Drawers of Water II

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

Summary

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Collaborators

The **International Institute for Environment and Development (IIED)** (www.iied.org) is an independent, non-profit organisation that seeks to promote sustainable patterns of world development through policy research, advisory services, networking and public information. Established in 1971, IIED advises policy makers and practitioners and supports and collaborates with Southern specialists and institutions working in similar areas. Focusing on the linkages between economic development, environmental change and human needs, the Institute has research programmes in a number of areas critical to advancing knowledge and understanding of sustainable development issues.

Community Management Training Services (CMTS) (EA) is a limited liability consulting company based in Nairobi, Kenya, specialising in water supply, sanitation, health and hygiene issues. For over a decade, members of CMTS have advised and provided technical and institutional support to government agencies, NGOs, CBOs and international organisations across Africa, including AMREF, The World Bank and the World Health Organisation.

The Institute of Resource Assessment (IRA), Tanzania, (http://www.udsm.ac.tz/ucb/instiofresources.html) was established at the University of Dar es Salaam in 1982 in response to the realisation that Tanzania must use its natural resources judiciously in order to achieve development without detrimental effects. IRA is an academic institution conducting independent scientific and policy research, but it also provides consultancy services to government ministries, parastatal organisations, private organisations and international agencies.

Makerere University, Kampala, Uganda, (www.makerere.ac.ug) is one of the oldest institutions of higher learning in Africa with a track record of academic excellence. It was founded as a technical school in 1922, and attained full university status in 1970. The Department of Paediatrics and Child Health (DPCH) in the Faculty of Medicine at Makerere is a leading centre of teaching, research and clinical practice on paediatrics and child health.

The African Medical and Research Foundation (AMREF) (amref.kco@amref.org) is Africa's largest indigenous health charity, and for 44 years in partnership with local communities, governments and donors, has worked to research and alleviate Africa's health problems. AMREF aims to sustain improved water supply, personal hygiene and sanitary environments in poor rural and peri-urban areas through integrated health promotion and education activities, in collaboration with government and non-governmental agencies.

Uganda Community Based Health Care Association (UCBHCA) is a non-governmental, membership-based organisation promoting local solutions to public health problems across Uganda in alliance with a variety of government agencies, NGOs, CBOs and international organizations, such as the United Nations Children's Fund (UNICEF).

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Glossary

AMREF	African Medical and Research Foundation, Kenya
CBO	Community-Based Organisation
CMTS	Community Management and Training Services (EA), Kenya
DFID	UK Department for International Development
DGIS	Ministry of Foreign Affairs, The Netherlands
DOW I	*Drawers of Water I* – 1966-68 (White, Bradley and White)
DOW II	*Drawers of Water II* – 1997-present (Thompson, Katui-Katua, Mujwahuzi and Tumwine)
DPCH	Department of Paediatrics and Child Health, Makerere Medical School, Makerere University, Uganda
IIED	International Institute for Environment and Development
IRA	The Institute of Resource Assessment of the University of Dar es Salaam, Tanzania
lcd	Litres per capita per day
pcm	Per cubic metre
pcwu	Per capita water use
Piped	Sites or households with water supplied by pipe to their homes or compounds
NGO	Non-Governmental Organisation
NP	Newly Piped – households with functioning piped supplies at sites that were categorised as 'unpiped' in DOW I
NU	Newly Unpiped – households with functioning piped supplies at sites that were categorised as 'unpiped' in DOW I
Sida	Swedish International Development Cooperation Agency
SS	Same sites as DOW I – data are taken from the same sites to allow like with like comparisons
UCBHCA	Uganda Community-Based Health Care Association
Unpiped	Sites or households where water is carried from an outside source to the home or compound
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Preface

Back in the 1960s there seemed few facts available about water supply in Africa and much of the developing world, 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. Two geographers, keen to investigate household decision making over water, were introduced to a medical researcher with a Land-Rover. All were funded by The Rockefeller Foundation. This led to a survey of some 20 or so households in each of 34 communities with diverse landscapes and settlement patterns 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 results were published as the book *Drawers of Water*, and clearly the time was ripe for it.

In the subsequent decade the whole subject opened up for research. Some of the findings were translated into public policy. Much of the subsequent work was more focused and detailed in answering specific questions. Domestic water, even in rural areas, became for over a decade an increased focus of attention for lending agencies for development, and governments claimed to be making many improvements. Intensive work, fostered by the World Bank and other organisations, was directed to the improvement of hand pumps, for example. Various strands of work contained in *Drawers of Water* were each developed by highly professional groups. Much of this work was utilised during the World Water Decade of the 1980s.

The broader picture received less attention, however, because the whole topic had become so complex. All the detailed data had been preserved by the US Army Corps of Engineers' Office of History at Fort Belvoir in Virginia. Against this background, Dr John

Thompson, over two decades later, conceived and developed the idea of carrying out a follow-up study of the original *Drawers of Water* communities, building on the same core methodology. This would first determine how the situation had changed, by precise replication of the original study questions and methodology, carried out in the same or nearby households to those studied in DOW I. But the findings were to be put in context: surveys of the policy literature (published or not, if utilised) and of its implementation were undertaken in each of the three East African countries involved in the original study, so documenting the evolution of policy over a critical three decades in which both developments within the domestic water sector and in the international agencies' and donors' approach to water were evolving. The overall public and private policy environment, had all changed more than in much of the previous century, so far as Africa is concerned. Thus, DOW II is much more purposefully sited in a policy context than was the original study and should lead to deliberate policy conclusions rather than only setting the conceptual scene for policy discussions.

In another crucial respect DOW II has progressed from DOW I. The original study was modestly conceived and it involved 13 African students from Makerere University College in Kampala as field workers, trained in social survey methods by Anne White. They collected data mostly in or near their own villages and home towns spread over the three countries. The principal investigators were developing methods as they proceeded and the work involved few senior local investigators. At that time, 1967, there was a scarcity of African academics, and the few available were more than over-worked. The interdisciplinary focus came from the eclectic interest and backgrounds of the researchers rather than from any extensive consultation.

By contrast, DOW II was conceived both as interdisciplinary and as more firmly grounded among African researchers. John Thompson searched for and found three co-investigators from East Africa who have had both the stature to organise work in their respective home countries and the range of expertise to guide specialist aspects of the research. Thus Dr Munguti Katui-Katua, who is responsible for the

Kenya part of the project, had specialised in sociology and economics, and brings detailed knowledge of water supply and sanitation issues in low-income communities; Professor Mark R Mujwahuzi, responsible for Tanzania, brings a lifetime's experience of water resource management in East Africa to the work as well as training in geography and water policy analysis; while Dr James K Tumwine, a paediatrician by background and former medical officer with Oxfam, is responsible for Uganda and brings medical and public health skills to the work, including research experience on hygiene, sanitation and water-related diseases. These various disciplines, along with Thompson's background in geography and natural resource management, and in participatory appraisal and policy research, exemplify the range of skills needed for an overall analysis of domestic water supply. Some disciplines, such as engineering and town planning, were missing, but have been available from many collaborators.

This study then, extends the already holistic view of DOW I but in a more professional manner as befits the development of the research field. It is better placed to have direct messages for policy, but it also remains rooted in solid field data. The ill-considered comment of one international agency staff member, during the difficult fund raising stage, that all it would initially do would be to "come up with facts", is surely its great strength. In an era when governments measure water supply coverage by simply adding new constructions to the previous year's figures the results of progress from DOW I to DOW II may be sobering but they provide the solid foundation for reality-based policy and planning. The initial difficulties the *Drawers of Water II* team encountered in getting their project fully funded make it remarkable that the work is now being completed. Thirty-year follow-ups are extremely rare in science and public policy. Would that there were more of them.

The results are beginning to appear, and it is now possible to see the diversity of changes that have occurred. Some are sobering – improvements have not occurred in some areas, particularly the rapidly growing urban sites – and others were unanticipated. It was unexpected that a simple change in technology, from the '*debe*' to the plastic jerrycan, for example, would affect the gender distribution of water-carrying by enabling men to carry water on a bicycle or cart and thereby avoid the ridicule that would have been the consequence of a *debe* as head-load.

The dearth of long-term longitudinal studies is well known, and this unique 30-year follow up of the same sites contributes 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 – either positive or negative – 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 more thoroughly. *Drawers of Water II* will surely stimulate both interest in domestic water use and a much richer level of understanding and explanation of possible improvements in what we originally referred to as one of mankind's basic transactions with nature.

Gilbert F White and David J Bradley
Boulder and London 2001

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Several people deserve special mention for their contributions to this initiative. In particular, the DOW II team members are deeply indebted to Professor Gilbert F White and Professor David J Bradley, two of the three principal investigators of the first *Drawers of Water* study. Their unceasing commitment to this project, along with their generosity, patience and wise counsel, gave us the motivation to see it through. We would also like to recognise the key contribution of Anne U White, the third member of the original *Drawers of Water* team, who endorsed this repeat study at the early stages of its design and development.

The field observations upon which this study is based would not have been possible without the contributions of an extremely dedicated and professional group of research assistants. Their efforts throughout two phases of intensive fieldwork, numerous planning and review workshops, and lengthy data analysis sessions are gratefully acknowledged:

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1 Assessing 30 Years of Change in Domestic Water Use and Environmental Health in East Africa: Learning from *Drawers of Water*

Research on Domestic Water Use and Environmental Health in Sub-Saharan Africa: A Brief Review

The benefits and costs of providing safe, convenient and reliable water supply to households in the developing world have been the subject of a vast and wide-ranging research effort for at least four decades. Most of this research has focused on the relationship of water and disease,[1] the efficacy of water supply programmes and projects in improving health,[2] the causes and consequences of differential access and control of water resources (particularly with regard to gender),[3] the financing, operation and maintenance of water supply systems and services,[4] and the estimation of coverage rates for water supply and sanitation and the projection of future demand based on different scenarios of population growth and changing patterns of demand.[5]

Despite the quantity of studies completed, relatively little is known about a number of key aspects of domestic water use. In particular, knowledge is scarce about the long-term trends and changes in household water use in any part of the world, as most studies have been limited to one season or one year. Because of the lack of good baseline information, there are few longitudinal or repeat studies to be found. Moreover, where studies have attempted to examine changes over time, they have tended to be limited in their geographic scope, frequently concentrating on a single community, city or country. There is also a lack of quality information about water use in rural areas, as most research has focused on the developing world's expanding urban centres and 'mega-cities'.[6] Among the regions of the world, both of these research gaps are most acute for Sub-Saharan Africa – the region whose population is the most rural and has the least access to improved water supply.[7]

This article focuses on the contribution that *Drawers of Water* has made to the literature on domestic water use and environmental health and its continuing influence on water policy and practice. It begins with a brief overview of the original study and its contribution to water policy and practice. It then describes how the current project – referred to here as 'DOW II' – has built upon and expanded the key themes addressed in that pioneering effort. It closes with a summary of some of the key findings emerging from the present study. These findings are elaborated in more detail in the later sections of this report.

Water Supply and Sanitation Provision: A Continuing Challenge

At the start of the 21st Century, 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.[8] The countries of Kenya, Tanzania 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 ranging from 72 to 89 percent and from 31 to 42 percent for rural water supply.

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 African countries to be higher than the

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.

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
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
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
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

continental averages, though, as the DOW II study found, questions remain about the hygiene-related aspects of sanitation.

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 in Africa will need to be provided with access to improved water supply services and 211 million people with sanitation services, if the international development targets for 2015 are to be met.[9] A similar number of people in rural areas will also need to gain access.

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.

Drawers of Water I: Assessing Domestic Water Use in Africa

In 1972, Gilbert F White, David J Bradley and Anne U White produced an authoritative and informative book entitled, *Drawers of Water: Domestic Water Use in East Africa*.[10] The study was the first large-scale assessment of domestic water use in Africa and is widely regarded as a major contribution to the study of community water supply and environmental health issues in the developing world. 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).[11]

East Africa was chosen as the study location because the diversity of landscape, climate, hydrology allowed for analysis of domestic water use under different environmental conditions. The region also possessed dispersed settlements in which many people lived in scattered compounds or households. This allowed for analysis of individual decision-making in domestic water use. Finally, it was home to a wide assortment of ethnic groups, which provided an opportunity to analyse the cultural dimensions of domestic water use.

The data reported in *Drawers of Water* were acquired between 1966 and 1968 by interviews and observations at 34 study sites in Kenya, Tanzania, and Uganda. Thirteen field workers (students from East African universities) assisted in collecting the water-use information in over 700 households. Twelve of the sites are in rural areas, while the other 22 are in and around towns and cities. Fifteen of the sites, all in urban places, had water piped to the houses at the time of the study. Water was carried to the houses in all 12 of the rural sites and in seven of the urban areas

The researchers examined the use of water for basic consumption, hygiene and amenities in domestic life. 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.

Figure 1.1 Map of East Africa study sites

Kenya	Tanzania	Uganda
Rural	Rural	Rural
• Kiambaa	• Kipanga	• Alemi
• Manyatta	• Mkuu	• Iganga
• Masii		• Kasangati
• Moi's (Hoey's) Bridge		• Mwisi
• Mukaa		
• Mutwot		
Urban	Urban	Urban
• Karuri	• Dodoma (2 sites)	• Iganga (3 sites)
• Nairobi (5 sites) – Makadara, Mathare Valley, Pangani, Parklands, Spring Valley	• Moshi (2 sites)	• Kamuli (2 sites)
	• Dar es Salaam (4 sites) – Changombe, Oyster Bay Temeke, Upanga	• Mulago, Kampala
		• Tororo (2 sites)

Main Lessons and Continuing Influence

Drawers of Water was to yield important findings that influenced water policy and practice on a number of fronts. First, it argued 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."

