act No. 42 of 1974 by introducing river and lake basins for management of water resources
1981	• Designation of Tanzania into nine water basins
1997–2001	• Water Resources Utilization (Control and Regulation) Act was later repealed by the Water Resources Management Act No. 11 of 2009. • Water Works Ordinance Cap. 272 was amended by Act No. 5 of 1966, No. 7 of 1981 and No. 8 of 1997. This Act was used in all regions except Dar es Salaam. • The Act was repealed by the introduction of the Water Supply and Sanitation Act No. 12 of 2009 (WM 2011), which has been recently repealed the Water Supply and Sanitation Act No. 5 of 2019.
2001	• The National Urban Water Authority Act was revised to Dar es Salaam Water Supply and Sewerage Authority Act serving Dar es Salaam city and parts of coastal region. Simultaneously the Water Works Ordinance continue to serve for other regions.
2001	• Ministry of Water merged with Ministry of Livestock Development

2002	• National Water Policy adopted, and basin-level management of water resources introduced.
2003	• Leasing of Dar es Salaam water supply to a private sector company
2006	• National Water Sector Development Strategy (NWSDS) developed.
2007	• Launch of the Water Sector Development Programme for the period 2006–25
2009	• Water Resources Management Act No. 11, and Water Supply and Sanitation Act No. 12 established
2015	• National Water Fund became operational
2016	• Water Sector Development Programme Phase I (2007–16) ended and Phase II was initiated
2019	• Water Supply and Sanitation Act No.5 was established repealing act No.12 of 2009 • Rural Water Supply and Sanitation Agency established • Community Based Water Supply Organization was established

Sources: Kabote, S.J. and John, P, 2017, "Water Governance in Tanzania: Performance of Governance Structures and Institutions", *World Journal of Social Sciences and Humanities*, Vol. 3, No. 1, 15–25

Sokile, C.S. Kashaigili, J.J. Kadigi, R.M.J., 2003, "Towards an integrated water resource management in Tanzania: the role of appropriate institutional framework in Rufiji Basin", *Physics and Chemistry of the Earth* 28, 1015–23.

Water Sector Status Report: 2015–20, United Republic of Tanzania, Ministry of Water, 2020, https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf

A total of 20 different ministries have been changed to manage the developments in the water sector since 1961. Apart from these ministerial changes, the history also saw the abolition of the water user fee in 1967 and abolition of local governments in 1972.

In the 1980s Tanzania had already adopted a River Basin Management Approach for water resource management—the country was divided into nine basins through Act No. 10 of 1981, which was an amendment of the Principal Act No. 42 of 1974. Since then, there have been several initiatives on formal water management institutions. Water Sector Development Plan (WSDP) programmes were launched in 1987, which helped increase coverage of rural water supply from 8 per cent to 40 per cent. In 1991, the National Water Policy was launched to provide access to clean and safe water to households. But the policy faced some limitations due to non-inclusion of the private sector, citizens and community groups. The policy neither considered preserving the resources nor did it address conflicts among stakeholders, and lacked a proper implementation strategy. In 1993, the Rufiji Basin Water Board was launched and the Rufiji Basin Water Office started operating in the same year. Later, in 1997, the Principal Act for water management, i.e. the Water Utilization (Control and Regulation) Act No. 42 of 1974 was amended to accommodate further changes.[38]

Considering the change, the National Water Policy, 2002 was launched as several household still lacked water supply and existing systems were not functioning properly. This policy was launched with a view to sustainable development and management of water resources and it still exists.

The Tanzanian water sector is also influenced by strategies such as Tanzania National Development Vision, 2025, and the National Strategy for Growth and Reduction of Poverty

(NSGRP also known as MKUKUTA in Kiswahili), where the country has committed to access to safe water to all. To achieve the targets of Tanzania Development Vision, 2025 and MKUKUTA by 2010, the National Water Sector Development Strategy (NWSDS, 2006) was laid down with the aim of conserving and utilizing alternative resources and removing disparities across the water sector.

A collaboration was required for the ministry with the regional administration and the local government (PMO-RALG, the Ministry of Health and Social Welfare, and the Ministry of Agriculture and Food Security). Further, the strategy aimed at reshaping and increasing sector financing through a smooth and manageable institutional arrangement. The National Water Sector Implementation Plan was established for implementing objectives of NWSDS within a five-year time frame. The strategy was eclipsed by the Water Sector Development Programme (WSDP) (which was essentially a framework to implement multiple standalone water supply projects).

Water Sector Development Plans (WSDPs) WSDP-1 and WSDP-2 have been among the largest ventures aimed at improving Tanzania's water resources, governance, service delivery and capacity building. It had a funding of US $1.414 billion, in which the Government of Tanzania contributed 28 per cent and the World Bank 18 per cent.[39]

The Government of Tanzania is also trying to promote rainwater harvesting through various policies such as MKUKUTA and WSDP. They have mandated demonstration sites in health centres, schools, etc. and post 2011, all new constructions have been mandated to have rainwater harvesting systems.

According to the National Water Policy (NAWAPO) 2002 and Water Resources Management Act No. 11 of 2009, the management of water resources is divided into five main levels: national level, basin level, catchment level, district level, and community level, which is the lowest level and integrates users of the same source.[40] The Act outlines the powers and functions of the boards, catchment committees and water users' associations responsible for the management of water resources (see ***Table 3: Broad institutional structure in Tanzania***).

Table 3: Broad institutional structure in Tanzania

Institutions	Functions
Ministry of Water and Irrigation (MoWI)	Responsible for regulation and coordination of the national water policy, the ministry finances and monitors project implementation of Basin Water Boards (BWBs), urban water supply and sanitation authorities (WSSAs), and Local Government Authorities (LGAs). The MoWI budget is almost 70 per cent less than what is allocated to other natural resources.
National Water Board	Advisory board to the Ministry of Water and Irrigation for integrated water resources planning, management and investment as well as resolution of national and trans-boundary water conflicts
Basin Water Boards	Responsible for managing water resource in respective nine basins. Catchment water committees work in coordination with them for activities like preparation and implementation of catchment plans, and resolution of conflicts within the catchments.
District Councils	Responsible for planning and development of water resources in accordance with Basin plans.
Water User Associations	Responsible for local level management of allocated water resources, conflict resolution, data collection, preparation of plans, efficient usage, protection and conservation of resources, enforcement of the law, etc.
Water Supply and Sanitation Authorities (WSSAs)	Autonomous government institutions which were established in 1998 to provide water services to urban areas.
Rural Water Supply and Sanitation Agency (RUWASA)	Responsible for implementation of rural water supply and sanitation projects.
Community-based water-supply organizations (CBWSO)	To enhance sustainability of rural water supply and sanitation services through public involvement and private sector participation in rural water services.
Water Institute (WI)	Institute was established in 1974 in order to supply the middle-level technical workforce needed to implement the Rural Water Supply Program. It runs various courses.
National Water Fund (NWF)	Established to address issues related to inadequate funding for water projects. It supports investment for water supply infrastructure; management of water resources; and related activities as well as interventions that are necessary for delivery of planned targets in the water sector.
Energy and Water Utilities Regulatory Authority (EWURA)	In urban areas, EWURA regulates the provision of water supply and sanitation services. It also issues license, reviews tariffs, monitor performance and standards with regards to quality, safety, health and environment. Annually, EWURA publishes performance review report of WSSAs for provision of water and sanitation services.
Tanzania Water and Sanitation Network (TAWASANET)	National network of Civil Society Organizations (CSOs) working in the water, sanitation and hygiene (WASH) sector. It was established in August 2008. It addresses the need for a coordinating body for strengthening voices of multiple sector CSOs across the country.

Source: 1. World Bank. 2018. Reaching for the SDGs: The Untapped Potential of Tanzania's Water Supply, Sanitation, and Hygiene Sector. WASH Poverty Diagnostic. World Bank, Washington, DC, http://documents1.worldbank.org/ curated/en/167791521012037920/pdf/124255-PUBLIC-P159 820-the-untapped-potential-of-Tanzania-s-water-supply-sanitation-and-hygiene-sector.pdf, viewed on May 23, 2021.

2. United Republic of Tanzania, Ministry of Water, 2020, "Water Sector Status Report: 2015-20", https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf, Viewed on 31st July, 2021

Tanzania has adopted a sector-wide approach (SWAP), through which the development partners, non-governmental organizations and civil society organizations can contribute. This is done to create a synergistic coordination. However, owing to limitations, policy and strategy implementation still remains a challenge on the ground.

Tanzania also needs to focus on better coordination, coverage and scope of legal framework for its wetland conservation. Wetlands are a major contributor of the Tanzanian economy as the rural population is highly dependent on wetlands for its livelihood needs.

The Wildlife Division of the Ministry of Natural Resources and Tourism (MNRT) is in charge of wetlands but with limited scope. It can intervene only in areas that fall in wildlife protected areas. Any other mismanagement in other areas need to be looked into by specific ministries.[41]

The four Tanzanian Ramsar sites—Lake Natron, Malagarasi Muyovosi and Kilombero Valley under the Tanzania Wildlife Management Authority (TAWA); and Rufiji-Mafia-Kilwa Ramsar Site under the Forestry Division—which should be conserved and managed by the responsible ministry, cover only about 5.5 per cent of all Tanzania's wetlands. Although 70 per cent of the Kilombero Valley and 95 per cent of the Malagarasi Muyovosi Ramsar Sites fall within protected areas, i.e. game reserves, national parks and forest reserves, management of such sites remain a challenge. About 32 per cent of the Rufiji-Mafia-Kilwa Ramsar site falls under Mangrove/Forest Reserve or under Marine Protected Areas (MPAs). For the Lake Natron Ramsar site, the Wildlife Management Area (WMA) was established on the Longido side of Lake Natron in 2011. Without adequate legal framework and comprehensive management plans of wetlands in Tanzania, most of the non-protected wetland areas in Tanzania become increasingly degraded and thus their ecological functions will be lost in the future.[42]

There is lack of coordination between these divisions and wetland management has hence become a major challenge for Tanzania[43] (see ***Table 4: Divisions for management of wetlands***).

A 2017 research study[44] conducted in Tanzania highlights the gaps in the country's governance and institutional structure in reference to its influence on district councils, village governments, village-level water users associations and committees, and private and civil sector organizations. They highlighted the fact that there is a huge scope of capacity development at these levels to be able to better implement the policies and water quality and government needs to focus on these areas and make funds and trained manpower available. They also found that informal institutions were fairly effective in changing people's perceptions but needed to be synced with formal institutions and required capacity development to be able to perform better on the ground. Tanzania local village and district level institutions were also found to be weak in resolving water conflicts at the inter- and intra-village level and required more guidance in conflict resolution.

Table 4: Divisions for management of wetlands

Implementing sector	Legal framework (Policy or Act)	Linked aspects in the framework	Gaps and opportunities
Wildlife conservation sector	Wildlife Policy of 2007	• Adopts the definition of wetlands from the Ramsar Convention	• Only wetland areas reserved for wildlife within a national park or game reserve are protected under this jurisdiction
	Wildlife Conservation Act of 2009	• Prohibits livestock keeping, crop cultivation or any agricultural activities in any wetland reserve areas	
Agricultural sector	Agriculture and Livestock Policy of 1997	• Recognizes that environmental issues cut across various sectors and require proper coordination fore resource conservation. • Irrational use shall negatively affect the resources for agriculture and livestock. • Traditional systems need to be recognized and rehabilitated to reduce the impact on wetlands.	• Promotes issues of food security and poverty alleviation • No mention of water resource exploitation in crop irrigation • Lacking of monitoring mechanisms and discharge criteria for contaminants released in the agricultural processes, industrial effluents and livestock waste.
	Pesticides Regulations of 1984 (made under Section 41 of the Pesticide Act 1979)	• All pesticides should be registered prior to usage • It also defines the criteria for protection of public health and environment due to pesticide contamination	
Land sector	The National Land Use Planning Commission Act, 1984	• Powers and functions for wetland conservation and management were defined.	• Proper policy planning for Protection of land use quality.
	Tanzanian Land Policy of 1997	• Sensitive areas, such as forests, river basins, areas of biodiversity and national parks cannot be developed. • Wetlands are categorized as unproductive and hazardous, which should not be developed. • Conservation of resources and prevention of coastal Erosion	• No recognition to wetlands as protected, rather declared them having no economic value. They should be properly studied for effective land use plans • Promotes land tenure systems that facilitate social and economic development without disturbing the ecological balance of the environment. • The Act recognizes other sectoral legislations that conserve and manage wetlands
	Land Act No. 4 of 1999 (as amended in 2004) as well as the Village Land Act of 1999	• Categorizes wetlands as "hazardous land"; development of which shall be dangerous for humans and environment	
Forestry sector	National Forest Policy of 1998	• Protects important water catchment areas such as mangroves and swamp forests, • Protects water sources and promotes watershed management	• Only the Central government should authorize and legalize the protection of watersheds or wild plants by the surrounding local communities • Does not protect wetlands and other river catchment areas that do not fall within the areas of forest reserves.
	Tanzania Forest Act of 2002	• Safeguards ecosystem stability through conservation of water catchments. • Requires all developmental projects in watersheds to adhere to Environmental Impact Assessment (EIA) mitigation measures.	
Mining sector	Mineral Policy of 1997	• Environmental and social aspects were integrated for mineral development projects	• Proper guidelines for mining in restricted areas is required to be made. • Lack of specific guidelines for protection of watershed/wetlands and river basins
	The Mining Act of 1998	• Protects the natural resources from adverse effects of mining operations	

