# TANZANIA:
# Groundwater Resource Assessment for the City of Dodoma

**Project Goal:**

To support management plans for the Dodoma water supply by assessing the sources of nitrate pollution, water budget, and the potential for artificial recharge of the Makutupora Basin using isotope techniques.

**Background:**

The city of Dodoma, the official capital of Tanzania, is in a drought prone, semi-arid region of central Tanzania. The only source of potable water for the 300,000 inhabitants of the city is groundwater from the Makutupora Basin, located 27 kilometers north of the town. Previous studies, using isotope and conventional techniques, have estimated a safe yield of 40,000 $m^3$/day, enough for the projected growth of the city over the next 20 years. Projects financed by the World Bank and the Chinese Government are currently underway to install the new production wells, pumps, pipelines, and tanks needed to boost capacity from the current 24,000 $m^3$/day to 40,000 $m^3$/day. Maintaining water quality is now a top priority, and the Ministry of Water is working to develop and implement groundwater protection plans for the basin.

The project is being conducted jointly by the Water Resources Department and the Central Water Quality Laboratory in the Ministry of Water. Major activities are carried out by the hydrogeology services section and the Central Water Quality Laboratory. The IAEA is providing analytical services for stable isotopes, expert services to guide project planning and implementation, and laboratory equipment to improve local analytical capacities.

**Project Summary:**

Previous hydrogeological and geophysical investigations have gathered much of the basic information needed to develop the Makutupora Basin water. Major recharge areas have been defined in the Chenene Hills and the uplands bordering the fault basin (Figure 1). Groundwater flows from these areas along the Mlemu and Kitope faults and associated fractures in the weathered granitic bedrock. At the well field, the aquifer is confined and isolated from surface water by up to 50 meters of clay and marl. Ongoing monitoring of water levels and basic water quality parameters performed by the water supply authority helps manage day-to-day operations.

To complement these available sources of information, the current project is examining issues affecting the long-term viability of the water supply, including water quality and the potential to increase the yield of the aquifer via artificial recharge. Isotopes analyses, including deuterium, $^{14}C$, $^{15}N$, $^{18}O$, and tritium offer the potential for determining the sources and migration paths of pollutants at a modest cost and with a relatively small number of samples. Combining isotope and conventional data, local authorities will be better able to devise a proper basin-wide program of waste management, groundwater protection, and sustainable use of the available water.