Building on *Drawers of Water*

The chief limitation of *Drawers of Water* is the relatively short period of time over which domestic water use was examined in the region. It is difficult to discern any long-term patterns or trends in the behaviour of the water users or to accurately assess the impacts of water policies and investments on the well-being of the sample households or communities from the study. As mentioned previously, this shortcoming is not unique to *Drawers of Water*, as few large-scale, repeat, cross-sectional or longitudinal studies of domestic water use have been conducted in any part of Africa.[12]

It is for this reason that the project partners decided to undertake a comprehensive follow-up to *Drawers of Water*. As the international community prepares to launch a new 'action agenda' for water in the 21st Century at the World Summit for Sustainable Development in Johannesburg in 2002 and as demand on an already scarce resource continues to mount, a re-examination of domestic water use and environmental health in East Africa three decades after that landmark study appears both timely and relevant.

Since the DOW II Project began in mid-1997, the research has addressed most of the original themes as well as a number of current issues in domestic water and environmental health planning. As mentioned above, *Drawers of Water* made a number of 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.[13] 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.[14] These issues were pursued in detail in the new study.

A third contribution of the original study is 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 also 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 service provision.[15]

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.[16] 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. This analysis involved intra- as well as inter-community comparisons, since the range and diversity of service levels and systems,[17] and thus the ability for local groups to operate and maintain them, varies considerably within, as well as between rural and urban communities.[18]

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.[19] 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.[20]

Three Decades after *Drawers of Water*: Repeating the Study

To combat the growing problems of degraded and depleted water supplies and poor environmental health, a number of new international water initiatives have been launched recently, including the Freshwater Initiative of the United Nations Commission on Sustainable Development (CSD), the Global Water Partnership (GWP) and the World Water Council (WWC). Despite these efforts, designing and implementing effective and equitable water and health policies and programmes remains extremely problematic. In part, this is because there are so few empirically rich, historically informed lessons on which to base current thinking and future practice. 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 the past three decades. 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.

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 the past three decades.

The biblical 'hewers of wood and drawers of water' were slaves and lowly servants (*Joshua* 9:21). In modern Africa drawers of water are frequently poor women and children who are widely subject to heavy costs and threats to their health. Over the past three decades, inappropriate public policies, inadequate investments in services and supplies, political turmoil and civil conflict, and poor governance have sometimes exacerbated rather than ameliorated water and health problems in Kenya, Tanzania and Uganda as population pressures and competition for scarce resources have increased.

In considering how best to meet these increasingly critical domestic needs for water, two sets of problems arise. One relates to how much and what kind of improvement in supplies is desirable. What are the effects on family and community life of different quantities and qualities of water? Since each improvement involves cost, what are the offsetting gains from making it? What combination of water supply, treatment, and delivery can best serve the individual and society? In the present state of economic development and political change in Africa, it is whimsical to suggest that every household should have a filtered, piped supply. But if that ideal cannot be achieved for most of the population, what are the desirable intermediate goals?

The second set of problems relates to the practical organisation and means to be used to obtain improved supplies. Since *Drawers of Water* was published in 1972, the countries of Kenya, Tanzania and Uganda have followed very different political and economic trajectories. Each has approached the problem of creating 'safe water environments' for its citizens in different ways, formulating different policies, creating different institutions, implementing different programmes and employing different technologies. Which of these policies, institutions, programmes and technologies has worked, which has not and why? What kinds of improvements have stood the test of time? Which ones have increased people's (particularly poor people's) access to and use of water? In what cases have people been willing to pay for and carry out needed operation and maintenance of systems? Against considerations of what is socially desirable must be set what is practically feasible, given current - and future - environmental, financial, human, institutional and technical constraints.

The first three questions examine the volume used and the social costs of different uses and sources of water, particularly their health costs. The last two questions explore the determinants of domestic water use and environmental health and how public policies and external support agencies can build upon achievements while avoiding the mistakes of the past. Aspects of each of these questions were the subject of this study of domestic water use and environmental health in East Africa (Figure 1.2).

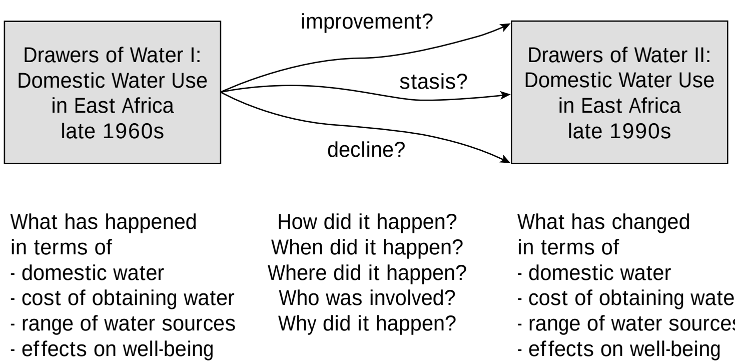

Figure 1.2 Analysing Change Over Time

With their great variety of economic, environmental and social conditions, the landscapes and peoples of Kenya, Tanzania and Uganda illustrate issues that are found throughout Africa and in the much of the rest of the developing world. Essentially these are issues of reconciling public and increasingly private investment and development policy with the decisions and actions of individual water users and local and external institutions with imperfect scientific understanding of the effects of water use on human life.

The original *Drawers of Water* research sites were chosen by White, Bradley and White to contrast the diversity of physical environments found in East Africa by their altitude, climate and water availability. They also reflected a range of socio-economic conditions, from cosmopolitan urban centres to remote rural villages, as well as households with and without piped connections. Sites also ranged from those that were integrated into the market economy to those that were peripheral to it. Technological conditions relating to water use covered the spectrum of service levels from primitive seeps and wells to protected springs and intricate urban water systems.

The data reported in *Drawers of Water I* were obtained by interviews and observations at 34 study sites in Kenya, Tanzania and Uganda, 12 rural and 22 urban and peri-urban sites. Research for DOW II began in 1997 and sought to carry out a comprehensive, repeat, cross-sectional analysis by replicating the original study closely, while adding several new lines of inquiry related to environmental health and hygiene.

The DOW II field assistants were university post-graduates who spoke the local languages and were trained in household survey methods, basic field measurement methods (for measuring distance, time, slope, caloric expenditure, etc.), participatory research methods, as well as data management and multivariate statistical analysis methods. The training involved a series of intensive workshops and fieldwork sessions, and provided an opportunity for the field assistants to familiarise themselves with the study's objectives and methodology and the key water and environmental health issues facing residents in each study site. They were also given opportunities to share their preliminary findings with their peers at rotating review and reflection workshops in the three countries. [21]

Sample households in unpiped sites were selected using a grid of 21 to 27 cells over an area of eight square kilometres, using the same sampling method originally used by White, Bradley and White. A point within each cell was selected by using the co-ordinates of random numbers, and the household nearest the point was chosen for interview. Piped sites were limited to the original urban areas studied in DOW I. Sampling in piped sites was quite different. Selected households in the piped sites were chosen by systematic random sampling, taking every 10th house beginning at a number selected at random.

At each unpiped household, semi-structured interviews were conducted and observations were made on domestic water use, socio-demographic characteristics, sources of water and conditions of use, prevalence of diarrhoea, and state and use of latrines. Wherever possible, reported water use was cross-checked by interviewing other respondents in the household and by observing the actual number of trips to the water source(s). Interviews and observations were carried out from 6am to 8pm. The actual amount of water used was measured by weighing it on a scale. Water used between 8pm and 6am was estimated by interviewing household members. Information on environmental health, particularly on the prevalence of diarrhoea, and state and use of latrines, was obtained by interview and observation. Additional data were collected separately about each site through interviews with key informants, field observations and review of secondary literature.

DOW II achieved a considerably higher sample size of 1015 households compared with 723 in DOW I (Table 1.2). To develop a better understanding of the changes that have taken place since 1966, the detailed household survey research has complemented by extensive participatory research at both household and community level in 12 selected sites in the three countries.

Table 1.2 *Drawers of Water* sample size – DOW I & II

Sample Household Types	DOW I	DOW II
Rural Unpiped	317	330
Rural Piped (NP)	-	71
Urban Unpiped (SS)	94	99
Urban (NU)	-	82
Urban Piped (SS)	312	349
Urban (NP)	-	84
Total Rural	317	401
Total Urban	406	614
Total Sample Size	723	1015

NP = Newly Piped – households with functioning piped supplies at sites that were categorised as 'unpiped' in DOW I
NU = Newly Unpiped – households with functioning piped supplies at sites that were categorised as 'unpiped' in DOW I
SS = Same sites as DOW I

Drawers of Water II: Key Findings and Emerging Lessons

Thirty years after *Drawers of Water*, there have been significant changes in water use and environmental health in East Africa (Table

Aspects	*Drawers of Water I*	*Drawers of Water II*
Date of Fieldwork	1966-68	1997-99
Principal Investigators	• GF White – Geographer • DJ Bradley – Epidemiologist • AU White – Sociologist	• J Thompson – Geographer • M Katui-Katua – Sociologist • MR Mujwahuzi – Geographer • JT Tumwine – Medical Doctor
Field Assistants	13 undergraduate students from the University of East Africa	21 post-graduates from Dar es Salaam, Makerere and Nairobi
Study Countries	Kenya, Tanzania and Uganda	Same countries
Study Sites	34 Sites - 19 'Piped' Sites and 15 'Unpiped' Sites – purposively selected to show diversity of social contexts, landscapes and water service levels	Same sites - Different levels of service found within many sites (mix of 'piped' and 'unpiped' systems)
Total Sample Size Rural Households Urban Households	• 723 households • 317 households • 406 households	• 1015 households • 401 households • 614 households
Research Focus	• Per capita water use • Types of water improvements • Cost of water • Range of choice • Effects on well-being	• Same focus, plus: • Analysis of diarrhoea, latrine use, hygiene and health issues • Policy and institutional issues
Methodology	• Detailed household surveys in wet season • Field observations and measurements of distance to water and use in the household • Secondary literature review	• Same methodology, plus: • Second phase of participatory research in 12 sites in dry season to assess dynamics of change • Policy studies
Political Context	• Post-Colonial era of African Socialism (Kenyatta, Nyerere, Obote) • Seeds of civil conflict sown in Uganda • Seeds of political nepotism and economic stagnation sown in Kenya and Tanzania • Rise of East African Community (before collapse in 1977)	• Privatisation of public services and declining role of the state • Push for decentralisation, public participation and democratisation driven by Civil Society actors • Rise of new East African Community – from divergence to convergence?
Economic Context	• Post-Independence era of economic convergence – East African Shilling • Economies based on agriculture and export of basic commodities (coffee, tea, cotton, etc.) through parastatals • Water treated as a public good – beginning of 'Water for All' policies	• Post-Structural Adjustment era of economic liberalisation and market-reform • Agriculture still accounts for large portion of GDP in region • Water treated as an economic good – emphasis on willingness and ability to pay
Social Context	• Population: 32 million (1967) • Predominantly rural society based on smallholder agriculture • Social agenda focuses on primary education and health care • Only one in 10 rural dwellers have access to improved water supplies	• Population: 83 million (1997) • Rapid urbanisation and rural-rural migration • Emergence of new social problems, such as HIV/AIDS • Four out of 10 rural dwellers have access to improved water supplies
Institutional Context	• State acts as main service provider and implementer in water sector, with support from key bilateral and multilateral donor agencies • Emphasis on development of urban water infrastructure • Functioning piped systems in urban areas managed by municipal authorities • Needs of rural populations only beginning to be addressed by paternalistic state	• State seeking new role – as regulator? facilitator?– with continuing support from donors, but private sector actors, NGOs and CBOs also play key roles • Emphasis on improving management of existing systems and ensuring cost recovery in urban areas and supporting community-financing and management efforts in rural areas • Start of public-private partnerships

Table 1.3 Main Aspects of DOW I and DOW II Research and Context

1.3). In particular, the population of the region has increased nearly threefold. Much of that growth has been in towns and cities, where municipal authorities have found it hard to cope with rising demand for water supply and sanitation systems and services. Private companies, parastatal organisations and community water-users' associations have taken over responsibility for service provision from the state in several study sites in the three countries, a trend increasingly found across the region. Most urban sites and some rural areas have experienced a diversification, if not an increase in market-related activities, including the private sale of water through kiosks and vendors. Furthermore, the difference in service levels between 'rural' and 'urban' sites has become less well defined, as have the distinctions between 'piped' and 'unpiped' households.

Changes in per capita water use

At a regional level, mean daily per capita water use has declined by 30 percent over the last three decades (from 61.4 to 39.6 litres). Water use by unpiped households has almost doubled, but that of piped households has dropped by about 50 percent, and this accounts for the overall decline.

Though the increase for unpiped households is small (under nine litres) it should bring significant environmental health benefits, because any surplus over drinking needs tends to be used for bathing, laundry or cleaning. Piped households continue to use over three times as much water as unpiped ones (Article 3).

Emergence of 'mixed' sites

In the original study, piped sites were predominantly urban while unpiped ones were rural. The repeat study found that this was no longer the case (Article 4). Several of the sites once classified as 'piped', such as Iganga in Uganda and Temeke-Dar es Salaam in Tanzania, now have significant numbers of unpiped households. Here, while the infrastructure still exists, water supply systems and services no longer function properly. This forces poor families to collect water from unprotected external sources or to buy it from private water vendors, where the cost of water can be prohibitive.

Deterioration of piped water systems and services

Drawers of Water II shows that the reliability of piped water supplies has declined at most sites over the past 30 years, in part because of the inability of government authorities to provide adequate services and because rising populations, particularly in urban areas, impose extra stresses on supplies (Article 6). Some newly piped households in urban sites receive reliable piped supplies but many households receive water for only a short period each day. Households have responded by storing water (90 percent now store water in the home as opposed to only three percent in DOW I) and by seeking alternative sources, many of which are either unimproved (and therefore a health risk) or private (and therefore frequently expensive).

