Drawers of Water II

30 years of change in domestic water use & environmental health in east africa

Tanzania country study

by **Mark R Mujwahuzi**

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Glossary

DANIDA	Danish Agency for International Development
DAWASA	Dar es Salaam Water and Sewerage Authority
DFID	Department for International Development
DGIS	Ministry of Foreign Affairs, The Netherlands
DOW	*Drawers of Water*
DOW I	Original *Drawers of Water* study by White, Bradley & White
DOW II	Repeat *Drawers of Water* study
EKWSP	East Kilimanjaro Water Supply Project
FA	Field Assistant
FGD	Focus Group Discussion
GDP	Gross Domestic Product
H	High-density population / site
IDA	International Development Agency
IIED	International Institute for Environment and Development
IMF	International Monetary Fund
ITCZ	Intertropical Convergence Zone
L	Low-density population / site
M	Medium-density population / site
MoW	Ministry of Water
N / A	Not applicable
NGO	Non Governmental Organisation
PLA	Participatory Learning and Action
PRA	Participatory Rural Appraisal
Sida	Swedish International Development Cooperation Agency
SRO	Senior Research Officer
TSH	Tanzania Shillings
UN	United Nations
UNICEF	United Nations Children Education Fund
USA	United States of America
VWC	Village Water Committee
VEO	Village Executive Officer
WHO	World Health Organisation
WSS	Water Supply and Sanitation
WUA	Water Users' Association
WUG	Water Users' Group

Preface

Back in the 1960s there seemed few facts available about water supply in Africa and almost none from the users' standpoint. There were no set ways to investigate the questions, nor was it clear what the key questions were. A geographer and a sociologist, keen to investigate household decision making over water, were introduced to a medical researcher with a Land Rover and this led to a detailed survey of twenty or so households in each of 34 communities to get a first cut at answers to an array of questions about domestic water use in the three countries of East Africa: Kenya, Tanzania and Uganda.

The findings of this research eventually were published in several journal articles and in the book *Drawers of Water: Domestic Water Use in East Africa*. Some of the results were unexpected, but their main value was to open up an area for future research and policy formulation. Subsequent work has been more focused and detailed in addressing specific questions but the broad picture has not been lost. Domestic water, even in rural areas, became for over a decade an increased focus of attention, and governments claimed to be making many improvements.

Against this background, Professor Mark Mujwahuzi of the Institute of Resource Assessment at the University of Dar es Salaam, along with his colleagues Dr John Thompson of the International Institute for Environment and Development, London, Dr James Tumwine of Makerere Medical School, Uganda, and Dr Munguti Katui-Katua of Community Management and Training Services, Kenya, sought to carry out a follow-up study nearly three decades later. It required much perseverance as funding agencies were initially not keen, but eventually with a dedicated group of young and able field assistants,

a 30-year follow-up was achieved, replicating the methodology and sites of the original work.

The results are beginning to appear, and it is possible to see the diversity of changes that have occurred. Some are sobering – improvements have not occurred in some areas – and others were unanticipated. That a simple change in technology, from the '*debe*' to the plastic can, has affected the gender distribution of water-carrying by enabling men to carry water on a bicycle and thereby avoid the ridicule that would have been the consequence of a *debe* as head-load, was unexpected.

The rarity of long-term longitudinal studies is well known, and this unique thirty-year follow up of the same sites will contribute a wealth of new knowledge to water supply and use for developing countries. Moreover it provides a tool for further research on the process of change. It is possible now to select communities where the changes are dramatic and to focus the search for explanations of process on these. The question 'why?' rather than simply 'how much?' is now being addressed, and *Drawers of Water II* will surely stimulate both interest in domestic water use and a much richer level of understanding and explanation of what we originally referred to as one of mankind's most basic transactions with nature.

Gilbert F White and David J Bradley
Boulder and London 2002

Acknowledgements

This report is the result of the scientific efforts, energies, time and material resources and commitment made by individuals, institutions and Tanzania Research team. Heartfelt thanks go to my Field Assistants who devoted their efforts and time, working hard to make this study a success. These include Cosmas Bahali, Desiderius Marco, John Kimaro, Frederick Mwakitwange, Stephen Kajula, and Sikitiko Kapire

Thanks also go to the Government of Tanzania, the Commission for Science and Technology, and the Institute of Resource Assessment of the University of Dar es Salaam, for having facilitated the undertaking of this study in Tanzania. This study also benefited from consultations with the District Executive Directors, Ward and Village Executive Officers of Kipanga, Dodoma, Moshi, Rombo and Dar es Salaam. Their contribution is appreciated greatly.

The local residents of the study sites cannot be forgotten for their support in the course of research both during survey and participatory appraisal research period. Although they are too numerous to be mentioned by name, their willingness to share their time and knowledge in interviews, field measurements and focus group discussions was appreciated greatly. Their contributions helped the research team to have a clearer picture of changes in domestic water use and environmental health that have taken place during the past three decades.

A special note of thanks goes to Professors Gilbert F White and David J Bradley, who, along with Anne U White, produced the pioneering research upon which this new study has been constructed. We are most grateful for your encouragement and support throughout this process.

Thanks also go to all the donors who generously supported the undertaking of the study. These include the Department for International Development (DFID), UK, The Ministry of Foreign Affairs (DGIS), The Netherlands, the Swedish International Development Cooperation Agency (Sida), and The Rockefeller Foundation's Regional Office for East and Southern Africa.

I am most grateful to Kathryn Jones, formerly of the London School of Hygiene and Tropical Medicine, for assistance with the initial research design and methodological preparations. Thanks must also go to Ms Ina T Porras, Dr Nick Johnstone and Ms Libby Wood at IIED, who reviewed the early drafts of this report, assisted with the statistical analysis and made constructive comments.

Special thanks are reserved for the Senior Research Officers of the Uganda and Kenya studies, namely, Professor James K Tumwine from Makerere University and Dr Katui Katua Munguti from Community Management and Training Services, whose collaborative work and advise was central to the success of the study. Last, but not least, thanks should go to Dr John Thompson from the International Institute for Environment and Development (IIED), UK, who was the architect, driver, facilitator, and efficient advisor and coordinator of the study. Without him the study would not have been carried out.

Mark R Mujwahuzi
Dar es Salaam 2002

Executive Summary

This study presents a cross-sectional historical analysis of changes in water use in Tanzania, replicating and revisiting the pioneering study *Drawers of Water* (DOW I) that was undertaken three decades ago[1]. This new study, referred to here as *Drawers of Water II* or 'DOW II' assessed three decades of change in household water use across a range of urban and rural settlements, taking into account the numerous shifts in national policies, strategies and guidelines related to water resources development and management since the first study was made in the late 1960s.

Drawers of Water made several significant contributions to our understanding of water-health relationships, which continue to be central themes in the scientific and policy literature. The first is the empirical investigation of the impacts of water use and water quality on hygiene and health.[2] The second is the analysis of the choice and use of domestic water supplies, including assessment of the range of available water sources, perceptions of water quality and needs for improved water sources.[3] Those themes are pursued in this new study.

A third contribution of the original study was the analysis of national and community investment in domestic water supplies and an assessment of benefits and costs. The DOW II research also reviewed changes in national priorities and investment, but focused on new trends, such as the reduction of state involvement in service provision, changes in donor disbursements to the sector, and the increasing role of the private sector – both large companies and independent vendors – in water delivery and management.

An important issue to have emerged over the last 30 years is community management of water supply and sanitation systems and

services. This includes operation and maintenance, which is now recognised as a critical but frequently neglected aspect of water development and environmental health[4]. The DOW II research agenda included an assessment of the collective action of local groups in several sample sites and their effectiveness in developing, operating and maintaining domestic water and sanitation systems.[5] This analysis involved intra- as well as inter-community comparisons, since the range and diversity of service levels and systems, and thus the ability for local groups to operate and maintain them, varies considerably within, as well as between rural and urban communities.[6]

Linked to this local-level analysis is an examination of higher-level institutional arrangements and relations related to the provision of water and health services. Over the past three decades, decentralised planning and power-sharing between national and local government authorities has had a profound effect on the nature, capacity and performance of public agencies involved in domestic water supply and environmental health.[7] Furthermore, the number, size and influence of non-governmental organizations (NGOs) and community-based organizations (CBOs) in the water and health sectors over the past two decades has been equally dramatic and warrants special consideration, especially with regard to their roles in the development and implementation of more participatory approaches to water supply and sanitation.[8]

Guided by these issues, the DOW II project, which began in 1997, examined various social, institutional, environmental, technical and health dimensions of domestic water use and environmental health in a cross-section of rural and urban sites in Tanzania, and similar numbers and types of sites in the other two East African countries. The project had two main phases of field research: Phase I – detailed household survey research (1997-98) and Phase II – participatory appraisal and historical analysis (1998-99). Since then, great effort has gone into computerising, cleaning and analysing the new DOW II dataset for all of East Africa and comparing the results against the original DOW I dataset.

The survey research was undertaken in 10 sites encompassing a wide range of settlement types (rural-urban; low-density-high density), ecosystems (arid/humid tropics) and service levels (piped-unpiped). These were Oysterbay, Upanga, Chang'ombe, and Temeke in the Dar es Salaam area, Dodoma (two sites), Kipanga, Moshi (two sites) and Mkuu.

The participatory research was undertaken in four of the sites that offered lessons into the factors leading to significant positive and negative changes in key aspects of water use and environmental health:

- Temeke, which has a great diversity of water selling activity (independent vendors, water bowsers, individual pumps, even mosques sell water) with equally wide range of prices (from Tsh 10 to Tsh 400 per 20 litres jerry can)
- Dodoma Urban, where chronic water shortages are forcing people to use a range of both piped and unpiped sources. Municipal Water Department supplies 4 mil gal/day, but demand is estimated at 6 mil gal/day.
- Kipanga, where the *Ujamaa* (Villagisation) policy of the early post-independence era established a new water system built by government, but people continue to use traditional sources. Moreover, many people lack adequate sanitation, such as latrines, while others use ones that are in a very bad state.
- Mkuu, where the East Kilimanjaro Water Supply Project is supplying water from Mount Kilimanjaro, but questions remain about whether this has led to increased water use and many people are still getting used to the idea of paying relatively high prices for intermittent service delivery.

Categories of Sites

The DOW I study categorised both sample households and study sites as being either 'piped' and 'unpiped'. By definition, 'piped' households have water supplied by pipe to their homes or compounds, while 'unpiped' households must obtain water from sources outside the home or compound. DOW II used the same categorisation, but found that only Kipanga maintained its category as 'unpiped' (i.e., where all sample households were unpiped) and Oysterbay and Upanga in Dar es Salaam as 'piped'. The remaining

seven sites were found to include a mix of both piped and unpiped households with differing service levels and water use patterns.

Mean per Capita Water Use

The new study attempted to compare water use in these study sites over three decades. The results show that in the piped sites the mean per capita water use has declined from 141.8 litres in DOW I to 80.2 litres in DOW II. The study has advanced factors to explain this situation, including the lack of investment in and aging of the water supply infrastructure, and increases in population, particularly in urban areas, which is attributed partly to migration from rural to urban centres. At the same time, in the unpiped sites the mean per capita water use has increased from 13.5 litres in the late 1960s to 18.6 litres in the late 1990s. While still a relatively low figure, this is a significant improvement of 27 percent over DOW I, which can bring real benefits to hygiene and health. The factors driving these changes include the reduction in distance to unpiped sources (thus reducing travelling time to and from the source), greater investment in rural water supplies, and, in some cases, local people's involvement in operation and maintenance.

Cost of Water

The study also examined what people pay for water in different sites and tried to find out whether the price of water affects the amount of water used. The cost of water was examined, either in terms of direct cash paid, or in cash equivalent in terms of energy expended in travelling to and from the source, queuing for water and carrying it home. The price equivalent was arrived at by calculating the amount of money required to purchase the amount of food required to generate the energy used in collecting water.

For all piped sites, the mean cost of water was approximately US$1.00 per cubic metre.[9] However, there was a considerable variation in price between sites, with households in piped rural sites paying far less compared to households in piped urban sites. In constant terms the cost of water for piped households has not changed significantly over the last 30 years (showing in fact a slight decrease).

It was also observed that average cost of water varied, sometimes significantly, within sites.

Determinants of Water Use

In their original *Drawers of Water* study, White, Bradley and White investigated the factors determining water use in households. In their study, they found that the variables determined water use were the number of people and cost of water, and level of material wealth. In DOW II, water use in piped households is influenced by some of the same factors and several new ones. The number of people in the household remained the most important factor affecting water use, the proportion of children becomes an important factor that decreases per capita water use in households. Moreover, the availability of water and increasing number of service hours, wealth, education level, and a number of rooms have a positive effect on per capita water use.

The most important factors determining per capita water use in unpiped households in DOW I were the number of people in the household and the cost of water, both of which were negatively correlated. The number of children in the household also decreased per capita water use. In addition, the time spent fetching water had a positive effect on per capita water use. Three decades later, the most important factor determining per capita water use was the relative wealth of the family. Furthermore, per capita water use decreases as the number of household members increases. Moreover the location is an important factor in determining per capita water use, where the results show that unpiped urban households are more likely to use more water than those living in rural areas.

The Drawers of Water

In investigating the collection and conveyance of water from external sources to unpiped households, the new study has revealed that women alone, or women and children are still the primary drawers of water. However, men have been found to take part in water collection activities either for commercial purposes as water vendors or for brewing local beer. It is revealed that women and children both in rural and urban areas account for 89 percent and 88 percent of

drawers of water in households respectively, while men take less part in the water collection activity (less than 19 percent).

Water Availability

The researchers also attempted to examine factors that determine water availability and assess the impact of human activities on the environment and water sources. The study established that climatic variability and seasonality of rainfall, level of financing, degree of involvement of stakeholders, quality of operation and maintenance, were found to have a severe influence on water availability, especially in the unpiped rural sites. It was also learnt that pollution of unprotected water sources and overgrazing were among the serious environmental problems. Moreover, population pressure on limited supplies has affected negatively water availability in several sites.

Water and Health

During DOW I, almost 25 percent of the unpiped households reported diarrhoea incidences during the week previous to the study. The incidence was very large for households who depended on streams, canals or rivers (67 percent reported incidences), followed by those from reservoirs or depressions and wells. The 'safest' water source was hydrants and standpipes, in which only 10 percent of households reported some diarrhoea case. Only approximately five percent of piped households reported a diarrhoea episode during the previous week.

In DOW II, low water use was found to impact negatively on the health of the people. Skin diseases and diarrhoea were found to be prevalent in areas with low per capita water use for cleaning and bathing. Furthermore, at least 17 percent of unpiped households experienced at least one incidence of diarrhoea during the previous week. Households using water from unprotected wells and other open sources reported very high diarrhoea incidence. Only three percent of piped households reported any incidence of diarrhoea.

Technological Issues

The technological changes in water collection and storage were examined. The results revealed that women and children of unpiped

households, who are the primary drawers of water, use a variety of vessels to collect and carry water home, usually on their heads. The common vessels used for carrying water were found to be 20 litre jerry cans, pots, gourds, basins and buckets. The most common containers are 20 litre jerry cans. The only major technological change over the past 30 years relates to the material from which these 20 litre containers are made. During DOW I, they were almost exclusively made of tin (*debe*), whereas today jerry cans are made largely of plastic materials.

During DOW I study, 200 litre steel drums were found to be used widely for water storage purposes by households. The only change in water storage technology between DOW I and DOW II has been the introduction of plastic 'polytanks' whose capacity ranges between 200 to 15,000 litres. Meanwhile water supply technologies being used in both rural and urban areas involve a mixture of pumps, pipes, gravity and shallow wells.

Water Sources

The study was also interested in identifying the different water sources from which a drawer could make choices. It was assumed that the drawer would always strive to achieve economic optimisation of obtaining the greatest returns from time and energy spent in collecting and carrying water home. This in fact turned out to be the case, although a certain inelasticity of demand was found whereby households collected and used roughly the same amount of water whether the source was 100 metres or 1,000 metres from the home. This 'plateau effect' in demand is similar to that found in DOW I, though there were anomalies found in some rural and urban sites. The other factors influencing source selection were the drawer's perceptions of the quality of the source, technical means available and costs and returns. It has been established that households in areas with reliable sources use fewer sources compared to those households in areas where sources are less reliable.

Policy Implications

Findings emerging from *Drawers of Water II* raise implications for current and future policies and strategies in the provision of water

supply and sanitation services. It is, for example, suggested that in order to enhance sustainability of water supply systems, communities will have to be empowered to initiate, own and manage their water supply schemes. It will also be necessary to promote participation of the private sector in the development and management (at the request of and on behalf of communities) of water supply and sanitation systems and services. Although the state's role will have to be limited to that of a regulator, facilitator, and coordinator, it will have to continue mobilising and providing financial support to complement community and private sector efforts.

Several other issues will need to be addressed:

1. Changes in domestic water use

   There has been a significant decline in per capita water use, especially in the piped households. While the mean daily per capita water use has almost doubled in the unpiped households, the level is still below the recommended 20 litres per capita per day.

   There is need to reverse the trend by increased investment in the water sector in the rural and urban areas. This means greater financial commitments, in real terms, by both government and foreign donors. Charging water users the real cost of water will not, in itself, bring about adequate improvements in coverage.

2. Determinants of water use

   In both unpiped and piped households the main determinants of per capita water use are the household's 'wealth' and cost of water. Piped households still pay much less than households obtaining water from vendors.

   There is need to institute policies and programmes to improve the economic well being of low-income households and to review the overall pricing of water in order to address the needs of the rural and urban poor.

3. Deterioration of piped water systems

   Most of the piped systems have experienced a significant

deterioration mainly because of the stress of increasing urban populations and lack of system maintenance and investment.

In order to halt this deterioration, there is need for innovative approaches to investment financing and capacity building of private and public and local water user groups.

4. Burden of water collection

The burden of water collection is still borne by women and children. This is aggravated by long waiting times at the source and labour intensive methods of carrying water.

There is a clear need to alleviate this burden by improving economic and general well being of women and children enabling them to participate in household and community decision making process.

5. Health and hygiene

Diarrhoea and other water-related diseases are still a problem. Unsafe water sources, poor sanitation and unhygienic practices increase the rate of diarrhoea.

There is a clear and pressing need to increase levels of investment in water and sanitation facilities. These must be accompanied by hygiene programmes to maximise health benefits.

On the issue of health, emphasis will have to be placed on integrating water supply, sanitation and hygiene education to maximize health impact of water supply investments.

Endnotes

1 The original study on which this project is based, *Drawers of Water: Domestic Water Use in East Africa*, was carried out by Gilbert F. White, a geographer, David J. Bradley, an epidemiologist, and Anne U. White, a sociologist, in 34 field sites in Tanzania, Kenya and Uganda. It remains one of the most comprehensive and influential texts on household water use in Africa nearly 30 years after it was first published by The University of Chicago Press in 1972.

2 See, for example: Cairncross, S. 1996. Water Quality, Quantity and Health. In J.O. Drangert, et al. eds. *Safe Water Environments*. Water and Environmental Health Studies No. 24. Linkoping University, Sweden. Cairncross, S. 1989. Water Supply and Sanitation: An Agenda for Research. *Journal of Tropical*

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3 See, for example: Churchill, A.A. 1987. *Rural Water Supply and Sanitation: Time for a Change*. World Bank Discussion Paper 18. The World Bank: Washington, DC. Elmendorf, M. and R.B. Isley. 1982. Water and Sanitation-Related Health Constraints on Women's Contributions to the Economic Development of Communities. In M.I. Aguwa, ed. *Conference on Women, Health and International Development*. East Lansing, MI: Michigan State University.