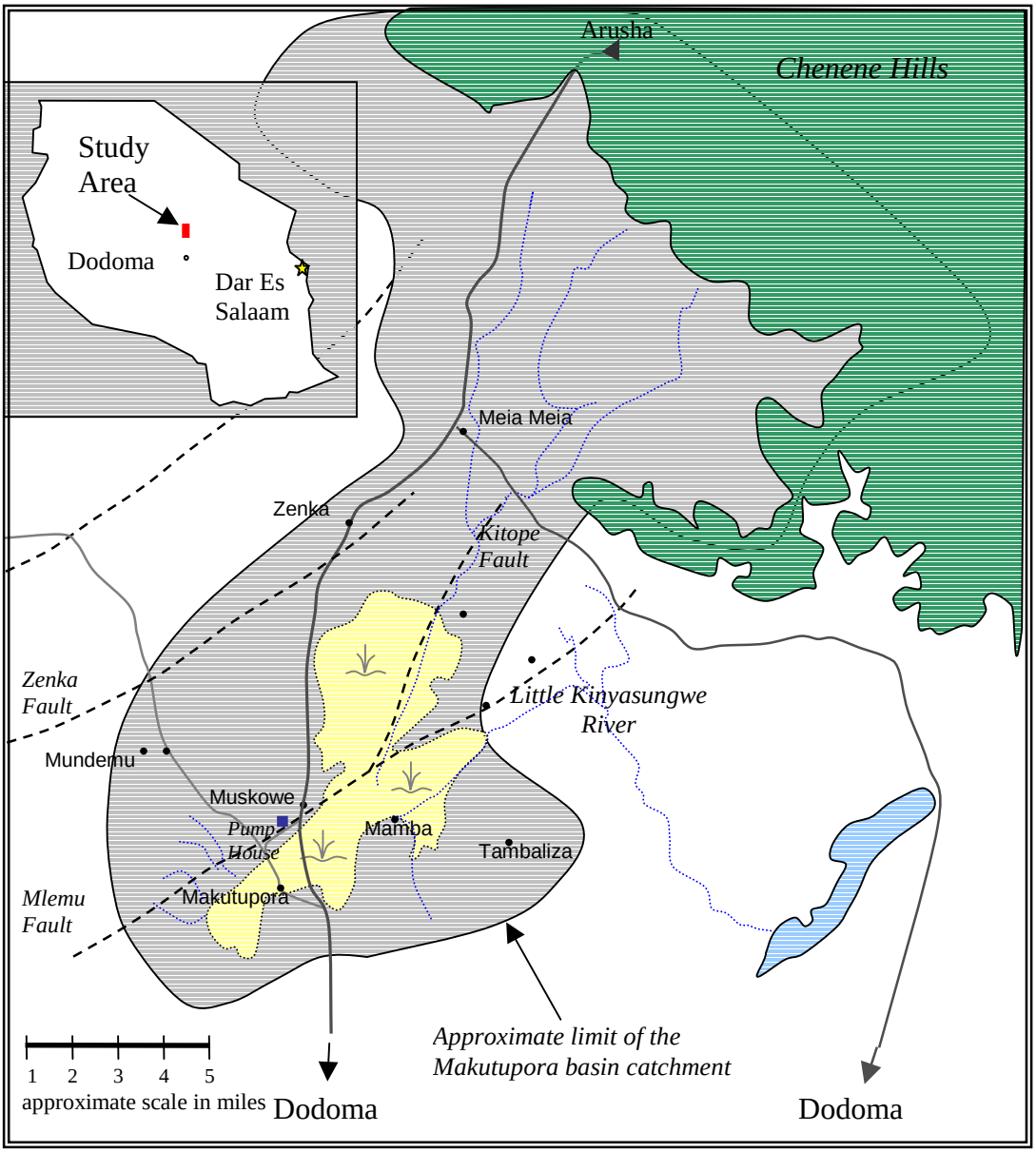
Nitrate pollution represents an immediate threat to water quality. Over the past 20 years, the population and agricultural activity in the catchment area has grown, increasing the potential human and animal waste loading to the aquifer. In the early 1990's, nitrate concentrations increased from background levels below 10 mg/L to as much as 135 mg/L in some boreholes, above the Tanzania Temporary Standard of 100 mg/L and much higher than accepted levels in the US and other developed nations. Well-head protection measures put in place at that time have helped reduce nitrate levels, but more data on the source(s) and pathways for nitrate pollution are needed to develop long-term management strategies.

**Preliminary Results:**

$^{15}N$ analysis of nitrate in the groundwater suggests a mixture of sources, most likely including human and animal wastes as well as fertilizers. Isotope data also suggest that the mean residence time of groundwater

in the basin is on the order of hundreds of years. This response time is very different from the time scale for changes in nitrate concentrations, suggesting that the source of the nitrate is decoupled from the source of most recharge. One pathway for the nitrate to enter the aquifer is along seasonal stream courses that cross the fault zone within a few hundred meters of several production wells. Rising water levels have been observed in these wells within a few days of rains that produce substantial stream flow, indicating a strong hydraulic connection. While nitrate concentrations in the stream water have not been regularly monitored, one sample from 1990 had over 100 mg/L nitrate. The details of the local hydrogeology and nitrate transport mechanisms need further clarification to confirm any connection between the streams and nitrate pollution, however. The total mass of nitrate produced in 1993 comes to approximately 3 tons of nitrate per day, which is much greater than local sources can have produced under normal circumstances.

Defining the hydrogeological and geochemical conditions that triggered the 1993 nitrate release to the well field is important in managing future groundwater production and implementing artificial recharge plans. The most promising recharge sites are where the stream courses draining into the basin cross the fault system. Small check dams along these streams could increase the recharge into the confined aquifer by capturing more of the storm water runoff during the rainy season. But if this runoff is polluted, increased recharge will only further contaminate the aquifer. Alternatively, if the 1993 nitrate release was triggered by the high pumping rates that year and the associated drawdown of the aquifer, then increased recharge may be important to help maintain water levels and prevent contaminated water in other parts of the aquifer from being pulled into the production wells.




**Makutupora Basin Location Map**