The burden of water collection

Women continue to carry water, but the study highlights an increase in the number of generally young men collecting it to sell on (Article 7). The average daily number of trips for water increased from 2.6 to 3.9 per household between the two surveys but the average distance travelled to collect it dropped slightly because of improved access to hydrants, standpipes and wells. Rural households continue to have longer trips than urban ones – because customary sources have dried up or because once public sources have come under private ownership. Despite shorter average travelling distances, the time taken to collect water has increased since the 1960s. Time spent queuing reduces that available for farming, cooking and cleaning as well as making children late for school and these factors have an adverse effect on livelihoods.

Cost of water

In real terms, the cost of water for piped households in East Africa has decreased since *Drawers of Water I*, particularly in Kenya, where it dropped by almost 40 percent (Article 8). Lower decreases were noted in Tanzania (five percent), while in Uganda it has remained nearly the same. The remarkable change in Kenya is due mostly to a significant reduction of cost in one site, Karuri, although all Kenyan sites also reported reductions in water costs. In Dodoma, Tanzania, households experienced a decrease of almost 60 percent in water cost, but this decrease was out-weighed by increases in Changombe and Moshi. In Iganga, Uganda, water decreased from a reported $0.89 to $0.58, but likewise it increased in Temeke, Tanzania, and Kamuli, Uganda.

On average, the cost of water for unpiped households in East Africa has increased by 10 US Cents per cubic metre in rural areas and 30 US Cents per cubic metre in urban areas over the past 30 years (in 1997 Dollars). At the same time, there has been a decrease of 13 US Cents per cubic metre for piped households in urban areas. In addition, the difference between the cost of water for unpiped households in rural areas and those in cities or towns increased from 30 to 60 US Cents per cubic metre, reflecting the effects of growing populations in urban areas and the rising costs of obtaining water from private vendors and other water suppliers.

In all three countries, lower-income households were found to spend a significant portion of their income on their water. Moreover, their expenditure was proportionately greater than richer households.[22] These differences between poor and rich in the proportion of total expenditure allocated to water are not primarily a consequence of differences in consumption levels. Rather, they are mainly due to the inequality in access to public facilities and the relative cost of some alternative sources of water. In fact, non-connection itself can be one of the important determinants of disposable income for poorer households.

Institutional and policy implications

The most important factor affecting water use in East Africa is whether or not a household has access to an improved piped system. Since *Drawers of Water I*, however, the gap between mean daily per capita water consumption in piped and unpiped households has narrowed considerably. This is mainly the result of a dramatic decline in mean daily per capita water use by households with access to piped services – a virtual halving in three decades – rather than major improvements in water use by unpiped households.

Reduced access to piped water services not only affects the quantity of water used, it also results in reliance upon alternative sources that are often costly, distant or polluted. This pattern is common to Kenya, Tanzania and Uganda despite their very different political trajectories since the late 1960s. It shows, in stark terms, that water supply services in East Africa are currently under severe stress and are likely to remain under pressure for the foreseeable future.

These findings highlight the complex environmental and ethical dimensions of water supply and sanitation service provision. Unlike many other environmental resources, access to improved water supply and sanitation services is a public concern of the highest order, not only because of the more traditional concerns of non-excludability (i.e., the difficulty of limiting potential beneficiaries (users) from using a good) and environmental externalities, but also because such access is a precondition for full participation in society, and even survival.[23] As such, it is a *basic need* and, as with all basic needs, society attaches a value to personal consumption patterns, even in the absence of negative environmental externalities and non-excludability of resource use (Article 10). Inadequate access to a basic need such as water, which is also potentially degradable and exhaustible, can constrain a household's choices to such an extent that the choice itself can hardly be considered an exercise of freedom in any sense. In practice, household members are forced to choose between bearing costs in terms of potential ill-health, use of extremely scarce financial resources (and thus other non-discretionary consumption), or through large expenditures of time and effort.

If we accept that access to improved water supply and sanitation facilities is a basic need, we are left with the question of how to improve entitlements to them. Clearly, a return to the 'water for all' policies of the past is not an option. The history of water strategies promoting universal coverage to piped facilities has retarded access to reasonable services for many households in East Africa, as have supply-driven sanitation policies and programmes.[24] As a result, users often do not pay the full cost of services, but neither do they receive reliable supply of adequate drinking water or functioning sanitary facilities. Service hours frequently are erratic and unreliable, and users do not know whether they will get water from the tap and how long they will have to queue.[25] Breakdowns are common and long lasting, forcing households to obtain water from expensive private sources or unimproved and sometimes contaminated public sources.

Not all is gloom and doom in the region, of course, as successful examples of reasonably effective, efficient and equitable service delivery were observed during the course of this investigation, from the community-managed, rural piped water system of Manyatta, Kenya, to the large, urban water and sanitation system of Tororo, Uganda, which operates through a public-private partnership. These remain isolated success stories, however, and a great deal more will need to be done if the current downward trend in water use is to be reversed.

The lessons emerging from *Drawers of Water II* suggest that there is need for a combination of innovative policies and institutional arrangements if water and environmental health issues are to be addressed for the rural and urban poor (Article 11). Some of these will focus on developing demand-responsive approaches to community water supply and sanitation, particularly in rural areas, smaller urban centres, and informal settlements in and around major cities. In those cases, users will no longer receive free or heavily subsidised water and sanitation services, but will contribute physically and financially to their development, operation and maintenance. After installation, the communities, through water users' associations, will assume responsibility for managing the operations and maintenance of the systems, as well as the financing of less complex piped networks, pumps, wells and drains. In larger towns and cities, public and private sector utilities will handle the design, development and management of the main parts of the system, such as intake and transmission works and treatment plants, while users' associations will finance and manage all or part of the local distribution networks and sanitation services. Small, independent vendors and operators will continue to fill the gaps in provision for the immediate future, but greater controls will be placed on the quality and cost of their services. At the same time, external support agencies, such as NGOs and international development organisations, as well as governments will foster an enabling environment by providing technical information and training, health and hygiene education, flexible funding mechanisms, and strategic direction and management advice. The more far-sighted of these initiatives will even provide a choice of options in service levels and technology and administrative and management systems to match local needs, preferences and capacities to finance, operate and maintain the systems.

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21 These training, field research and review and reflection activities were supervised and facilitated by the Project Co-ordinator (Thompson) and the three Senior Research Officers (Katui-Katua, Mujwahuzi and Tumwine). Various statisticians and database specialists provided advice, information and training during key phases of the work.

22 Additional analysis of the *Drawers of Water* datasets on the proportion of total household expenditure allocated to water is being undertaken at present. Thus, the final results on this topic are not reported in this paper.

23 The goods and services in the world that individuals value differ in terms of their *excludability*, that is the degree to which it is easy or costly to exclude or limit potential beneficiaries (users) from consuming them once they are provided by nature (e.g., an unimproved surface water or groundwater source) or the activities of individuals (e.g., an improved piped water network). The legal and economic feasibility of excluding or limiting use by potential beneficiaries is derived both from the physical attributes of the goods and from the institutions used in a particular jurisdiction.

24 'Water for all' policies promoting universal coverage in water supply were formulated in Kenya, Tanzania and Uganda and were particularly prominent during the 'Water Decade' of the 1980s, but their implementation fell far short of their intended goal in all cases. For details, see Krhoda, G.O. 1998. National Policy Studies of Domestic Water Supply and Environmental Health in Post-Colonial Africa. Draft paper. London: IIED and Nairobi: African Centre for Technology Studies; Mujwahuzi, M.R. and F.P. Maganga. 1998. Historical Analysis of the Impacts of Water Development Policies, Programmes and Institutions in Tanzania Since Independence. Draft paper. London: IIED; and Muzaale, P.J. 1998. Uganda's Water Policies and Strategies in Historical Perspective. Draft paper. London: IIED. See also Therkildsen, O. 1988. *Watering White Elephants? Lessons from Donor Funded Planning and Implementation of Rural Water Supplies in Tanzania*. Centre for Development Research Publications 7. Uppsala: Scandinavian Institute of African Studies.

25 See Article 6 in this report. For further details, see Thompson, J. I.T. Porras, J.K. Tumwine, M.R. Mujwahuzi, M. Katui-Katua, and N. Johnstone. 2000. Waiting at the Tap: Changes in Urban Water Use in East Africa over Three Decades. *Environment and Urbanization* 12 (2): 37-52.

2 Types of Water Use: *Drawers of Water II*

Mean per capita water use was found to be 38.7 litres per day in *Drawers of Water II*.[1] However, there were major differences in the quantity of water used by piped and unpiped households and between households in different sites.[2] Piped households used on average almost three times more water per capita than unpiped households (Figure 2.1). Similarly, households in urban sites had significantly higher levels of per capita water use than those in rural sites. There was also considerable variation between the three study countries. Water use was highest for both piped and unpiped households in Tanzania, and lowest in Uganda for unpiped households and in Kenya for piped households.

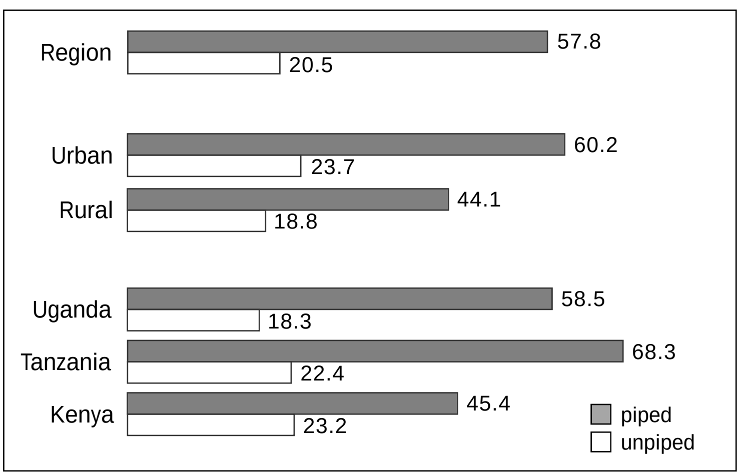


Figure 2.1 Differences in Mean Daily Per Capita Water Use (litres) in piped and unpiped households

1 This article deals only with findings from DOW II, since the dataset from the original study did not allow a full disaggregation and analysis of different types of water use. For a comparison of changing levels of water use from DOW I to DOW II, see Article 4 in this report.

2 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.

Four types of domestic water use

A typical urban East African household uses water for a broad range of purposes, from the small quantities needed for drinking and cooking to larger volumes used for bathing, cleaning, washing, gardening and beer-brewing. Thus, to gain insight into how these differing levels of water use affect general health and well-being it is necessary to take a closer look at where these differences lie.

In DOW I White, Bradley and White grouped domestic water use into three conceptual categories: (i) *consumption* (drinking and cooking) (ii) *hygiene* (bathing, washing and cleaning) and (iii) *amenities* (watering lawns, car-washing and other non-essential tasks). We have added a fourth category, *productive* uses, which includes watering livestock and kitchen gardens and beer-brewing, given the significant quantities recorded for these purposes in certain sample households and sites (Figure 2.2).

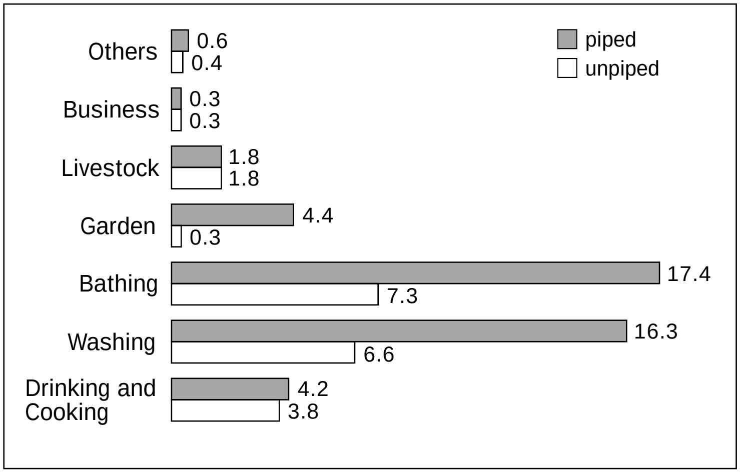


Figure 2.2 Mean Daily Per Capita Water Use by Type of Use (litres)

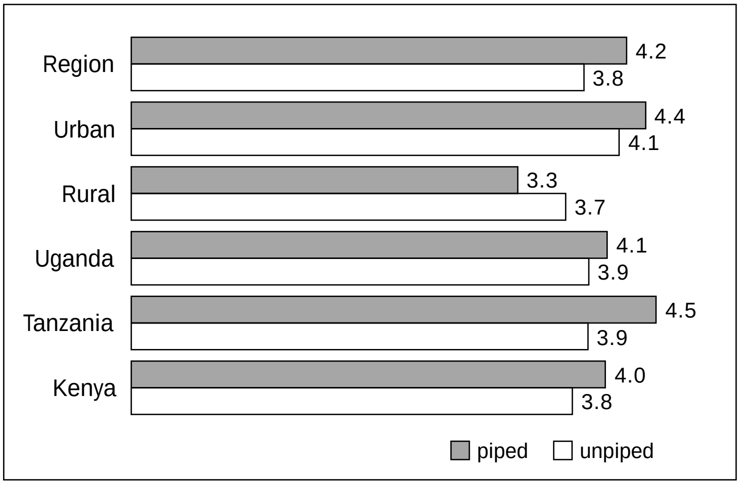
Note: Washing' includes washing dishes, clothes and cleaning the house but excludes washing of hands and the person

Consumptive Uses

DOW II found the levels of water used for consumption (i.e., drinking and cooking) purposes to be non-discretionary, meaning that it remained constant (in statistical terms) for all individuals in all households regardless of the type of connection (piped or unpiped), level of wealth, or other important variables, such as urban/rural location or country of residence.[3] The mean per capita water used for drinking and cooking was estimated to be a little over four litres per day, with very little variation across the sample population (Figure 2.3).