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7 Mujwahuzi, M.R. and F.P. Maganga. 1998. Historical Analysis of the Impacts of Water Development Policies, Programmes and Institutions in Tanzania Since Independence. London: International Institute for Environment and Development. Krhoda, G.O. 1998. National Policy Studies of Domestic Water Supply and Environmental Health in Post-Colonial Africa. London: International Institute for Environment and Development and Nairobi: African Centre for Technology Studies. Muzaale, P.J. 1998. Uganda's Water Policies and Strategies in Historical Perspective. London: International Institute for Environment and Development. *Environment and Urbanization*. 1993. Health and Wellbeing in Cities. Special issue, 5 (2), October 1993. London: IIED. *Environment and Urbanization*. 1991. Rethinking Local Government - Views from the Third World. Special issue, 3 (1), April 1991. London: IIED.

8 Edwards, M. and D. Hulme. eds. 1992. *Making a Difference: NGOs and Development in a Changing World*. London: Earthscan. *Environment and Urbanization*. 1990. Community-Based Organizations: How They Develop, What They Seek and What They Achieve. Special issue, 2(1), April 1990. London: IIED.

9 See Figure 18 in this report.

1 Introduction and Background

1.1 Background

This report presents the main findings of a repeat, cross-sectional study of domestic water use and environmental health, based on the pioneering study *Drawers of Water: Domestic Water Use in East Africa*. Specifically, it reports on changes in domestic water use, sanitation, health and hygiene over three decades in 10 rural and urban sites Tanzania, reflecting the diversity of environments, living conditions and water service levels found in the country (Figure 1.1). The determinants of the changes in per capita and household water use are examined at site and household level. The findings reveal both positive and negative changes in water use, in terms of levels and types of use, reliability of supply, access and cost.

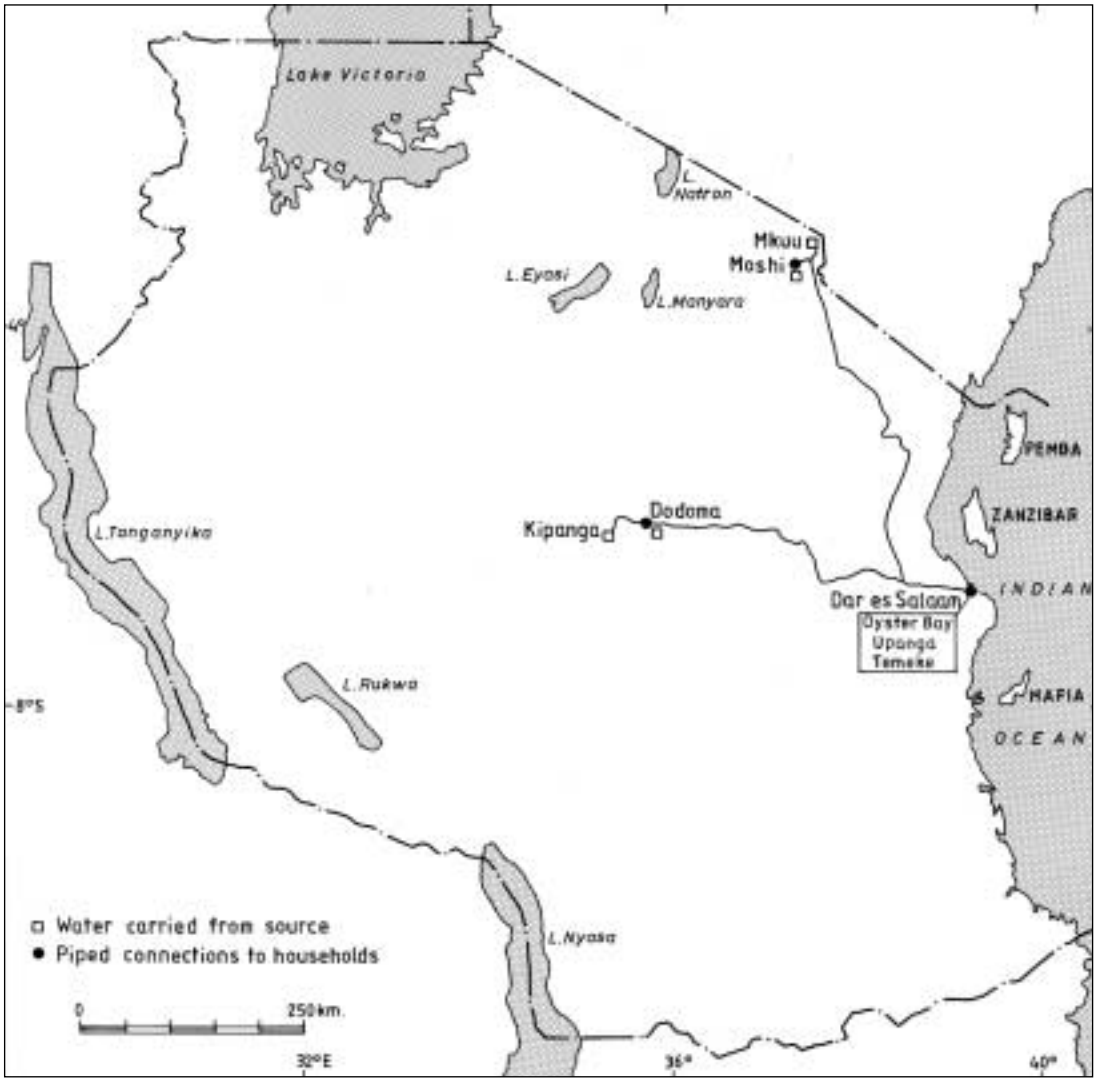
A comparison of the water use and environmental health data from the late 1960s and 1990s indicates that while statistically significant improvements in domestic water use and environmental health have been achieved in some quarters, there have been measurable declines in others. In particular, marked increases in per capita water use were observed in several rural sites, while there have been corresponding declines in many of the urban sites.[10]

This report also presents an assessment of the linkages between water use, latrine use and hygiene and their effects on diarrhoea in the household. Comparisons with DOW I were not possible for this part of the research, since data on latrine use and hygiene behaviour were not collected during the original study. The new results suggest, however, that increased per capita water use, proper disposal of faeces and use of hygienic sanitation facilities contributed to lower levels of diarrhoea.

10 These trends were common to the rural and urban sites examined in Kenya and Uganda, the other two study countries, as well as Tanzania.

As the population of Tanzania continues to grow rapidly, particularly in urban areas, and thus places added pressure on already over-stretched services, the long-term prospects for increasing per capita water use in the region appear limited. The cost of supplying water to low-income communities, already a major challenge, is likely to increase. Only concerted action by international external support agencies, in partnership with municipal and national governments, local communities and private service providers, will these trends be reversed or at least slowed.

Figure 1.1 Map of Tanzania with *Drawers of Water* Research Sites



1.2 *Drawers of Water* – Lessons, Impacts and Continuing Influence

Drawers of Water was to yield important findings that influenced water policy and practice on a number of fronts. First, it established empirically that increasing the quantity of water used per capita is more important for a household's health and well being than improving its quality. Because faecal-oral diseases have multiple transmission routes – hands, food, and dishes, as well as drinking water – they are more likely to be water-washed than waterborne. If a household has only a small quantity of water to use, it is likely that all aspects of hygiene – from bathing and laundry to washing of hands, food, and dishes – will suffer.

Second, a typology of water-related diseases was presented in *Drawers of Water* that was used to assess the basis of their transmission routes from the environment to humans, rather than on the taxonomic characteristics of the pathogens, as used in traditional Western medical science. The strength of that classification system is that it indicates almost immediately the types of interventions that are likely to be effective in reducing the incidence of water-related diseases. As a result, a modified version of this typology has by and large set the agenda for thought about water interventions and diarrhoea for the last 30 years, precisely because it focused on the objects of such interventions.

A third important contribution of *Drawers of Water* was to suggest that the addition of a closer but still distant water source, such as a centrally located standpipe or well, would not necessarily increase household water use. White, Bradley and White found that if water must be carried, the quantity brought home varies little for sources between 30 metres and 1000 metres from the household. The understanding of the inelasticity of demand – the so-called 'plateau effect' – remains an important consideration in the design of community water supply points.

Fourth, *Drawers of Water* raised incisive questions about the desirable intermediate goals needed to meet demand for water in both rural and

urban areas. The study showed that rural water supply provision needed a more flexible response to demand, rather than a supply-driven approach, and argued for greater support for community-based and individual initiatives. In urban water supply, it suggested that more attention be given to single-tap levels of service and the provision of more standpipes for low-income communities. Over the past three decades, planners and engineers did not always take on board these insights regarding levels of service, but gradually they have come to be accepted as good practice.

The crux of the document may well be epitomised, in the words of the authors, as follows: "The way people respond to present and improved supplies and the effect this has on community health and welfare should be examined for the whole range of theoretically possible improvements. Increased volume of use does not necessarily bring proportionate gains in health. Neither does the construction of additional safe supplies necessarily result in increased use by those people who most need them."

1.3 Domestic Water Supply and Environmental Health: A Continuing Challenge

Nearly three decades after *Drawers of Water* was published, household water supply and sanitation remains a challenge, not just in Tanzania but on a global scale. Today, some 1.1 billion people, nearly one-sixth of the world's total population, are without access to a safe water supply and two-fifths lack access to adequate sanitation facilities. The situation is most acute in Africa, where only 62 percent of the population has access to improved water supply. The situation is worse in rural areas, where coverage is only 47 percent, compared with 85 percent in urban areas.[11]

In East Africa, the countries of Tanzania, Kenya and Uganda have slightly lower averages for water and sanitation coverage than for Africa as a whole (Table 1.1). Presently, the three countries have coverage rates for urban water of 80 percent and 40 percent for rural water supply . Specifically, Tanzania provides 80 percent of its urban residents with improved supplies and 42 percent of its rural dwellers.

11 The definition of 'coverage' used in the *Global Water Supply and Sanitation Assessment 2000 Report* from which these data are drawn is based on technology type. In past assessments, the coverage figures referred to 'safe' water supply and 'adequate' sanitation. One of the findings of the current assessment is that there is a lack of information on the safety of the water served to the population and on the adequacy of sanitation facilities. Population-based surveys do not provide specific information on the quality of the drinking-water, or precise information on the adequacy of sanitation facilities. Therefore, the WHO and UNICEF assessment assumed that certain types of technology are safer or more adequate than others and that some of them could not be considered as 'coverage'. The terms 'safe' and 'adequate' were replaced with 'improved' to accommodate these limitations. The population with access to 'improved' water supply and sanitation is considered to be covered.

Country	Year	Total population (000s)	Urban population (000s)	Rural population (000s)	% urban water supply coverage	% rural water supply coverage	% total water supply coverage	% urban sanitation coverage	% rural sanitation coverage	% total sanitation coverage
Tanzania	1990	25,470	5,298	20,172	80	42	50	97	86	88
	2000	33,517	11,021	22,496	80	42	54	98	86	90
Kenya	1990	23,552	5,671	17,881	89	25	40	94	81	84
	2000	30,080	9,957	20,123	87	31	49	96	81	86
Uganda	1990	16,457	1,837	14,620	80	40	44	96	82	84
	2000	21,778	3,083	18,695	72	46	50	96	72	75
Region	1990	65,479	12,806	52,673	83	36	45	96	83	85
	2000	85,375	24,061	61,314	80	40	51	97	80	84

Table 1.1 Water Supply and Sanitation Coverage in East Africa, 1990-2000

Source WHO and UNICEF. 2000. *Global Water Supply and Sanitation Assessment 2000 Report*. WHO: Geneva and UNICEF: New York.

Sanitation coverage in Africa is also poor, with only Asia having lower coverage levels. Currently, only 60 percent of the total population in Africa has access to improved sanitation, with coverage varying from 84 percent in urban areas to 45 percent in rural areas. Table 1.1 shows sanitation coverage for East Africa to be significantly higher than the continental averages. Tanzania in particular has sanitation coverage rates of approximately 98 percent in urban areas and 86 percent in rural areas.

According to the recent WHO and *UNICEF Global Water Supply and Sanitation Assessment 2000 Report*, the water supply and sanitation sector in Africa will face enormous challenges over the coming decades. Presently, the worst levels of coverage are in rural areas, but with urban populations projected to more than double over the next 25 years, the coverage rates are expected to decline in towns and cities. As a result, approximately 210 million people in urban areas will need to be provided with access to improved water supply services and 211 million people with sanitation services, if the international coverage targets for 2015 are to be met. A similar number of people in rural areas will also need to gain access.

1.4 Analysing Long-Term Trends and Changes

While the use of regional and national aggregate statistics can provide an overview of broad trends in water supply and sanitation, they can also mask considerable variation at the sub-national level. Moreover, they frequently fail to give insights into the *dynamics of long-term changes* in water use and environmental health, particularly at the local or household level. In fact there is a general dearth of quality information on long-term changes in domestic water

use and the factors influencing it. Consequently, the design and implementation of water supply and environmental health policies and programmes remains highly problematic.

This is particularly the case in Africa, where, according to Sydney Rosen and Jeffrey Vincent of Harvard University:

> "Knowledge of household water supply and productivity… is limited to a handful of original studies, which continue to be cited and recycled in the literature. Foremost among them is *Drawers of Water*… which reported the results of a data collection effort spanning 34 communities in three countries over three years. *Drawers of Water* remains the most comprehensive and compelling account available [of] ...water use in... Africa (emphasis added)."

The ground-breaking book to which Rosen and Vincent refer, *Drawers of Water: Domestic Water Use in East Africa*, was published in 1972 by The University of Chicago Press. Its authors, Professor Gilbert F White, a geographer, Professor David J Bradley, an epidemiologist, and Dr Anne U White, a sociologist, invested several years in the late 1960s carrying out detailed field studies in Kenya, Tanzania and Uganda with a group of African research assistants from the then University of East Africa. They examined the use of water for basic consumption, hygiene and amenities in domestic life across a range of rural and urban settings in Kenya, Tanzania and Uganda. They also assessed the social cost of obtaining water in terms of direct monetary costs as well as less readily measured costs in energy and time. Quantities of household water use were recorded and the factors affecting variations in use were assessed. The effect of water use on health was also examined, as were implications for public policy on domestic water service provision.

Nearly three decades after White, Bradley and White produced their landmark study, a multidisciplinary team of African, European and North American scientists returned to the original research sites in East Africa and used the same methodology to assess changes in

domestic water use and environmental health. This work involved more than 1,000 sample households and two phases of intensive survey and participatory research. In addition, the original Drawers of Water dataset was assembled, re-computerised and cleaned to allow for a multivariate statistical comparison of the water and environmental health situation in the late 1960s against that of the late 1990s.

By using the *Drawers of Water* data as its baseline and carrying out detailed historical analyses across a spectrum of rural and urban communities in East Africa, this new study has sought to chart the major trends and changes that have occurred in the domestic water and environmental health sectors over 30 years. Few studies offer as rich an array of insights into the complex issues surrounding domestic water use and environmental health as that classic text, and no study provides a better foundation on which to base a new, interdisciplinary, multi-country research project to explore the links between water, health, policy and poverty.

1.5 Project Objectives and Report Structure

Given this background, the major objectives of this research were to:

- carry out a comprehensive, repeat, cross-sectional analysis of domestic water use and environmental health in Tanzania, as well as Kenya and Uganda, based on the original *Drawers of Water* methodology;

- reconstruct the history of domestic water use and environmental health changes and impacts in selected research sites through policy research and participatory appraisals;

- assess inter- and intra-household and community-level variations in domestic water use related to investments in water supply and environmental health systems and services;

- examine the influence of local and external actors, policies and programmes on the water and environmental health changes; and

- inform and influence national and international debates on water, health, poverty and policy via a series of workshops and formal and informal publications.

The following sections present the main results emerging from the *Drawers of Water II* research in Tanzania and a comparative analysis of the DOW I and II datasets. Chapter 2 sets the scene by describing the national water and sanitation situation in the country and reviewing key aspects of the water policy history over the past 30 years. It then introduces each of the study sites, providing summaries of their main water and health characteristics.

Chapter 3 briefly describes the methodology used to guide the study through two phases of field research. It also gives details on the selection and training of the field assistants, the approach used to identify sample households and the actual research process.

The main results are presented in Chapters 4–8. Chapter 4 assesses changes in water use for piped and unpiped households, and rural and urban households from DOW I to DOW II. The main types of water uses and their impacts on hygiene and health are also examined. This is followed by an analysis of the changing cost of water for piped and unpiped households, and shows how the poor continue to pay more for their water than the well-off. The chapter closes with an assessment of the main determinants of water use and an exploration of the 'drawers of water', which introduces a gender-dimension to the analysis.

Chapter 5 examines a range of environmental considerations surrounding water use, including variations in water availability (some related to seasonal and climatic changes and others resulting from service delivery problems), environmental degradation and pollution, and population-environment interactions.

A short discussion on health and sanitation issues follows in Chapter 6, with an analysis of the links between water use, latrine use, hygiene and diarrhoea incidence.

Chapter 7 addresses a series of technological issues related to water collection and storage. This includes an analysis of the changes in the type and size of water collection and storage vessels and in water supply technologies. It also touches on the issue of 'range of choice' in the selection and use of water sources for unpiped households.

The changing roles of government, the private sector and civil society in water supply and sanitation in Tanzania are examined in Chapter 8. During the time DOW I was carried out, the state was the main actor in terms of water supply and sanitation (WSS) service provision. Today, a plethora of local and international NGOs and CBOs are engaged in the design, development, operation and maintenance of WSS systems. So too are private companies and small, independent vendors, who are increasingly important players in the sector in both high and low-income areas, particularly in urban areas. The Government of Tanzania is struggling to learn how best to become more of a co-ordinator and facilitator of civil society activities and a regulator of private sector participation in WSS. These changing institutional arrangements create a host of new challenges and opportunities for all actors working in the sector.

The ninth and final chapter presents a set of implications for future water and environmental health policy and practice, based on this research. It suggests actions needed to improve both rural and urban water supply and sanitation systems and services, particularly for low-income groups.

2 Country Profile and Study Sites

2.1 National Water and Environmental Health Situation

Tanzania is currently going through political, social and economic reforms to improve the well being of its people. Tanzania is endowed with abundant natural resources and yet it is listed as one of the poorest countries in the world. The Government now realises that sound economic development can only be brought about when the available natural resources are exploited in a more sustainable manner. That is why Tanzania is, among other things, concerned with the sustainable development and management of its water resources. It is expected that a sustainable water system would guide and support "the provision, in an economically viable, environmentally sustainable, and socially equitable manner, of potable water and sanitation facilities, protection from floods, and drainage as well as of water for productive activities".[12] (World Bank, 1993).

In Tanzania there is great variation in the availability of water in the different parts of the country. This variation is due to existing differences in topography, hydrology, rainfall and evapotranspiration. Some areas of the country are already experiencing water stress. It is therefore useful, before discussing the water resources in the country in general, to look at the physical background of the water resources in Tanzania, and this will be the subject of the subsequent paragraphs.

2.1.1 Physiology

Tanzania, covering an area of 937,062 km^2, lies 1.5 degrees South of the Equator. It shares common borders with Kenya, Uganda, Rwanda and Burundi in the north, Zaire in the west and Zambia, Malawi and Mozambique in the south. The country has a narrow coastal plain

12 The World Bank. 1993. Water Resources Management. *A World Bank Policy Paper*. The World Bank: Washington, DC.

occupying the eastern seaboard. Most of the country, however, lies on the Great African Plateaux with altitudes between 1000 m and 2000 m.

2.1.2 Climate

For a country close to the equator, Tanzania is relatively dry. More than half of the country receives, on average, less than 800 mm of rain per year. Rainfall is the most dominant climatic factor. It depends upon air circulation patterns and the movement of convergence zones in the region. Due to the northbound migration of what is called the Intertropical Convergence Zone (ITCZ) most parts of the country receive rain during the wet season, from December to April. The dry season in the months of June to October reflects the subsequent retreat of the ITCZ. Mean annual rainfall over the country is dependent to some extent upon relief.