Implementing sector	Legal framework (Policy or Act)	Linked aspects in the framework	Gaps and opportunities
Fishery sector	National Fisheries Policy and Strategy Statement of 1997	• Protects biological diversity of fragile coastal and aquatic ecosystems • Promotes the conservation, development and sustainable management of fisheries resources	• Focused on managing the coastal wetlands and aquatic ecosystems and not the inland wetlands
	Fisheries Act No. 22 of 2003 and Fishery Regulations Pursuant to Section 44 of the Act	• Prohibition of fishing activities by unfair means such as using any poisonous chemical or toxic substance • Release of poisonous material in any form (solid, liquid or gas) is prohibited for release into waterbodies	• Does not regulate industrial, municipal and agricultural effluents, which might be harmful to aquatic organisms
	The Water Utilization (Control and Regulation) Act, 1974	• Conditions laid down to regulate the extraction of water by nay person, for use of forestry, industrial purposes and power generation • Any extracted water to be returned from the same source from which it was extracted.	• Wetlands considered to be vulnerable to water supply changes. • Makes cross-reference to forests ordinance in granting water rights for forestry purposes. • Guidelines set to prevent pollution of waterbodies and wetlands by human activities.
Water sector	The National Water Policy of 2007	• Wetlands included in definition of water resources • Mentions about improving the management and conservation of wetlands	• Human water consumption prioritized as a basic need • Lack of guidelines for neither penalties nor sanctions regarding polluting water sources/wetlands, or destruction aquatic biodiversity.
	Water Resource Management Act No.11 of 2009	• Protects water resources and aquatic biodiversity • Need for establishment of protected zones of any catchment, swamp, reservoir, wetland, spring or any other sources of water is identified	
Environmental sector	National Environment Policy of 1997	• Aims at improving environmental management and conservation of biodiversity and wetlands. • Identifies the dangers such as encroachment of public land, wetlands and woodlands associated with economic investment projects and agricultural intensification. • An attempt to minimize the pollution of surface and ground water bodies by controlling agrochemicals run-off	• Formulated to unify natural resource policies in order to lessen existing contradictions, minimize sectoral conflicts, and reduce the overlap of activities in respect to natural resources management
	Environment Management Act No. 20 of 2004	• Wetlands recognized as important but fragile ecosystems • National Environmental Management Council (NEMC), established in 1983, to manage the natural resources including wetlands	• All matters regarding advisories, awareness, coordination, etc. related to law enforcement for conservation, management and sustainable use of environmental resources is coordinated by NEMC

Source: Silvia Francis Materu, Brigitte Urban and Susanne Heise (2018) A critical review of policies and legislation protecting Tanzanian wetlands, Ecosystem Health and Sustainability, 4:12, 310-320, DOI: 10.1080/20964129.2018.1549510, https://www.tandfonline.com/doi/full/10.1080/20964129.2018.1549510, viewed on July 31, 2021.

3. Challenges due to poor quality and scarcity of groundwater

- The Tanzanian economy has seen huge economic losses and rise in food prices after successive droughts.
- It needs to manage its water resources better to meet the present and future demands for water supply and address challenges during droughts and floods.
- Tanzania has major river basins that feed the groundwater. In view of the impacts of climate change, it is vital to manage these river basins.
- Tanzania has had agriculture losses of up to US $200 million, loss of 80 per cent livestock, and increased dependence on diesel for power generation in the previous drought years.
- Choice of water quality is affected with strata, awareness level and economic reach in the society. Lower-income groups opted for shallow wells, which were found to be contaminated with faecal sludge, while higher-income group opted for clean water sources and deeper borewells.
- The groundwater was found to be polluted with sulphates, nitrates and chlorides in certain regions and unfit for human and agricultural consumption.
- The Tanzania government needs to move towards providing water that is clean and fit for consumption as well as towards an equitable distribution.

According to a 2017 World Bank study,[45] if the Tanzanian economy is to sustain its growth trajectory, it must work towards improving its investments and management of its water resources. As its economy expands, the demand for water will only increase. Tanzania may be home to the world's highest percentage of freshwater resources, but these resources may be rendered useless if they are not managed well. The question of whether Tanzania's existing resources will be enough to keep pace with increasing population arises, given that most of its rivers are already water stressed.

The World Bank study also reports a 400 per cent inter-annual variation in rainfall, making the country heavily prone to floods and droughts. Is it possible for Tanzania to proactively store floodwater to address drought-related challenges? If not, economic growth will continue to be hampered. Additionally, climate change is exacerbating Tanzania's challenges by disturbing existing rainfall patterns, making way for more unpredictable droughts and floods.

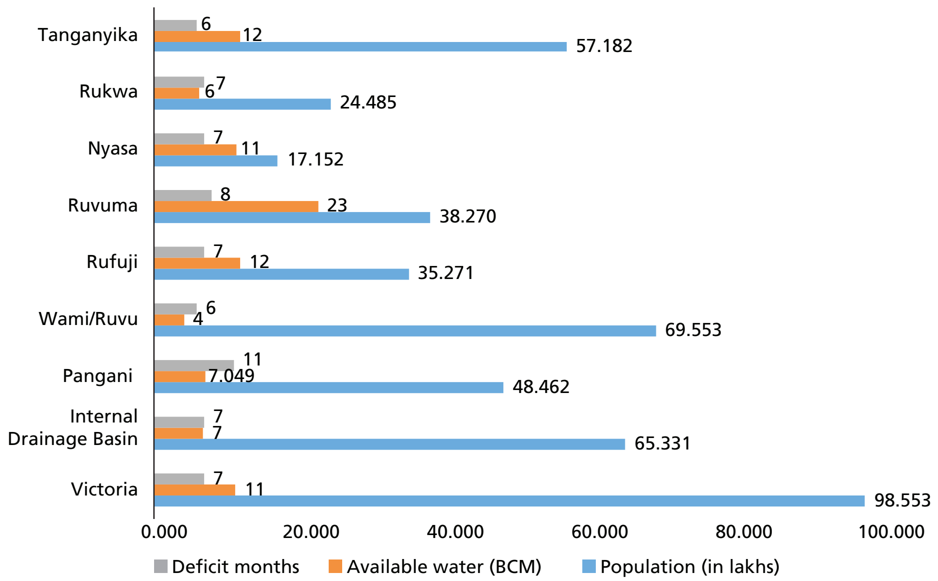
Until 2017, Tanzania had seen eight droughts in the last 20 years, each of which resulted in huge losses in various sectors and threatened future growth. As per a 2014 report published by the 2030 Water Resources Group, drought affected water supply and hydropower production, negatively affecting GDP growth, which fell from 7 per cent to 6.4 per cent in 2011. This corresponds to a loss of US $142 million.[46] The 2009 drought resulted in the mortality of 80 per cent of livestock of northern Tanzania while the 2017 drought resulted in an average increase of 12 per cent in food prices.

Hydropower production was also affected because of the droughts. Excessive groundwater withdrawals for irrigation during the 2009–11 drought resulted in decline in levels of surface water reservoirs in the Rufiji and Pangani Rivers, the main sources of hydropower production in Tanzania. This resulted in use of diesel-driven power generation at a higher cost as against low-cost hydropower generation.

As per a 2008 assessment[47] on the impact of infrastructure quality on the total factor productivity of Tanzania—an indicator for efficiency and competitiveness—Tanzania had approximately 40 per cent dependence on water infrastructure, which is higher than that in many sub-Saharan African countries. Proper management of water resources thus affects GDP loss for any country as the water needs increase with growing population.

In comparison to its neighbours Kenya, South Africa and Uganda, Tanzania stands better in terms of availability of natural resources. The challenge ahead is for Tanzania to efficiently manage the existing water resources. Tanzania is largely an agrarian economy, highly dependent on water. Other sectors, including domestic household usage, mining and tourism, also rely on hydropower.

Figure 8: Demand versus supply stress on various river basins of Tanzania



Source: World Bank, 2017, *Tanzania Economic Water Update*, Managing Water Wisely—The Urgent Need to Improve Water Resources Management in Tanzania, https://documents1.worldbank.org/curated/en/673961509974154698/pdf/120954-NWP-PUBLIC-p156957-p164469-86p-WorldBankNovFR.pdf

Managing the economy will be a challenge if the demand for water is greater than its supply. As per the 2017 Economic Update Report, Tanzania's demand for water is 150 per cent of its accessible water during dry seasons, and will increase to 216 per cent by 2035 (see ***Figure 8: Demand versus supply stress on various river basins of Tanzania***). Most of the country's river basins have a major demand for agriculture and hydropower. A stress in the basins directly impacts groundwater levels as the rivers feed the groundwater. In such a scenario, over-allocation and unplanned allocation has led to almost the entire country facing a deficit for at least six months in a year and not all stakeholders receiving adequate amounts. Even in the wet months, when river flows are maximum, Tanzania cannot—due to lack of planning and storage reservoir—capture enough.[48] The country must act more wisely to budget water requirements and optimize usage.

Health and socioeconomic impact

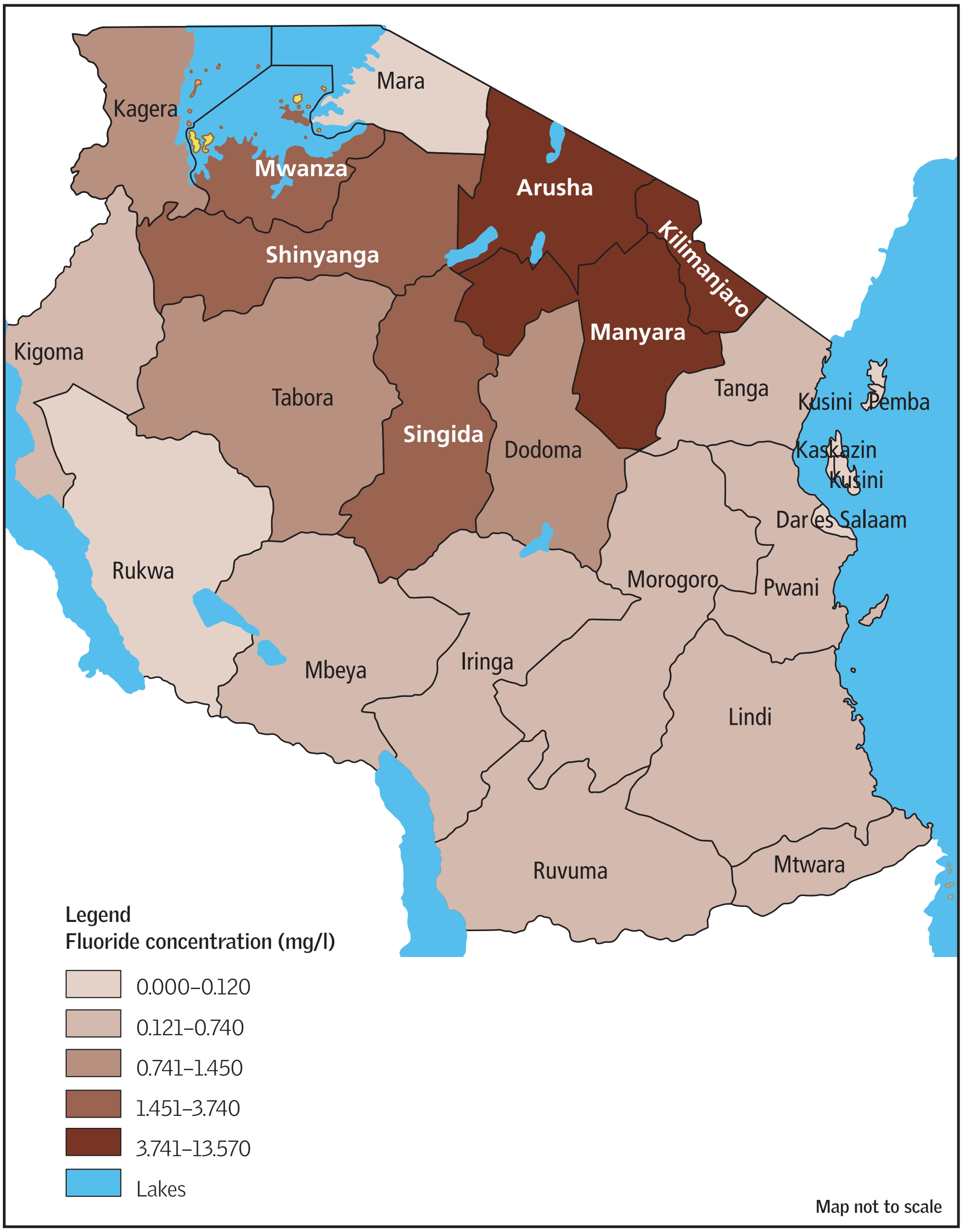
Tanzania is also dependent on groundwater for—apart from agriculture—its drinking needs. This was corroborated in a study[49] in Dar es Salaam, where dependence on groundwater was reported to be more in Tanzania is more than other sub-Saharan countries. Basic water requirement per capita was also found higher than 25 litres per capita per day. Due to this, the average collection time for water was hardly 10 minutes per day.