3 The non-discretionary nature of water consumption for drinking and cooking was confirmed by econometric estimation, although the evidence provided was negative. While estimates of total (all uses) per capita water consumption consistently revealed significant coefficients of the expected sign, per capita consumption of drinking and cooking water appears largely insensitive to economic and environmental conditions. The only factors that are statistically significant are those that are associated with household size and the proportion of children in the household. Presumably the former would reflect household economies of scale in the use of water for cooking and the latter would reflect the different 'requirements' of children relative to adults.

Figure 2.3 Water Used for Consumption (litres per capita per day)

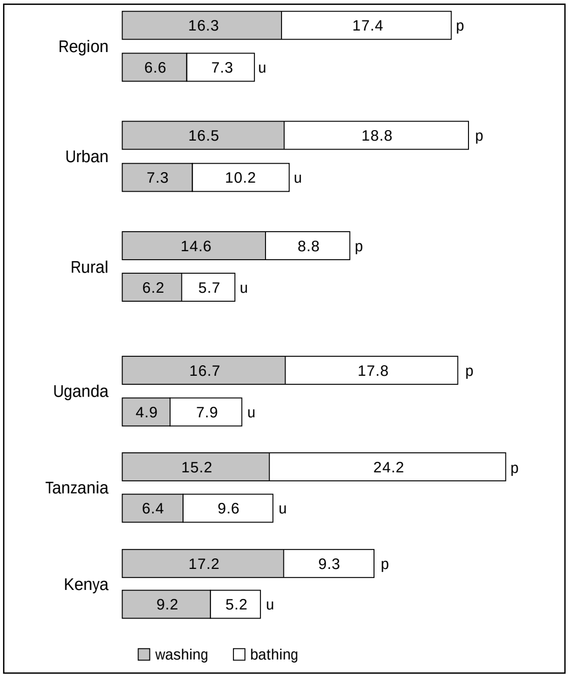


Hygiene Uses

Hygiene uses include bathing, washing dishes and clothes, cleaning and toilet flushing. The findings shown in Figure 2.4 clearly indicate that unpiped households suffer from lower hygiene levels as a consequence of not having water piped to the household. Indeed the quantity of water used for hygiene purposes by piped households is more than twice that used by unpiped households and this difference is fairly consistent across all categories of hygiene use.

Figure 2.4 Water Used for Hygiene Purposes by Piped and Unpiped Households (litres per capita per day)

Note:
P = Piped
U = Unpiped



Unpiped households suffer from lower hygiene levels than piped households as a consequence of less water available per capita for washing, bathing and cleaning.

For example, on average unpiped households used 6.6 litres per capita per day for washing clothes and dishes and 7.3 litres for bathing, compared to the 16.3 and 17.4 litres used by piped households for the same activities. Although not included in the category analysis, the greatest difference lies in the quantity of water used for toilet flushing. Indeed, 64 percent of piped households in this study have flush toilets and use on average 19.2 litres of water per capita per day. Moreover, this figure underestimates the amount used by piped households for toilet flushing since, given the sensitivity of the issue, not all of the interviewers were able to record it for all households. In part, the difference in the amount of water used for hygiene purposes between piped and unpiped households is due to the presence of water appliances in piped households (such as flush toilets, baths and showers) which account for considerable quantities of water use. It is hardly surprisingly that unpiped households that have to carry water from outside sources to the home consume less for hygiene purposes. Indeed because of the time and effort involved in this, 30 percent relied on unprotected sources outside of the home, such as streams or lakes, to wash clothes since these were more convenient than other more distant protected sources.[4]

4 The quantity of water used at the source was accounted for in this analysis only where direct measurements or clear estimations could be made. Every effort was made to ensure accurate assessments of use outside the home.

It is important to recall that one of the most notable contributions the original *Drawers of Water* study made to the water policy literature was on the understanding of the relationship between water and health. Through careful analysis and persuasive argument, White, Bradley and White demonstrated that, in many cases, water quantity is more important for

Water for Hygiene: Children being washed, Iganga, Uganda

Water scarcity, health and hygiene in Uganda

Mwisi, an unpiped rural site in southwest Uganda, recorded the lowest mean per capita water use in East Africa during the original *Drawers of Water* study in the 1960s, only 4.5 litres per person per day. DOW II found some improvement in water use per capita, to 9.1 litres per capita per day, but this remains the lowest in the region and is well below the regional average of 38.7 litres. Respondents stated that because of the continuing lack of water, clothes are seldom washed. Moreover, in many households people go for several days without bathing. Cooking habits are also affected, as foods that require long cooking times and substantial amounts of water are avoided.

In Alemi, an unpiped rural site in northern Uganda, which has suffered chronic conflict and instability, households used an average of 15.7 litres per person per day (down from 17.6 litres in DOW I). It was found that continuing water scarcity prevented households from smearing their houses with mud as often as they would like to. There was also an accumulation of disease vectors such as fleas, jiggers, bed bugs and *ololo* (pilikini) in the homes which people associated with poor hygiene. In addition, water frequently was collected from unprotected seeps, many of which are contaminated by livestock and other people.

improving people's health and well being than water 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.

The significant decline in the amount of water available per capita in urban East Africa since the 1960s suggests that people's health and hygiene will be affected negatively. Less water in the home means there is less water available for washing hands after defecating, cleaning utensils after cooking and eating, and regular bathing of both adults and children. Given this background, the significant drop in water use for hygiene purposes over the past three decades among of lower-income urban dwellers in East Africa should raise serious concerns among policy makers and health professionals. The findings suggest that unpiped households suffer from lower hygiene levels as a consequence of not having access to a regular supply of piped water. For both bathing and washing (e.g., dishes, clothes, house, etc.), these households used less than half the amount of water as those with piped connections.

Water for Hygiene: Woman washing clothes at home, Kiambaa, Kenya

Amenity Uses

Amenity uses include washing cars, watering gardens and swimming pools. The only use recorded in this category in *Drawers of Water II* was watering gardens. Although the quantities recorded are small compared with other categories, the difference between piped and unpiped households is vast (Figure 2.5). However, these figures need to be treated with caution since, particularly in rural areas, gardens are not always kept for aesthetic purposes but may contain subsistence crops and therefore have a productive dimension to them (below).

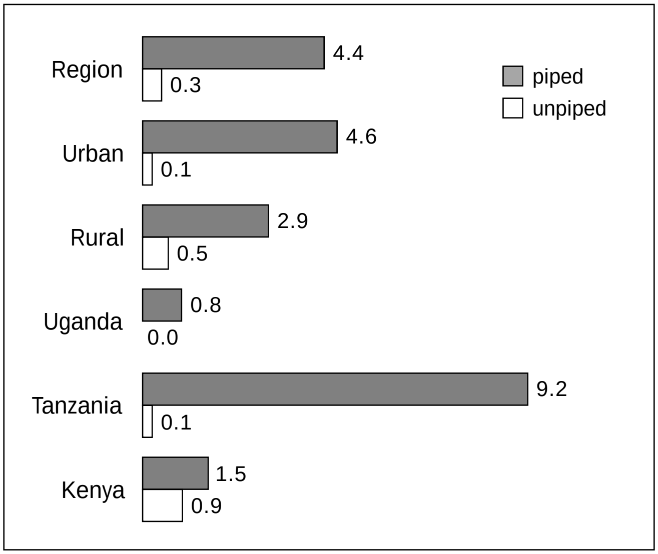


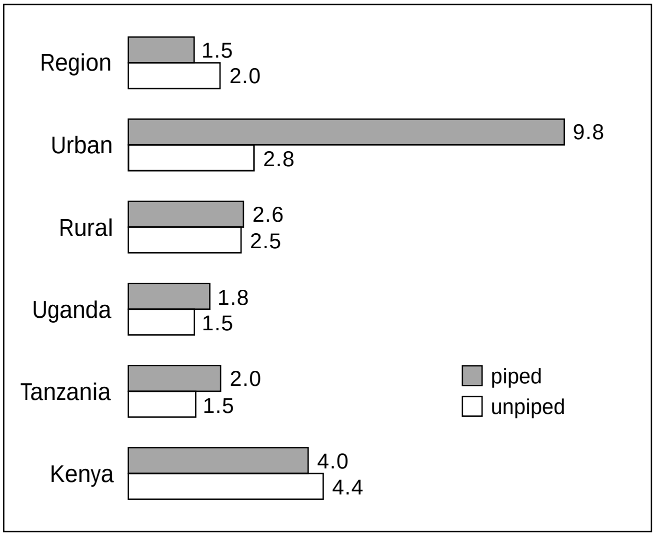
Figure 2.5 Water Used for Amenities (in litres)

Productive Uses

Productive uses include consumption by livestock (e.g. cattle, goats, pigs and sheep), brewing beer, distilling gin, making fruit juice, brick making and the construction of homes, and irrigating tree and horticultural crops. At a regional level the difference in the quantity of water used for productive purposes by piped and unpiped households is not very large (Figure 2.6). What is interesting is the significant quantities used by rural households, particularly those with piped supplies. This suggests that access to piped water is beneficial to rural households from a productive as well as a health and well-being perspective.

Access to piped supplies increases water use in rural households significantly, and is beneficial from both a productive and a hygiene perspective.

Figure 2.6 Water Used for Productive Purposes (in litres)



These figures should be treated as indicative, since as with hygiene use, where these tasks were undertaken away from the home, the quantity used was not always recorded. Productive uses outside of the home are common. For example, in households with large herds of livestock, the animals are usually taken for watering at distant sources. In this study, such activities were not treated as being a 'domestic use'.

The Productive Use of Water: Watering crops, Masii, Kenya

3 Changing Levels of Domestic Water Use

The Ups and Downs of Water Use

At a regional level, average daily per capita water use has declined by 30 percent over the last three years, from 61.4 to 39.6 litres. This general figure masks tremendous variations in use between rural and urban and piped and unpiped households.

At a regional level, average daily per capita water use has declined by 30 percent over the last 30 years, from 61.4 to 39.6 litres (Figure 3.1). This is a reflection of the almost universal decline in water use by piped households. While water use by unpiped households has almost doubled (rising from 11 to 19.7 litres), use by piped households has decreased by approximately 50 percent from 128 to 66 litres. Despite this decline, piped households use over three times the amount of water consumed by unpiped households (during DOW I the ratio was 11:1).[1]

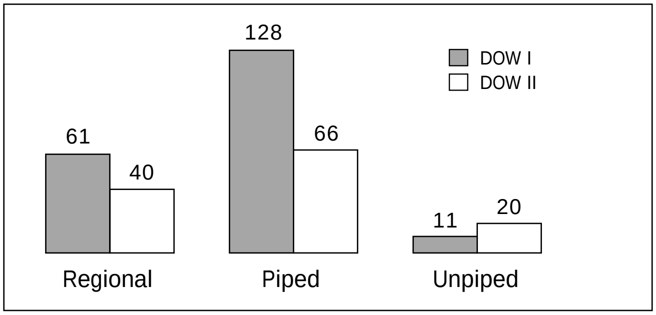


Figure 3.1 Change in Mean Daily Per Capita Water Use for Piped and Unpiped Households (litres)

Although in absolute terms the increase for unpiped households is relatively small it should bring significant environmental health benefits to unpiped households since, after satisfying basic consumption needs, the additional water is likely to be used for hygiene purposes such as bathing, washing and cleaning.

In piped households, the decrease is likely to be reflected in a reduction in water use for amenities such as watering gardens, but may also be reflected in a reduction in the use of water for hygiene purposes.

1 To enable comparisons to be drawn from the same sample sites from DOW II only those piped households located in sites which were piped in DOW I are included in the analysis. The same rule was applied to unpiped sites. Thus, for example, piped households located in sites that were categorised as 'unpiped' in DOW I are not included since they are not drawn from the same sample and may display different characteristics.

Urban Dwellers Continue to Use More Water than Rural

Water use in unpiped households increased by roughly the same amount in rural and urban areas – an average of eight litres per capita per day (lcd) (Figure 3.2). As in *Drawers of Water I*, however, mean daily per capita use for unpiped urban households remains approximately six litres higher than that for unpiped rural households. As was discussed in Article 2, this small, but significant margin can make a real difference to people's hygiene and health.

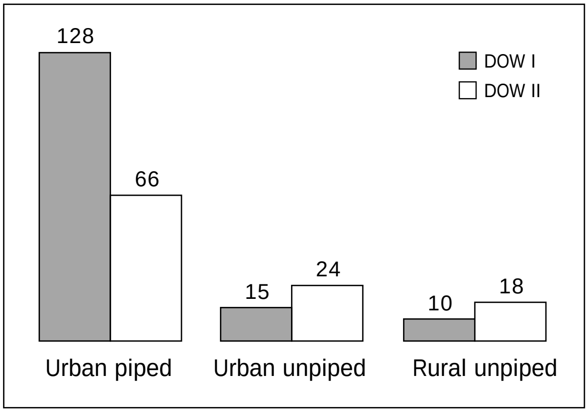


Figure 3.2 Changes in Mean Daily Per Capita Water Use for Urban and Rural Households (litres)

Urban piped households experienced a large drop in water use to only 66 lcd, a decline of nearly half the level recorded in DOW I (128 lcd). This pattern was common across all three countries. The explanation for this phenomenon is not straightforward, but one factor that has contributed to this trend is the inability of municipal authorities to operate and maintain effective and efficient water services and increase supplies to meet rapidly growing demand. For example, in Iganga, Uganda, which in DOW I was described as a fully piped site (i.e., where all sample households had access to reliable, piped supplies 24-hours a day), less than 15 percent of sample households had a working piped connection during the repeat study.

Not all urban households have seen their water use levels decline over the past 30 years. Unpiped households living in urban areas increased their per capita water use levels from an average of 15.4 to 23.7 litres per day, a rise of 35 percent. Many of these households obtain water from a range of sources, both improved and unimproved. Frequently, they purchase water from public or private kiosks or vendors, sometimes at a very high price per litre, which they use for drinking and cooking. Water from unimproved sources is often used for other purposes. See Article 8 for details on the changing cost of water in East Africa.