Hydrologic and moisture conditions in Tanzania are determined by the quantity and pattern of rainfall. River and lake levels rise during the wet season and recede during the dry season. The central and northern parts of the country, including areas immediately south of Lake Victoria, are dry for an average of seven consecutive months in a year. River flows in these areas are intermittent. In the southern, western and northern highlands, however, which receive more than 1,000 mm/year of rain, rivers are perennial. Some of these areas experience frequent floods.

Hydrologically, Tanzania is divided into five major drainage basins; the Indian Ocean Drainage System, the Internal Drainage of Lake Eyasi, Lake Natron and Bubu Depression Complex, the Internal Drainage of Lake Rukwa, the Atlantic Ocean Drainage and the Mediterranean Sea Drainage Basin. Each of these drainage systems comprises a network of rivers and lakes of various sizes.

Groundwater is one of the major sources of water in the country, particularly in the dry areas which cover the central regions of Shinyanga, Dodoma, Singida and Arusha. The quality of groundwater in Tanzania is generally good, and acceptable for most uses. The main problems are salinity and high fluoride concentrations.

2.2 "Free Water for All" Policy

After Tanzania gained Independence in 1961 the Government started contemplating and formulating the "*free water for all*" policy. The free water policy was put in place in 1969 when rural inhabitants were no longer required to pay for water they used for domestic purposes and for livestock. This policy was consolidated in 1971 and the Government was required to have provided every rural inhabitant with easy access to adequate and potable water free of charge by 1991. In other words, from that time, it was the government's responsibility to develop, operate and maintain rural water supply schemes with no cost recovery from the users. The end result of this approach was the creation of a "no commitment" attitude on the part of the beneficiaries.

During the period 1971-1985 many water supply schemes were constructed. It soon became evident that operation and maintenance of the constructed schemes was a burden to the government. Government funding was not sufficient to cover operation and maintenance. In a recent report on rural water supply it has been observed that the 1991 target:

> "...remained a dream. It is estimated that by 1996, installed water supply facilities in the country have a capacity to serve only about 48 percent of the rural population with improved water supply. In reality, a smaller percentage is actually being served because an estimated 30 percent of the schemes have broken down or are partially inoperative and are in need of restoration. The coverage has been achieved after 25 years of unrelenting effort and if the remaining, more than 52 percent has to be supplied with water, development of additional sources will have to be made. [13]"

Poor performance of the "*free water for all*" policy called for a change in the water supply policy. The first step which government took was to introduce a cost-sharing strategy in construction, operation and maintenance of community based water supply systems.[14] The cost-sharing approach was to be effected through the establishment of Village Water Committees and formation of Village Water Funds. It was expected that through this approach, village communities would

13 Njau, Frederick Z. 1998. Social Principles of the Rural Water Supply Component of the Water Policy. Paper presented at the *National Workshop on the Review of the Rural Water Supply Component of the National Water Policy*, Arusha, 23–25 April 1998.

14 Ng'wandu, Pius, Y. 1998. Opening Address by Honourable, Dr. Pius Y. Ngw'andu, (MP), Minister for Water, to the *National Workshop on the Review of the Rural Water Supply Component of the National Water Policy*, Arusha, 23–25 April 1998.

have the opportunity of participating throughout the scheme cycle involving the following stages: initiation, planning, construction, operation and maintenance.

Introduction of the cost-sharing approach did not deal effectively with the "no commitment" attitude which the beneficiaries had developed over time as a consequence of being provided with water free of charge. Furthermore, the cost-sharing introduced was not based on any costing formula. In some water scheme cost-sharing took the form of providing unskilled labour. In addition, communities and villages who participated in cost-sharing exercises did not own the water scheme facilities. There was thus a lack of a sense of ownership and this affected operation, maintenance and sustainability.

2.3 National Water Policy

From 1985, the Ministry of Water began thinking about formulating a National Water Policy which was intended to guide the development and management of water resources in the country. The Policy was finally adopted by the Government of Tanzania in 1991. It had many objectives, one of which is:

> "to increase the health and productivity of the population through the provision of safe and adequate water supply and sanitation services to the people, and to provide effective water supply and waste water disposal services to commerce and industry to help and maintain their productivity, as well as recognising agricultural and recreational needs."

Thus the objectives of the Strategy were to:

- provide clean and safe drinking water within easy reach as a first priority and then satisfy the needs for other uses;
- give equal priority to both urban and rural water supply;
- improve all urban water supplies and establish efficient customer services; and
- optimise use of the limited water resources.[15]

15 Ministry of Water. 1997. *Draft Rural Water Supply Component of the National Water Policy*. Government of the United Republic of Tanzania: Dar es Salaam.

In order to achieve these objectives, the following strategies were adopted for the implementation of the water policy in respect to rural water supply:

- adopting low-cost, intermediate technologies;
- training of village water caretakers to carry out maintenance of the schemes;
- establishing village water committees for managing the water schemes;
- establishing village water funds for meeting operation and maintenance costs;
- handing over of the completed schemes to the respective communities;
- Standardising designs as well as pumps, pipes and fittings; and
- Local manufacture of water supply related facilities (spares, hand pumps, pipes, etc.) so as to guarantee their availability.

Introduction of the above strategies has called for a review of all the three components of the National Water Policy, namely: the Rural Water Supply component, the Urban Water Supply and Sanitation component, and the Water Resources component. In the revision of the Rural Water Supply component, emphasis has been put on defining the roles and responsibilities of stakeholder groups instead of those of the individual sector ministries and institutions. Emphasis has also been placed on cost recovery for operation and maintenance services as opposed to the concept of cost sharing. Furthermore, the supply-driven approach that, in the past, guided the development of water supply has been replaced by the demand-driven approach. Involvement of the private sector is also being emphasised, as well as the management of water supplies to be at the lowest appropriate level, as opposed to centralised management.[16]

It is the opinion of the author of this paper that these changes in policy and strategies may have had some influence in what has been found in the field in so far as water supply and use is concerned. Preliminary results of the field study will be discussed in Chapter 4.

16 Ministry of Water. 2000. *Draft National Water Policy*. Government of the Republic of Tanzania: Dar es Salaam.

2.4 Study Site Descriptions

DOW II was carried out in ten sites in Tanzania.[17] Two of the sites were rural and the rest were urban. As discussed below, socio-economic conditions differ between the study sites.

2.4.1 Kipanga: Site No. 22 (rural)

Kipanga village (known as Chipanga by the indigenous Gogo people) is in Dodoma rural district. It lies west of Dodoma town (Figure 2.1). The residents of this village are Wagogo and keep cattle as well as practising agriculture, growing mainly millet, which is a drought resistant crop, maize and vegetables.

The village lies in the semi-arid part of the country. The sources of water are rivers, some of which carry water only during the rainy season, shallow ponds, and water holes which are dug in the dry sand river beds and ground sources. The primary drawers of water are females and children.

Water selling is not practised much in Kipanga village. It was observed that only males were selling water. Water vendors deliver water from door-to-door especially to the beer-making households. Some males also draw water for brick-making and construction purposes.

17 Maps of the sites referred to in this section can be found at the end of this chapter.

Kipanga women and children carrying water home. Note a variety of utensils used

For a greater part of the year people depend on shallow ponds and dug holes for their water supply. These sources are unprotected and are heavily polluted especially by livestock which use the same sources to satisfy their water needs.

From the water sources, people carry water home using bicycles, carts driven by people, and yolk held by people. Females and children usually carry water on their heads. The common water vessels used in carrying water are pots, jerry cans, gourds, plastic basins, and buckets while storage vessels include drums and all of the vessels used in carrying water home. In addition to the sources mentioned above, there is also a borehole fitted with a pump and a series of pipelines and standpipes. These facilities were developed by the Government in the 1970's. However, at present the pipes are rusty and taps broken, and the pumping machine is not widely used due to lack of funds to buy diesel to run the machine. Sometimes, individual people in the village voluntarily provide diesel to run the machine.

2.4.2 Mkuu: Site No. 19

The Mkuu is a rural study site, located in Rombo district on the eastern slopes of Mount Kilimanjaro (Figure 2.2). Mkuu has been described as a woodland village enjoying numerous perennial streams which flow down from Mount Kilimanjaro. Residents of this village are Chagga people who are mainly agriculturalists growing coffee as a commercial crop, and bananas, maize, beans and an assortment of vegetables mainly for domestic consumption. Residents of Mkuu also keep a few dairy cattle in barns. They are known for their zero grazing practices.

There is a long tradition of damming and diverting streams flowing down the mountain mainly for irrigation purposes. The same sources are also used for domestic purposes. Building of dams and irrigation canals and management of this infrastructure is governed by Chagga customary laws which specify the rights and responsibilities of individuals, households and even village communities. These laws are elaborate and seem to work effectively in allocating water resources for different uses and in solving water use conflicts.

Mkuu village is in the area served by the East Kilimanjaro Water Supply Project (EKWSP). The EKWSP is intended to serve 57 villages in Rombo District and 13 villages in Moshi Rural District. Water is supplied to Mkuu by gravity through pipelines. Some of the households have water connections while other collect water from standpipes. The quantity of water used or drawn by each household differs depending on the size of the family, socio-economic status as well as environmental changes and, in case of unpiped households, the distance one has to travel to collect it.

The cost for water differs from site to site. For instance, at two nearby research sites, Moshi Unpiped and Moshi Piped (below), each piped household pays respectively Tshs.1,364/= or Tshs.2,046/= per month, residents of Mkuu Rombo pay Tshs. 660/= per month. Costs for unpiped households also differs from place to place. This is because there are no payments being made at the source. A few households pay minimum rates of about Tshs. 100/= to 330/= per month to the source owner.

2.4.3 Moshi (Unpiped)

At Moshi, an unpiped site , the situation is slightly different (Figure 2.3). Most of the unpiped households buy water from the kiosks and pay approximately Tshs. 5/= per 20 litre container. A few of them depend on the water vendors who charge double this amount for a 20 litre container. A minority draws from neighbours.

2.4.4 Moshi (Piped)

A piped site was also investigated in an urban area of Moshi town, which is the headquarters of Kilimanjaro region. The study site and Moshi town are located on the foot-slopes of Mount Kilimanjaro in northeast Tanzania (Figure 2.4).

The study area is occupied by a number of ethnic groups. At the time of the study residents of this area included Africans, mainly Chagga and Pare, people of Asian origin and a few Europeans. Inhabitants of Moshi town involved in a variety of occupational activities, including the civil service and a variety of small and medium enterprises.

In general, residents of this area can economically be described as being well off with relatively high income, by the standards of the DOW II study and Tanzania as a whole. The houses found in this area are built mainly of cement bricks with iron roofs. Storied buildings are also to be found in this area.

At the time of the DOW II study, the area was receiving water intermittently during only specific hours. Uninterrupted 24-hour service was a rare event. There was a kind of rotating water rationing whereby certain areas were not being served on some specific days or hours in a day. Households with water connection were paying a flat rate of Tshs. 2046 per month irrespective of whether the household was getting a 24-hour water service or not.

2.4.5 Dodoma (Unpiped)

This is an urban study site in Dodoma Municipality (Figure 2.5). At the time of DOW I, the study site was totally unpiped. In contrast, in DOW II, of the 35 households interviewed, 23 households received piped water. Judging by the percentage of households which get water from piped sources one is tempted to conclude that there has been some improvements in water supply at this site over the past 30 years.

In households without a water connection, females and children are the primary drawers of water. These households also depend on water sellers, found at the old water kiosks, and porters who bring water to the house, whether by order or through door-to-door water vending. Shortages of adequate water sources at this site have created employment for water vendors. For example, one 17-year old male vendor, when asked about his water vending business had this to say:

> "I usually buy a 20 litre jerry can from private standpipe owners or from the Water Department standpipes and sell the same amount of water at Tshs. 100/= to 150/= (0.82-1.23 US* Cents per litre) depending on the severity of the problem. In my water vending activities, I use a cart to carry six jerry cans per trip. I can easily make Tshs.3,000/=, even 6,000/= per

* US dollars are expressed in 1997 terms

day (approximately US$5-10), but very much depends upon the extent of water shortage problem. This is actually my most lucrative employment."

During the survey, as was the case in all study sites, interviewees were asked about the quality of water sources and the number of sources they depended on. The findings show that households at this site largely depend on standpipes, vendors and unimproved hand-dug wells. The physical environment surrounding the unimproved wells was poor. Some wells were dug in the line of flow of waste water systems and it was obvious that the groundwater water sources being used were polluted. This observation was backed-up by the finding that the highest incidence of diarrhoea was found in households using water from these hand-dug wells.

2.4.6 Dodoma Urban (Piped)

This study site is located in the southern part of Dodoma town (Figure 2.6). It is locally known as "Uzunguni" (European) area because senior government officers, who were mainly government administrators of British origin during colonial period, used to have their residences in this area. The site is characterized by low density and high quality housing for senior government and parastatal employees.

The site is piped getting its water from the central municipal water supply system. At the time of the study, the whole central region was experiencing a severe dry spell. Consequently there was water rationing. To cope with periodic water shortages, residents of this study site had to store water at home using polytanks and other storage facilities.

Although residents of this study sites were employees yet some of them were supplementing their salaries with incomes generated from other economic activities such as keeping dairy cattle, chicken farms, growing vegetables and even running groceries. It was observed that these economic activities, especially the keeping of livestock and growing vegetables increased water demand.

As dairy cattle were kept in residential areas, the agro-pastoralist owners had therefore to practice zero grazing. The problem which arose was where to dispose the manure from the animals. One could observe heaps of cow manure along street sides, thereby causing environmental pollution and inconveniences to neighbours.

Interviewing vendors in Dodoma

2.4.7 Chang'ombe

In DOW I, Chang'ombe is described as 'a suburb to be found well out of town with a mixture of styles of living' (Figure 2.8). Development which have taken place within the past three decades have changed the nature of Chang'ombe. It can no longer be regarded as a suburb as the urban sprawl of Dar es Salaam has engulfed it. Thus, there are no more open spaces in this flat, medium-density, urban area. Residents of Chang'ombe get their water from the municipal water supply system. However, supply is erratic and some households are forced to buy water from independent, private vendors, to whom they pay high prices.

2.4.8 Temeke

Temeke is also an urban study site situated south of Dar es Salaam city centre (Figure 2.8). It is characterised by flat sandy terrain with a few scattered trees. It has a high density of housing. For the past 10 years, the area has not received a good water supply and many households do not get water from the municipal water supply system

at all. For those who get piped water, they can get water for about 2-10 hours a day and others get water for the same hours but for only 2-4 days a week. This has forced the households to store water in large quantities. Containers used range from 20-200 litres, depending on the size of the family. This has also raised concern about their water bills. Piped households complain of paying bills which cover the whole month when in the reality they get water for less than 20 days a month. In addition, a number of households, who have not received water through their taps for six years, continue to receive water bills.

'Maji Yanauzwa Ndoo Sh 10' – "Water for sale, ten shillings per bucket". '*Mutusi Hayatakiwi by Kamati*' – "No quarrelling at this source – The Committee" – Temeke, Tanzania

Problems of low pressure in the pipes has led some household to install water pumps in their homes. The installation of private pumps attached to the distribution lines has disrupted the whole system of distribution resulting in some households not getting water altogether. An example of this case was found in Rusende Street where residents stopped receiving water after one person installed a pump on the distribution line and filled his reservoirs in order to sell water.

2.4.9 Oyster Bay and Upanga

Oyster Bay and Upanga are both urban study sites. The Oyster Bay site is a low density urban area of Dar es Salaam, which is occupied by

high officials employed by the government and international organisations (Figure 2.9). In contrast, Upanga site is a medium density urban area, occupied by middle-class people, both employees and business people, mostly of Asian origin (Figure 2.10). Both study sites are piped.

Water supply in these two sites is generally reliable, although a number of households experience some shortages from time to time. Many households have installed storage tanks to overcome the problem of water shortage. However, some residents were buying water from water sellers who use the water trucks (bowsers) in carrying out their business.

Although population growth in the two sites has affected water supply services through increasing the number of people to be served by the little amount of water available, Oyster Bay is still very pleasant environmentally. The inhabitants try to beautify their surroundings, even if this means purchasing water for gardening.

However, this is not the case in Upanga where the situation now is worse than it was three decades ago. The flats are occupied by more people, and those staying upstairs have to rely solely on the storage tanks for their water supply. The surrounding environment is also less pleasant, with overcrowded housing blocks, increasing amounts of waste and poor drainage providing visible evidence of an area in decline.

Site Maps

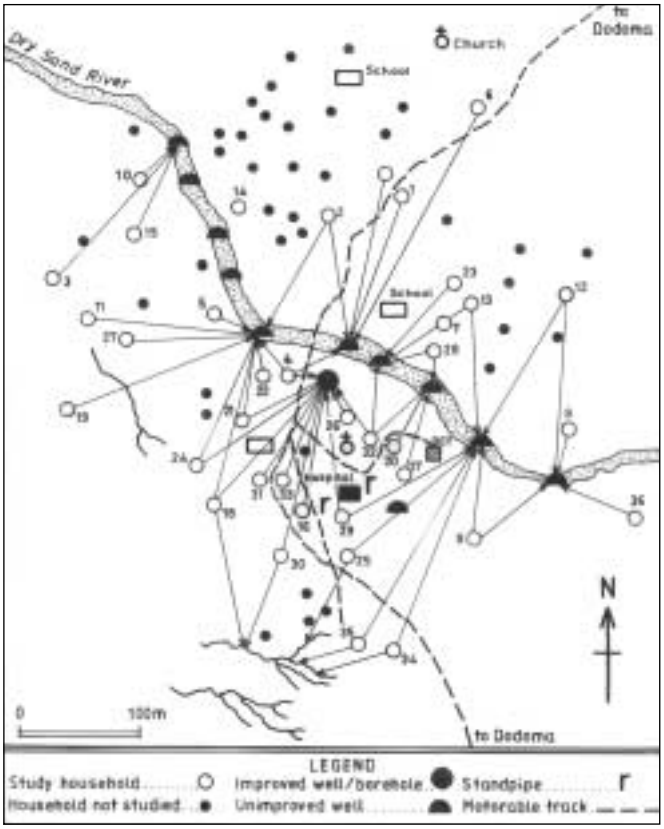


Figure 2.1 Kipanga 'A' and 'B'