The onus for collecting water, however, lay on women and time taken to collect water will increase with increase in water scarcity. This hidden cost of water collection is still not accounted for and needs attention as the situations worsen. It will also lead to increase in cases of gender violence. The study also found that higher income and cost of clean water significantly affected the choices of people. Marriage and employment affected the water quality risk choices of households.

Tanzania thus needs to work towards reducing the groundwater exploitation and avoiding the contamination of its groundwater sources. A study[50] in Babati town of Tanzania reported contamination of unlined wells due to pit toilets located near to the wells. The toilets were not built properly and thus contaminated the groundwater. The phenomenon was found more in areas with high population density. The study also found that the shallow wells were contaminated with faecal coliform as well as with the nitrates. Such contamination will increase with increase in population.

Similar results were found in another study[51] done around the slopes of Mount Meru, Arusha. Hence to avoid contamination of groundwater the government should ensure that guidelines are followed while constructing pit toilets. Another study done in 2019,[52] in the same area, found that fluoride was a major pollutant in the groundwater, making it unfit for domestic consumption. The quality of water was also unfit for irrigation and livestock due to presence of chlorides, sulphates, sodium and carbonate beyond permissible limits. Usage of this water not only lowers the crop potential, but also the crop products contain fluorides, which are further harmful to consume.

Map 4: Regional concentration of fluoride in groundwater in Tanzania



Source: Malago, J. Makoba, E. Muzuka, A.N.N, 2017, "Fluoride Levels in Surface and Groundwater in Africa: A Review", *American Journal of Water Science and Engineering*. Vol. 3, No. 1, 2017, pp. 1–17. DOI: 10.11648/j.ajwse.20170301.11, http://fluoridealert.org/wp-content/uploads/malago-2017.pdf

Fluoride concentration was found as high as 99 mg/l against the Tanzanian standard of 4mg/l in the springs of Manyara[53] (see ***Map 4: Regional concentration of fluoride in groundwater in Tanzania***). Arusha, Manyara, Kilimanjaro and Singida were found to have highest fluoride concentration in their surface water while Dar es Salaam and Tanga were found to have the lowest fluoride concentration. Although studies in surface water have[54] not reported long-term concentration of fluoride in surface water**,** fluorosis has become endemic to African countries and governments have to spend on de-fluoridation of their water supplies.

A 1995[55] study in the Dodoma area reported that the quality of groundwater was affected due to anthropogenic sources, weathering and evaporation sources. The report suggested salinity of groundwater due to salt leaching and high nitrate concentrations originated mainly from sewage effluents which reached the water table by bypass flow. A similar study in 2015[56] also stated the same reason along with increased usage of fertilizers in agricultural activities and inefficient planning of sanitation facilities. The study reported the highest values of nitrates found in Dar es Salaam (up to 477.6 mg/l), Dodoma (up to 441.1 mg/l), Tanga (above 100 mg/l) and Manyara (180 mg/l).

The groundwater in Dar es Salaam was also found[57] to have high pH (5.67–7.40), CoD (127–659), iron (0.09–1.09 mg/l) and coliform levels beyond the specified limits. This was due to uncontrolled dumping and disposal of solid waste. Poor waste management practices also resulted in fire, pest outbreak, odour and air contamination.

The concentrations of these nutrients increase in dry season, thus affecting the aquatic life and the health of the citizens of Tanzania. However deep borewells were found to have low concentration of these anthropogenic pollutants and natural sources contributed more to these concentrations.[58]

Over abstraction of groundwater not only affects the quality of groundwater but the quantity as well. Its not being monitored and regulated has led significant spatial variations and concentration of pollutants in the groundwater. A study done in Arusha, Northern Tanzania found that the southern part of the study area had better quality of groundwater for human consumption than the northern zone[59] (see Map 5: ***Nitrate distribution in spring and well waters— Arusha, Northern Tanzania***, Maps 6: ***Spatial distribution of fluoride in spring and well waters— Arusha, Northern Tanzania***, Map 7: ***Chloride distribution in spring and well waters— Arusha, Northern Tanzania*** and Map 8: ***Sulphate distribution in spring and well waters— Arusha, Northern Tanzania***.

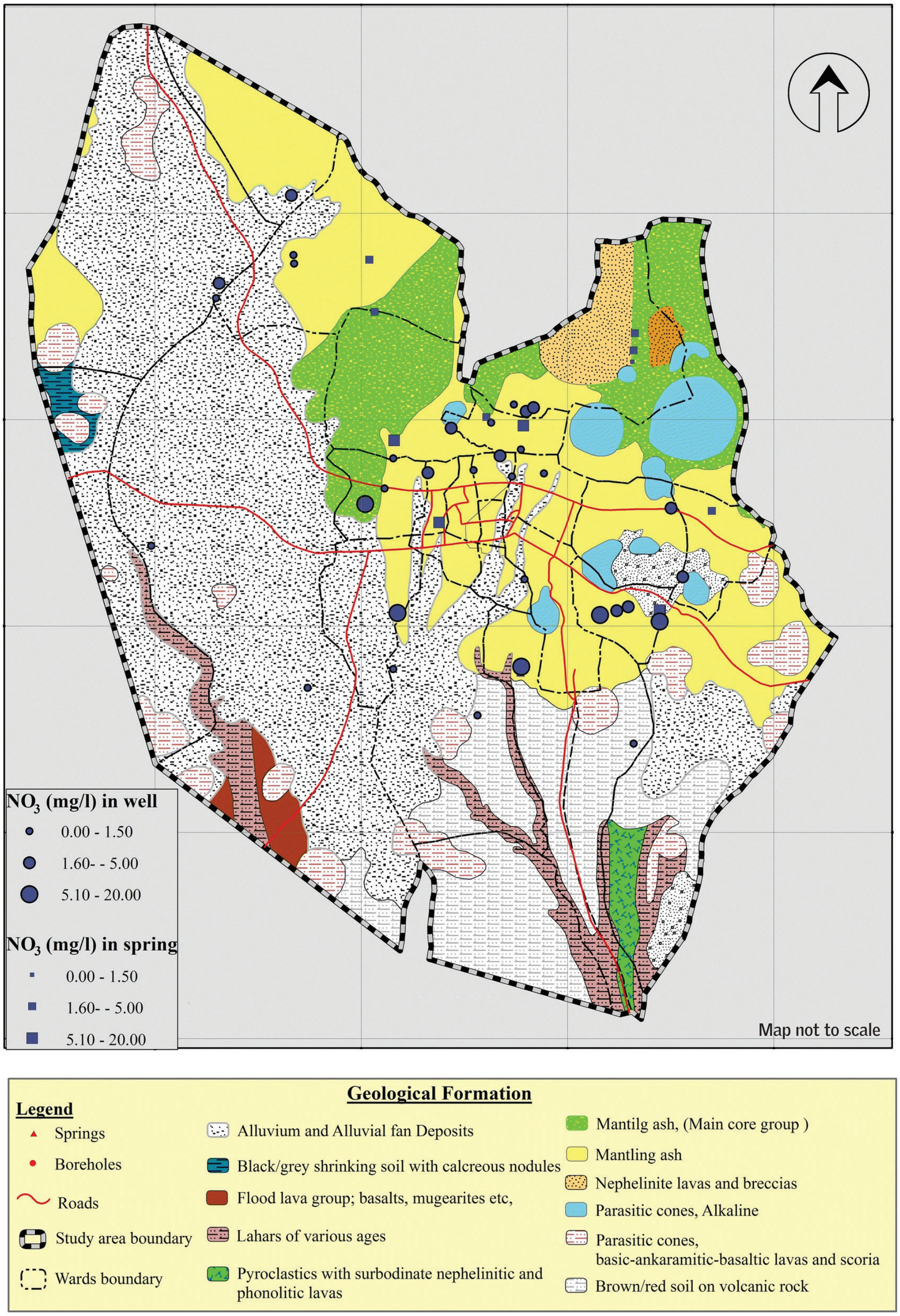
Another study in 2020[60] in Arusha estimated that growing urbanization would reduce groundwater recharge by 23 per cent due to increased urbanization of 179 per cent by 2050 over 2021 levels. It will also lead to a drop in groundwater levels to the tune of 30–44 per cent owing to climate change and global warming, which will increase the warming trends, leading to more evapotranspiration and lesser recharge. It will also lead to drying of wells and wetlands. The price of water will increase, cash crops will shrink and agricultural products become costly. This will increase burden on poor communities who already are paying higher price for groundwater. Power struggles for water shall intensify and economic, social and environmental conditions will degrade. Groundwater reserves are an important weapon to tackle climate change for any country and with depletion in quantity and quality of groundwater, how Tanzania will tackle the new issues is the big question.

Tanzania needs to address how it will support the future growth with regard to water demand. Drilling of borewells may not be a long-term solution as the after effects of drilling exacerbate water scarcity.

High fluoride levels in drinking water sources can lead to dental and skeletal fluorosis. This was evident in a study in schools in northern Tanzania, where 90 per cent of the students had dental fluorosis.[61] The coastal aquifers have brine contamination, which pollute groundwater reserves in the long run. Control and mitigation of such issues is needed.[62]

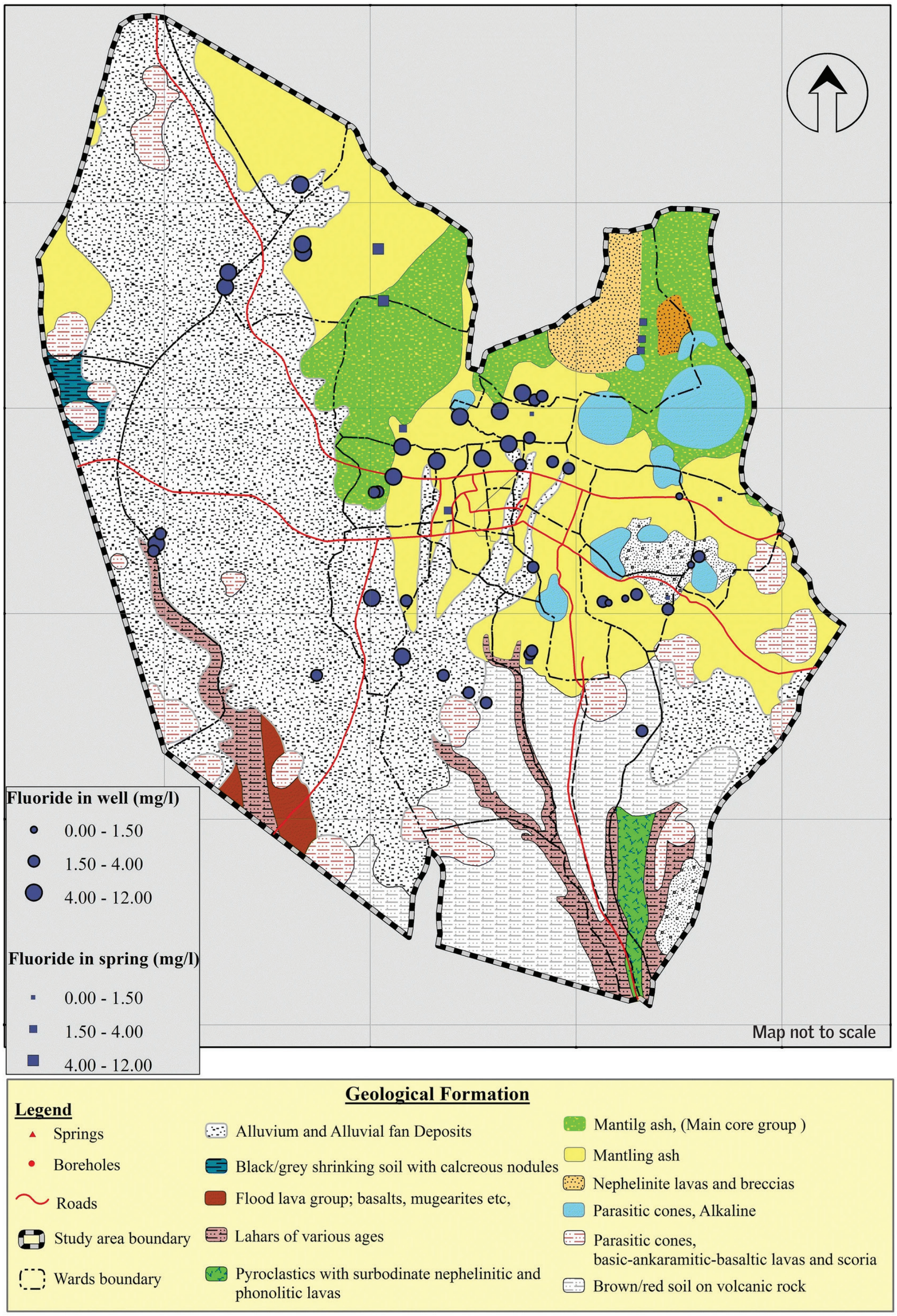
Tanzania also needs to look into equitable access of groundwater.[63] While the poor and farmers are dependent on shallow-water resources, which have been found to be more polluted than deeper borewells, large users have access to deeper borewells. Extraction of groundwater resources needs to be regulated to make it more sustainable.