Long queues of drawers are a common sight at many urban water points, such as this one in Dodoma, Tanzania

Kenya Experiences the Greatest Changes

This regional trend of increased use by unpiped households and decreased use by piped households pertains to each country. Of the three countries, Kenya has experienced the most profound changes in per capita water use since the first study (Figure 3.3).

Children collect water from a newly built, improved, private well in rural Mutwot, Kenya

Kenya has experienced the most profound changes in mean daily per capita water use over the past 30 years, both positively and negatively. Water use in unpiped households increased by over 270 percent, while in piped households it decreased by nearly the same margin - over 250 percent.

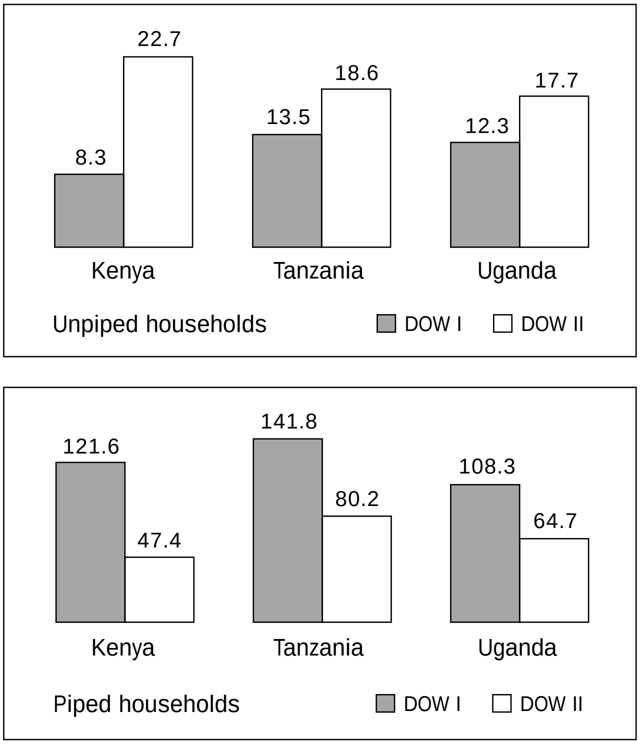


Figure 3.3 Country level change in per capita water use (in litres)

Use in piped households decreased by 74.5 litres and increased in unpiped households by 14.3 litres. As a result, whereas in 1967 per capita water use in unpiped households in Kenya was the lowest in the region it is now the highest. In contrast, consumption by piped households is now significantly lower than in Tanzania and Uganda.

4 Understanding the Change in Domestic Water Use

Determinants of water use

In order to explain why such significant changes in the quantity of water used in East Africa have occurred since *Drawers of Water I*, an understanding of the determinants of water use is required. Per capita water use will depend on a broad range of quantifiable factors, including the uses for which it is required, the monetary and social cost of obtaining it and the availability of sources. Other less quantifiable factors are also important such as cultural or personal beliefs and the hygiene behaviour of individuals and social groups. To identify the most important factors influencing water use and to assess how these have changed over the past three decades, a regression analysis was performed for piped and unpiped sites using the DOW I and DOW II data sets independently.

Factors influencing water use in unpiped households

The original study found that physical factors, such as whether or not a household was located in an urban area and distance to the source, were important in determining levels of water use. Thirty years later, water use seems to have become more strongly influenced by economic factors.

In *Drawers of Water I*, physical factors such as distance to the source were important in determining levels of water use in unpiped households. Thirty years later, economic factors have increased in importance.

In *Drawers of Water I*, per capita water use for unpiped households was related positively to container size, educational level and wealth (Table 4.1). Moreover, households located in urban areas were found to consume more water than those residing in rural areas. At the same time, per capita water use was found to decrease the greater the proportion of children in the household, the number of household members and cost per litre. Although not statistically significant, water consumption was found to be smaller for households who obtained their water from an unimproved surface source (e.g., stream, river, canal or lake).

When the same model is applied to *Drawers of Water II* data, slightly different results are obtained for both unpiped and piped households (Table 4.1). Although most of the variables found to be statistically significant during DOW I remain important today, the magnitude of their influence has changed. In contrast to DOW I where container size and household location were the most important determinants of water use, the household's level of wealth is now the most important factor followed by the cost per litre of water. Thus, consumption seems to have become more strongly influenced by economic factors. Per capita water use remains negatively correlated to household size, in part because of economies of scale in cooking and cleaning.

Table 4.1 Changes in the Determinants of Water Use for Unpiped Households

Degree of influence in order of importance	DOW I		DOW II	
	Influencing factor	Nature of relationship	Influencing factor	Nature of relationship
1	Container size	Positive	Relative wealth of household	Positive
2	Household is located in an urban area	Positive	Cost per litre	Negative
3	Number of household members	Negative	Number of household members	Negative
4	Percentage of children	Negative	Household is located in urban area	Positive
5	Cost per litre	Negative	Household uses rainwater	Negative

Factors influencing water use in piped households

At the time of *Drawers of Water I*, water services in piped sites were accessible and in good condition. Per capita water use was mainly influenced by the relative wealth of households. Subsequent to this period, piped sites have been characterised by a general deterioration in their water supply systems such that the reliability of service has become an important determinant of water use.

In *Drawers of Water I*, per capita water use in piped households was positively correlated with the number of hours of service, water appliances (taps, showers, baths and hot water heaters) and rooms per capita. Per capita use was also significantly higher for those households who used water for gardening. As with unpiped sites, per capita consumption decreased the greater the number of household members and cost per litre. Other 'wealth indicators' such as use of water for gardening and educational level were also important.

Analysis of *Drawers of Water II* data demonstrates that the nature and relative importance of factors determining water use have changed to some extent but that 'wealth indicators' remain the most important determinants of water use (Table 4.2). Use was found to be greater in households that use water for gardening and, as in *Drawers of Water I*, in those with the greater number of water appliances. Greater per capita water use was also lower for households in which the head is a farmer.

Degree of influence in order of importance	DOW I		DOW II	
	Influencing factor	Nature of relationship	Influencing factor	Nature of relationship
1	Number of rooms per capita	Positive	Household uses water for gardening	Positive
2	Number of water appliances	Positive	Household is located in Kenya	Positive
3	Cost per litre	Negative	Number of water appliances	Positive
4	Number of household members	Negative	Number of household members	Negative
5	Household uses water for gardening	Positive	Number of hours of service	Positive

Table 4.2 Changes in the Determinants of Water Use for Piped Households

As with unpiped sites and in *Drawers of Water I*, per capita water use decreases the greater the size of the household. A new factor which influences water use is the number of hours of service, reflecting the effect that the increasing unreliability of services has had on water consumption in a 24-hour period. Since the majority of households pay a set monthly fee, cost per litre is no longer statistically significant.

Signs of improvement: A household with piped supply in a previously 'unpiped' site, Masii, Kenya

In *Drawers of Water I*, piped water services were accessible and in good condition. Per capita water use was mainly influenced by the relative wealth of households. Piped sites have been subsequently characterised by the general deterioration in the water supply system such that the reliability of service has become an important determinant of water use.

The likelihood of access to piped water

Due to the discrete (qualitative) nature of the dependent variable, the determinants of a household having access to piped facilities were estimated using logit analysis. The dependent variable equals one if the household has a piped water connection, and zero if not.

Explanatory variables included the household's country, the location (whether urban or rural to reflect economies of density), the number of household members (to reflect household economies of scale in having a connection), a proxy for household wealth based upon the number of household members per room , the number of years of education of the head of household, and the number of years of residence of the household (to reflect the investment costs of obtaining a connection).

The model correctly predicted 82 percent of the cases. All of the coefficients outlined in Table 4.2, except the dummy variable for Kenya and the estimated years of residency, are of the expected sign and statistically significant. The likelihood of a household having access to a piped connection increases by 5.1 percent for a 10 percent increase in the years of formal education of the head of household. The dummy for location is also significant and large. Holding other factors constant, urban households are 53 percent more likely to have access to a piped water connection, presumably due to economies of density. The coefficient for household wealth is statistically significant, but not exceptionally large. A 10 percent increase in the wealth proxy (rooms per household member) results in a 3.4 percent increase in the probability of a given household having access to a piped connection.[1]

Thus, access to piped water facilities is far from random. Wealthier, better-educated, urban and large households are more likely to have piped connections. This is hardly surprising, and would be consistent with economic factors on both the demand and supply side. However, it does mean that it is often poorer, less-educated, rural and smaller households that are forced to make the most difficult choices about sources of service provision.

1 A similar exercise was carried out for access to private network toilet facilities. In this case, the dependent variable was equal to one if the household had a flush toilet, as well as access to piped water facilities (inclusion of the latter serves as an additional check on the reliability of responses). The same explanatory variables were used and the results were comparable, with considerable predictive power – there are just over 84 percent correct predictions. All but one of the variables (the dummy variable for Kenya) was statistically significant. However, the variable for years of residency was not of the expected sign.

It should be emphasised, however, that piped water facilities are by no means universally preferable.[2] This is particularly true in rural locations where densities are lower, increasing the costs of piped systems and potentially reducing externalities from alternative systems.[3]

The emergence of 'mixed' sites

At a site level, one of the most significant changes to have occurred is the emergence of unpiped households in sites that were previously entirely piped, and of piped households in sites that were entirely unpiped. In fact 12 of the 19 sites that were defined as 'unpiped' in DOW I (i.e., where all sample households carried water to the home) contained some households with functioning piped connections by the end of the 1990s. Similarly, seven of the 15 sites that were categorised as 'piped' in the original study (i.e., where all sample households had reliable piped connections) contained unpiped households by DOW II, reflecting a decline in service levels. In general, this mixing represents improvement in previously unpiped sites (most of which are located in rural areas) and general decline in piped sites (most of which are located in urban areas).

Crumbling infrastructure in many urban centres, such as Temeke, Tanzania, have forced many households to purchase water from expensive private vendors or use unimproved sources

In accordance with the general trends in water consumption, households that have remained unpiped in previously 'unpiped'

2 See D. Mara (1996) Low-Cost Urban Sanitation (New York: John Wiley & Sons) for an excellent review of the relative merits of different 'on-site' sanitation facilities.

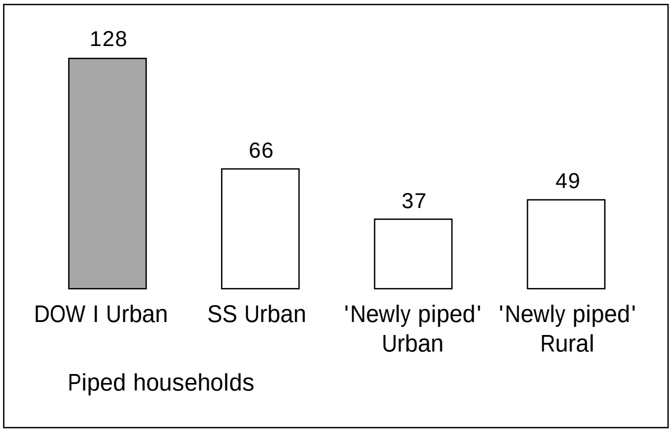
3 Indeed it has been shown that efforts to achieve universal access to network facilities can sometimes result in even lower levels of access to improved facilities for poorer households. For a discussion, see Johnstone, N. and L. Wood. 2000. *Private Firms and Public Water: Realising Social and Environmental Objectives in Developing Countries*. Cheltenham, UK: Edward Elgar.

The emergence of mixed sites represents improvements in per capita water use in previously unpiped sites and decline in piped sites.

sites have increased their per capita consumption while piped households in 'piped' sites have experienced a decline. However, piped households resident in sites which were previously 'unpiped' have benefited from an almost threefold increase in water consumption and consume almost twice as much water per capita as their unpiped neighbours. In previously 'piped' sites, those households that do not have access to piped resources have experienced an even greater decline in per capita water use than their piped neighbours. Interestingly, there is little difference in the consumption levels of piped and unpiped households in sites that were previously defined as either 'piped' or 'unpiped' (Figure 4.1).

Figure 4.1 Changes in Daily Per Capita Water Use (litres) in 'Mixed' Sites

NP = Newly Piped – households with functioning piped supplies at sites that were categorised as 'unpiped' in DOW I
SS = Same sites as DOW I



5 The Change in Water Sources Used by Unpiped Households

Different Sources, Different Uses

Households in East Africa without access to piped water supply rely on different sources to obtain their water than those with piped supplies. These sources range from unprotected springs and streams to standpipes, hydrants and private or independent vendors. These sources can be grouped into four broad categories:

1. *Unimproved sources*, such as springs, seeps, streams, rivers and lakes.
2. *Improved sources*, such as wells (pumped or hand-pumped), and pipes from neighbours and/or buildings that serve as a water source.
3. *Standpipes or kiosks and hydrants:* These could be either public or private and might charge for the water.
4. *Other paid sources*, like vendors or independent providers, who deliver water directly to the home at a price.

In general, unimproved sources tend to be highly seasonal, leaving households prone to water shortages during certain times of the year. The positive aspect of these sources is that they are often common-pool resources, meaning that local residents have usufruct rights to the water (i.e., the right to use the water at no charge, provided the source remains undamaged through such use).[1] The negative aspect is that they are usually open to contamination and can carry health risks.