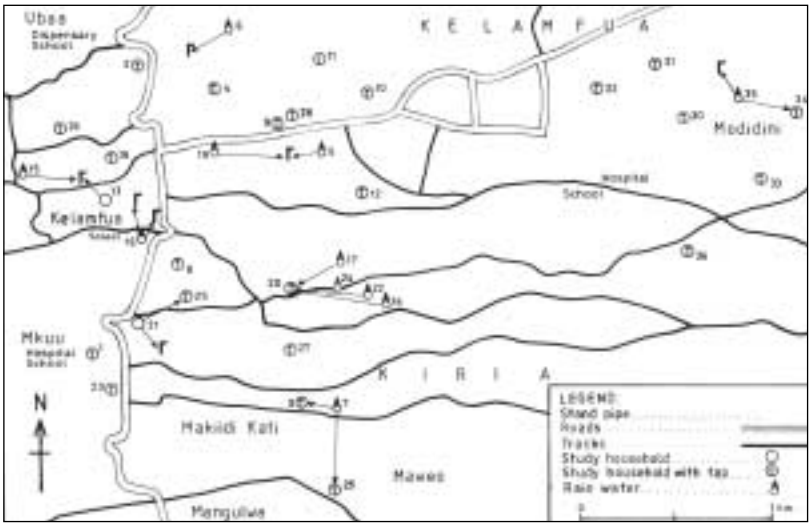


Figure 2.2 Mkuu

Figure 2.3 Moshi – Majengo

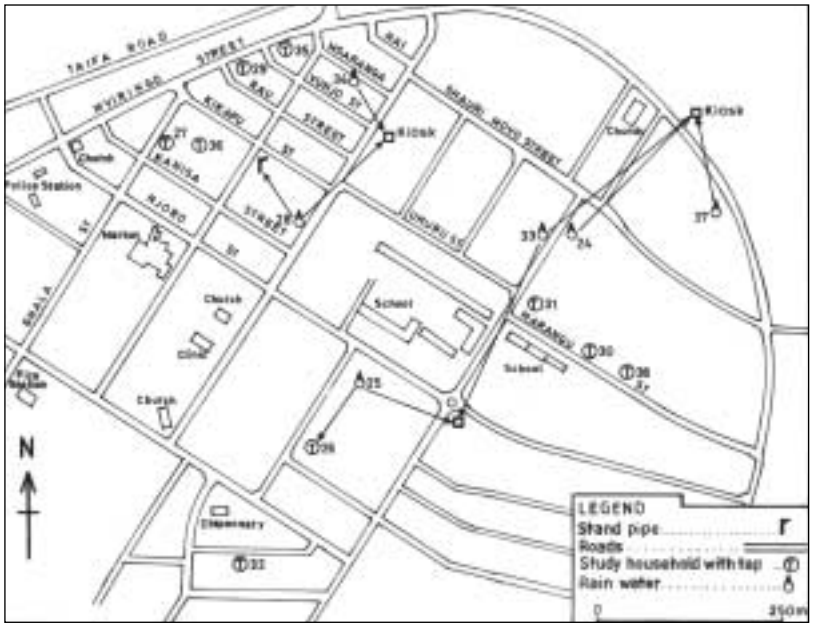
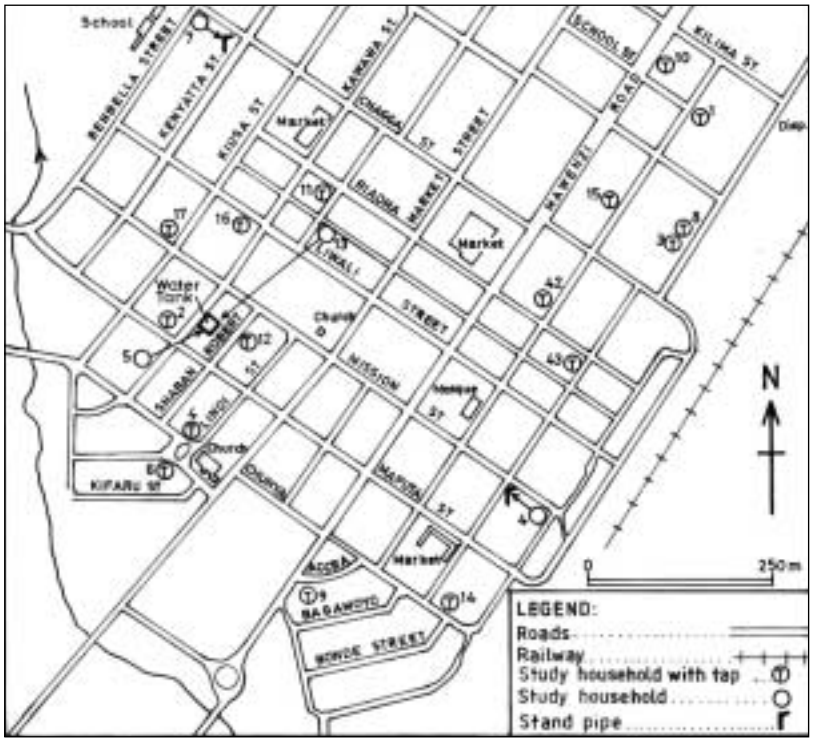


Figure 2.4 Moshi – Town Centre



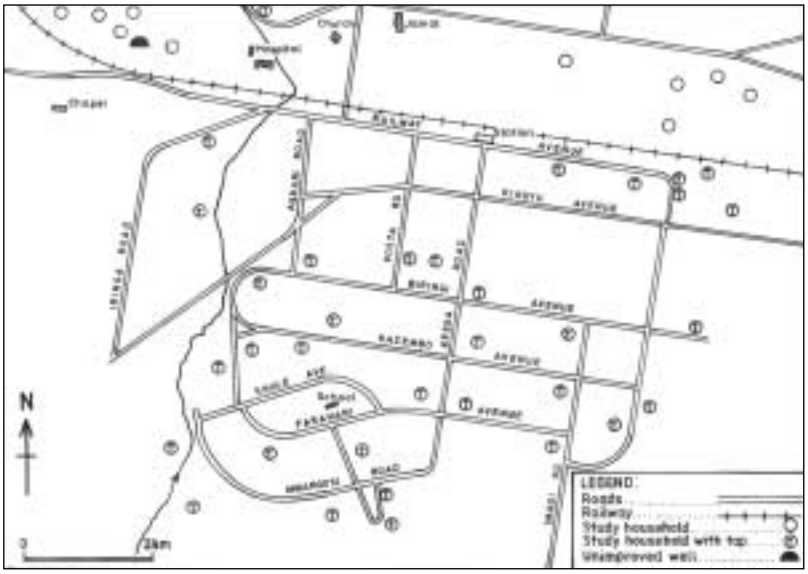


Figure 2.5 Dodoma Urban

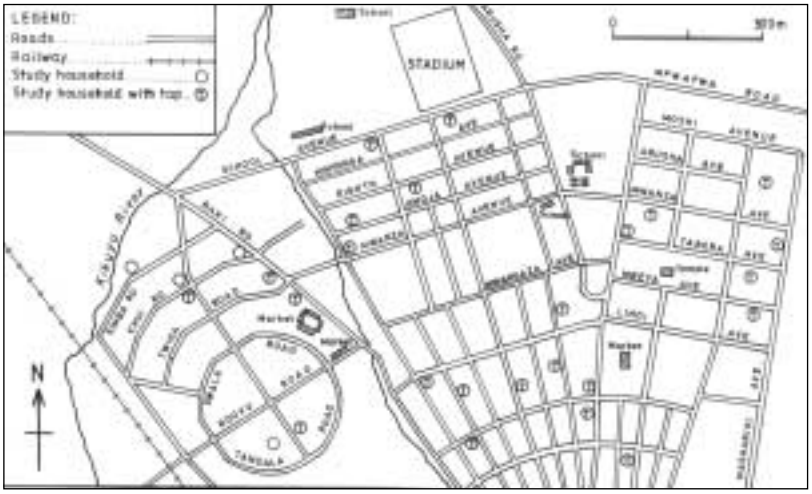


Figure 2.6 Dodoma – Urban

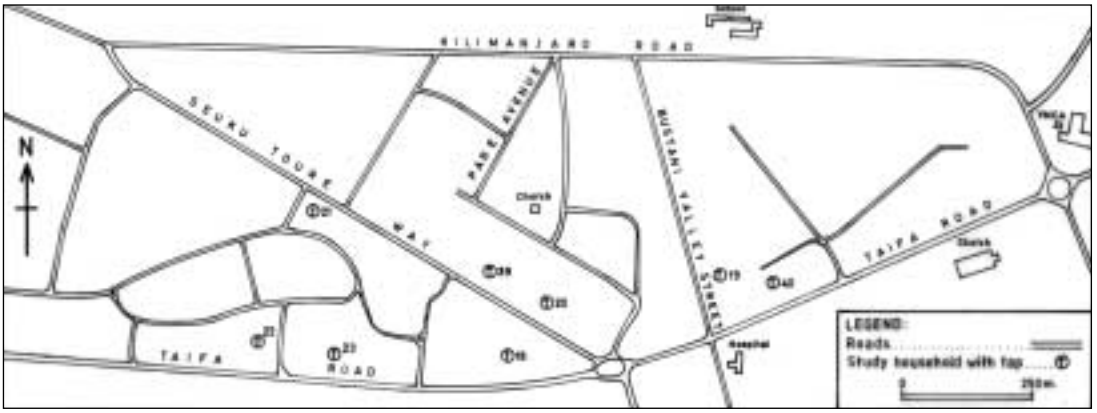


Figure 2.7 Moshi – Shanty Town

Figure 2.8 Mkuu

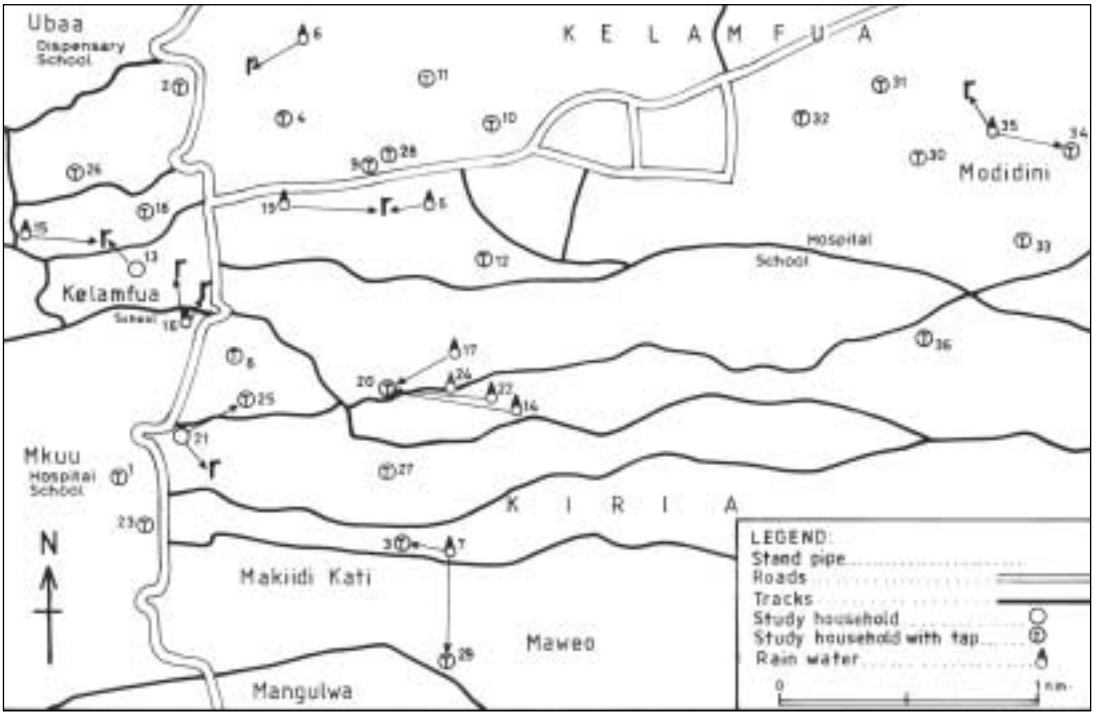


Figure 2.9 Oyster Bay

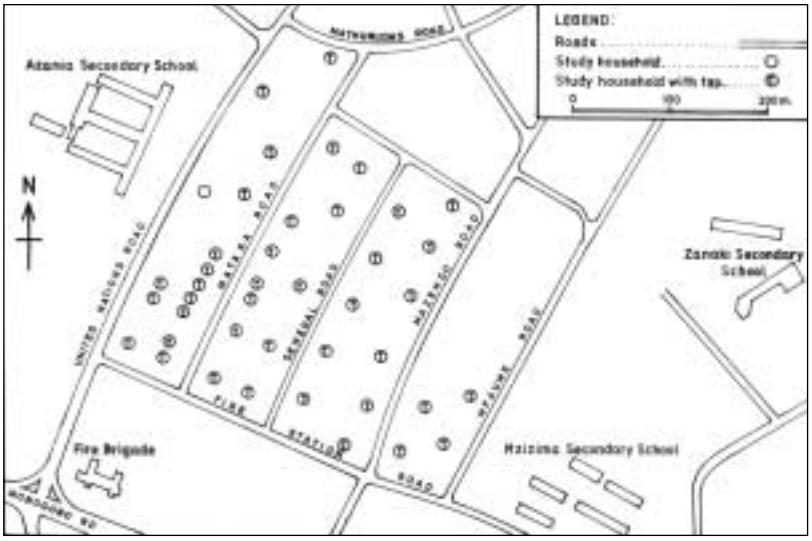


Figure 2.10 Upanga

3 Methodology

3.1 A Repeat, Cross-Sectional Analysis: From DOW I to DOW II

The country-level research in Tanzania was carried out in the same research sites studied in DOW I. The sites give a diverse range of physical and social settings and characteristics, including agroecology, altitude, climate, population density, and water infrastructure.

Field assistants spent at least one full day (from the time the family began their day to the time the last member went to sleep) with each sample household carrying out observations and conducting semi-structural interviews. In addition, they measured the slope and distance to water sources, weighed the amount of water carried to the home and noted the people carrying it, calculated the amount of energy (calories) expended in water collection, and observed and recorded the amount of water used in the home. They also collected information on household socio-economic characteristics, prevalence of diarrhoea, state and use of latrines, sources of water and conditions of use.

For unpiped households, reported water use was checked by interviewing members of the household and observing the actual number of trips to the water sources, whenever possible. In the piped sites, readings for a full year were obtained (where available) from the local water or town council office of each of the houses and similar observations made for the unpiped sites.

During the second phase, participatory appraisal methods were used in four sites to involve local people in the analysis of key trends and changes in their water use and environmental health histories. These

methods, including focus group discussions, semi-structured interviews, resource maps, matrix scoring, pair-wise ranking, time lines, pie charts, Venn diagrams, transect walks, daily activity diagrams (daily routine), key informant interviews, seasonal calendars, cause-effect diagrams, flow diagrams and mini case studies, allowed the researchers and local participants to critically examine the activities and interactions of internal and external organisations and institutions that influenced water development in their communities.

3.2 Selection and Training of Field Assistants

In order to ensure quality research, the Senior Research Officer (SRO) recruited five highly skilled Field Assistants (FAs). The selection was based on criteria set out at a regional planning workshop of the senior research team at Makerere University in Uganda in 1997. The criteria included: academic background, previous research experience, language skills, geographic proximity to study sites, gender balance, and availability for the entire research period. The rigorous selection process ensured the recruitment of highly experienced and motivated Field Assistants (FAs).

3.3 Sampling Procedures and Household Surveys

To enable comparison of research findings, the same ten sites studies in DOW I were studied in DOW II. The FAs recruited came either from the study site areas or were conversant with the local language, living conditions and culture of the areas.

3.3.1 Sampling Method

Since this was a repeat, cross-sectional study, the field sites were predetermined: these were the same 34 rural and urban sites studied by White, Bradley and White in the 1960s, 10 of which were in Tanzania. Moreover, two different sampling methods were used to select households, based on DOW I.

Selection of sample households in the *sites without piped services to households* (i.e., unpiped sites) an area of approximately three square miles (7.77 square kilometres) was selected to cover all major types of water sources. Within this, a grid of 21-27 cells was laid out, and a point

within each cell was selected by using coordinates of random numbers. The household nearest that point then was taken for interview. The demographic characteristics of the samples were compared with census data for the same areas where available and samples were found to be relatively representative of aggregate census findings.

For the *sites with piped services* the methods were somewhat different. Selection necessarily was limited to urban areas in which many, but not all households had meter records. Using maps of land use, the towns were divided into areas having approximately the same density of residential structure per lot. Within areas of similar housing density, samples were taken by selecting every tenth house beginning at an arbitrary point. Meter readings for a full year then were obtained from the municipal water office for each of those houses for an adjacent house if the records were inadequate. An interviewer then went to the house and completed other information.

3.3.2 Household Surveys

Between June and October, the Field Assistants (FAs), under the guidance of the Senior Research Officer (SRO), carried out 301 household surveys in the 10 sample sites. As in the original study, those households to be interviewed were randomly selected in each of the communities. The samples ranged from urban to rural, high to low income, and from piped to unpiped households (Table 3.1).

	Dow I	Dow II
Total Sample Size (N)	**239**	**301**
Percent		
Unpiped	34	28
Piped	66	72
Total	**100**	**100**
Rural	19	23
Urban	81	77
Total	**100**	**100**

Table 3.1 Sample Size by Type of Connection and Rural / Urban Location (Same Sites)

The SRO helped the FAs to gain research authorisation and the support of government officials and local leaders, and visited each of the FAs at different stages of the research.

Two different survey instruments, one for unpiped households and the other for piped households, were developed for collecting responses to questions, field measurements and observations. For unpiped households, data were collected on socio-economic characteristics, types and amount of water use, the social cost of obtaining water, water sources, and conditions of choice.[18] Data were also collected on latrine use, hygiene status, and incidence of diarrhoea in the unpiped households. For piped households, the same socio-economic and water use data were gathered, along with the financial cost of obtaining water.[19]

Observations and interviews were carried out with a single sample household each working day, starting from the time the first water user began the day until the last water user went to bed in the evening. The FAs, who lived in or nearby the field sites during the duration of the fieldwork, were trained to memorise the questions and make notes in small field notebooks, rather than entering information into a formal set of pre-coded data entry sheets. Photographs were also taken to record various aspects of water collection, transport, storage, and use, as well as of the types of sources, collection and storage vessels and of the drawers of water themselves. The data were transferred to the forms at the end of the day, at which time initial calculations and analyses were carried out. The FAs' data entry sheets and calculations were checked by the SRO as the field research progressed.

A number of methodological challenges arose, the most common of which was encountering a mixture of piped and unpiped households as well as households using a combination of piped and unpiped sources in each of the research sites. This meant that the original categorisation of the field sites from DOW I was no longer valid and the FAs therefore had to use both sets of survey forms (for piped and unpiped households) at many of the sites, a point we will return to later.

In addition, various logistical problems were encountered during the fieldwork, including high transport costs, difficulties in reaching remote sites, and problems in gaining access to high-income households who were often suspicious of the FAs' intentions. Despite

18 For *unpiped sites*, the following data were collected: number in household, number of rooms, number of housekeepers, electric light, children under 15 years of age, number of males in house, highest education level attained in household, occupation, type of source, unit withdrawn daily, size of unit, carried distance per trip, slope, round trip time, purchased cost, number of houses using source, type of water disposal, estimated per cent consumed, where clothes are washed, whether the usage is different in the dry season, whether water is stored, whether water is used in garden, choice and perception of source. They were asked to list the advantages and disadvantages of a piped supply and if charges for water should be made. Moreover, they were asked if they ever suffered from shortages of water and if so, when and where. Finally, they were asked how many severe shortages of water they expect in the next 10 years.

19 For *piped sites*, the following information was gathered: number in household, number of rooms, number of housekeepers, electric lights, number diarrhoea cases in the past 24hrs and seven days, children under 15 years, number males, highest education level, and occupation. The type of rate, service in number of hours daily, withdrawal for a number of months, number of days in this period, estimated supply from other sources, type of disposal of water, number of taps, bath tubs, showers and water heaters, and where clothes were washed. Respondents were also asked if their use was different in the dry / wet season, if water is stored, if water is used in garden, and common facilities, and they have ever lived where water was not piped as a child or as an adult. They were asked to list the advantages and disadvantages of a piped supply and if charges for water should be made. Moreover, they were asked if they ever suffered from shortages of water and if so, when and where. Finally, they were asked how many severe shortages of water they expect in the next 10 years and if they know of any other ways in which they might get water.

these challenges, the DOW II research team managed to replicate the original Drawers of Water study in its entirety and add a number of new lines of enquiry related to environmental health and hygiene. Moreover, a second phase of research was undertaken to help fill in the 30-year gap between the DOW I and DOW II surveys.