Map 5: Nitrate distribution in spring and well waters— Arusha, Northern Tanzania



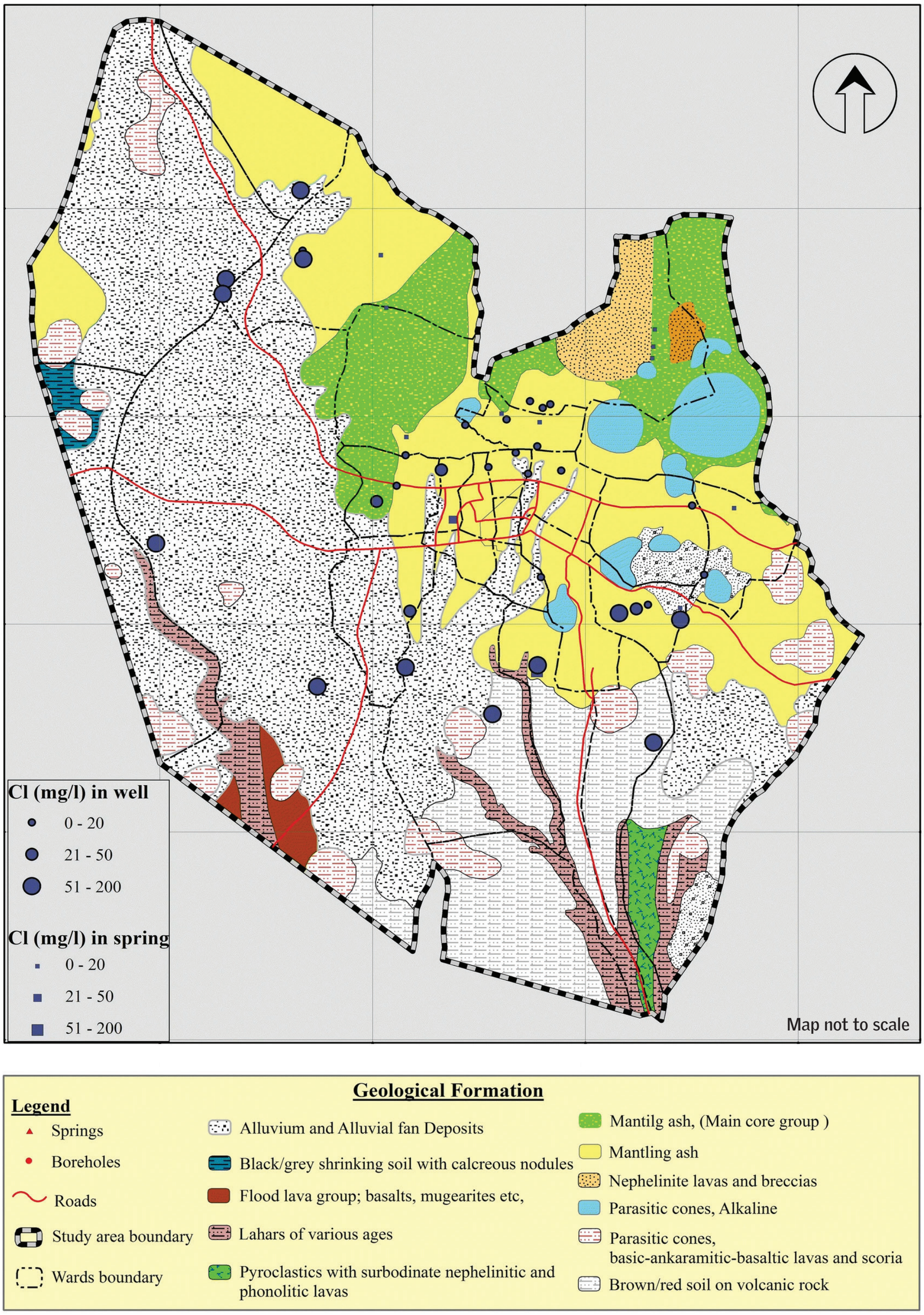
Source: Chacha, N. Njau, K.N. Lugomela, G.V. Muzuka A.N.N., 2018, "Hydrogeochemical characteristics and spatial distribution of groundwater quality in Arusha well fields, Northern Tanzania", *Applied Water Science* 8, Article Number 118, DOI: 10.1007/s13201-018-0760-4, https://link.springer.com/article/10.1007/s13201-018-0760-4

Map 6: Spatial distribution of fluoride in spring and well waters—Arusha, Northern Tanzania



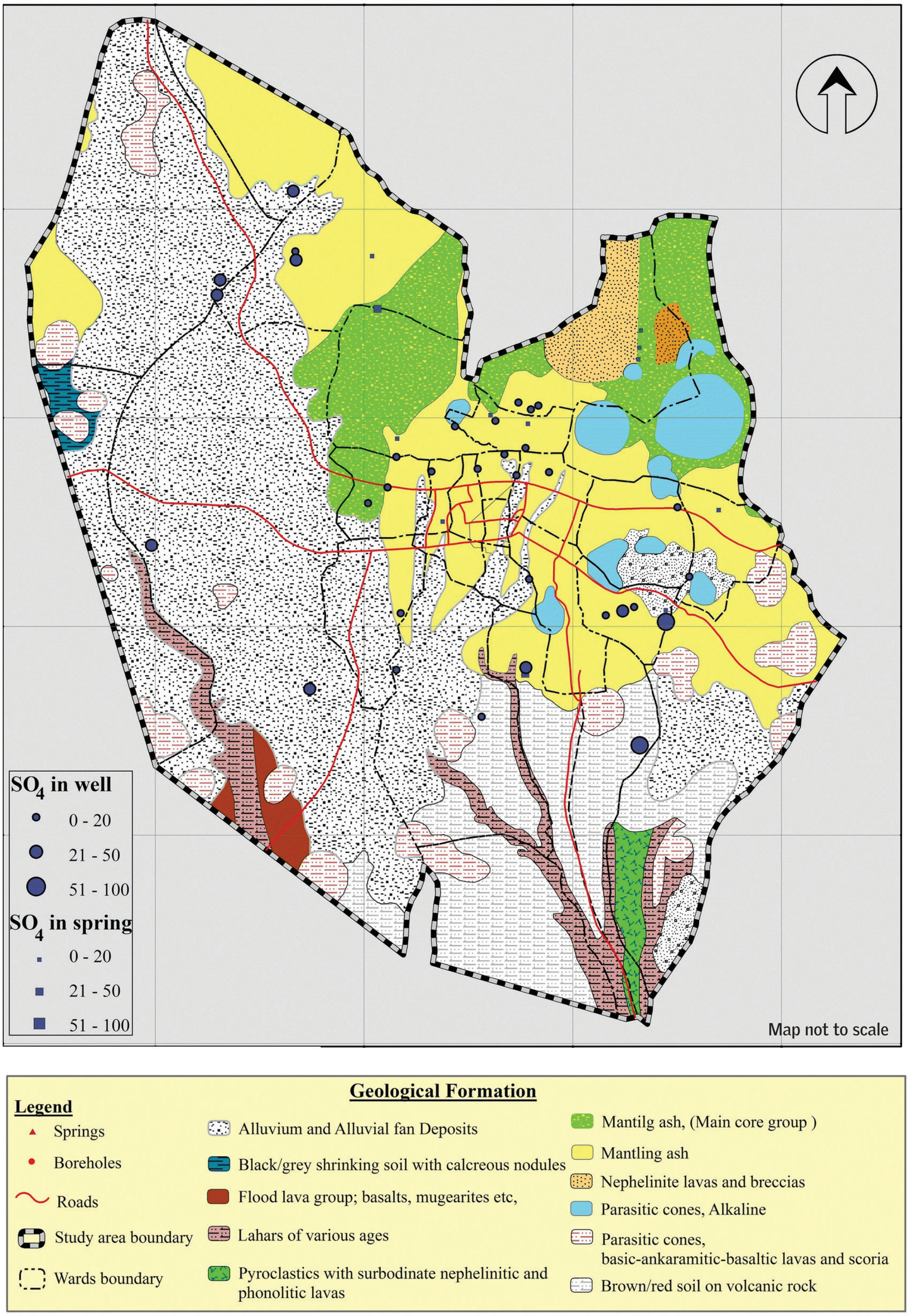
Source: Chacha, N. Njau, K.N. Lugomela, G.V. Muzuka A.N.N., 2018, "Hydrogeochemical characteristics and spatial distribution of groundwater quality in Arusha well fields, Northern Tanzania", *Applied Water Science* 8, Article Number 118, DOI: 10.1007/s13201-018-0760-4, https://link.springer.com/article/10.1007/s13201-018-0760-4

Map 7: Chloride distribution in spring and well waters— Arusha, Northern Tanzania



Source: Chacha, N. Njau, K.N. Lugomela, G.V. Muzuka A.N.N., 2018, "Hydrogeochemical characteristics and spatial distribution of groundwater quality in Arusha well fields, Northern Tanzania", *Applied Water Science* 8, Article Number 118, DOI: 10.1007/s13201-018-0760-4, https://link.springer.com/article/10.1007/s13201-018-0760-4

Map 8: Sulphate distribution in spring and well waters— Arusha, Northern Tanzania



Source: Chacha, N. Njau, K.N. Lugomela, G.V. Muzuka A.N.N., 2018, "Hydrogeochemical characteristics and spatial distribution of groundwater quality in Arusha well fields, Northern Tanzania", *Applied Water Science* 8, Article Number 118, DOI: 10.1007/s13201-018-0760-4, https://link.springer.com/article/10.1007/s13201-018-0760-4

4. Suggested action plans to augment groundwater sources through rainwater harvesting

- The government of Tanzania promotes rainwater harvesting to store rainwater.
- Technological options for groundwater recharge need to be sought as Tanzania will face a problem of declining natural groundwater recharge in the near future
- Other initiatives of water conservation such as reuse of wastewater, renovation and restoration of traditional water-harvesting structures and demand-side management should be included in policies and strategies related to groundwater.
- A water quality and surveillance programme is required.
- All such programmes and policies for groundwater recharge, monitoring and evaluation should be community-centric.
- Communities should be made aware of the issues and solutions through well-developed information and communication strategies.

Rural Tanzania's water supply is largely groundwater-based. Clean and steady sources of water through the year are essential for the rural population. There is no dearth of groundwater in areas that do not have piped-water supply, but there may be local water shortages due to high density of population and poor quality of groundwater.

To achieve sufficient quantities of clean water through the year, judicious use of available water along with water-conservation measures should be taken up. Many villages face water scarcity not only due to long spells of drought but also due to contaminated sources of water. It is important to ensure sustainability of sources of water through effective management of demand and supply of water.

Judicious use of available water and water conservation measures are important to ensure water security. A source is considered sustainable only when it delivers desired quantities of safe water through the year. Sustaining a source for water supply requires specific interventions for source sustainability, optimal use and management of water sources. To strengthen the source of water, there is a need to prepare a budget—with an assessment of the amounts of water available and analysis of its demand and supply.

The most practised mode of rainwater harvesting is storing rooftop rainwater. It is now also recognized a key solution to accessible and safe water, particularly in rural areas.

While management of demand is connected with controlling demand and usage patterns, supply is connected with average annual rainfall, intensity of rainfall, type of aquifer, soil, rock, drainage pattern and physiography of the area. Availability of groundwater can be increased by simple interventions, including groundwater recharge through different traditional and contemporary technologies. Recharge can also improve the level of contamination of groundwater. According to the Groundwater Survey and Development Agency of Maharashtra, India, while supply-side interventions can increase groundwater recharge by 1.47–2.47 per cent of the total annual groundwater recharge, demand-side management can save 20–33 per cent of groundwater.[64]

Fixing gaps in existing policies

Water stresses that occur locally in Tanzania are due to high population density and crisis of contamination-free groundwater. But the impact of climate change, changing pattern of rainfall and high rates of urbanization may reduce the availability of groundwater in Tanzania. This alarming vulnerability calls for immediate policy action from national and local governments.

Among the barrage of threats to human survival—economic crises, terrorism, inequality—perhaps the most urgent—groundwater—is the least prioritized. Fortunately, many policy options can address groundwater depletion. Agencies at the national, district and local levels should cooperate by monitoring the same variables, committing to the same frequency and robustness of data collection, and sharing results even if they generate competitive pressure or embarrassment. Water is a larger public concern than individual political image. This approach is possible with proper incentives from the federal government.