Improved sources tend to be a better alternative in terms of quality, accessibility and, to a degree, reliability. They are, however, susceptible to technical failures and in the East African context are often used by a large number of households. Public and private

1 Many scholars have made the erroneous assumption that most common-pool resources are open-access resources. This is because it is difficult to exclude potential beneficiaries from them. If left as open-access resources where everyone is able to appropriate the resources freely, they will soon fail from overuse. The successful common property management systems that have evolved to maintain and regulate such facilities have established some form of property rights to these systems that are complex and change over time. Each operates under different rules adapted to local conditions. For more on this subject, see Meinzen-Dick, R., A. Knox, and M Di Gregorio, eds. 2001. *Collective Action, Property Rights, and Devolution of Natural Resource Management: Exchange of Knowledge and Implications for Policy*. Feldafing, Germany: Zentralstelle für Ernährung und Landwirtschaft, Food and Agriculture Development Centre. Ostrom, E., R. Gardner, and J Walker, eds. 1994. *Rules, Games, and Common-Pool Resources*. University of Michigan Press: Ann Arbor; Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*; and Berkes, F. ed. 1989. *Common Property Resources: Ecology and Community-Based Sustainable Development*. Belhaven Press: London.

standpipes or kiosks are very common in urban areas in East Africa, and although water is often of good quality, some work only at certain times during the day or serve large numbers of people. Thus, users frequently encounter lengthy waiting times at the point of collection. Private vendors, though reliable and a good way to save time spent collecting water, tend to be the most expensive in monetary terms and may be prohibitively expensive for poorer households. Furthermore, it is usually these susceptible groups who are left dependent on these expensive water sources.

Changes over 30 Years

The use of **surface** or **unimproved** sources in rural areas, such as unprotected springs and rivers, has increased by eight percent since DOW I, with 208 sample households using them as their primary water source in DOW II. At the same time, very few households living in urban areas depend on surface sources (Table 5.1 and Figure 5.1).

Table 5.1 Reported primary water source (number of households, for DOW I and DOW II)

Note DOW II total includes the category 'other', with 17 observations from Mutwot, Kenya and 6 from Dodoma, Tanzania.

	DOW I			DOW II		
	No Charge	**Charge**	**Total**	**No Charge**	**Charge**	**Total**
SS Rural						
Rain fed cistern	23	0	23	2	2	4
Surface	173	3	176	206	2	208
Improved	67	0	67	52	20	72
Kiosk/standpipe	27	14	41	12	10	22
Vendor	1	7	8	0	1	1
Total	**291**	**24**	**315**	**272**	**35**	**307**
SS Urban						
Rain fed cistern	10	5	15	0	6	6
Surface	10	1	11	6	2	8
Improved	2	4	6	10	14	24
Kiosk/standpipe	22	22	44	12	35	47
Vendor	0	18	18	0	6	6
Total	**44**	**50**	**94**	**28**	**63**	**91**
New Unpiped Households						
Rain fed cistern	-	-	-		1	1
Surface	-	-	-	3	0	3
Improved	-	-	-	2	33	35
Kiosk/standpipe	-	-	-	1	20	21
Vendor	-	-	-	0	20	20
Total	**-**	**-**	**-**	**6**	**74**	**80**

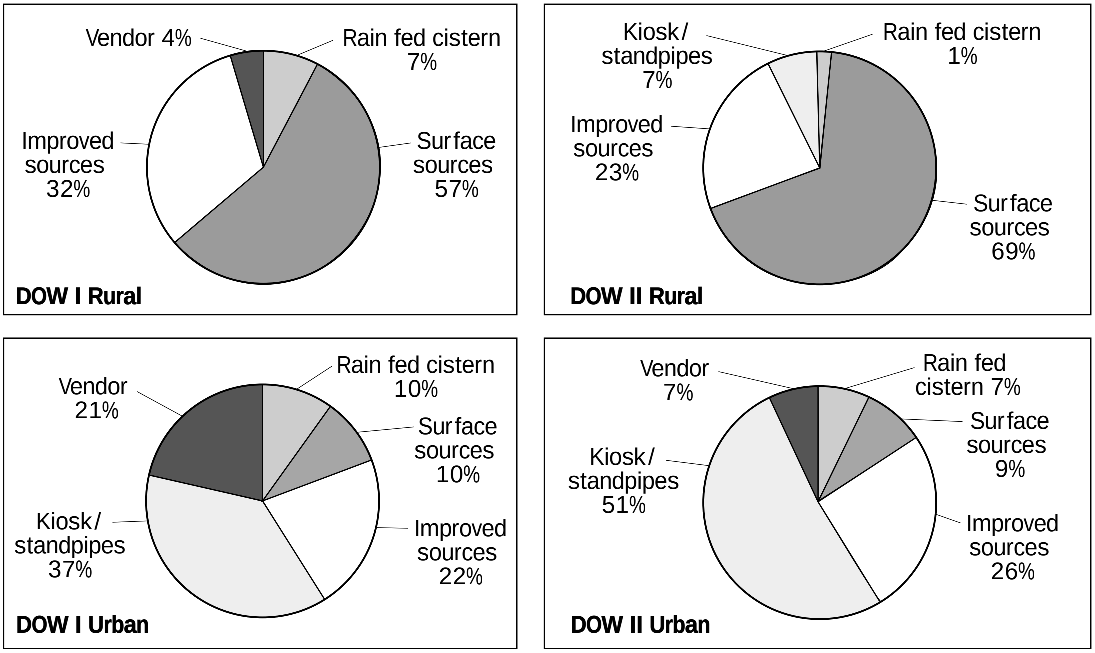


Figure 5.1 Water sources for unpiped households, DOW I and DOW II

A community-managed, gravity-fed, piped system delivers water to a rural household in Manyatta, Kenya

Rural areas in Kenya rely heavily on surface or unprotected water sources, although certain sites, such as Kiambaa and Hoey's Bridge (Moi's Bridge), have experienced a significant increase in improved water sources since DOW I. Alemi, in Uganda, experienced a notable decrease in the quality of its water sources, as households saw a drop from 100 percent using improved sources to 90 percent depending on surface and unprotected water sources. Most of these water sources are free of charge in monetary terms.

During *Drawers of Water I*, 32 percent of households in rural areas and 22 percent in urban areas reported the use of **improved water sources** (99 and 23 households, respectively). Some 30 years later, however, many of such systems have fallen into disrepair (Article 6). During DOW II, only 23 percent in rural areas reported using these sources, although their use in urban areas has increased to 26 percent (72 and 35 households, in that order). Nearly all of these water sources were free in rural areas, while more than half of households using them in urban areas reported some monetary transaction at the source (both in DOW I and II).

Kiosks and standpipes were used by a substantial number of households during DOW I. For instance, all households in Karuri and Mathare Valley, Kenya, fully depend on these water sources, as do a large proportion of households in Iganga and Kamuli in Uganda. The situation in the first two sites was almost exactly the same 30 years later, while residents in Iganga and Kamuli have switched to other improved water sources. Households living in 'newly unpiped' sites are heavily dependent on for-profit water sources, and 21 households reported using kiosks as their main water source (especially in Iganga and Temeke). Rural areas, on the other hand, are not so heavily dependent on kiosks, and only seven percent of rural households reported their use during DOW II. Generally, these sources tend to be charge some cash payment for their water, although this was more the case during DOW II.

The striking change has been the increase in the number of kiosks, which, despite their higher cost, supply water to nearly a quarter of unpiped households living in urban areas in East Africa.

'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

Vendors were reported during DOW I by 12 households in rural areas (located in Kiambaa, Manyatta, and Kasangati), and by 22 households in urban areas, most of them located in Dodoma and Kamuli. Despite their relatively high cost, it is quite surprising that these private actors remain an important water source, supplying water to 21 percent and 15 percent of households in urban areas during DOW I and II, respectively.

Kiosks and vendors are particularly important in lower-income communities, such as Karuri, Kenya, and Dodoma and Moshi, Tanzania. Sites that were previously piped, like Iganga (urban), depend almost entirely on paid sources, with high negative effects on the household budget. These water sources are not particularly common in rural areas, although 22 households reported the use of kiosks or standpipes during DOW II.

In summary, as Table 5.2 shows, after 30 years of water development initiatives, unprotected surface sources such as springs and seeps continue to be the main water sources in rural areas, while in urban areas the majority of unpiped households both in DOW I and DOW II used standpipes and kiosks as their primary water source, followed by improved sources. Although improved facilities are available to unpiped households living in sites previously categorised as 'piped', they are more likely to purchase water from private suppliers, such as kiosks or vendors.

	DOW I	**DOW II**
Rural Areas	Surface sources (57%)	Surface sources (69%)
Urban Areas (*same as DOW I*)	Kiosk and standpipes (37%)	Kiosk and standpipes (51%)
	Improved sources (22%)	Improved sources (26%)
Urban Areas ("*newly unpiped*")	NA	Improved facilities (44%)
		Kiosk/standpipe (26%)
		Vendor (25%)

Table 5.2 Most commonly used type of water source by location, DOW I and DOW II

Reasons for Change

A broad range of internal and external factors have influenced the availability and quality of water sources. It is therefore difficult to give a definitive explanation for changes in source types over the past three decades. At some sites, changes have resulted from specific interventions or withdrawals by individuals or external support agencies (e.g., government departments, NGOs, donor agencies). In others, internal factors such as an increase in population pressure and conflict, privatisation and changing tenure arrangements, poverty and social differentiation, and environmental degradation have affected the type, quality, accessibility and reliability of water sources:

- *Population pressure and conflict* - In Mwisi, Uganda, population growth has forced people to settle in ecologically sensitive areas such as hilltops and wetlands, leading to a loss of previously available water sources. At several of the sites in all three countries, it was reported that increasing population pressure has led to conflicts within communities and fighting at water sources. At one site in Tanzania, sabotage of a public piped network by unknown vandals forced individuals to either purchase water at high prices from private vendors or use unimproved alternatives.
- *Privatisation and changing tenure arrangements* – In a number of sites in Kenya, water sources that had been accessible to the public had come under private control due to changing tenure arrangements, thus forcing people to pay to regain the right of access or seek alternative sources.
- *Poverty and social differentiation* – In several sites in the three countries, respondents mentioned poverty as a major contributing factor to the prevailing poor water situation in their communities. For example, in Alemi, Uganda, the community members claimed they were not in a financial position to contribute to the repair of a borehole, forcing them to collect water from unprotected seeps. Elsewhere growing gaps between rich and poor have led to increasing intra-community, as well as intercommunity differences in access to water.
- *Environmental change and degradation* – As one respondent in Uganda explained: *"In Kamuli [an unpiped urban site], a number of the springs and swamps that existed in the past have dried up… [this] is largely due to the draining of wetlands for agriculture."* Similarly in Mkuu, Tanzania, a site located on the slopes of Mount Kilimanjaro, the recent decline in water

Factors such as the increase in population pressure, rising poverty levels and environmental degradation have contributed to the poor state of many water sources found in the region, while changing tenure arrangements and the privatisation of once public sources has restricted access in some cases.

availability was attributed largely to increasing cultivation in areas adjacent to water sources, frequent fire outbreaks and recurrent droughts.

Changes in the Number of Sources Used by Households

In DOW I, most sample households obtained all of their water from one primary water source, though many had a range of sources available to them. In DOW II, reliance on additional sources had become common although the majority of water was still obtained from one source. In some cases, this is a result of a reduction in water available from the primary water source (due to disruptions in service, lengthy queues, etc.), while in others it reflects an increase in the availability of other sources such as wells, standpipes private vendors and kiosks.

Variation in the sources used between countries

The nature of sources used varies considerably between Kenya, Tanzania and Uganda, as do the changes that have taken place.

In rural areas in **Kenya** the use of hydrants or standpipes has declined (mainly due to lack of maintenance), however, there has been an increase in the use of wells, and a decline in the use of surface or unprotected sources like streams, canals, rivers, springs and seeps (Figure 5.2). Although very few observations were reported, the use of paid sources such as kiosks and vendors has declined since DOW I. The story is different for urban areas, where practically all households depend on kiosks for their water supply. Vendors are reported during DOW II in sites that were previously unpiped, but not in the newly unpiped sites.

Manyatta is a rural site in northeastern Kenya where small-scale horticulture production is the dominant activity. In *Drawers of Water I* the site was categorised as 'unpiped', meaning all households carried water to the home. Due to its location on the slopes of Mount.Kenya, Manyatta enjoys a reliable source of high-quality water throughout the year. With the help of the Ministry of Water Resources and a foreign donor agency, the community was able to construct a gravity-fed, piped network to supply water direct to households. As a result, more than three-quarters of all households interviewed during the repeat study had piped water connections and mean per capita water use had almost trebled from 10.4 to 29.8 litres per day. A local water users' association is responsible for the operation and maintenance of the system and residents appear reasonably satisfied with the arrangements.

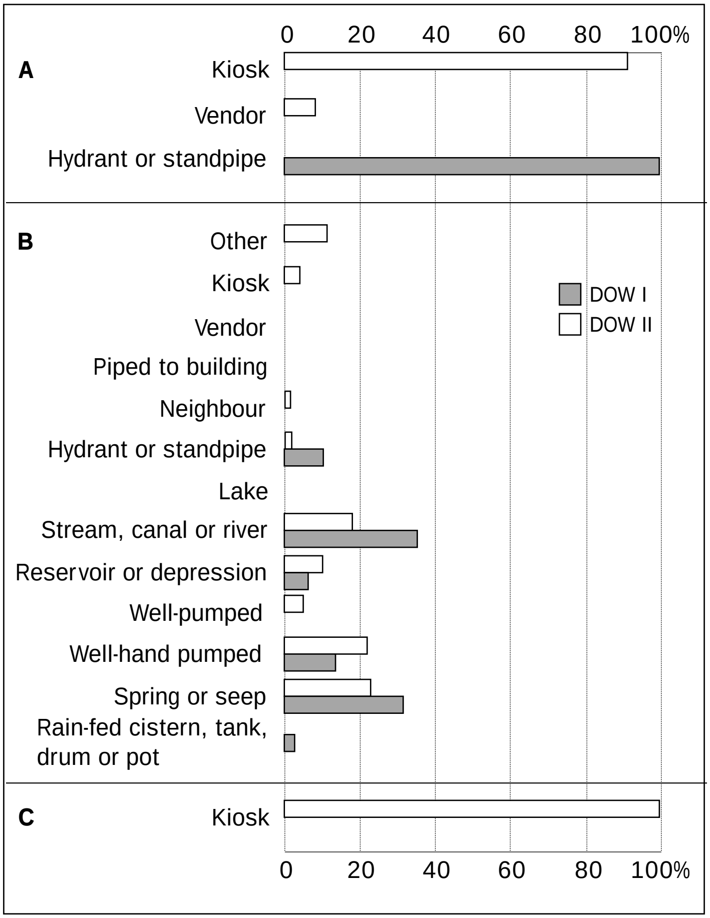


Figure 5 2 Primary water sources used in Kenya (percent of households)

➤

Note

A: same sites urban unpiped, sample = 19 and 12 (DOW I and II respectively)

B: same sites rural unpiped, sample = 143 and 145

C: new urban unpiped, sample = five for DOW II

In Temeke, a densely populated, low-income, piped district of Dar es Salaam, the purchase of water from vendors has become commonplace. This is particularly so in the dry season when most vendors operate on a full-time basis charging as much as Tsh.100 (0.82 US Cents) for a 20 litre jerrycan. Some religious institutions collect rainwater and provide connections to sell to vendors or households at reduced rates.