3.3.3 Participatory Appraisals of Water and Environmental Health Histories

Following the preliminary analyses of the household survey data, the Senior Research Officer for Tanzania, in consultation with the other SROs for Kenya and Uganda and the DOW II Research Co-ordinator, identified 13 of the 34 DOW field sites for a second phase of in-depth research. Four sites were chosen in Tanzania: Temeke in Dar es Salaam, Dodoma Urban, Kipanga and Mkuu in Moshi. These sites appeared to offer valuable insights into positive and negative changes in domestic water use and environmental health in the country (Table 3.2).

Table 3.2 Drawers of Water Field Sites Selected for Participatory Historical Analyses

Field Site	Topics of Investigation
• Dar es Salaam - Temeke	great diversity of water selling activity (independent vendors, water bowsers, individual pumps, even mosques sell water) with equally wide range of prices (from Tsh 10 to Tsh 400 per 20 litres jerry can)
• Dodoma Urban	chronic water shortages are forcing people to use a range of both piped and unpiped sources. Municipal Water Department supplies 4 mil gal/day, but demand is estimated at 6 mil gal/day
• Kipanga	DOW I study carried out before *Ujamaa*; new water system built by government, but people continue to use traditional sources; many people lack latrines, while others use ones that are in a very bad state
• Mkuu	Kiliwater, a community-managed, limited water company is supplying piped water from sources on Mount Kilimanjaro, but questions remain about whether this has led to increased water use; many people are still getting used to the idea of cost sharing

The second phase of research involved participatory analyses of the important trends and changes with the key actors (i.e., the local people, government officials, NGO staff, etc.) who had been an integral part of the water-health history of the selected sites over past three decades.

An intensive, two-week, field-based workshop was held in Arusha, Tanzania, in January 1999 to introduce the three national research teams from Tanzania, Kenya and Uganda to the participatory research

methodology. Each national team then tested the field methodology in one of the original *Drawers of Water* sites in their respective countries. Once this pilot testing was completed, the Senior Research Officers, together with the Research Co-ordinator, reviewed the results of the trials and made several small alterations to the research design.

The unit of analysis of this phase of research was the focus group, rather than the household, as in the first phase survey research. These participatory group analyses were used to examine and explain intra-community (e.g., by gender, age, etc.) as well as inter-community variations in water use and well-being. They were also used to examine the roles that government, private sector and civil society actors have played in improving access to reliable water supplies and adequate sanitation, and changing hygiene behaviour.

Rather than sending a single Field Assistant to assess the water and environmental health situation of individual sample households, the research was carried out by a multidisciplinary research team of FAs, along with the SRO and an officer providing logistical and technical support. Each site was investigated over the course of one week, occasionally with follow-up visits. Participatory research methods were employed by the researchers to help the local people reconstruct the last 30 years of domestic water supply and environmental health trends, changes and impacts in their communities. These included semi-structured, focus group interviews, as well as a variety of interactive, visual methods, such as historical profiles, seasonal calendars, daily activity diagrams, systems diagrams, network diagrams and social maps, to carry out these analyses.

The first step in the participatory historical analysis was to determine when important water supply and sanitation facilities were constructed, who was and is now involved in their development, operation and maintenance, and whether they have been abandoned or are still functioning. If certain systems had been abandoned or were only partly used, then the reasons for their abandonment or low use were investigated. If the water systems were functioning the researchers explored how frequently they are used, by whom, and at what cost.

This information on the functioning and use of the water and sanitation facilities revealed insights into the history of water development and improvements in a community. However, it also required further investigations to gain a clear sense of the impacts these facilities and other interventions have had on the health and well being of the residents. Using new or improved water and sanitation facilities involves a change in behaviour. Without those behavioural changes, water supplies and sanitation are not likely to offer direct health benefits.

Given the wide range of strategies employed and the diversity of institutional actors involved in water development over the past quarter century in Tanzania (from multilateral and bilateral donors to government agencies and from non-government organisations and community-based organisations), this second phase of participatory historical research may be likened to a kind of 'archaeology' of water and health programmes and systems, as many 'monuments' have yet to be excavated or their 'remains' interpreted.

3.4 Details on Data Processing and Analysis

3.4.1 Data Management

To ensure regular communication and co-ordination among the principal collaborating agencies involved in this multi-country research project, a series of planning, training, review and co-ordination workshops and meetings were organised at different stages of the research process during 1998-2000 in Tanzania, Kenya, Uganda and UK. These included an intensive workshop to train the country research teams in the use of *SPSS for Windows* software, the statistical database package used to analyse the *Drawers of Water* data, and a second training workshop in multivariate statistical analysis.

After finalising a common database structure and agreeing common data management procedures, each of the three country teams entered their own DOW II data independently during late 1997 and early 1998. The initial data cleaning and analysis was done with the assistance of the Project Co-ordinator Dr John Thompson and several associates from the International Institute for Environment and

Development, London (Kathryn Jones, Libby Wood, Dr Nick Johnstone and Ina T Porras), and a number of professional statisticians in each country. The three country datasets were then brought together at a meeting in Nairobi in July 1998, where they were checked for bugs and cleaned and tested further.

This 'first cut' analysis was to prove very important for it revealed several trends in water use and environmental health that were common to the three countries. The most significant of these were that per capita use appeared to have increased in unpiped households and decreased markedly in piped households since DOW I.

While the early analysis of the DOW II dataset was continuing at country and later regional level, the original DOW I data had to be re-computerised. These data were held with the other *Drawers of Water* records at the archives of the Office of History of the US Army Corps of Engineers outside of Washington, DC, in the USA. They had to be reassembled, copied and organised by the Project Co-ordinator before they could be entered into the new SPSS database. The laborious process of re-entry and cleaning of the DOW I data was undertaken by the Uganda country team, led by Dr James Tumwine, at Makerere Medical School in Kampala, with the assistance of IIED, London. This involved several months of painstaking data entry, testing and cleaning before the original DOW I data were ready to be reanalysed and compared against the new DOW II data.

3.4.2 Role of the Field Assistants

The Field Assistants, who had played a crucial role in carrying out the household surveys and measurements of water use and environmental health in the first phase, and later facilitating the participatory historical analyses in the second phase, assisted with the data entry and analysis. Evaluations of their performance during the fieldwork and of the reports of their findings by the Senior Research Officer showed that the research was done to a high standard and that all of their terms of reference were fulfilled satisfactorily. To ensure that all of the key lessons emerging from the research were captured for later use, the FAs were asked to:

- conduct a peer review of each other's work - double-checking all forms, adding any missing information, correcting any mistakes in calculations and clarifying any remaining questions;
- write-up their field notes and complete detailed narratives of the research process followed and the insights into domestic water use and environmental health gained at each study site;
- finalise all household sketches and site maps, ensuring that all symbols and references used on the maps are recorded properly in the keys and the field notes; and
- prepare presentations of their research process and findings for the next training workshop.

These reports provided extremely useful contextual information on the study sites to complement the data on domestic water use and environmental health obtained from the household surveys. They also informed the preparations for the second phase of participatory research, described above.

3.4.3 Initial Write-Up and Reporting of Results

A common report structure was developed at a meeting in October 1998 at the University of Dar es Salaam to guide the country-level comparative analysis of the DOW I and II datasets. The three SROs and their teams used this outline and the two datasets to carry out preliminary analyses of the trends and changes in domestic water use and environmental health in each study site. They also included qualitative and quantitative information about changes in water use and cost, and other socio-economic, environmental, technological and institutional issues drawn from the first phase of field research.

Each report considered the following questions:

- What key changes have occurred in each of the study sites over the past three decades with regard to domestic water use and environmental health?
- What internal and external factors appear to have contributed to these changes?
- What was the single biggest change found in each study site?

The early findings included in these reports were peer-reviewed at a set at three national consultation workshops in Kenya, Tanzania and Uganda in mid-2000. The Tanzania national consultation workshop took place on the 1st of September 2000 and included 28 professionals involved in the water supply and sanitation sector, including the Permanent Secretary of the Ministry of Water, the Director of Water Resources, the Director of Rural Water Supply, and the Director of Water Supply at DAWASA. In addition, the results were presented at several major international meetings and conferences, including the Stockholm Water Conference in Sweden in 1999 and the Second World Water Forum in The Netherlands in 2000. These events had two main purposes: to gain expert reactions to the data to ensure that the initial results were valid and reliable, and to raise awareness about the *Drawers of Water II* project.

This arduous and iterative process of data entry, careful checking, comparative analysis, write-up and peer-review ensured that the data management procedures were sound and the data themselves were trustworthy. The results discussed in this report are the culmination of that process.

4 Research Results

4.1 Socio-Economic Issues

Although the study was carried out in only 10 sites in Tanzania, it is the opinion of the author of this report that what was found in the study sites is true of other areas not covered by the study. This is based on the fact that the changing national policies, strategies and guidelines on water resources development and management which have taken place in the country since DOW I have significantly influenced the performance of the domestic water supply sub-sector.

When DOW I was carried out in 1966, the study sites were divided into two categories, piped and unpiped. In preparing for DOW II, it was assumed that the categorisations used for each site in DOW I would still apply. However, field experience demonstrated that this was not the case. In fact, the only study sites which maintained their categorisation were Kipanga in Dodoma region as 'unpiped', and Oysterbay and Upanga in Dar es Salaam region as 'piped'. The remainder of the sites were found to contain both piped and unpiped households. Consequently, in analysing the results, households that were found to be piped in a site which was expected to be unpiped were grouped with piped sites or a specific sub-sample and vice versa. This ensured that we always compared like with like households in the analyses.

4.2 Unpiped and Piped Households

The study was interested to find out whether in the past thirty years there were changes in the methods of water supply. The first step was to find out the percentage of households which have access to piped sources. The information obtained was compared with the number of households with piped water supply in 1966 when DOW I study was carried out. The results of this comparison is shown in Figure 4.1 below.

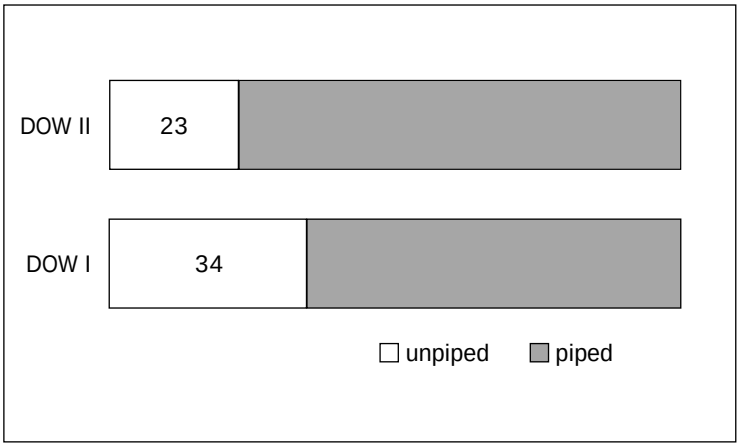


Figure 4.1 Percentage of Sample Households with Piped and Unpiped Water (Same Sites)

In DOW I, the study team was interested in finding out which factors influenced water use. The researchers started with an assumption that the amount of water which households used was influenced by at least seven factors, namely; size of family, income level, education, cultural heritage, character of water supply, cost of obtaining water as measured by energy or cash expenditure, climate and terrain. These factors were investigated by reviewing their association with the volume of water use among all users and individual users. The same approach has been used in analysing DOW II field data and the results are as discussed in the following paragraphs.

4.3 Per Capita Water Use

In 1971, Tanzania embarked on a 20-year programme of providing access to a source of adequate potable water for every rural inhabitant. It was expected that easier access to water sources would lead to increased per capita water use and that this in turn would lead to improved health by reducing the incidence of water-washed diseases. The expected increase in per capita water use was reflected in the design standards subsequently adopted, which catered for a per capita use of 25 litres. This was double the design figure which was being used during the DOW I study period.

One of the objectives of *Drawers of Water II* was to see whether there had been changes in water use given tremendous efforts directed by the government towards improvement of the water supply sub-sector.

Consequently the study attempted to compare water use changes over the past three decades. The results of this comparison are shown in Table 4.1 and Figure 4.2.

Table 4.1 Mean Per Capita Water Use in Tanzania (Litres Per Day)

	Mean	Std. Deviation	Minimum	Maximum	Valid Sample
Piped Households					
DOW II	80.2	70.4	20.6	568.5	131
DOW I	141.8	92.9	7.1	431.9	156
Unpiped Households					
DOW II	18.6	13.1	5.0	72.5	61
DOW I	13.5	9.2	3.6	48.7	82

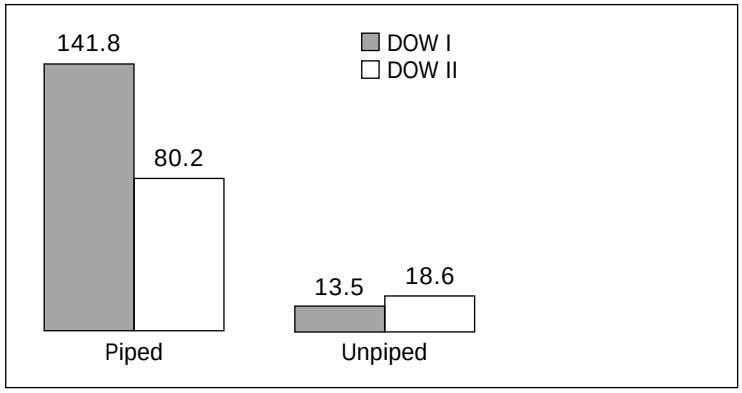
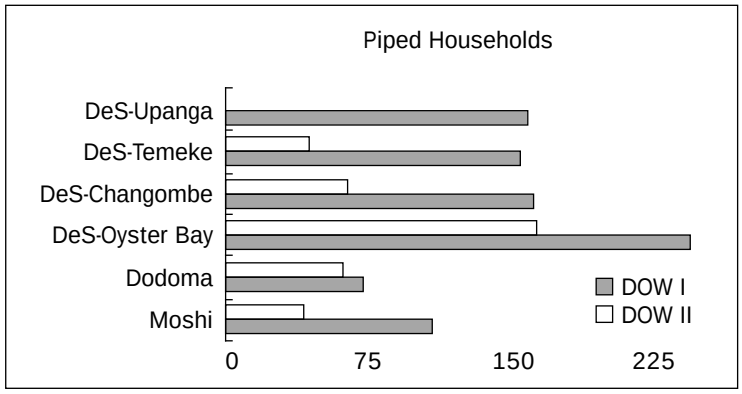


Figure 4.2 Mean Per Capita Water Use (Litres Per Day), by Type of Connection

4.3.1 Per Capita Water Use in Piped Sites

As it was pointed out in the preceding paragraphs, the study examined water use in both piped and unpiped households. And in analysing the data, household water use during DOW I and DOW II was also compared. The results of the analysis on this issue of water use are as summarised in Table 4.1 above and in Figure 4.3 below.

Figure 4.3 Piped Households Per Capita Water Use (DOW I vs DOW II Litres Per Day), by Site



Note that in the late 1960s the average per capita water use in Dar es Salaam was approximately the same for the different sites (with the exception of the high-income area of Oyster Bay whose residents used more). By the late 1990s, the disparities in water use levels within the city of Dar es Salaam had grown markedly between high and low-income districts and households.

From the table the mean per capita water use in piped households is shown to be 80.2 litres for DOW II, a striking decline from 141.8 litres found for the equivalent households in DOW I. The mean per capita water use in piped households has thus decreased over 40 percent in the past 30 years.

One would have expected that with the passage of time and the Government's commitment to provide its citizens with easy access to water sources the per capita water use by households with water connections would have in creased or at least remained the same. This has not been the case in Tanzania. What are the cause(s) of this decrease in water use by households with water connection? Several factors can be advanced to explain this development. These would include: the ageing of the water supply infrastructure; lack of adequate maintenance; and increased pressure on the existing inadequate infrastructure due to increased industrial and domestic demand. The increase in domestic demand especially in urban areas can be attributed to an increase in the urban population due to natural growth and immigration from rural areas.

4.3.2 Per Capita Water Use in Unpiped Sites

According to DOW I data the mean per capita water use in unpiped household in 1966 was 13.5 litres and by thirty years later it had increased to 18.6 litres per day. The variation within the study sites was still notable, as can be seen in Figure 4.4. For example, in DOW II unpiped households living in Dodoma (which is an urban site) were using on average nearly twice as much as those unpiped households living in Mkuu (rural site).

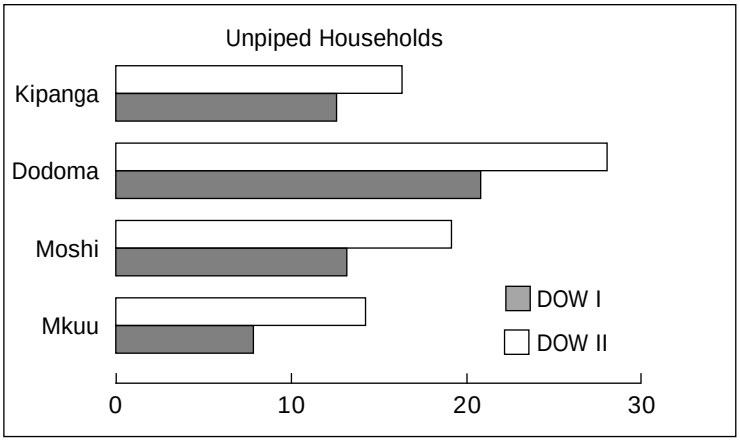


Figure 4.4 Unpiped Households: Per Capita Water Use (DOW I & II), by Site

Table 4.2 Per Capita Water Use by Site (Litres Per Day), DOW I & II

	DOW II			DOW I		
	Mean	Valid Sample	Range	Mean	Valid Sample	Range
Piped Households						
Moshi	40.7	18	57.1	108.2	24	389.7
Dodoma	62.1	35	242.5	72.1	47	237.4
Dar Es Salaam-Oyster Bay	164.3	30	491.6	243.9	31	362.5
Dar Es Salaam-Chang'ombe	64.4	28	33.1	161.1	22	227.9
Dar Es Salaam-Temeke	43.7	20	47.3	153.5	6	100.8
Dar Es Salaam-Upanga				157.7	26	237.1
Total	**80.2**	**131**	**547.9**	**141.8**	**156**	**424.7**
Unpiped Households						
Mkuu	14.2	10	19.5	7.8	24	20.4
Moshi	19.3	6	24.3	13.3	15	31.8
Dodoma	28.3	11	41.3	21.0	21	27.5
Kipanga	16.6	34	67.5	12.7	22	44.4
Total	**18.6**	**61**	**67.5**	**13.5**	**82**	**45.1**

Woman scooping water from a waterhole dug in a dry sand river bed in Kipanga

4.3.3 Per Capita Water Use: Rural vs. Urban Households

The study was also interested to find out whether being located in an urban or rural area would affect water use. The results of this inquiry is shown in Table 4.3 and Figure 4.5 below. It is important to note that

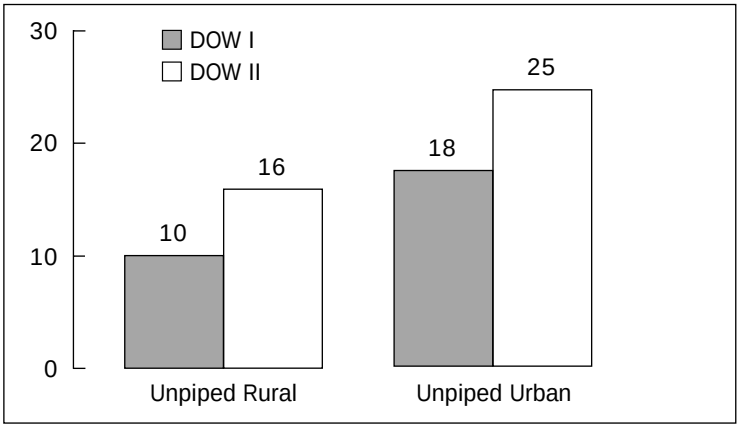
the analysis for piped households corresponds only to those located in urban areas, since at the time of DOW I piped connections were rarely available in rural areas.