As data provides a more comprehensive view of the groundwater crisis, a reasonable assumption could be that more government policy attention and resources will be devoted to mitigation efforts.

There are several areas for such intervention, including:

- Unplanned and rapidly expanding urban areas contribute to steadily declining groundwater levels. Urban development boundaries can curtail sprawl encroachment on sensitive wetlands and agricultural areas, while permeable pavement and protection and revival of wetlands can increase rainwater absorption and minimize the shock effect of flash floods.
- Scaling up efforts of rainwater harvesting through implementable policy frameworks and additional incentives can significantly improve water availability.
- Existing delivery infrastructure must be improved to manage water that is extracted more efficiently. Good maintenance should be neither politically nor technically complicated.
- Treatment and reuse of wastewater practices and processes must be improved significantly. Much of the groundwater contamination is the product of untreated wastewater discharged into the groundwater. Thus more intensive treatment measures are essential. Additionally, rural Tanzania must adopt wastewater reuse programmes

more aggressively, including purification systems that enable water to be cycled back for agricultural, industrial and even household use. The latter will depend on public trust of government actions.

These measures in addition to conservation awareness campaign and innovative technologies to recharge the groundwater can arrest groundwater loss and possibly reverse it. They would also boost the quality and supply reliability of rural water, reducing incentives for individuals/communities to install water pumps, which exacerbate groundwater depletion. So far, many local initiatives have not motivated communities due to lack of coordinated guidance. Elevating the groundwater crisis to the national policy agenda is essential, and the federal government must oversee a system that is at once distributed, standardized and robustly monitored and documented. Tanzania's social, environmental and economic future will pivot on water.

Institutional mechanism and strategy for planning and implementation at district and national levels

Historically, as social intelligence grew, people realized that human society cannot grow without the bounties of monsoon water extending from the wet months to the dry months. Thus grew the resourceful tradition of water harvesting. Wells were an important source of irrigation in groundwater-rich regions, but people learnt to harvest groundwater in other ingenious ways too, especially where water in general, and groundwater in particular, were scarce.

The principle of water harvesting is to conserve rainwater—according to local needs and geophysical conditions—where it falls. In the process, groundwater is also recharged.

Traditional water-harvesting systems meet domestic and irrigation needs of people. There is ample evidence to show that community management of traditional systems ensured that basic minimum requirements of all individuals were met.

It is challenging to plan modern systems for villages due to high costs involved. People in rural areas continue to depend to a large extent on traditional systems of water-harvesting structures for both irrigation and drinking water. "Traditional systems" do not connote old and decrepit structures but they are distinct from large capital-intensive, government-managed structures. Modern systems have, apart from their high monetary costs, enormous ecological costs too. Use of water generated by them usually goes against the basic norms of sound agroclimatic planning. Traditional community-based structures contribute to social cohesion and self-reliance.

The responsibility of taking decisions and action should be left to individuals, groups and local communities working together, encouraging economic independence and optimization of local resources at the micro-level. Traditional systems use low-cost, user-friendly techniques and were easily kept in good operational condition by local communities. Building water-harvesting structures to augment or conserve a groundwater source is a simple task—any contractor with some money can do it. But building an effective structure that launches the process of self-management in village communities is a much more difficult task. Rainwater harvesting demands a new approach to governance itself—a participatory form of governance rather than a top–down bureaucratic one.

The following are the proposed steps for the government to manage traditional water-harvesting structures to conserve and recharge groundwater in Tanzania:[65]

1 **Community-based governance**: This should be the starting point for all water and natural resource planning and management. Communities should be the key decision-makers for these water systems. The national policy should be worked out to encourage building of small water-harvesting structures that would depend on and contribute to community governance of natural sources. The communities should be encouraged to continue to play a big role in maintaining traditional water-harvesting structures.

Communities know that their water-harvesting systems would die if the catchment area deteriorates or the tank bed is encroached upon. If catchment areas of traditional systems are maintained properly and new ones in- stalled wherever feasible, then despite mounting population pressure they can sustain a large part of the people's water needs.

Local communities, represented by appropriate institutions—village council or village water and sanitation committee (VWSC)—will have absolute right on all rainwater that falls over the common lands of the community, local aquifers, streams and unharvested surpluses from private properties or government lands. This right will be exercised on behalf of all members of the community and with every member treated as an equal partner in all benefits and costs. Costs can be shared according to two principles—that of equal benefits and equal payments or ability to pay. The abiding principle will be decided by the community. Resolution of conflicts and disputes between settlements or communities over the use or misuse of common water resources should take place through institutions of the community instead of the district council. The principles of resolving such issues are best decided by the communities concerned but broadly speaking riparian rights can be one such principle.

2 **Encouraging traditional systems**: Instead of large-scale surface-water systems, community-based institutions associated with traditional water harvesting systems should be focused on. Traditional water-harvesting uses every drop of rain. Conjunctive management of surface and groundwater should be prioritized where availability of clean water is scarce. In situ water conservation and harvesting systems are technological marvels and have proved to be more reliable and durable than modern systems. They

use local material and labour and are planned to suit the micro environment to serve the communities.

In situ collection of rainwater is desirable as contamination is low in water thus collected. Moreover, expensive transportation costs are eliminated. Long-distance transport of water for community use should be discouraged, especially if it leads to iniquitous distribution of water between different village communities. Habitations should as far as possible be sited keeping water availability in view.

3. **Management of small water-harvesting structures**: The principal role of managing water-harvesting systems should be that of the local community. The role of government agencies has to be minimized. Emphasis should be not on community participation but on community governance. This implies not merely the social management of water-harvesting structures but involvement of the community in both planning and implementation.

   Developing community institutions to construct and manage traditional water-harvesting systems is a difficult task. Wherever possible existing institutions can be used to serve as a nucleus or catalysing agency. But in all likelihood new forms of participatory institutions will have to be evolved. Processes and structures for evolving such organizations and institutional forms should emanate from the grassroots rather than from above but legal support for such institutions will be vital. In evolving appropriate organizational forms for different parts of the country, parameters that should be taken into account include nature of the existing water-harvesting systems, historical traditions in the area, governmental policies and their effects, socio-political factors and the water availability–demand relationships in systems.

4. **Water rights**: Communities should be involved in all government plans for water supply to villages. Any changes in the existing traditional technologies should be based on the principles of participatory research and made after the discussion with the communities. Individuals and households should have the right to harvest all the precipitation that falls over their house, property or land, and store it in containers or other systems built, owned and maintained by them. They will, however, not have the right to take water from underground aquifers without the permission of the community and/or Village Water Sanitation Committee (VWSC) or from a stream or body of surface water that depends on inflows from catchments beyond the limits of privately owned property. This right will encourage surface-water harvesting. The use of the harvested rainwater, however, shall be such that similar rights of other individuals are not compromised in any way, groundwater recharge is not affected and water sources do not get polluted. Community institutions must have a say in deciding whether a polluting activity can be sited in the catchment areas of traditional systems, regardless of whether this catchment area covers government land or not.

5. **Investments**: Traditional water-harvesting systems cannot be managed in isolation from other systems of community life. Holistic village planning—planning of all village natural resources (land, forests, water and people)—is essential. Investments will have to be made not only in physical structures but also in human resources as desired by communities. Major investments will also need to be made in training people who can interact with the communities. Finances for the initial construction and rehabilitation of the structure should come from the community as much as possible. At least 25 per cent can be obtained from the community, provided the investment planning for rehabilitation is undertaken by the community itself, with district council and other external agencies playing only a supportive role. The exact modalities of financing and cost recovery should be left to the community. The community must contribute effectively at all stages of the project.

   While state subsidies may be necessary, their levels should be decided according to community needs and regional specificities. Further, greater emphasis has to be on subsidies to the community rather than on private subsidies to individuals. District financing becomes relevant where the rural community can barely meet its basic needs. But this investment should be carefully subordinated to and integrated with the interests and decisions of the local communities. Investment planning should have a micro-level focus, preferably a watershed perspective. Every effort must be made to mobilize investment resources from the rural community itself and to the maximum extent possible. Finances should be invested in research and development of all aspects of traditional systems. The conventional cost–benefit analysis does not give any importance to cultural parameters or scarcity values attached by a society to water—this has to change. Methods of project evaluation need to be revised.

6. **National body**: A national body to support and coordinate the building and rejuvenation of traditional water-harvesting structures by local communities is needed. But this body should not be allowed to replace community control over the structures created or regenerated. At best, it will provide broad management principles more as guidelines, and act as an apex body to set government policy, and ensure coordination between various governments departments. To enable successful water-harvesting in traditional ways, clear laws to prevent overexploitation of groundwater are necessary. The national body should also fund research on traditional systems to evolve new organizational and institutional mechanisms and help in the development of technologies for up gradation of traditional water-harvesting structures.

7. **New interventions and role of women**: To combine traditional technologies with modern ones, a wide body of realistic data (on groundwater resources, for example) has to be collected. At present, there is a heavy reliance on thumb rules. Almost no information exists on the linkages between big systems and small ones, both in the past and at present.

Women play a pivotal role in the operation and maintenance of traditional systems but they do not figure in any research work. As a first step, a comprehensive list of local names and descriptions of different systems throughout the country needs to be prepared.

Domestic water is not utilized fully and nearly 85–90 per cent of the water is returned as wastewater. With appropriate treatment, this can be used for irrigation, groundwater recharge or even recycled for domestic use. All such possibilities should be explored.

Another important means of optimizing water resources is by promoting the drip and sprinkler irrigation methods.

Technological options to augment groundwater sources

As mentioned in earlier sections, augmentation of groundwater resources ensures clean and sustainable water supply to the villages. There is an urgent need to build small water-harvesting structures following traditional methods.

For effective recharging of groundwater to improve quality and groundwater levels, the following techniques can be applied:

1. Check dams
2. Gabion structures
3. Subsurface dykes
4. Farm ponds
5. Gully plugs
6. Contour bunding
7. Contour trenches
8. Percolation tank
9. Rooftop rainwater harvesting

Table 5: Different technological options for different soils, rock and terrain

Type	About the technology	Soil, rock and/or pre-conditions	Advantage
Check dams	Constructed across small streams with gentle slopes	Can be effective in both hard rock and alluvial formation	• As the structures can impound larger quantities of water, it is helpful in deeper infiltration of water into the ground
Gabion structure	Rock and wire dams constructed across drainage lines in catchment areas	Can be effective in both hard rock and alluvial formation	• Economical as local material can be used • Easy to maintain • Can be constructed on high- to medium-velocity streams • Can withstand medium- • intensity flash floods
Subsurface dykes	Underground structures made of soil or cement. They arrest the flow of groundwater out of the sub-basin and thus increase the storage of the aquifer	Can be effective even in undulating hilly terrains	• Impounding subsurface water on the upstream side helps the water, which may otherwise flow away, to percolate into deeper layers of the soil profile • Can withstand high intensity • rain/flood
Farm ponds	Dug-out structures with definite shapes and sizes, with proper inlet and outlet structures to collect the surface runoff flowing from the farm area	For storage, underlying soil should be impermeable in soil. A farm pond must be located within a farm drawing the maximum runoff possible in a given rainfall event	• Easy to construct
Gully plugs	Loose boulder structures made on small drainage lines or seasonal streams	Effective in areas with sandstones	• Economical as local material can be used • Easy to maintain • Reduces soil erosion and enhances soil moisture
Contour bunding	Watershed management practice aimed at building up soil moisture storage involve construction of small embankments or bunds across the slope of the land	Suitable for low rainfall areas (normally less than 800 mm) where gently sloping agricultural lands with very long slope lengths are available and the soils are permeable	• Easy to design and maintain • Enhances soil moisture
Contour trenches	Rainwater harvesting structures, which can be constructed on hill slopes as well as on degraded and barren wastelands. The trenches break the slope at intervals and reduce the velocity of surface runoff. The water retained in the trench will help in conserve the soil moisture and groundwater recharge	Suitable for hilly areas in both low and high rainfall areas	• Easy to design and maintain • Enhances soil moisture