In contrast, for the majority of unpiped households in **Tanzania**, water sources have deteriorated since *Drawers of Water I* (Figure 5.3). The proportion of households depending on streams, canals or rivers in rural areas has increased since the late 1960s, while at the proportion of those using improved water facilities has decreased (with hydrants or standpipes at half their original levels). In urban areas most households had access to improved water facilities such as hydrants and standpipes in DOW I, although vendors were reported by 30 percent of households, while by DOW II less than half used improved sources and approximately 24 percent of them depended on vendors. Most households living in newly unpiped sites obtain their water from neighbours with taps

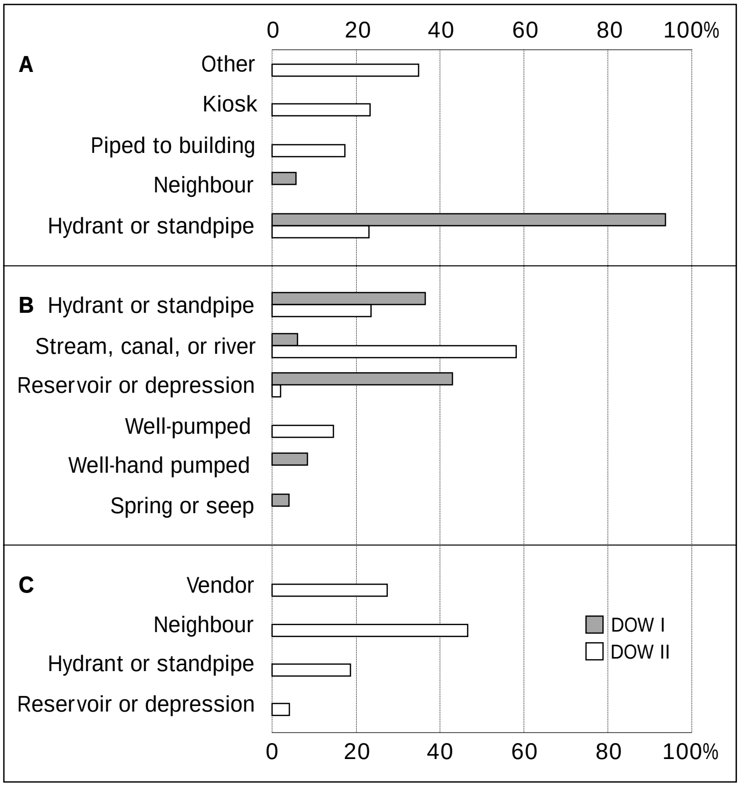


Figure 5.3 Primary water sources used in Tanzania (% of households)

Note

A: same sites urban unpiped, sample = 36 and 18 (DOW I and II respectively)

B: same sites rural unpiped, sample = 46 and 46

C: new urban unpiped, sample = 21 for DOW II.

In **Uganda**, the general situation in rural areas has not improved since *Drawers of Water I* (Figure 5.4). The proportion of households reliant on unprotected and highly seasonal sources such as springs or seeps has increased by almost 35 percent, while those having access to improved water sources decreased by 20 percent.

In urban areas (same sites as DOW I) the picture is different. The proportion of households using springs and seeps decreased to half their DOW I levels, while significantly more households now have access to hydrants, standpipes and wells. The use of vendors and kiosks has decreased significantly since DOW I, although almost 10 percent of households in DOW II reported the use of vendors. On the contrary, there is a large reliance on vendors and kiosks in newly unpiped sites, although a significant amount of households

In some sites in Uganda, the water situation is very poor. For example, in Alemi the main water sources are small seeps dug at the edge of swamps by women. The availability of water is highly variable throughout the year. In the rainy season, the seeps flood forcing the women to higher ground to dig. The seeps are also susceptible to contamination, particularly when it rains. Consequently, inhabitants of Alemi have devised a basic method of purifying their water by letting it settle for a couple of days to allow the impurities to sink to the bottom. When it is extremely dry the seeps dry up and women are forced to collect water from the Okole River some six kilometres away. Water obtained from this river is also perceived to be of poor quality.

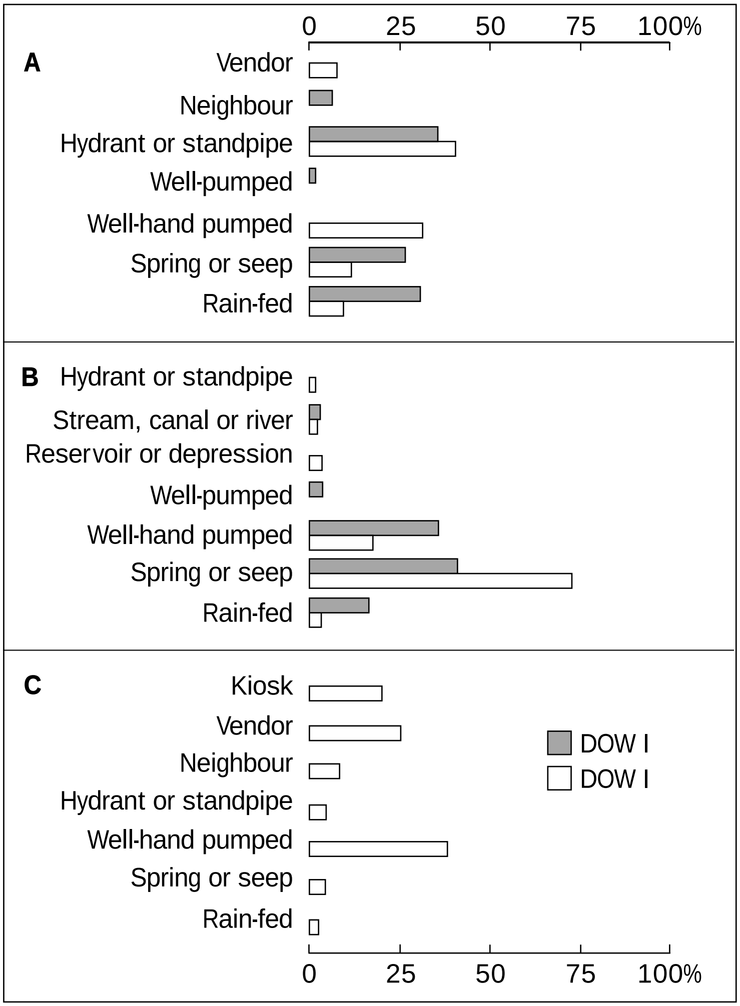


Figure 5.4 Primary water sources used in Uganda (percent of households)

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Note

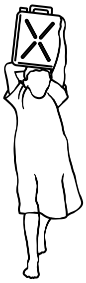
A: same sites urban unpiped, sample = 49 and 69 (DOW I and II respectively)

B: same sites rural unpiped, sample = 118 and 135

C: new urban unpiped, sample = 56 for DOW II

Child collecting water from an unimproved seep in Alemi, Uganda

6 The Deterioration in Piped Water Services



Changes in the Reliability of Piped Water Services

The reliability of piped water services has declined significantly over the last three decades in most of the study sites. Different factors contribute to this situation, including the inability of municipal governments to operate and maintain the systems effectively and the stress placed on existing network capacity by an ever-increasing urban population.

Comparison of the findings of *Drawers of Water I* and *II* confirms this worsening of the situation across the region. While in DOW I practically all sampled piped households received 24-hour service delivery, the repeat study found only 56 percent benefit from the same level of service in the same sites, and roughly 20 percent receive only one to five hours of service per day (Figure 6.1, represented as Same Sites (SS) Urban Piped).

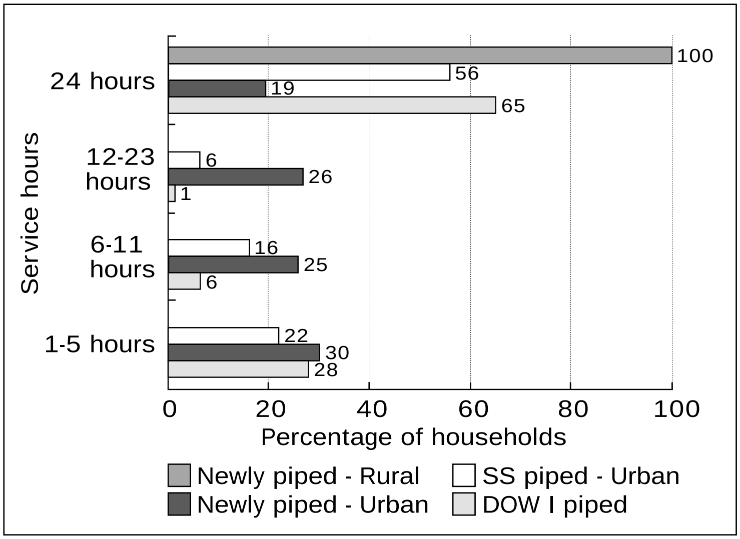


Figure 6.1 Average hours of water supply service

Not surprisingly, more affluent areas such as Parklands in Nairobi, Kenya, Oyster Bay in Dar es Salaam, Tanzania, and Tororo in Uganda all enjoy virtually continuous 24-hour water supply, while many households living in higher-density, lower-income settlements such as Karuri, Kenya, and Dodoma, Tanzania, can count on a maximum of only five hours of service per day.

It seems that the best service is provided to newly piped households in rural areas, where on average 65 percent of them receive 24-hour supply. Although the sample size is not large enough to make inferences, all sampled households in Mukaa, Masii and Manyatta, Kenya, received water 24 hours a day. This is not the case for all rural households with piped connections, however, as approximately 30 percent of them had access to functioning piped connections only one to five hours per day, especially those living in Mkuu and Kiambaa (75 percent and 56 percent, respectively).

Signs of Improvement

Despite the deterioration of systems and services in sites previously classed as 'piped', piped households are now found in sites which were totally unpiped in the original study, indicating some improvement at these sites. In fact, 30 percent of all piped households interviewed in the repeat study were located in previously 'unpiped' sites. Of these newly piped households, 46

Well maintained urban infrastructure and services were commonplace in the 1960s, such as these in Iganga, Uganda – DOW I percent were located in rural areas and their service is reported to be remarkably good when compared to piped service in urban areas, since over 65 percent of households receive 24-hour piped water supply and only 28 percent receive five or fewer hours per day.

In the ‘newly piped’ urban sites, service tends to be particularly poor. Only 20 percent of sample households in those sites receive 24-hour supply, most of which are located in Mulago, Uganda. More generally, households will receive water during 12 hours or less, and approximately 25 percent of them receive less than five hours. This situation is most common in Dodoma, Tanzania. In many cases the situation has not improved in terms of service since DOW I. For example, in one of the three field sites in Iganga, Uganda, classified as urban unpiped during *Drawers of Water I*, only two households reported piped connections, both with less than 12-hours of service per day.

Responding to Uncertainty: Storing Water for Periods of Shortage

Given the increasing unreliability of piped water services, households have come to depend on storing water to cater for times of shortage. The increase in water storage is striking with only three percent of piped households storing water in DOW I compared with 90 percent by DOW II. Water was stored by 90 percent of piped households in sites that were classed as ‘piped’ in DOW I, 79 percent of those living in ‘newly piped’ urban households, and 79 percent of ‘newly piped’ rural households.

While this study did not set out to investigate this issue in detail, it is clear that while storage in the home can ensure that water is available when required, even if piped services are interrupted, it also exposes the household members to greater risk of contamination.

Many studies have documented the process of contamination of drinking water within the home, an issue that demonstrates the interwoven nature of water quality and quantity. Some of these studies show increased contamination over time of water in the home

Changes in Municipal Water Service Reliability in Iganga, Uganda

When the original *Drawers of Water* study was conducted in Iganga, an urban site in south central Uganda with a population density of over 350/km2, investigators found that all sample households received adequate supplies of water 24 hours a day. Thirty years later, however, the municipal water system had deteriorated to such a degree that only 13 percent of sample households now receive piped water. Even for this minority water supply is inadequate, trickling out of pipes for only a few hours each day. It is also highly irregular and some households report being without piped water for up to three days at a time.