Table 4.3 Mean Per Capita Water Use, by Location in Rural or Urban (Litres Per Day)

	DOW II	DOW I
Unpiped-Rural	16.0	10.1
Unpiped-Urban	25.1	17.8
Piped-Urban	80.2	141.8

It is important to note that unpiped households experienced an increase of approximately 6 or 7 litres in their average per capita water use, regardless of being located in urban or rural areas. However, urban households consumed on average more water than those living in rural areas, both during DOW I and in DOW II (25 lt as opposed to 16 lt). Despite the fact that urban households with piped connections experienced a decline in their water use levels since DOW I, the disparity of their water use with respect to unpiped households in rural areas remains a striking fact that must be addressed at once.

Figure 4.5 Mean Per Capita Water Use (Rural – Urban, Litres Per Day)



4.3.4 Water use by Type

In the preceding paragraphs the per capita water use has been shown irrespective of what that water has been used for. In this section an attempt is made to find out how the different uses have affected the per capita water use.

Water for Drinking and Cooking. Table 4.4 shows the overall per capita water use for drinking and cooking to be only 3.3 litres for

unpiped sites, and very low for unpiped rural, actually the lowest in the East African region. The question is, why do unpiped rural (in Tanzania) was found to use so little for consumption?

With these results, at first the researchers thought that there might have been errors in the collection and analysis of data. However, after carrying out a PRA study it was established that the results reflected the existing water use situation at the time of the study. There are several factors which have caused the observed small water use for drinking and cooking. Some of these factors are as follows:

The study was carried out in areas which were, at that time, facing drought conditions. For unpiped sites water had to be carried longer distances than usual. In addition to long distances which had to be traveled carrying water, drawers of water had, at times, to wait for a long time at the water point before they could fill their water containers. Consequently less water was carried home and this contributed to lower per capita water consumption.

It was also noted that generally in the study areas people prefer to drink local beer than water. Consequently their water demand is met through drinking the locally brewed beer.

Water for Hygiene. Table 4.4 shows that unpiped households in rural areas are using only 4.6 litres for *cleaning*, half of the amount of water used by unpiped households in urban areas and only a quarter of the amount used by piped households. *Bathing* shows the same trend. Unpiped households in rural areas use the lowest amounts for bathing, less than a quarter of the amount used by piped households. The researchers wanted to know why is so little water is used for cleaning and bathing and whether the low water use has an impact on health.

Very little water is used for cleaning and bathing because first, taking a bath is not a daily activity for people in the study areas. People usually take a bath after three or even for days. Second, people have very few clothes to wash in addition to the fact that washing of clothes

is not done daily. Another factor that complicates the determination of the amount of water that is used for washing is that in many instances washing of clothes is done at the source. Third, there are few utensils to wash and it appeared to be a common practice of using utensils two to three times before they are washed. Fourth, the type of house floors does not require cleaning by using water. The floors are made of mud and are, therefore, cleaned by sweeping.

Low water use was found to impact negatively on the health of the people. Skin diseases and diarrhoea were found to be prevalent in areas with low per capita water use for cleaning and bathing.

Water for Amenities. Urban piped (and even urban unpiped) households reported water use for such activities as gardening, livestock watering, and business. Rural unpiped households, however, did not report any water for these uses. Why?

One explanation is that none of the sampled households was involved in these activities. Another explanation is that at the time of the study the areas in question were experiencing very dry weather and water was not readily available for such activities. In fact, many of the unpiped households are located in semi-arid rural areas. Yet another equally plausible explanation, that was raised during the participatory research phase, is that the cost of obtaining water is simply too great for many unpiped households to allow them to use it for non-essential purposes.

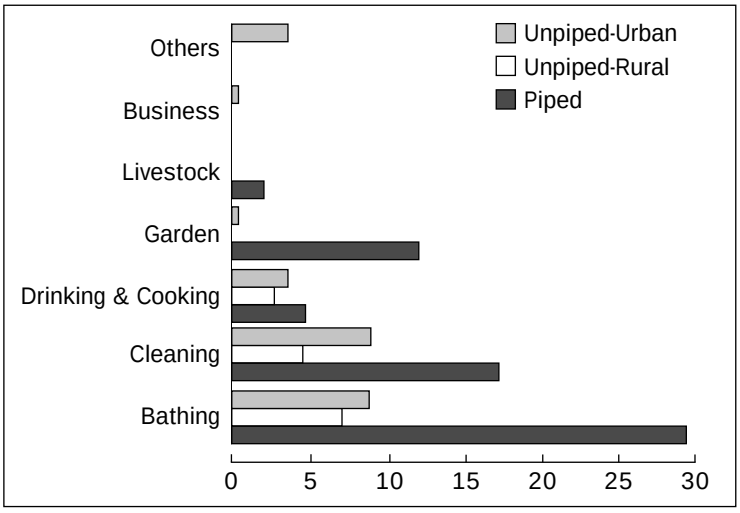


Figure 4.6 Per Capita Water Use by Type, for rural and urban households (Litres Per Day)

Table 4.4 Average Per Capita Water Use, by Type, as reported in DOW II (Litres Per Day)

Note * Does not include water used for toilets, which is approximately 20 litres.

	Piped	Unpiped (all)	Unpiped-Rural	Unpiped-Urban
Bathing	29.35	8.2	6.9	9.0
Cleaning	17.31	7.3	4.6	8.9
Drinking & Cooking	4.73	3.3	2.7	3.7
Garden	12.21	0.2	0.0	0.3
Livestock	2.00	0.1	0.0	0.1
Business	0.03	0.2	0.0	0.3
Others	0.00	2.0	0.0	3.1
Total	**65.64***	**21.2**	**14.2**	**25.3**

4.4 Cost of Water

4.4.1 Piped Households

Under normal circumstances, the cost of water is expected to influence the amount of water used. This study attempted to do two things: first, to find out what people pay for water in different sites, and second, to see whether the price of water affects the volume of water used.

During DOW II, the mean cost of water for all piped households in the sample was $0.61 per cubic metre (Table 4.5). There was a considerable variation in price between sites, however, with households in piped rural sites paying far less compared to households in piped urban sites. For example, residents of Temeke and Chang'ombe (same sites as in DOW I) were paying the highest price of water (almost one US dollar per cubic metre), while households living in Mkuu, Dodoma (unpiped) and Moshi (sites that were unpiped during DOW I) were paying approximately half that amount. Moreover, the cost of water varied widely within the sites, with some households paying significantly more for their water than others.

Table 4.5 Average Cost of Piped Water (US$ per cubic metre)

Note * During DOW I only piped households in urban areas were included.

	DOW II		
	All Sites	Same sites as in DOW I	DOW I
Rural	0.37	n/a*	n/a
Urban	0.65	0.73	0.77
Total	**0.61**	**0.73**	**0.77**

In constant terms the cost of water for piped households (comparing only the same sites as in DOW I) has slightly decreased over the last 30 years, although this is because of a large decrease of cost in Dodoma, while water cost increased for Moshi, Chang'ombe and Temeke

(Figure 4.7). During DOW I, the cost of water averaged $0.77 pcm, and as in DOW II there was significant variation of prices across sites (Dodoma paying the highest costs, and showing the highest variability, and Moshi paying the lowest prices).

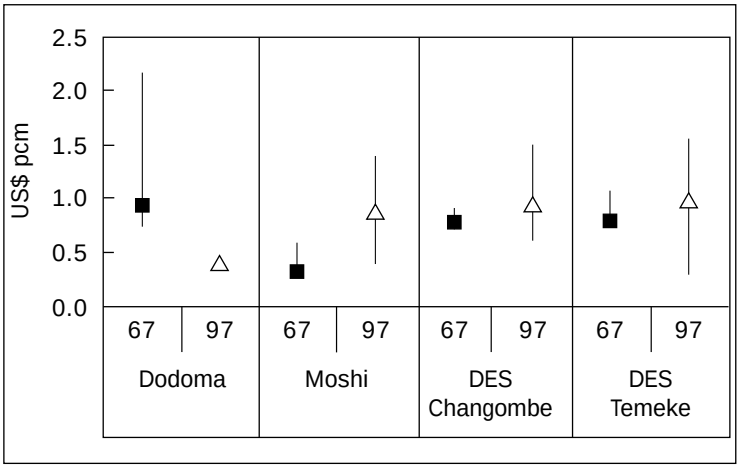


Figure 4.7 Change in Cost of Piped Water (same sites, US$ pcm)

Note Vertical line shows the range between minimum and maximum values.

It is difficult to explain why there is so great variation in price within and between sites. One possible reason is that the providers of water services varied and probably each provider determined his/her own price. However, the nature of the area (whether urban or rural) to be provided with water, the social economic status of the people served and the institutional arrangements had an influence in determining the

Drawing water from a damaged pipeline in Temeke

price of water. It is, for example, observed that households in Mkuu paid the lowest price for water. A close look at the providers of water in Mkuu shows that it is a company that is owned by the beneficiaries. They are therefore in a better position to influence the price, as opposed to Temeke where the water consumers have no say in setting the water tariffs and many purchase water from private, independent vendors.

Another reason for variability in cost within sites is linked to the existence of proportional or block rates. Households paying proportional rates show little variation within sites (for example, Upanga and Dodoma (unpiped)), while those paying block rates showed very big differences, such as Dodoma (piped) and Temeke. These households have to pay monthly rates and in many cases do not receive water for long periods. In fact, during *Drawers of Water II*, one of the key issues of discontent among piped households is the unreliability of the piped water supply. While during DOW I all households interviewed received 24-hour service, the situation was sharply different in DOW II. Only 27 percent of households living in urban areas (directly comparable with DOW I) received 24-hour supply, and 37 percent of them received only between 1 to 5-hour service. In rural areas the situation was even worse, as over half of the piped households received water for only 5 or less hours per day (Table 4.6).

Table 4.6 Hours of Service for Piped Water Supply: DOW II (Percentage)

	Rural	Urban
1-5 hours	52	37
6-11 hours	9	22
2 hours	0	14
24 hours	39	27
Total	**100**	**100**

The degree of unreliability varied within and between sites. More than 70 percent of piped households in better off neighbourhoods, such as Oyster Bay and Upanga in Dar es Salaam, received continuous 24-hour water supply. At the same time, all of the households interviewed in Moshi received less than 12-hour service and more than half of households in Mkuu and Dodoma received less than 5-hour water supply service, and according to some households only some times during the week. In Chang'ombe and Temeke, the 24-hour service was reported by only 10 percent of the households.

4.4.2 Unpiped Households

Deriving a methodology for comparison. The nature and complexity of the costs faced by both piped and unpiped urban households in obtaining water differ greatly. Households with piped water supply simply pay a fee to the service provider, which could be a block or flat rate, a proportional rate (according to consumption), or a residential rate.

Estimating the cost of water is a more complex situation for households without piped connections. It usually involves a direct cash price paid at the source, as well as the time and energy expended in travelling to and from the source, queuing for water and carrying it home. In addition, there is the opportunity cost of activities that individuals could be doing if they were not collecting water that could be as much as two hours per day for those drawers collecting water from kiosks.

Converting these costs into a comparable cash value is difficult. In the original *Drawers of Water*, a cash value was derived by estimating the amount of energy used by each household, determining the amount of a staple food (maize) required to supply this energy and then calculating the price required to purchase that amount of food. White, Bradley and White referred to this as the 'social cost of obtaining water'.

Energy expenditure was estimated based on previous estimates from other studies on African people approximately the same size of East Africans. Table 4.7 presents an estimation of the calories per hour used to walk to the source (with empty buckets), waiting at the source to collect the water, and coming back home carrying loads of different weights (14, 20 and 40 kg). Special graphs were prepared for field interviewers to make quick calculations of total amount of calories per trip.

	Walking at approx. 2.5 mph (3.5 C/K/hr)	**Sitting or standing** (1.5 C/K/hr)	**Carrying loads of:**		
			14 kg (3.7 C/K/hr	**20 kg** (3.9 C/K/hr)	**40 kg** (4.9 C/K/hr) for woman)
	C/hr	C/hr	C/hr	C/hr	C/hr
Man (58 kg)	203	87	215	226	-
Woman (54 kg)	189	81	200	211	265
Child (25 kg)	88	38	93	98	-

Table 4.7 Calories used per hour in collecting water

Source Adapted from White, Bradley and White (1972)

The other factor that contributes to energy expenditure is the gradient of land surface. More energy is required to walk uphill, especially when carrying a heavy load, and although less energy is needed to walk downhill, additional energy is needed to keep the body upright while descending a very steep slope. To overcome this issue, the original Drawers of Water used a table of slope factors, based on previous studies, and the energy expenditure was multiplied by the factor appropriate to the gradient to and from the source (Table 4.8).

Table 4.8 Calories used per hour in collecting water

Source Adapted from White, Bradley and White (1972)

Gradient (degrees)	Slope factor	
	Uphill	Downhill
0-2.5	x 1	x 1.0
2.6-5.0	x 2	x 0.8
5.1-7.5	x 3	x 0.7
4.6-10.0	x 4	x 0.6
10.1-12.5	x 5	x 0.9
12.6-15.0	x 6	x 1.0

Finally, one gram of maize meal, yielding 3.5 Calories, was used as the unit of food to provide the energy requirements. Maize was, and still is, the basic staple in East Africa, used as food or beer in the diet of farmers and people living in towns. It is also one of the cheaper foods, which is appropriate in the study to avoid overestimation of costs. This method has been repeated for *Drawers of Water II* to enable direct comparison of the cost of water for piped and unpiped households and the assessment of how the cost of water has changed over the past three decades.[20] It is important to recall that while this measure might not be directly comparable with other values estimated in different studies, it still is a very useful tool to enable direct comparisons of how the cost has varied since the first *Drawers of Water* study.

Results. The reported average cost for all unpiped households during DOW II was $1.4 pcm (ranging from $0-$6.5 pcm). Furthermore, unpiped households living in urban areas, were also found on average, to pay more than twice the costs faced by households without water connection in rural areas (Table 4.9). The cost of water for unpiped households has increased an average of 30 US Cents per cubic metre over the last thirty years (comparing only sites that were unpiped during DOW I). The change was bigger for unpiped households located in rural areas, where costs were more

20 The methodology developed by *Drawers of Water I* to estimate the cash price of water for unpiped households has a number of shortcomings, making its reliability problematic. For example, the opportunity cost of time is not included, and the use of the average price of staple food masks seasonal and inter-household variation.

than double the original levels, while the cost for urban unpiped households remained almost unchanged. Extending the analysis to incorporate unpiped households living in sites that were categorised as 'piped' in DOW I makes the average cost increase, and shows how unpiped households in Tanzania are paying twice as much as they did in DOW I (from 0.7 to 1.4 US Cents).

	DOW II		DOW I
	All Sites	Site was unpiped in DOW I	
Rural	0.95	0. 95	0.4
Urban	1.94	1.24	1.13
Total	**1.4**	**1.0**	**0.7**

Table 4.9 Mean Cost of Water for unpiped households (US$ per cubic metre)

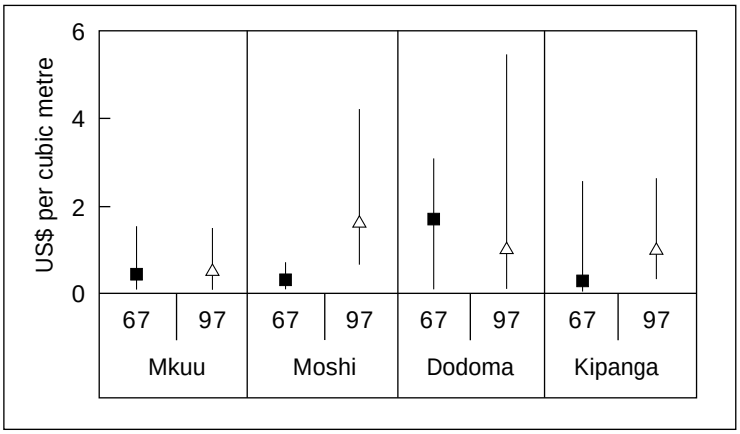


Figure 4.8 Change in Cost of Water for Unpiped Households (US$ per cubic metre)

Note Vertical line shows the range between minimum and maximum values. "New unpiped" households not shown in the graph are Moshi (piped), Chang'ombe, and Temeke.

Water cost is consistently lower in the rural sites (Mkuu and Kipanga), although it has increased in the past thirty years. Water sources have not changed considerably since DOW I, and standpipes or hydrants are used as the primary source by most households in Mkuu, while over 80 percent of those living in Kipanga depend on unprotected sources such as streams, rivers or reservoirs.

Households living in previously pipes sites reported high costs of water in DOW II, like Chang'ombe and Temeke ($4 and $3 pcm respectively. Households living in these densely populated sites rely on the most expensive water sources: 'Neighbour' (50 percent and 60 percent in Chang'ombe and Temeke, respectively) and 'Vendor' (50 percent and 33 percent, respectively). It is important to recognise the magnitude of inequalities and wealth disparities that are hidden in

situations like these, where the poorest households are forced to pay the highest prices to cover their basic needs.

Women, children and a boy queuing for water at a water point in Moshi urban

	Cost ($US pcm)	Distance (metres)	Time (Return, minutes)
Vendor	5.6	0	0
Kiosk	1.8	158	40.3
Other	1.2	220	12.0
Neighbour	1.1	37	12.2
Stream, canal, or river	1.1	1110	58.1
Well-pumped	1.0	233	16.0
Hydrant or standpipe	1.0	230	44.3
Piped to building	0.6	54	95.3
Reservoir or depression	0.6	114	25.0
Total Average	**1.4**	**460**	**38.0**

Table 4.10 DOW II- Average Cost, Distance and Time in Water Collection for Unpiped Households, by Primary Source

The cost of water depends to a large degree on the source. As Table 4.10 shows, water bought from vendors is the most expensive in the country (5.6 US$ per cubic metre and sometimes even more. It is often poorer households living in unpiped urban areas or areas with erratic piped services that are forced to use these sources. Kiosks are the second most expensive water sources in Tanzania. Although they were usually conveniently located within an average of 150 meters to the household, waiting times were long and on average, households invest 40 minutes per trip to this source. The same applies for other sources such as hydrants, located within a range of 230 meters but with long waiting times. Households obtaining water from pipes to buildings outside the home (churches, mosques, government offices, etc.) had to wait, on average, 95 minutes per trip. Water obtained

from unprotected sources such as streams and rivers usually did not involve a cash price at the source, but the energy requirements were usually higher for them, involving long distances (more than 1 kilometre) and an average of one hour per trip to the source.

4.5 Determinants of Water Use

In addition to developing an understanding of daily per capita and total household water use, the DOW I study team also investigated the factors that they thought would have significance in shaping water use. When White, Bradley and White carried out their original analysis of water use in East Africa in the 1960s, they singled out several factors, such as size and composition of family and level of material wealth as being important variables.

In order to investigate whether determinants of per capita water use have changed over the last three decades, a multivariate regression analysis was performed. The analysis used DOW I as a baseline and estimated the best fitting model. This model was then applied to the DOW II data, thus allowing for direct comparison over time. Due to major differences between the groups, the analysis was done separately for piped and unpiped households.

4.5.1 Piped Households

Table 4.11 presents the most important variables that affect per capita water use in piped households. In DOW I the two most important variables determining water use were the number of people in the households and the cost of water (both with a negative effect). Ethnicity was an important factor. In the 1960s the three major ethnic groups described by White, Bradley and White were Urban-Asian, Urban-African, and Urban-European (39, 36, and 20 percent respectively). The model shows that the third major factor influencing water use is whether or not the household belongs to the Urban-European group; most of them (80 percent) were living in Oyster Bay, Dar es Salaam. At the same time, per capita water use would decrease if the individual belongs to the Urban-African group. As expected, the number of rooms and the number of taps, both proxies for wealth, have a positive effect on per capita water use.