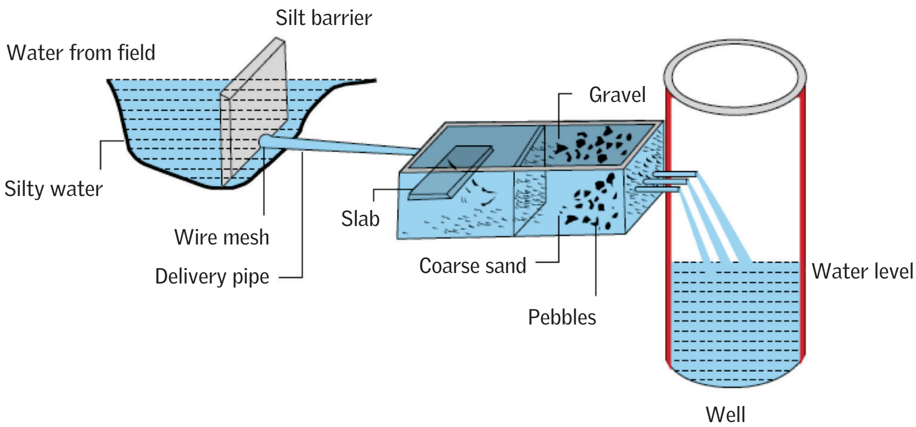
Type	About the technology	Soil, rock and/or pre-conditions	Advantage
Percolation tank/pond	An artificially created surface waterbody for surface run- off to percolate and recharge groundwater storage. The percolation tank should have adequate catchment area	Effective in areas where soil is permeable. Can also be effective in hard rock areas that are highly fractured and weathered	• Economical • Easy to maintain • Existing village tanks which are normally silted and damaged can be modified to percolation tanks
Dug well recharge	Dug wells in rural areas that have gone dry can be used as structures to recharge groundwater. Storm water, tank water, canal water, etc. can be diverted into these structures to directly recharge dried aquifers. This will guide the recharge water through a pipe to the bottom of well, below the water level to avoid scoring of bottom and entrapment of air bubbles in the aquifer. In rural areas rainwater runoff can be channelized and recharged to dug wells through a filter.	Can be effective in both hard rock and alluvial formations	• Economical structure
Recharge shaft	An artificial recharge structure that penetrates the overlying impervious horizon and provides effective access of surface water for recharging the phreatic aquifer	Suited for areas with deep groundwater levels	• Requires only small land area • No loss of water through evaporation • Economic and can be designed by locals • Rate of recharge is high and impact can be observed • quickly
Rooftop rainwater harvesting	Rooftop rainwater can be conserved and used for recharge of groundwater. This approach requires connecting outlet pipes from rooftops to divert water to either existing wells/ tube wells/ bore well or specially designed wells.	Both hard rock and soft rock areas	• Can be implemented on local plots

Source: Compiled by CSE

Check dam built across a stream

Source: CSE

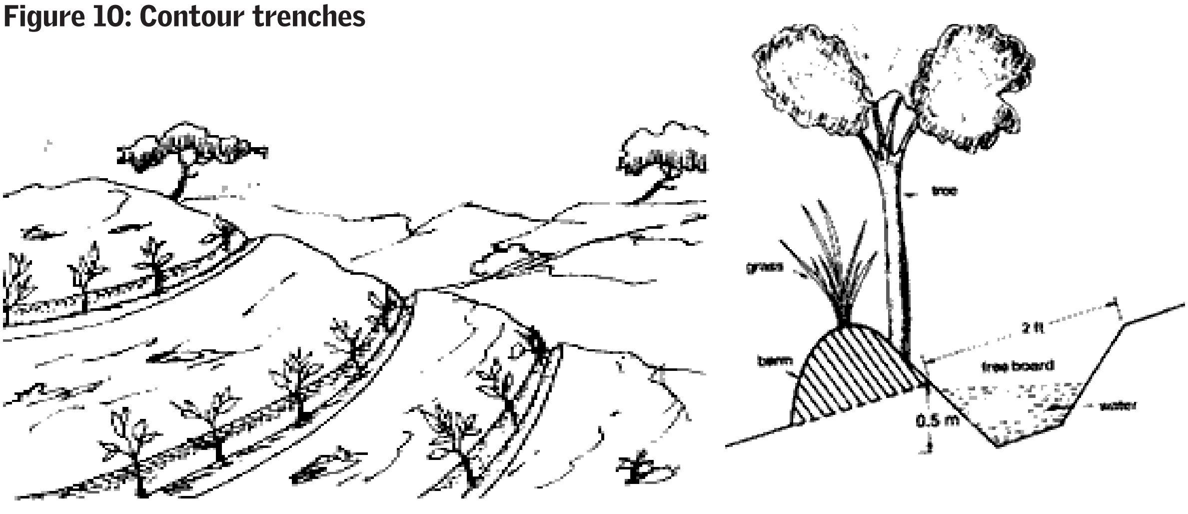
Figure 9: Dug well recharge



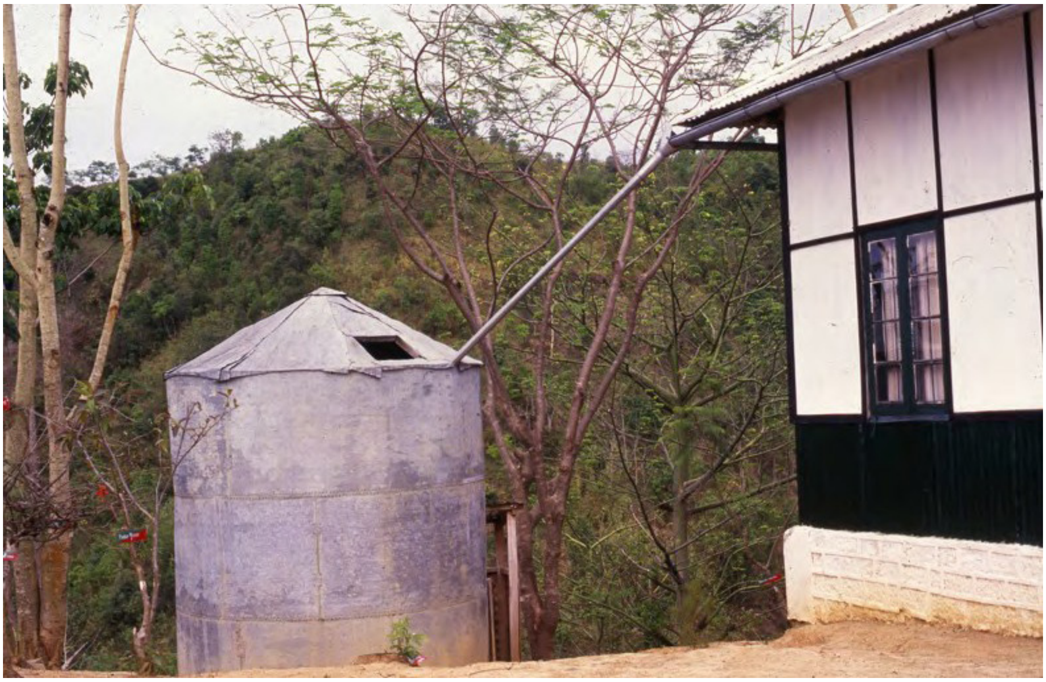
Farm ponds store rainwater and supply water through the year.

Source: CSE

Figure 10: Contour trenches



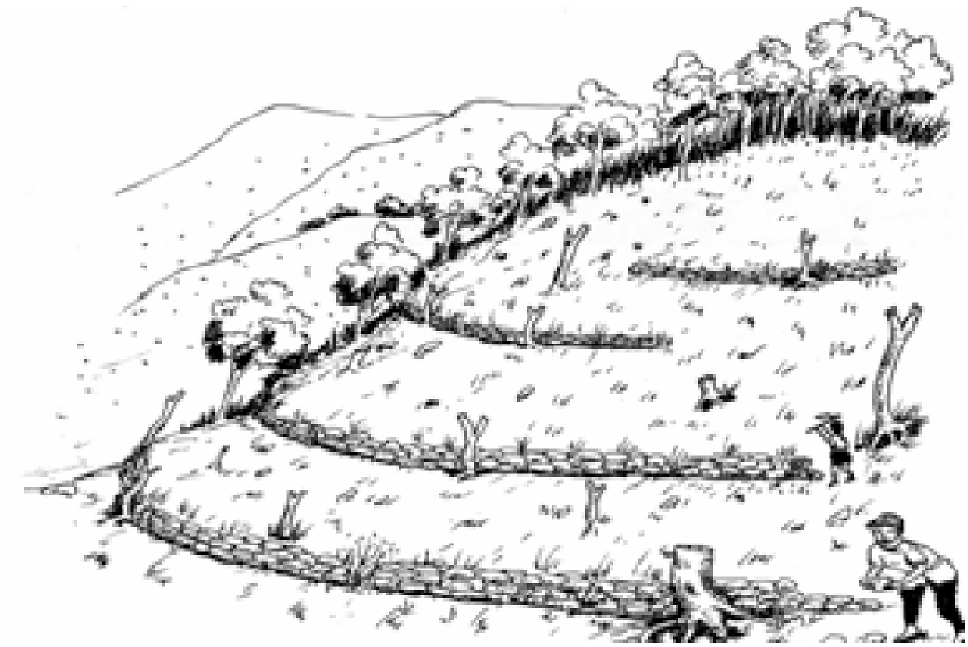
Source: https://www.indiawaterportal.org/articles/techniques-slow-runoff-and-erosion-steeply-sloping-land



Rooftop rainwater harvesting helps sustain drinking and cooking requirements throughout the year in Northeast India.

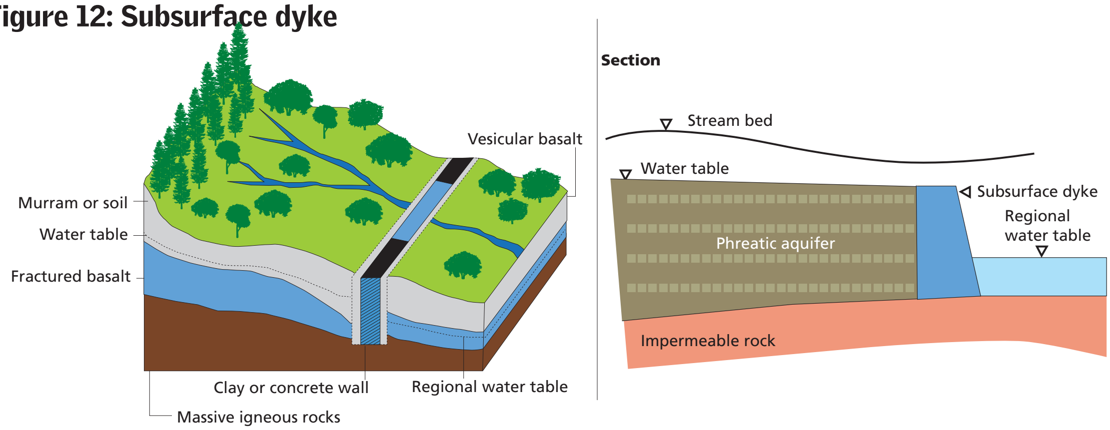
Source: CSE

Figure 11: Contour bunding



Source: Aryal, K.P. et al., 2014. How Can Research and Development Help Upland Farmers Improve their Farming Systems? Experiences in Participatory Technology Development. Sustainable Sloping Lands and Watershed Management Conference.

Figure 12: Subsurface dyke



Source: http://cgwbchd.nic.in/ar11.htm

Monitoring and evaluation

Inadequate participation of the community in planning, implementation and monitoring of the groundwater-based water supply in rural areas are the main impediments to sustainability of the source.

Safe drinking water sourced from groundwater should be free from bacteriological and chemical contamination. Bacteriological contamination may cause diarrhoea, dysentery, typhoid fever, cholera, jaundice, etc. Fluoride in drinking water many cause dental, skeletal and non-skeletal fluorosis. Arsenic contamination of drinking water causes dermatosis and excess nitrate may result in blue baby syndrome in newborn babies.

There is a need for water quality and surveillance programmes to monitor the quality and quantity of groundwater sources. A community-based management system is essential for this. The village council and the VWSC should be made responsible for implementing the programme to supply regular clean water for the village. There is a need to develop capacities of the members of VWSC, community leaders, primary teachers, health workers etc. for effective implementation of this programme.

The two main key steps for implementing such programmes are as follows:

1. Assessment of water quantity and quality
2. Preventive measures

1. Assessment of water quantity and quality

The first part of implementation is measuring the groundwater level. This needs to be done every month to record any rise or decline in the level of groundwater. Generally, water level measurements are carried out from dug wells or from purpose-built piezometres (observation bore wells or tube wells).

Groundwater levels should be monitored to:

a. Have an overview about the groundwater regime. Monitoring gives a good idea about water scarcity, water logging and changes in water level.
b. Understand natural recharge or withdrawal and seasonal fluctuations.
c. Demarcate the area falling under the stress of groundwater extraction
d. Map areas where groundwater augmentation is required/possible through artificial methods.[66]

Piezometers may be used to accurately measure groundwater levels. Their location should be decided in communication with the community and Village Water Sanitation Committee (VWSC). Members of the village council and VWSC should be trained to record the readings. In remote and/or rocky areas, however, where geographic or economic conditions make it difficult to implement piezometers, recording the level of the groundwater in open dug wells is economical. To make the system economical or for easy handling, sensor-based cables can also be immersed in borewells/tube wells to get a reading of groundwater level. It is essential to know about the type and condition of groundwater abstraction structures from which the water level will be recorded.

The following are important criteria to fix a well as an observation well (also referred to as recording station):

a. The well should be in use and have regular withdrawal; and
b. It must be representative for the general geomorphic set up prevailing in the area.

The database generated through regime monitoring forms the basis for planning the groundwater development and management programme. Not just the quantity but the quality of the groundwater must be analysed.

The groundwater samples, collected every fortnight, have to be checked for contamination. It is important to identify the source of contamination and likely solutions. Contamination sources should be surveyed on a regular basis (biweekly) wherever groundwater is the source of drinking water. The survey is expected to pinpoint possible reasons for contamination of sources. Once the reasons are known, solutions can be accordingly be devised and adopted.

The following points need to be considered and observed during the sanitary survey:

- Cleanliness around the source and in the catchment;
- Accumulated water around the source;
- Likely causes of pollution of percolation tanks and/or village tanks etc. on the upstream side;
- Presence of nearby toilets.

Field testing kits can be used at the local level. Trained technicians should test pH, alkalinity, hardness, chloride, total dissolved salts (TDS), fluoride, nitrate, nitrite, phosphate, turbidity and residual chlorine through field testing kits. The H_2S strip test should be performed to detect indication of bacteriological contamination. The village council and VWSC should see that they have trained technicians to perform such field tests. They should also ensure that they have collection bottles as per laboratory guidelines and proper filed testing kits. If the communities note any contamination, it has to be reported to the District Council.

2. Preventive measures

To prevent contamination of the groundwater sources, villages should be open-defecation free, and solid and liquid waste should be safely disposed of or reused. Industrial effluents should not seep into the soil and communities should be made aware of the ill effects of high doses of chemical fertilizers and pesticides.

The following preventive measures should be taken to protect groundwater from anthropogenic contamination[67]:

- Area around the groundwater abstraction should be kept clean;
- The catchment around the groundwater should be protected so that clean runoff can recharge the groundwater;
- Wastewater (black and grey water) should not seep into the soil or ground- water. Toilets should be installed with the appropriate technology to treat black and grey water from bathrooms and kitchens before further disposal;
- Washing clothes and utensils around the abstraction point should be banned;
- Toilets and soak pits should be at least 15–20 metres from the source of groundwater;
- Cattle farms should also not be allowed within a radius of 15 m of the groundwater source;
- Percolation tanks near the groundwater source or upstream of the source should be protected;
- Growth of bushes and algae should be prevented in the vicinity of the groundwater source; and
- The source should be fenced off so that the area in the vicinity of the groundwater can be well protected.

Data evaluation: This involves processing large amounts of data generated in the course of monitoring the groundwater quality and quantity. This information can be utilized for decision-making and for improving the O&M component of the surveillance programme. Reports based on evaluated data should be presented to the village council/ VWSC for further inputs that can be incorporated into the planning.

Information, education and communication

While preparing the information, education and communication (IEC) for awareness on conservation of groundwater sources in the village, a comprehensive evidence-based strategy has to be developed so that it can be easily adopted by policymakers and implementers of the strategy.

Communication strategies aim to change the behaviour of household owners, members of Village Water and Sanitation Committees (VWSCs) or village council.

They should seek to:[68]

- Create awareness on efficient use of groundwater;
- Promote safe disposal of black and grey water to stop contamination of soil and groundwater;
- Create awareness on maintenance of quality and quantity of groundwater;
- Create awareness for urgent need for mutual cooperation and adopting integrated planning and participatory approach in the management of groundwater;
- Create awareness among the people about the necessity of water conservation;
- Promote documenting and disseminating of knowledge of groundwater science and technology as well as issues concerning sustained development of the water resources;
- Create awareness about necessity of adopting measures for rainwater harvesting and artificial recharge of groundwater to meet present and future water needs; and
- Strengthen awareness infrastructure, especially campaign mechanism and support structure.

To reach these objectives, the following activities are suggested:

A. For village councils/VWSCs:

- Factsheets, FAQs, multimedia presentations;
- Meetings in local language;
- Workshops, conference and/or seminars to spread the knowledge on technologies, financial options; and
- Communications by celebrities and ministers to sensitize the population about the benefits of water conservation.

B. For households and communities

- Fairs and exhibitions;
- Talk shows on radio and television; jingles; including the subject of ground- water management in serials and radio shows; and
- Painting competitions for school children.

C. For media

- Meetings with journalists and editors to make them aware about groundwater management and conservation.
- Exposure to success stories and fellowships offered to cover stories on the subject.

A. ***For corporates***

- Meetings and special events to raise awareness on water conservation through rainwater harvesting and groundwater recharge, especially among corporates interested in funding safe sanitation.

B. ***Masons and plumbers***

- Factsheet, FAQs, multimedia presentations on water conservation through rainwater harvesting and groundwater recharge;
- Meetings in the local language; and
- Workshops on technologies.
- The output of such strategies will be as follows:
    - » Reduction in contamination of water and soil;
    - » Reduction in expenditure on health-related issues;
    - » Every household starts using 'sanitary toilets' following design specifications;
    - » Faulty toilets are retrofitted;
    - » Household owners voluntarily make soak pits for groundwater recharge;
    - » The communities start using water judiciously;
    - » Rooftop rainwater harvesting is seen in all the households;
    - » Communities stop washing clothes and utensils near groundwater abstraction structures;
    - » Farmers use water-efficient irrigation systems;
    - » Village council and/or Village Water and Sanitation Committee (VWSC) make construction of groundwater-recharge structures a priority in the annual implementation plan;
    - » VWSC/village council monitor the groundwater levels and quality at a regular basis;
    - » VWSC members are well trained to monitor and document groundwater level and quality;
    - » Village council/VWSC maintain not only the groundwater structures but also catchments;
    - » Well-trained masons and plumbers are available in the villages to construct technologically appropriate groundwater structures.

5. Conclusion and recommendations

Groundwater—supplied through borewells and shallow wells—constitutes over 90 per cent of the water supply for rural areas in Tanzania. The reserve is no doubt currently quite sufficient except in semi-arid and arid regions in the country.

Unplanned urbanization and variability of temporal and spatial rainfall will, however, soon impact the natural recharge of the groundwater. Additionally, Tanzania also faces the problem of contaminated groundwater due to poor management of faecal sludge and fertilizers in agriculture. There are also issues of natural contamination of chloride in coastal areas, fluoride contamination surrounding the Rift Valley region (central Tanzania) and iron contamination in the Mtwara (south eastern Tanzania) and Kagera (north western Tanzania) regions.

The country should thus plan for groundwater recharge policies and strategies to make groundwater reserves sustainable and safe. Bacteriological contamination can be removed by strategizing the management of faecal sludge.

The government of Tanzania has promoted rainwater harvesting through storage of rainwater. But the country needs to focus on groundwater recharge as natural recharge is declining mainly due to high rate of urbanization and change in rainfall pattern due to climate change. This impacts groundwater reserves. The country now needs to gear up to implement policies and strategies with regard to groundwater and catchment protection with a help of a mix of technological solutions and capacity-building and behaviour-change strategies planned carefully for different levels of stakeholders.

Task 1: Strengthen policies and strategies on water conservation: Although there are several policies and strategies on groundwater, we recommend the following to strengthen the policies and strategies:

1. Instead on supply-side management, the country should focus on demand-side management;
2. Protection of wetlands and waterbodies to recharge groundwater efficiently and protect the areas from flash floods should be strategized;
3. Policies on reuse of wastewater should be in place;
4. Policies on safe management of faecal sludge should be introduced to protect the groundwater from bacteriological contamination; and
5. Village council should be incentivized for water conservation.

Task 2: Create manual and menu on rainwater harvesting and groundwater recharge technologies: Tanzania has diverse hydrogeological conditions, varying from unconsolidated sediments to hard and consolidated basement rocks. We recommend the following:

1. Creation of database on technological interventions for groundwater recharge;
2. Promotion of small water-harvesting structures;
3. Reviving and renovating traditional water-harvesting structures; and
4. Surveillance of groundwater should be part of all the projects.

Task 3: Improve the institutional mechanism for the implementation of the policies on groundwater recharge: For the better implementation of the policies on groundwater recharge, we recommend the following:

1. Communities (especially women) should be the key decision makers for all the government plans on rural water supply, from planning to implementation;
2. Capacity-building and awareness programmes should be planned for users, artisans, NGOs, CSOs and government authorities involved in the water supply sector; and
3. A national body to support and coordinate the building and rejuvenation of traditional water-harvesting structures by local communities is needed.

The Centre for Science and Environment (CSE), New Delhi, India, will work closely with the Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDEC), Tanzania. CSE will help the Ministry to plan policy/strategies for augmenting groundwater reserve through rainwater harvesting.

References

1. Kashaigili, J.J. 2010. Assessment of groundwater availability and its current and potential use and impacts in Tanzania. International Water Management Institute.
2. Sushmita Sengupta, Swati Bhatia and Shivangi Agarwal, 2021, *Tanzania: The State of Sanitation*, Centre for Science and Environment, New Delhi.
3. Kashaigili, J.J. 2010. Assessment of groundwater availability and its current and potential use and impacts in Tanzania. International Water Management Institute.
4. Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC), Tanzania Mainland, Ministry of Health (MoH), Zanzibar, National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS) and ICF. 2016. 2015–16 TDHS-MIS Key Findings. Rockville, Maryland, USA: MoHCDGEC, MoH, NBS, OCGS, and ICF
5. World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2021. Progress on household drinking water, sanitation and hygiene 2000–2020: five years into the SDGs
6. Olarinoye, T. et al., 2020. Exploring the future impacts of urbanization and climate change on groundwater in Arusha, Tanzania. *Water International*. Vol. 45, no. 5, 497–511
7. Eliamringi, L. and Kazumba, S. 2017. Sustainability of rural water supply services in Tanzania. *Water Science and Technology: Water Supply*.
8. Elisante, E and Muzuka, A. N.N. 2017. Occurrence of nitrate in Tanzanian groundwater aquifers: A review. Appl Water Sci, 7:71–87, https://link.springer.com/article/10.1007/s13201-015-0269-z. (viewed on July 31, 2021).
9. Kamukala, G.L. and Crafter , S.A. (Editors), 1993, "Wetlands of Tanzania", Proceedings of a Seminar on the wetlands of Tanzania, Morogoro, Tanzania, 27–29 November, 1991,vi+170pp, https://portals.iucn.org/library/sites/library/files/documents/WTL-008.pdf (viewed July 31, 2021).
10. United Republic of Tanzania, Ministry of Water, 2020, "Water Sector Status Report: 2015-20", https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf (viewed on July 31, 2021).
11. Bakobi, B.L.M, n.d., "Conservation of Wetlands of Tanzania", https://legacy.oceandocs.org/bitstream/handle/1834/522/Wetlands1526.pdf?sequence=1 (viewed on July 31, 2021).
12. https://upgro.org/country-profiles/tanzania/ (viewed on July 31, 2021).
13. United Republic of Tanzania, Ministry of Water, 2020, "Water Sector Status Report: 2015-20", https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf (viewed on July 31, 2021).
14. Ibid.
15. 2030-Water Resource Group, 2016, "Water for Growth, People and Environment 2030 WRG Tanzania Partnership", https://www.2030wrg.org/wp-content/uploads/2015/10/2030-WRG-Tanzania-Factsheet-May-2016.pdf (viewed on July 31, 2021).
16. Borhara, K. Pokharel, B. Bean, B. Deng, L. Wang, S.S., 2020, "On Tanzania's Precipitation Climatology, Variability, and Future Projection", 8(2), 34, DOI: 10.3390/cli8020034, https://www.mdpi.com/2225-1154/8/2/34/htm (viewed on July 31, 2021).
17. Ngondo, J. Mango, J. Liu, R. Nobert, J. Dubi, A. Cheng, H., 2021, "Land-Use and Land-Cover (LULC) Change Detection and the Implications for Coastal Water Resource Management in the Wami–Ruvu Basin, Tanzania", 13(8), 4092, DOI: 10.3390/su13084092, https://www.mdpi.com/2071-1050/13/8/4092 (viewed on July 31, 2021).
18. Said, M. Hyandye, C. Mjemah, I.C. Komakech, H.C. Munishi, L.K., 2021, "Evaluation and