The Rise of the Water Vendor

While private water vendors were observed in the original Drawers of Water study, they have come to play an important role in Tanzania in recent years as piped water services have become more unreliable and unpredictable. Most water vendors are independent entrepreneurs who pass from house to house, delivering water in 20-litre containers. The most common method of transportation is using two-wheeled pushcarts carrying six to eight jerry cans of 20-litres capacity. The vendors are generally young men, with an average age of 27-30 years. The majority have only primary school education. They are driven to do this kind of job mainly because of lack of alternative employment opportunities. Thus, while they work for long hours from early morning till late in the evening (to meet peak demand), they can also make a reasonable return on their investment.

Most of the pushcart water vendors in Dar es Salaam buy their water from reselling households or from standpipes owned by a public utility, Dar es Salaam Water and Sewerage Authority (DAWASA). It appears that the choice of a source to use by the water vendor is influenced by distance, water quality and reliability of supply.

A second type of water vendor that has sprung up, especially in Dar es Salaam, involves mostly well-to-do people who use tank trucks. The tankers have the capacity to carry between 10,000 and 20,000 litres of water and vendors sell water to households with storage tanks. The third category of water vendor comprises households with standpipes who sell water to neighbours without water connections and sometimes to other water vendors.

Table 4.11 Determinants of Per Capita Water Use: Piped Households

DOW I			DOW II		
Name	**Effect**	**Estimated Coefficient**	**Name**	**Effect**	**Estimated Coefficient**
Number of people in the household [a]	Negative	-0.69	Number of people in the household [a]	Negative	-0.28
Cost of water* (US Cents per litre)	Negative	-0.42	Proportion of Children	Negative	-0.57
Urban European Ethnicity [b,c]	Positive	0.39	Cost of water [a] (US Cents per litre)	Negative	-0.14
Number of Rooms [a] (proxi for wealth)	Positive	0.29	Hours of Service [a]	Positive	0.18
Number of Taps [a]	Positive	0.15	Education[a]	Positive	0.36
Urban African Ethnic [b,c]	Negative	-0.16	Number of Roomsa, [b] (proxi for wealth)	Positive	0.13

Note In a) the natural logarithm was used to facilitate elasticity estimates. b) statistically significant at 0.15 percent level (all other variables are statistically significant at 0.05 percent). c) Variable is in Dummy Form (Yes, No). No evidence of heteroskedasticity was found.

Thirty years later both the composition and the degree of influence of determinants of per capita water used had changed. While number of people in the household remains being the most important factor affecting water use, the proportion of children becomes an important factor that decreases per capita water use in the household.[21] In Dodoma and Moshi, for example, more than 30 percent of members in the household are of age 15 or less. This situation is critical for children care, since less water is available to provide for basic needs. As in the late 1960s, cost of water has a negative effect on per capita water use. As we could expect, the availability of water supply is important in water use, and increasing number of hours of service has a positive effect on per capita water use. The last two variables (proxies for wealth) education and number of rooms have a positive effect on per capita water use.

21 Although not statistically significant, in 1967 the proportion of children was positively correlated with per capita water use in the household.

It is somehow not surprising that factors like number of taps do not seem to be significant in determining water use, since in many cases water supply does not depend on the number of taps but on how often they have running water. Ethnicity was not statistically significant, either. By the late 1990s, the ethnic composition in Tanzania was predominantly Urban-African (50 percent) and Urban-Asian (27 percent), with only 6 percent of Urban-European (most of which is still in Oyster Bay).

4.5.2 Unpiped Households

As it was the case for households with piped connections, in DOW I

the most important factors determining per capita water use were the number of people in the household and the cost of water, both with a negative impact (Table 4.12). One major difference with respect to piped households is the fact that the proportion of children in unpiped households seem to decrease per capita water use, while for the first group its impact was positive. As was discussed previously, this situation has important issues to be address regarding children's rights to water. Not expected, time spent fetching water seem to have a positive effect on per capita water use. This is probably related to the fact that drawers will carry larger amounts of water to make fewer trips to the source. Urban-African households seem to use more per capita water than other ethnic groups. This is expected if we consider that this factor is very related to rural/urban location. For example, ethnic groups like Chagga and Gogo are predominantly located in rural areas. That said, the model also shows that per capita water use is higher for unpiped households living in urban areas (although this result is not statistically significant).

In DOW II the most important factor determining per capita water use was the relative wealth of the family. Due to the difficulty to obtain a direct measure of income, this variable was approximated by an equipment index, which contains information such as type of roof, electricity, and household appliances. Also, as for the previous models, the amount of water for each member decreases as the number of people in the household increase. Households that wash their clothes only at home seem to use less per capita water, probably indicating the greater effort involved in carrying the water instead of using it directly at the source.

Location is also important in determining per capita water use, and the results show that urban households are more likely to use more water than those living in rural areas. Cost of water comes fifth in the scale of water use determinants, and as expected it is negatively correlated, which indicates that as price increases, per capita water use decreases. Ethnic origin does not have any statistically significant effect in per capita water use.

Table 4.12 Determinants of Per Capita Water Use: Unpiped Households

DOW I		DOW II	
Name	**Effect**	**Name**	**Effect**
Number of people in the household [a]	Negative	Equipment Index [a]	Positive
Cost of water [a]	Negative	Number of people in the household [a]	Negative
Proportion of Children in Household	Negative	Household washes clothes at home [c]	Negative
Time (minutes) [a]	Positive	Site is Urban [b]	Positive
Urban African Ethnic [c]	Positive	Cost of water [a]	Negative
Household head is a farmer [b, c]	Negative	Rain-Water is used [c]	Negative
Household washes clothes at home [b, c]	Positive	Education [a, b]	Positive

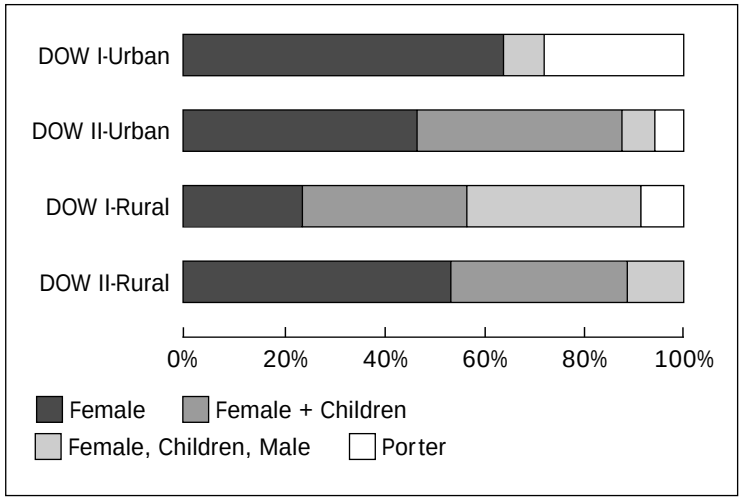
Note In a) the natural logarithm was used to facilitate elasticity estimates. b) its magnitude is significant although it is not statistically significant at 0.05 percent level.c) Variable is in Dummy Form (Yes, No). No evidence of heteroskedasticity was found.

In DOW I, the primary drawers of water for domestic purposes were women and children. In urban areas, the responsibility of water collection relied primarily on women (64 percent of the households), although almost 30 percent of unpiped households in urban areas reported using a vendor as their primary source (all of which were of Urban-Asian origin). In rural areas men were more likely to take part in water collection activities, either for commercial purposes, as water vendors or for brewing local beer.

4.6 Who are the Drawers of Water?

As reflected in Figure 4.9, this remains the case thirty years later with women alone or women and children being cited as the primary drawers of water both in rural and urban areas (88 percent and 89 percent of households, respectively). Men take less part in the water collection activity (less than 10 percent of households, most of them belong to the Chagga ethnic group).

Figure 4.9 Primary Drawers of Water in Unpiped Households, DOW I and II



5 Environmental Issues

5.1 Variations in Water Availability

The performance of water supply facilities was found to vary from place to place depending on a number of factors including; climatic variability, availability of adequate financing, involvement of stakeholders and degree of maintenance. Seasonality of rainfall was found to have a severe impact on water availability, especially in rural unpiped areas. In these areas, people were found to depend on seasonal rivers, which carry water during the rainy seasons but are dry during the dry season.

In Kipanga, one of the rural unpiped sites, people were found to draw water from shallow holes dug in the dry sand river beds of these seasonal rivers. Lack of adequate financing, especially for operation and maintenance, has had a negative impact on water availability. It was found, for example, that in Kipanga the water supply infrastructure was not delivering water because there was no money to pay for diesel to run the pump. Broken pumps and pipelines lying in disrepair are a common sight in some places. This state of affairs can be blamed on the lack of a proper maintenance which is partly the outcome of the past policy whereby all activities related to water supply were the responsibility of the central Government. Stakeholders were never required to participate in water supply activities but were, instead, passive receivers of Government benevolence, a role they played very well but to their own detriment.

During the study, respondents were asked whether they had experienced water shortages and, if so, how long they had lasted for. Sixty-six percent of respondents had experienced shortages and foresaw that shortages would continue in the future, assuming that no change in water supply management is expected to take place.

5.2 Environmental Degradation and Pollution

The impact of human activities on the environment in general, and on water supply in particular, has varied among the study sites depending on the type of activity and the ambient environment. For example, the extension of agricultural activities into the forested catchment areas on the slopes of Mount Kilimanjaro has led to severe soil erosion and to an increase in surface run-off. As a result, rivers flowing down the slopes of the mountain are now carrying a heavy sediment load, thereby affecting the quality of water and sometimes leading to blockages in pipes.

In Dodoma, the negative environmental impact of human activities is evident in the form of water source pollution and overgrazing. Signs of overgrazing have started to appear due to an increase in the number of livestock in the area. Furthermore, due to the scarcity of surface water sources, livestock use the same sources of water as humans. Consequently, these sources (which in many cases are unprotected water holes dug in the dry sand river-bed) get heavily polluted by the dung from livestock.

5.3 Effect of Population on Water Availability and Use

The increase in population has exerted pressure on water supply facilities and has affected water availability negatively, especially in urban areas. The results from *Drawers of Water II* show that per capita water use in urban areas has declined over the past thirty years. This decline is probably due to the fact that although the population of the urban centres has more than doubled over the past 30 years, water infrastructure has either remained the same or expanded only slightly. Water supply has not kept pace with population increase.

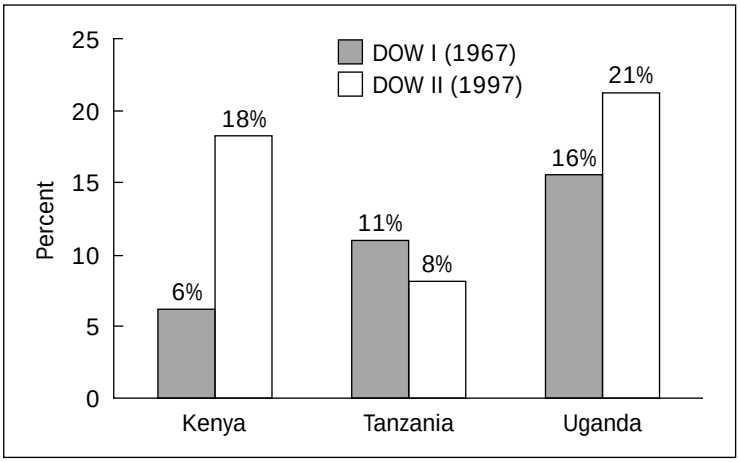
6 Health and Sanitation Issues

Water is universally recognised as a critical resource that is closely related to health. Besides being critical to the sustenance of life, the quality and quantity of water consumed is also critical to the transmission of many diseases. When arguing for the importance of water, it is common to oversimplify its role, and overemphasise the significance of contaminated drinking water. In actual fact, the role of water in washing away pathogens from people is at least as important as its role in bringing pathogens to people. Consequently, in areas where faecal-oral diseases are endemic, how much water people get, and how they use it, are probably more important than its quality. This is why issues of per capita and household water use were closely examined in this study.

Diarrhoea is commonly associated with the digestion of contaminated water. Therefore, in this study, one way of trying to understand the quality of water people were using was to find out whether people in the study sites were suffering from diarrhoea diseases. Information was obtained on the incidence of diarrhoea during the past week and within the last 24 hours in both piped and unpiped sites.

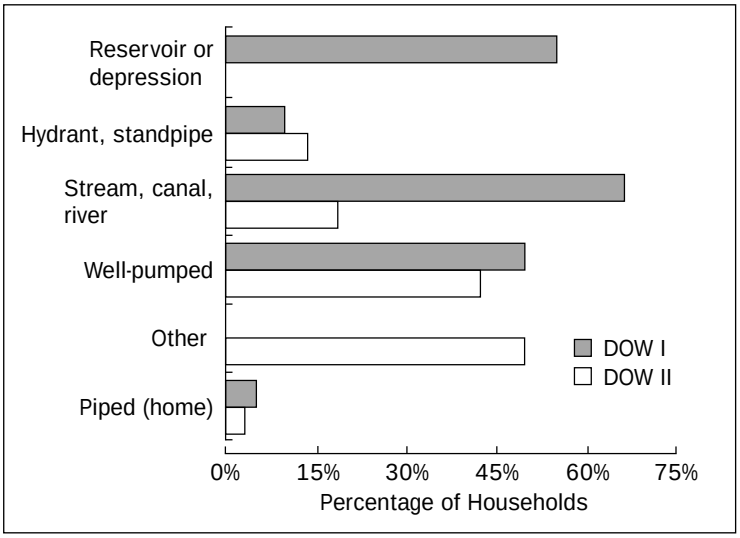
There was considerable discrepancy between the diarrhoea rates of sample households in Tanzania and those in Kenya and Uganda in terms of the percentage which responded that there had been a case in the last week and those which said this was not the case, with Tanzania showing much lower report rates. The prevalence of diarrhoea has increased in Kenya and Uganda, while declining a little in Tanzania over the three decades. (Figure 6.1)

Figure 6.1 Prevalence of Diarrhoea by Country, East Africa, DOW I & II



In DOW I, almost 25 percent of unpiped households in Tanzania reported diarrhoea incidences during the week previous to the study. The incidence was very large for households who depended on streams, canals or rivers (67 percent reported incidences), followed by those from reservoirs or depressions and wells. The 'safest' water source was hydrants and standpipes, in which only 10 percent of households reported some diarrhoea case. Only approximately five percent of piped households did report a diarrhoea incidence (Figure 6.2).

Figure 6.2 Households who reported Diarrhoea during the Previous Week (Percent), by Water Source



During DOW II at least 17 percent of unpiped households experienced at least one incidence of diarrhoea during the previous

week. The highest incidence was in Dodoma, where 33 percent of the households reported at least one case of diarrhoea, followed by Kipanga (23 percent) and Mkuu (20 percent). Only three percent of piped households reported any incidence of diarrhoea, most of which were located in Moshi. It is interesting to note that 50 percent of households using 'other' water source reported incidences of diarrhoea. Households drawing water from unimproved wells also reported very high diarrhoea incidence.

What has clearly emerged out of this study is that hygiene related factors are important determinants of prevalence of diarrhoea in the study sites. While there is no single proxy for hygiene behaviour, regression analysis showed that the means of disposal of faeces, the amount of water used for household cleaning, and the level of education of the head of household were important. For example regression analysis revealed that unsafe disposal of children's faeces increases the diarrhoea rate by 2.5 per cent for East Africa as a whole, while households which increase their use of water for household cleaning purposes by 10 per cent will reduce the incidence of diarrhoea by 1.3 percent.

Other hygiene and sanitation related factors influencing the prevalence of diarrhoea include unsafe wastewater disposal and presence of faecal matter in the toilet surroundings.

The availability of water for personal hygiene is important. A comparison of DOW I and DOW II reveals a significant decline in mean per capita water use over the past three decades. This is a reflection of the almost universal decline in water use by households with a piped connection. While per capita water use in unpiped households almost doubled (from 13.5 to 18.6 litres) use for piped households decreased from 141.8 to 80.2 litres. This decline in the amount of water available, especially in the urban areas in the region, means that people's health and hygiene are likely to be affected. When there is not enough water to go round, it means that there will be less water for cleaning utensils, for washing hands after defaecation or handling children's faeces, regular baths, cooking and eating.

Despite the increase in the amount of water available per capita for unpiped households, the amount available (18.6 litres per capita per day) is hardly adequate. In fact our study has shown that the unpiped households suffer lower hygiene levels as a result of not having a regular water supply. For example the unpiped households use less than half the amount of water used by households with piped connections for bathing, washing dishes, clothes and house cleaning. Yet recent studies have demonstrated that many diarrhoeal diseases can be prevented or reduced by improving water related hygiene behaviour. [22]

Thus, a number of key conclusions have emerged from the study:

- The greater the quantity of water used for cleaning the lower the incidence of diarrhoea. Households which increase their use of water for household cleaning purposes by 10 percent will reduce the incidence of diarrhoea by 1.3 percent.
- Unsafe faeces disposal increases the rate of diarrhoea by 2.5 percent
- Increased education levels reduce the incidence of diarrhoea by 3.7 percent for each 10 percent increase in the number of years attended.

Thus, while there is a clear and pressing need for increased levels of investment in water and sanitation facilities in Tanzania specifically and East Africa in general, well-designed hygiene programmes must accompany these improvements or some of the environmental health benefits will be lost.[23]

22 van der Hoek, W., Konradsen, F. and Jehangr W.A. 1999. Domestic Use of Irrigation Water: Health Hazard or Opportunity? *Resources Development* 15 (1/2):107-19. Esrey, S.A. 1996. Water, Waste and Well-Being: A Multi-Country Study. *American Journal of Epidemiology* 143(6): 608-623.

23 Further details on this issue will be addressed in a forthcoming article by the DOW II team: Tumwine, J., J. Thompson, et al. 2001. *Diarrhoea and Effects of Alternative Water Sources, Sanitation and Hygiene Behaviour In East Africa*.

7 Technological Issues

In sites where water is carried from the source to the home, several technological issues were examined including who collects and carries water, what type of vessels are used, whether water is stored and what type of storage vessels and facilities are used.

7.1 Water Collection

Women and children, who as noted earlier are the primary drawers of water, use a variety of vessels to collect water, which after filling them with water they carry on their heads. Bicycles, carts, donkeys and a yolk are also used in transporting water containers. The most common vessels used for carrying water were found to be pots, jerry cans, gourds, basins and buckets.

Male child carrying water in Kipanga

7.2 Container Size

Although drawers of water use a wide array of containers to carry water yet the most common container appears to be a 20-litre jerry can. There has been very little change in the average size of containers since DOW I. The only change is that during DOW I study period the 20 litre container was made of tin (debe), now the present jerry cans are made of plastic materials.

7.3 Water Storage

In low-income households, vessels which are used in collecting water are also used as water storage facilities. In addition to the small water collection vessels, 200-litre steel drums were found to be widely used for storage purposes by households which could afford to purchase them. Due to the unreliability of water supply experienced in many urban centres, many households, with or without house connection, are now using polytanks of various capacities to store water for domestic use. The only change in water storage technology between DOW I and II has been the introduction of polytanks whose capacities range from 200 to 15,000 litres. These storage facilities are, however, found mainly in urban centres.

7.4 Water Supply Technologies

Water supply technologies being used in both rural and urban areas involve a mixture of pumping, piping, gravity and shallow wells. At one time Tanzania expected to meet 50 percent of its rural water needs from ground sources. This led to the development of deep, medium and shallow wells in many parts of the country. There are, however, other parts of the country, which are well endowed with surface sources, where water flows by gravity. These sources have been tapped by building gravity supply schemes, as is the case in the study site of Mkuu.