Prediction of the Impacts of Land Cover Changes on Hydrological Processes in Data Constrained Southern Slopes of Kilimanjaro, Tanzania" 2(2), 225-247, DOI: 10.3390/earth2020014, https://www.mdpi.com/2673-4834/2/2/14/htm (viewed on July 31, 2021).
19. Mussa, K.R, Mjemah, I.C. Walraevens, K., 2019, "Quantification of Groundwater Exploitation and Assessment of Water Quality Risk Perception in the Dar es Salaam Quaternary Aquifer, Tanzania", 11(12), 2552, DOI: 10.3390/w11122552, https://www.mdpi.com/2073-4441/11/12/2552/htm (viewed on July 31, 2021).
20. https://upgro.org/country-profiles/tanzania/ (viewed on July 31, 2021).
21. Kwezi, L., 2021, "A review of the Tanzanian water sector budget for 2021/22.", IRC Blog, https://www.ircwash.org/blog/water-sector-budget-how-much-enough (viewed on July 31, 2021).
22. Kwezi, L., 2017, "Rural water supply access in Tanzania: why has it stagnated?", IRC Blog, https://www.ircwash.org/blog/rural-water-supply-access-tanzania-why-has-it-stagnated (viewed on July 31, 2021).
23. Policy Forum, n.d, " Water Summary Budget Analysis-TGNP Brief", https://www.policyforum-tz.org/sites/default/files/Policy%20Forum%20-%20Water%20Summary%20Budget%20Analysis-TGNP%20BRIEF.pdf (viewed on July 31, 2021).
24. Ibid.
25. Kwezi, L., 2021, "A review of the Tanzanian water sector budget for 2021/22.", IRC Blog, https://www.ircwash.org/blog/water-sector-budget-how-much-enough (viewed on July 31, 2021).
26. Unicef-Tanzania, n.d., "Water and Sanitation Budget Brief –F.Y 2011/12-2015/16", ISBN 978-9987-829-07-1, https://mof.go.tz/mofdocs/budget/reports/UNICEF-TZ-BB-WASH-WEB-final.pdf (viewed on July 31, 2021).
27. Water Aid, 2021, "Mission-critical: Invest in water, sanitation and hygiene for a healthy and green economic recovery", https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/mission-critical-invest-in-water-sanitation-and-hygiene-for-a-healthy-and-green-economic-recovery_0.pdf (viewed on July 31, 2021).
28. Shushu, U.P. Komakech, H.C. Dodoo-Arhin, D, Kansal, M.L., 2021, "Managing non-revenue water in Mwanza, Tanzania: A fast-growing sub-Saharan African city", *Scientific African* 12 (2021) e00380, DOI: 10.1016/j.sciaf.2021.e00830, https://www.sciencedirect.com/science/article/pii/S2468227621001344 (viewed on July 31, 2021).
29. Eliamringi, L. Kazumba, S., 2017, "Assessment-of-sustainability-of-rural-water-supply", *Water Supply* (2017) 17 (2): 372–380, DOI: 10.2166/ws.2016.141, https://iwaponline.com/ws/article/17/2/372/28151/Assessment-of-sustainability-of-rural-water-supply (viewed on July 31, 2021).
30. Farré, L., 2017, "Assessing Community Management of Water Sources in Rural Tanzania", Master's Thesis Academic Year- 2017, University of Basel, Basel, Switzerland, https://www.rural-water-supply.net/en/resources/details/815 (viewed on July 31, 2021).
31. United Republic of Tanzania, Ministry of Water, 2020, "Water Sector Status Report: 2015-20", https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf (viewed on July 31, 2021).
32. Kahimba, J. and Niboye, E.P., 2021, "From raising alarms to sound practices: the impacts of water sector reforms on communities in Tanzania", African Geographical Review, DOI: 10.1080/19376812.2021.1892497, https://www.tandfonline.com/doi/abs/10.1080/19376812.2021.1892497 (viewed on July 31, 2021).
33. Lameck, E., Sesabo, J. and Mkuna, E., 2021, "Household behaviour towards water conservation activities in Mvomero District in Tanzania: a convergent parallel mixed approach", Sustainable Water Resources Management- 7, 45, DOI:10.1007/s40899-021-00514-y, https://link.springer.com/article/10.1007/s40899-021-00514-y (viewed on July 31, 2021).
34. Samwel J. Kabote, and Pius John, "Water Governance in Tanzania: Performance of Governance

Structures and Institutions." *World Journal of Social Sciences and Humanities*, vol. 3, no. 1 (2017): 15-25. DOI: 10.12691/wjssh-3-1-3. https://www.researchgate.net/publication/319401725_Water_Governance_in_Tanzania_Performance_of_Governance_Structures_and_Institutions, (viewed on July 31, 2021).

35. Ibid.
36. Ibid.
37. Ibid.
38. Sokile, C.S. Mwaruvanda, W. Koppen, B.V., 2005, "Integrated Water Resource Management in Tanzania: interface between formal and informal institutions", International workshop on "African Water Laws: Plural Legislative Frameworks for Rural Water Management in Africa", 26-28 January 2005, Johannesburg, South Africa, https://publications.iwmi.org/pdf/H038764.pdf (viewed on July 31, 2021).
39. World Bank. 2018. Reaching for the SDGs: The Untapped Potential of Tanzania's Water Supply, Sanitation, and Hygiene Sector. WASH Poverty Diagnostic. World Bank, Washington, DC, http://documents1.worldbank.org/ curated/en/167791521012037920/pdf/124255-PUBLIC-P159820-the-untapped-potential-of-Tanzania-s-water-supply-sanitation-and-hygiene-sector.pdf (viewed on May 23, 2021).
40. United Republic of Tanzania, Ministry of Water, 2020, "Water Sector Status Report: 2015-20", https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf (viewed on July 31, 2021).
41. Silvia Francis Materu, Brigitte Urban and Susanne Heise (2018) A critical review of policies and legislation protecting Tanzanian wetlands, Ecosystem Health and Sustainability, 4:12, 310-320, DOI: 10.1080/20964129.2018.1549510, https://www.tandfonline.com/doi/full/10.1080/20964129.2018.1549510 (viewed on July 31, 2021).
42. Ibid.
43. Ibid.
44. Samwel J. Kabote, and Pius John, "Water Governance in Tanzania: Performance of Governance Structures and Institutions." *World Journal of Social Sciences and Humanities*, vol. 3, no. 1 (2017): 15-25. DOI: 10.12691/wjssh-3-1-3. https://www.researchgate.net/publication/319401725_Water_Governance_in_Tanzania_Performance_of_Governance_Structures_and_Institutions (viewed on July 31, 2021).
45. World Bank, 2017, "Tanzania Economic Water Update, Managing water wisely-the urgent need to Improve Water resources management in Tanzania", https://documents1.worldbank.org/curated/en/673961509974154698/pdf/120954-NWP-PUBLIC-p156957-p164469-86p-WorldBankNovFR.pdf (viewed on July 31, 2021).
46. 2030 Water Resources Group, 2014, "Executive Summary: Hydro-Economic Overview— An Initial Analysis in Tanzania", https://www.2030wrg.org/wp-content/uploads/2014/08/Tanzania-ExecSum-08-19.pdf
47. World Bank, 2017, "Tanzania Economic Water Update, Managing Water Wisely—the Urgent Need to Improve Water Resources Management in Tanzania", https://documents1.worldbank.org/curated/en/673961509974154698/pdf/120954-NWP-PUBLIC-p156957-p164469-86p-WorldBankNovFR.pdf (viewed on July 31, 2021).
48. 2030 Water Resources Group, 2014, "Executive Summary: Hydro-Economic Overview— An Initial Analysis in Tanzania", https://www.2030wrg.org/wp-content/uploads/2014/08/Tanzania-ExecSum-08-19.pdf (viewed on July 31, 2021).
49. Mussa, K.R. Mjemah, I.C. Walraevens, K. "Quantification of groundwater exploitation and assessment of water quality risk perception in the Dar Es Salaam quaternary aquifer, Tanzania", Water 2019, 11(12), 2552, DOI: 10.3390/w11122552, https://www.mdpi.com/2073-4441/11/12/2552/htm (viewed on July 31, 2021).
50. Pantaleo, P.A. Komakech, H.C., Mtei, K.M. Njau, K.N., 2018, "Contamination of groundwater

sources in emerging African towns: The case of Babati town, Tanzania", *Water Practice & Technology*, Vol. 13 No. 4 980 DOI: 10.2166/wpt.2018.104, https://iwaponline.com/wpt/article/13/4/980/65124/Contamination-of-groundwater-sources-in-emerging (viewed on July 31, 2021).

51. Elisante, E., Muzuka, A.N.N., 2016, "Sources and seasonal variation of coliform bacteria abundance in groundwater around the slopes of Mount Meru, Arusha, Tanzania", Environmental Monitoring and Assessment 188, 395 (2016). DOI: 10.1007/s10661-016-5384-2 https://link.springer.com/article/10.1007/s10661-016-5384-2 (viewed on July 31, 2021).
52. Makoba, E., Muzuka, A.N.N., 2019, "Water quality and hydrogeochemical characteristics of groundwater around Mt. Meru, Northern Tanzania", Applied Water Science 9, Article No. 120, DOI:10.1007/s13201-019-0955-3, https://link.springer.com/article/10.1007/s13201-019-0955-3 (viewed on July 31, 2021).
53. Malago, J. Makoba, E. Muzuka, A.N.N, 2017, "Fluoride Levels in Surface and Groundwater in Africa: A Review", American Journal of Water Science and Engineering. Vol. 3, No. 1, 2017, pp. 1-17. DOI: 10.11648/j.ajwse.20170301.11, http://fluoridealert.org/wp-content/uploads/malago-2017.pdf (viewed on July 31, 2021).
54. Ibid.
55. Nkotagu, H., 1996, "Origins of high nitrate in groundwater in Tanzania", Journal of African Earth Sciences, Volume 22, Issue 4, Pages 471-478, ISSN 1464-343X, DOI: 10.1016/0899-5362(96)00021-8, https://www.sciencedirect.com/science/article/abs/pii/0899536296000218 (viewed on July 31, 2021).
56. Elisante, E. and Muzuka, A. N.N. 2017. Occurrence of nitrate in Tanzanian groundwater aquifers: A review. Appl Water Sci, 7:71–87, https://link.springer.com/article/10.1007/s13201-015-0269-z (viewed on July 31, 2021).
57. Kihampa,C., 2013, "Environmental exposure and public health concerns of municipal solid waste disposal in Dar es Salaam, Tanzania", *Journal of Sustainable Development in Africa*, Volume 15, No. 3, ISSN: 1520-5509, https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1078.1763&rep=rep1&type=pdf (viewed on July 31, 2021).
58. Chacha, N. Njau, K.N. Lugomela, G.V. Muzuka A.N.N., 2018, "Hydrogeochemical characteristics and spatial distribution of groundwater quality in Arusha well fields, Northern Tanzania", *Applied Water Science* 8, Article Number 118, DOI: 10.1007/s13201-018-0760-4, https://link.springer.com/article/10.1007/s13201-018-0760-4 (viewed on July 31, 2021).
59. Ibid.
60. Olarinoye, T. Foppen, J.W. Veerbeek, W. Morienyane, T. Komakech, H., 202, "Exploring the future impacts of urbanization and climate change on groundwater in Arusha, Tanzania", *Water International*, Vol. 45, No. 5, 497–511, DOI: 10.1080/02508060.2020.1768724, https://www.tandfonline.com/doi/epub/10.1080/02508060.2020.1768724?needAccess=true (viewed on July 31, 2021).
61. Shorter, J.P. Massawe, J. Parry, N. Walker, R.W., 2010, "Comparison of two village primary schools in northern Tanzania affected by fluorosis", *International Health*, Vol. 2, Issue 4, 269–274, DOI: 10.1016/j.inhe.2010.09.010 https://academic.oup.com/inthealth/article/2/4/269/687654?login=true (viewed on July 31, 2021).
62. Miraji, H., 2018, "Brination of Coastal Aquifers: Prospective Impacts and Future fit-for-use Remedial Strategies in Tanzania", WWJMRD 4 (1), 202-206, https://www.researchgate.net/publication/323218856_Brination_of_Coastal_Aquifers_Prospective_Impacts_and_Future_fit-for-use_Remedial_Strategies_in_Tanzania (viewed on July 31, 2021).
63. Komakech, H.C. and Bont, C.D, 2018, "Differentiated access: Challenges of equitable and sustainable groundwater exploitation in Tanzania", *Water Alternatives* 11(3): 623-637 https://www.water-alternatives.org/index.php/alldoc/articles/vol11/v11issue3/457-a11-3-10/file (viewed on July 31, 2021).

64. Department of Drinking Water and Sanitation, Ministry of Jal Shakti. 2019. Resource Material for Field Trainers, "Sujal and Swachh Gaon" (viewed on July 31, 2021).
65. Agarwal, A., Narain, S. 1997. *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems* (State of India's Environment), Centre for Science and Environment
66. http://cgwb.gov.in/RGI/Tier%20III%20Trainig%20module%20English. pdf (viewed on July 31, 2021).
67. Ibid.
68. http://jalshakti-dowr.gov.in/sites/default/files/IEC-Eng_0.pdf (viewed on July 30, 2021).

More than 70 per cent of Tanzania's population lives in rural areas, which depend largely on groundwater for drinking. The country, however, lacks safely managed potable water. The best available drinking water—i.e. uncontaminated and available at the nearest point—is from the basic water services.

The groundwater fed by rainwater is currently adequate for the country's needs but temporal and annual variations of rainfall and unplanned urbanization have reduced natural recharge of the groundwater. Additionally, groundwater also faces contamination due to natural and anthropogenic reasons.

Tanzania has been promoting rainwater harvesting through storage of rainwater in tanks. But it also needs to focus on community-centric technical options for groundwater recharge. Almost 25 per cent of the country has high groundwater recharge potential, which can be used effectively to augment groundwater resources. It is crucial that policies and strategies on water conservation, including groundwater augmentation, are strengthened.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phones: 91-11-40616000 Fax: 91-11-29955879
Website: www.cseindia.org