7.5 Range of Choice

Households without piped water supply have to make choices over which source of water to use and how much to collect. Drawers of Water II tried to shed light over which factors influenced source selection. Examination of source preferences was based on several assumptions. It was first assumed that a drawer of water will always strive to achieve

economic optimisation by obtaining the greatest returns from time and energy spent in collecting and carrying water home. This assumption was investigated by looking at distance travelled and energy spent in fetching water relative to the amount collected. The thinking behind this was that the nearer the source, the more water would be used. Other factors expected to influence source selection were the drawer's perception of the quality of the source, the technical means available to the drawer for drawing water from the source, costs and returns.

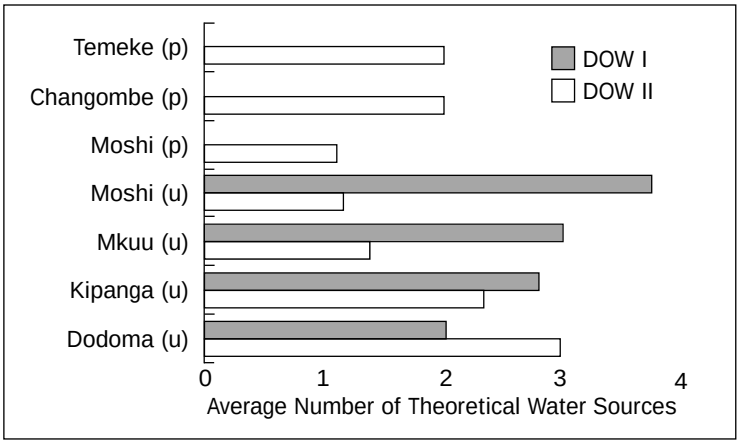


Figure 7.1 Unpiped Households: Average Number of Theoretical Water Sources, by Site

The study assumed that in unpiped sites the drawer would have a wide selection of sources. In fact, in designing the research instruments, there were provisions for recording as many as seven sources from which a water collector could choose. However, field results did not support this assumption. Although all sample households interviewed used more than one source, very few households used more than three sources. The mean number of sources for all respondents was 2.1, with a minimum of 1 and maximum of 5. In fact, the average number of sources used is almost the same to that found in DOW I (3).

The use of a general average hides the variations between households and study sites. It appears that households in areas with reliable sources (such as hydrants in Mkuu) use fewer sources compared to those households in areas where sources are relatively less reliable or that are more likely to overcrowding, such in Dodoma, Temeke and Kipanga.

8 Institutional Issues

8.1 The Role of Government

Water supply in Tanzania has historically been the responsibility of Government. The Ministry of Water has been the main actor at the national level as well as at a more local level through its regional and district offices. This has been especially so since the introduction of the Free Water Programme in 1971, which until recently, the Ministry of Water has been playing a key role in implementing. The Ministry has consequently been responsible for the design and construction of large water supply projects which are regarded to be beyond the capacity of the regions and districts in terms of technical and managerial expertise as well as financial capacity. Operation and maintenance, especially of large schemes, has also been the responsibility of the Ministry of Water.

However, as described in the introduction, an increase in the number of water schemes constructed, coupled with the dwindling government budgetary allocation to the sector, left the Government unable to run the sector by following the centralised top-down approach. It became evident that the mandated role of the Ministry of Water had to change from being an implementer to a facilitator, regulator and promoter. Under this new thinking, the Ministry of Water will now responsible for:

- Reviewing and coordination of National Water Policy development, and supervision of its implementation.
- Development and updating of strategies, plans and programmes.
- Identification of water sources; facilitation, regulation, supervision, monitoring and coordination of surface and groundwater water resources development and management

including monitoring of quality and quantity, assessment, regulation of its utilization and control of pollution.
- Coordination of resource utilization and mobilization with stakeholders including urban water authorities, donors, NGOs and the public.
- Ensuring and protecting National interest in, and development of programs for the utilization of internationally shared water sources.
- Facilitation of the provision of adequate, clean and safe water for domestic, agricultural and industrial, power generation and other uses.
- Facilitation of the development and management of sewerage systems.
- Promotion of technologies that enhance water use efficiency.
- Preparation of programs and strategies for the management and mitigation of water related disasters, such as floods and droughts.
- Promotion and implementation of integrated water resources management and development.
- Facilitation of research on water resources, water development and sewerage disposal, appropriate technologies and dissemination of research findings.
- Provision of guidance and advisory services in the development and management of water resources, water supply and sewerage services.
- Coordination of donors sponsored or assister water projects.
- Creation of enabling environment for private sector participation in the development and management of water supply and sanitation.
- Prepare and supervise programs for dam safety monitoring.
- Developing and providing various publications and dissemination on water resources, and provide regular reports on the status of the National water resources.
- Respond to public queries on the sector.

In addition to the Ministry of Water, other Ministries also have a role to play in the management of water resources. Their roles have fortunately been clearly stated in the draft National Water Policy. This is intended to eliminate overlapping of responsibilities and conflicts in the use and management of the resource.

Definition of the new roles has called for a new organisation structure. Currently the Ministry of Water is divided into three technical departments: (i) Water Resources, (ii) Rural Water Supply, and (iii) Urban Water Supply and Sewerage. In addition, there are two technical units: (a) the Central Water Board, which handles the regulatory functions of water resources management and development, and (b) the Central Water Laboratory, which deals with water quality issues and monitors water pollution.

8.2 Water Users' Associations

In reviewing the performance of different organs dealing with water supply, it has become evident that water users and their organisations are crucial for the sustainability of water supply systems. It has therefore been resolved that Water Users' Associations (WUAs) or Water Users' Groups (WUGs), smallholder or small scale users such as Village Water Committees (VWCs) will be the lowest appropriate level management and will, among other things, be responsible for:

- Self-policing, conservation and protecting water sources.
- Management of water resources at their local, catchments or sub-catchments level.
- Formulate and perform local water allocations among competing uses from stipulated quantities of water rights.
- Crisis management including water allocations during droughts periods.
- Resolve disputes among users.
- Guard and take readings from national gauging stations.
- Operations and maintenance of their water supply schemes.
- Communication with wards, districts and Basin water Offices on water related matters.
- Participating in various surveys, collection of various fees and charges from users and community members.
- Participating in the integrated planning of the use of water resources.

8.3 The Role of the Private Sector

Because the delivery of water supply services has been dominated by the public sector, the private sector has been involved in only a few

cases. Foreign firms have dominated the scene. Domestic firms have at best been involved minimally in spite of being conversant with local conditions, easily obtainable when the need arises, and generally requiring payment in local currency.

The marginalisation of the private sector in water delivery services has been influenced by the Government's outlook on this issue. For example, in the National Investment Promotion Act No. 10 of 1990 the provision of water for domestic and industrial purposes is defined as an area of strategic importance reserved exclusively for investment by the public sector. Furthermore, for many years, water has been regarded as a "free" commodity offered by the Government to the people, and as such, it has been difficult to attract the private sector into the water industry, as the environment has not been conducive for private investment. For the private sector to be involved more effectively in water supply activities it is necessary for the government to create an enabling environment. One such measure is an amendment of the National Investment Promotion and Protection Act schedule which exclusively addresses public sector participation in the water industry.

A number of domestic private drilling firms have been registered. However, the private sector is not seen to be effectively picking up momentum in the field of water well drilling considering the enormous potential that exists. The scene is still dominated by the public sector and a few foreign firms. However, due to inherent inefficiencies, output of Government-owned drilling equipment is far from satisfactory.

In a recent study on private sector involvement it was observed that the major problems facing private drilling companies can be summarised as:

- high cost of purchasing drilling equipment;
- non-availability of drilling materials including spare parts, casings and chemicals;
- uncertainly on a steady volume of work to meet overheads;

- the difficulties in obtaining bank loans; and
- the high interest rate (30 percent per annum) on loans from local commercial banks.

Local drillers complain of bureaucratic red-tapes which they experience in the course of registering and establishing themselves. They are required to pay in advance, business taxes on projected assessment of their future earnings, thus distorting free and fair competition in favour of foreign firms. Local drillers are thus left with little alternative to charging higher prices or providing inferior quality service.[24]

8.4 The Role of Civil Society Groups

In addition to private sector involvement in the provision of water, local communities through their various organizations are increasingly getting involved in water supply activities. Village communities have, for example, formed water users associations that are charged with the responsibilities of managing water supplies in their communities. In some areas local communities have formed water companies which are responsible for looking after water supply affairs. Villages have formed water committees and established water funds.

Non Governmental Organizations (NGOs) are playing a big role in improving the water supply situations especially in rural areas. Another category of players are religious organizations which are assisting local communities in solving their water supply problems.

The contribution of these civil society groups in improving the water supply conditions in the country is well recognised by the government. That is why in the revised new National Water Policy the participation of the civil society groups is encouraged and their roles and responsibilities are clearly articulated.

24 Ministry of Water. 1995. *Water and Sanitation Sector Review*. Government of the Republic of Tanzania: Dar es Salaam.

9 Policy Implications

Drawers of Water II study results do not show an improvement in the level of domestic water supply service in Tanzania over the past 30 years. There has, in general, been a decline in the mean per capita water use in piped households. Distances travelled to the water sources have not been reduced as anticipated. Unpiped households are using less water per capita and are paying more per unit of water collected compared to piped households. Water supply systems are either functioning below installed capacity or, in some cases, not functioning at all due to various reasons. All these findings have some policy implications as discussed here below:

9.1 Rural Areas

It has been observed that in a majority of cases water supply and sanitation facilities have been provided without the active participation of the beneficiaries in planning, operation and maintenance. Consequently, ownership of these facilities have never been perceived to be, nor legally invested in user communities. As a result, sustainability has been lacking due to lack of commitment on the part of the beneficiaries to operate, maintain and protect the facilities. It is imperative that if sustainability is to be achieved in water supply in rural areas, the following will have to take place:

- Communities will have to be empowered to initiate, own and manage their water supply schemes

- It will be necessary to promote participation of the private sector in the development and management (on request of and on behalf of communities) of rural water supply and sanitation. It is likely that, in most cases, this will come in the form of small-scale

service providers, such as independent vendors.

- Government role will have to be limited to that of a regulator, facilitator, and coordinator

- Emphasis will have to be placed on integrating water supply, sanitation and hygiene education to maximize health impact of water supply investments.

- The basic level of service for domestic water supply, in rural areas, will have to aim at supplying all year round, a minimum of at least 25 litres of potable water per capita per day, through domestic water points which must be located not more than 400 metres from a homestead

- Government will have to continue with the responsibility of mobilising and providing financial support to compliment community efforts. Water scarce areas will have to be given priority in investment

9.2 Urban Areas

Urban water supply systems have been found to be old and dilapidated. Furthermore the urban systems are required to meet higher demands beyond their design capacities.

To improve on their performance the following steps will have to be taken:

- Water supply and sanitation (WSS) systems shall have to be effectively operated and assets adequately maintained with a view of attracting capital and motivating customers to pay for the services provided

- Recognising the existence of low-income groups in the urban and peri-urban areas, WSS entities shall be required to provide them with, at least, basic WSS services at a cost which they can afford.

9.3 Policy Actions

9.3.1 Changes in domestic water use

The *Drawers of Water II* research results show that although the mean per capita water use in unpiped household increased from from 13.5 litres in 1966 to 18.6 litres in 1997, yet it falls below the design standard of a per capita use of 25 litres.

> Efforts should therefore be directed at enabling people to have access to a basic service level of 25 litres of water per capita per day. This means greater financial commitments, in real terms, by both government and foreign donors. Charging water users the real cost of water will not, in itself, bring about adequate improvements in coverage. It will also have to be accompanied by appropriate technology options.

9.3.2 Determinants of water use

In both unpiped and piped households the main determinants of per capita water use are the household's 'wealth' and cost of water. Piped households still pay much less than households obtaining water from vendors.

> There is need to institute policies and programmes to improve the economic well being of low-income households and to review the overall pricing of water in order to address the needs of the rural and urban poor.

9.3.3 Deterioration of pipe water systems

Most of the piped systems have experienced a significant deterioration mainly because of the stress of increasing urban populations and lack of system maintenance and investment.

> In order to halt this deterioration, there is need for innovative approaches to investment financing and capacity building of private and public and local water user groups.

9.3.4 Burden of water collection

The burden of water collection is still borne by women and children. This is aggravated by long waiting times at the source and labour intensive methods of carrying water.

There is a clear need to alleviate this burden by improving economic and general well being of women and children enabling them to participate in household and community decision making process.

9.3.5 Health and hygiene

Diarrhoea and other water-related diseases are still a problem. The study results show that the highest incidence was in Dodoma followed by Kipanga and Mkuu. Provision of safe water alone is not enough to eradicate water related diseases. Provision of improved water supplies and services has to be accompanied with hygiene education which would greatly improve the health impact of water and sanitation interventions.

There is a clear and pressing need to increase levels of investment in water and sanitation facilities. These investments must be accompanied by effective environmental health and hygiene programmes to maximise health benefits.

On the issue of health, emphasis will have to be placed on integrating water supply, sanitation and hygiene education to maximize health impact of water supply investments.

9.3.6 Stakeholders and sustainability

It was observed that sustainability of water supply schemes is still a problem. This was, for example, a case in Kipanga, where the village water supply scheme was not operating properly. The explanation given for this state of affairs was that the community was not responsible for the operation and maintenance of the borehole and the pumping machine. It is argued that sustainability of water schemes, especially the small rural water supply schemes, like the one at Kipanga, can be enhanced if the stakeholders own the scheme and are involved in the planning, development, operation and maintenance.

Communities should be empowered to initiate, own and manage their water schemes. They should therefore be well informed to be able to make choices of the most appropriate technology options that will give them the highest service level that they want, can afford and can operate and maintain.

In executing their responsibilities communities should be responsible for letting and supervising design and construction contracts to private consultants/ contractors. They should also manage operations and maintenance of their schemes.

The study results show that in addition to government agencies there are other institutions like church organisations, NGOs, and private sector actors that are engaged in the supply of water services. Water vendors using different delivery means were, for example, observed in Dar es Salaam, Dodoma and Moshi. It is evident that private sector, in particular, has an important role to play and may even play a greater role in future, bearing in mind that the current water policy requires the Government to act as a facilitator and not a provider of water. Under these circumstances it is to be expected that

In future, the Government will need to limit its role in the water sector to that of a facilitator and coordinator. To do this, it will need to develop new capabilities to oversee and regulate the increasing range of private and public actors. Training and capacity strengthening of staff will be required to take on these new responsibilities, as will new organisational norms and operational procedures.

An enabling investment and regulatory climate for private sector participation in development and management of water supply schemes in poor urban and rural areas will need to be created. This will involve changes in laws and policies to stimulate private sector involvement, support effective public-private partnerships, and ensure that water users and service providers all benefit from the new arrangements.

Appendix

Appendix 1. Summary Averages for Piped Households, DOW I & II

		Same Sites as DOW I	Moshi	Dodoma	DES-Oyster Bay (L)	DES-Upanga (ML)	DES Chang'ombe (MH)	DES Temeke (H)	'Newly Piped'	Mkuu	Moshi	Dodoma
Sample size	DOW II	161	18	35	30	30	28	20	55	23	9	23
	DOW I	157	25	47	31	26	22	6	--	–	–	--
Number of Household Members	DOW II	6.10	7.6	7.7	4.2	4.3	3.8	13.8	6.1	6.4	5.8	5.8
	DOW I	6.31	5.6	6.9	6.0	5.9	6.8	6.4	--	–	–	--
Years of Education	DOW II	14.13	11.2	13.8	17.2	14.7	14.7	12.6	9.3	9.0	10.1	9.4
	DOW I	9.80	8.8	8.6	14.0	9.4	9.4	6.8	--	–	–	--
Per Capita water use (litres/day)	DOW II	65.81	40.7	62.1	164.3	n/a	43.7	64.4	38.9	30.5	29.1	51.1
	DOW I	128.14	108.2	72.1	243.9	157.7	161.1	153.5	--	–	–	--
Total Water in Household (litres/day)	DOW II	367.77	221.5	365.5	791.2	n/a	431.4	264.5	236.0	196.0	167.9	297.8
	DOW I	691.27	777.7	473.7	924.7	637.0	540.8	1157.0	--	–	–	--
Cost of Water (US$/m3)	DOW II	0.73	0.87	0.41	--	--	--	0.97	0.41	0.37	0.41	0.49
	DOW I	0.77	0.32	0.95	--	--	--	0.81	--	--	–	--
Receive 24-hour supply	DOW II	55.70	0	11.40	70	73	11.00	10	0.18	0.39	0	0.04
(percent of households)	DOW I	97.00	96	100	100	100	100	100	–	–	–	--
Principal Alternative Source if	DOW II		Spring	Other	Vendor	Vendor	Vendor	Vendor		Hydrant	Spring	Vendor
Piped System breaks	DOW I		Spring	Rain	Well	Stream	Spring	Hydrant	--	--	--	--
Reported diarrhoea Incidence	DOW II	0.03	0.11	0.03	0.07	0	0	0	0.09	0.09	0.11	0.09
during the previous week	DOW I	0.06	0.04	0.11	0.06	0.04	0	0	--	--	--	--
(% households)												

Appendix 2. Summary Averages for Unpiped Households, DOW I & II

		SS as DOW I	Mkuu	Moshi	Dodoma	Kipanga	'Newly Unpiped'	Moshi	DES-Chang'ombe, MH	DES-Temeke, H
Sample size	DOW II	64	11	6	12	35	21	4	2	15
	DOW I	82	24	15	21	22	--	--	--	--
Number of Members in Household	DOW II	5.1	5.3	5.2	5.3	4.9	7.2	6.8	6.0	7.5
	DOW I	5.1	6.7	5.7	3.8	4.1	--	--	–	--
Number of Years of Education	DOW II	5.8	6.7	8.0	8.6	4.1	11.9	11.5	13.5	11.7
	DOW I	5.2	6.6	7.8	4.3	2.6	--	--	–	--
Equipment Index	DOW II	5.0	6.8	8.7	6.7	3.2	9.4	9.5	11.5	9.1
	DOW I	3.6	4.4	6.1	2.6	2.0	--	--	–	--
Per Capita water use (litres/day)	DOW II	18.6	14.2	19.3	28.3	16.6	32.7	22.2	30.0	35.9
	DOW I	13.5	7.8	13.3	21.0	12.7	--	--	--	--
Cost of Water (US$/m3)	DOW II	1.0	0.6	1.6	1.1	1.1	2.6	1.7	3.7	2.7
	DOW I	0.7	0.5	0.3	1.7	0.3	--	--	–	--
Principal Water Source	DOW II		Hydrant	Kiosk	Standpipes,	Stream		Hydrant	Neighbour,	Neighbour,
	DOW I		Hydrant	Hydrant	vendors	Reservoir			vendor	vendor
					Hydrant					
Time per Trip (Minutes)	DOW II	42	31.2	33.2	35.1	49.2	25.8	172.0	10.0	8.5
	DOW I	16	28.6	9.3	20.7	4.8	--	--	–	--
Distance to Water Source (Meters)	DOW II	603	342.8	118.3	171.3	903.5	32.3	27.5	75.0	27.9
	DOW I	449	1015.5	270.1	186.2	34.2	--	--	--	--
Number of Trips	DOW II	3.72	3.9	4.2	3.6	3.6	8.3	5.5	2.0	9.5
	DOW I	2.96	3.00	2.87	3.50	2.70	--	--	--	--
Diarrhoea Incidence in Previous Week	DOW II	0.22	0.18	0.00	0.33	0.23	0.00	0.00	0.00	0.00
	DOW I	0.24	0.13	0.13	0.14	0.55	--	--	--	--

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