The decline of the system has taken place over a number of years. As one respondent explained: “*During the ’60s and early ’70s the situation was good, but from the late ’70s the water services began to deteriorate. The situation worsened in the ’80s when water pumps and most of the distribution lines broke down. Of the four pumps operating in the ’60s only one was still working by 1980*”. In addition to the shortage of functioning pumps, it was reported that water storage tanks are rusty and tend to leak, as do the distribution lines which date back to the 1960s. According to one local official: “*Most of the revenue collected from water bills is spent on repairing the pipes and pumps. Moreover, since the water pumps run off electricity that are subject to frequent power cuts, water supply is unreliable. It is really beyond our control.*”

By the late 1980s, in an attempt to compensate for these problems, alternative sources were developed. Private individuals began to drill boreholes and establish their own water kiosks. In 1998 these private sources were supplemented with kiosks built by the Iganga Town Council. At the time of the repeat study, piped supply had also improved a little as a result of repairs to the non-functioning pumps. In light of the success of these improvements, inhabitants expressed some optimism about the future prospects of increasing their water use.

and describe factors influencing this contamination, such as season, whether water had been transferred between vessels, proximity of stored water to animals, type of water supply, and whether the container was open and/or refrigerated. While none of these studies documented precisely how this contamination was occurring, several stated that improved hygiene education needed to accompany water provision efforts in order to reduce risk.[1]

When the System Fails: Alternatives to Piped Supply

The water and sanitation infrastructure in urban Iganga, Uganda, deteriorated significantly over the past 30 years, leading to erratic and unpredictable service provision

The unpredictability of piped water supply in urban East Africa forces many households to take precautions, which is evidenced by the increased number of sample households who store water at home. In many cases, households need to rely on these secondary and tertiary sources of water to cater for both short and longer-term shortages and the intermittent failure of their primary piped services. Although in DOW I piped households were less reliant on other sources, approximately 50 percent reported that they would use a rain-fed pot or cistern as their alternative source if they encountered a water shortage. Today, in areas such as Dodoma, Tanzania, and Iganga and Tororo, Uganda, all local respondents must collect water from various sources and store it at home to ensure adequate supply because their piped systems are so unreliable. Improved facilities such as wells and hydrants are used by slightly more than 32 percent

1 For further discussion on various aspects of contamination of drinking water in the home, see Molbak K, et al. 1989. Bacterial Contamination of Stored Water and Stored Food: A Potential Source of Diarrhoeal Disease in West Africa. *Epidemiology and Infection* 102: 309–316; Han AM et al. 1989. Contamination of Drinking Water During Collection and Storage. *Tropical and Geographic Medicine* 41: 138–140; Lindskog RUM and PA Lindskog. 1988. Bacterial Contamination of Water in Rural Areas: An Intervention Study from Malawi. *Journal of Tropical Medicine and Hygiene* 91: 1–7; Young. B. and J. Briscoe. 1987. A Case-Control Study of the Effect of Environmental Sanitation on Diarrhoea Morbidity in Malawi. *Journal of Epidemiology and Community Health* 42: 83–88; Khairy AEM et al. 1982. The Sanitary Condition of Rural Drinking Water in a Nile Delta Village. *Journal of Hygiene* 88: 57–61; Feachem R et al. 1978. *Water, Health, and Development: An Interdisciplinary Evaluation*. London, Tri-Med Books Ltd.

of all households as their alternative source in cases of piped supply failure. Improved surface sources such as protected springs were used by over 18 percent of piped households, most of them located in high-density, low- and middle-income centres such as Pangani in Nairobi, Kenya, and Changombe in Dar es Salaam, Tanzania.

By DOW II the nature of alternative water sources had changed significantly (Table 6.1). During *Drawers of Water I* nearly half of the respondents said that they would use rain water as their main source if their piped water service failed and 32.4 percent said that they would use wells or hydrants.

Levels of Service	DOW I	DOW II		
		Site Piped in 1960s	Newly Piped Rural	Newly Piped Urban
Rain-fed cistern	49.2	1.0	3.0	0.0
Improved facilities	32.4	18.4	28.3	10.9
Surface sources	18.4	20.6	59.7	36.4
Vendor/ porter/kiosk	0.0	37.8	4.5	41.8
Other	0.0	22.2	4.5	10.9
Total (%)	**100**	**100**	**100**	**100**

Table 6.1 Main alternative source in case of a shortage in piped supply (percent)

In previously piped sites, more than 18 percent of sample households used local (often private) wells (in areas like Kamuli and Makadara the figure rose to over 75 percent and 64 percent respectively). Surface sources were used by approximately 20 percent of sample households. This figure includes a large proportion of households from richer areas such as Parklands in Nairobi, Kenya, and Oyster Bay in Dar es Salaam, Tanzania, who obtain their water from nearby protected reservoirs when the system fails. This is in contrast to households in Moshi, Tanzania, and Tororo, Uganda, where 50 percent and 20 percent respectively rely on springs as back-up.

The single most important change in the nature of secondary water supplies in previously piped sites is the introduction of private sources such as kiosks and vendors, which are used by almost 40 percent of piped sample households. These private sources are particularly important in low-income areas, such as Changombe and Temeke, in Dar es Salaam, Tanzania and Iganga, Uganda, where over

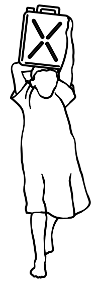
60 percent of piped households use vendors as their primary source. Hydrants were rarely reported as secondary sources except in newly piped rural sites. Surface sources are still the main water source for rural piped households when their service is interrupted (60 percent reported that they would use surface sources). Improved facilities, such as hydrants, would be used by 28.4 percent of rural piped households. Although kiosks were reported to be used by only 4.5 percent of rural piped households, this source was selected by half the respondents in Masii, Kenya, as their primary source in the event of breakdown.

Vendors are the main alternative source for many urban newly piped households (almost 40 percent) particularly in Dodoma, Tanzania, with another 3.6 percent of households using kiosks.

The continuing unreliability of many municipal services and supplies, combined with the growing demand for water in most urban centres in East Africa, has contributed to the rapid rise of private water vending, which is now a booming business in many of the low and medium-income study sites. Despite frequently costing considerably more than public supplies, private kiosks were seen in a positive light by some respondents because of their convenient locations, reliability of supply, good quality of water, and positive customer relations. Vendors who delivered water directly to the home were also viewed positively, despite the added expense of this service, as they offer both convenience and reliability.

Nevertheless, their higher water costs have a real impact on per capita use and family expenditure on water, and these private sources should not be viewed as the best or only option to the way many public systems are operated. Many sample households reported that they chose private suppliers not because they wanted to or felt they provided a superior level of service, but because they had no choice. Moreover, researchers encountered several instances where public supplies were sabotaged, leaving local residents no alternative but to purchase water from private vendors. Whether the private suppliers had an actual hand in these disruptions could not be corroborated (except in one instance in Tanzania), but they certainly benefited from the collapse of the 'competition'.

7 The Burden of Water Collection



Who Bears the Burden?

Obtaining water for domestic use in East Africa often comes at a significant cost to the drawers, usually women and children, in terms of the time spent in collection, the physical effort required and the negative health effects which may result. In many ways, the burden of water collection for unpiped households seems to have increased since *Drawers of Water I*.

As was the case in original study, women bear primary responsibility for water collection in Kenya, Tanzania and Uganda, though some changes have occurred. For example, by *Drawers of Water II* there had been an increase in the number of child drawers as well as in the number of males, notably teenagers, collecting water for commercial purposes.

The principal mode of transport has also remained largely unchanged. Women and children continue to walk to and from the source, carrying water on their heads or backs using jerrycans or *sufuria* (large metal cooking pots). As a result, they are prone to experiencing health problems such as headaches, general fatigue and pains in the chest, neck, back and waist.

To a large extent, however, the mode of transporting water depends on the gender of the drawer. Amongst males there has been an increase in the use of bicycles and hand-driven carts. These are the principal modes used by vendors (75 percent), enabling them to transport large quantities of water over relatively large distances.

How Many Trips are Made

On average, the daily number of trips for water made per household increased from 2.6 in DOW I to 3.9 in DOW II. An average of three trips to the primary source was reported by almost 80 percent of unpiped households in rural areas in the original study, while in the repeat study the number of trips had increased and 45 percent of households reported more than three trips to the source. Again, 70 percent of urban dwellers reported three trips or less to the source in the late 1960s, while only 50 percent of them made at most three trips (Table 7.1). One explanation of the increase in the number of trips is largely due to the increase in water use by unpiped households.

The average number of trips made to collect water increased from 2.6 in DOW I to almost four per day in DOW II.

Number of Trips Per Day	Rural DOW I	Rural DOW II	Urban DOW I	Urban DOW II
0	5%	5%	12%	3%
1	21%	17%	25%	12%
2	60%	37%	46%	33%
3	78%	55%	70%	51%
4	91%	75%	89%	74%
5	95%	83%	96%	88%
6	98%	90%	98%	94%
>7	100%	100%	100%	100%

Table 7.1 Number of Trips Per Day to Source: Cumulative Probability

Waiting at the Tap: Collection Times and Distances

The average distance that unpiped households walked to obtain their water from their primary source increased slightly over the past three decades, from 428 to 459 metres (Table 7.2). Unpiped households living in rural areas walked on average almost 150 metres more in the late 1990s than in the late 1960s. Those households relying on surface sources in DOW II faced the daunting task of walking an average of 780 metres compared to 534 metres in DOW I (an increase of over 30 percent per trip). Distances to improved sources in rural areas were found to be slightly shorter in the follow-up study (384 metres) than in the original study (477 metres).

Table 7.2 Collection time and distance for unpiped households, DOW I and II

Note SS = Same Site

Household Type	Distance (metres) DOW I	Distance (metres) DOW II	Return Time (minutes) DOW I	Return Time (minutes) DOW II	Number of Trips DOW I	Number of Trips DOW II
Newly Unpiped Urban	96		14.4		4.5	
SS Unpiped Rural	484	622	16.6	25.3	2.5	3.8
SS Unpiped Urban	230	204	9.8	21.4	2.6	4.0
All Sites	**428**	**459**	**15.1**	**23.0**	**2.6**	**4.0**

Households living in urban areas experienced a decrease in the average distance to the source, especially for those using improved facilities (from 260 m to 176 m). Unpiped households living in previously piped urban sites walked, on average, less than 100 m to their sources, although for the few of them who used surface sources the average distance was 580 m.

The time spent queuing for water has increased significantly over the past three decades in Mulago, Uganda

In theory distance and time are correlated. This is evident in the case of rural households for which the average return time increased by 10 minutes, from 16.6 to 25.3 minutes along with the average increase of 150 m to the source. This relationship does not necessarily apply for households using improved sources. Despite a decrease of 113 metres in the average distance to the source, the time involved in collecting water actually increased by only six minutes.

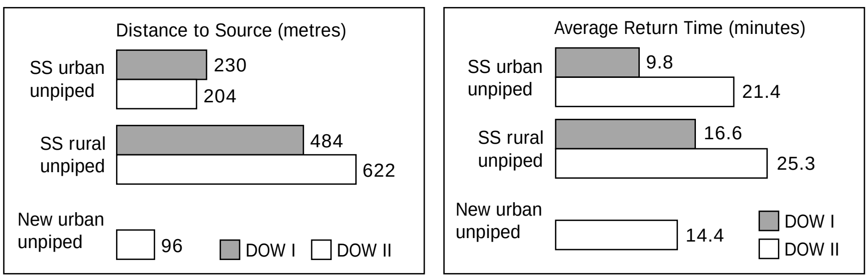
The same relationship is found for unpiped households living in urban areas, for which average time increased from 15 to 23 minutes (14.4 for households in 'newly unpiped' sites), despite the relatively shorter distance to the source. Disaggregating this figure, it is possible to see that time spent collecting water in improved sources nearly doubled since DOW I, from 12 to 21 minutes, despite the fact that distance to the source actually decreased.

Kiosks present some of the most striking cases. Unpiped households living in urban areas used on average 37.2 minutes per trip to obtain water from kiosks, while walking only an average of 362 metres to the source. If the average number of trips is 4, then households could spend an average of more than two hours and 40 minutes per day fetching water.[1] The reason for this situation, in many cases, is the increase in time spent queuing for water. As existing piped water systems break down or services are interrupted, households are forced to seek alternative sources away from the home, some of which must cater to very large numbers of water users. In economic terms, this represents an increase in the opportunity cost of obtaining water.

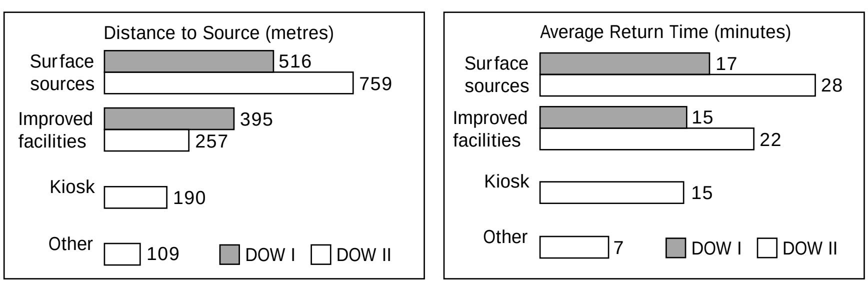
1 In a recent review of the literature on household water use in Africa, Stanley Rosen and Jeffrey Vincent found that the drawers of water (primarily women) spend an average of 134 minutes / day collecting water. Time saved by bringing water supplies closer to households is likely to dominate estimates of the benefits of improving water supplies. For details, see S. Rosen and J.R. Vincent. 1999. Household Water Resources and Rural Productivity in Sub-Saharan Africa: A Review of the Evidence. *HIID Development Discussion Paper* No. 673. Harvard Institute of International Development: Cambridge, MA.

Figure 7.1 Changes in average collection time and distance

By Location



By Type of Source

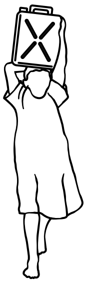


In the context of broader development issues, the time and energy that women and children have to give to water, means less time available for other more economically productive and personally rewarding activities. Apart from sheer physical exhaustion and the ever-present danger of injury from carrying heavy loads, there is less time for income-generation and child care, including education.

Despite the importance of the woman's role, life in many communities where water is scarce is dominated by men. They may make the 'strategic' decisions on resource provision but the women are left to bear the consequences. It may be a male decision to install piped water to a village, but the women often have to operate and maintain the water supply and deal with problems when it fails. In fact, in many places, it would seem shameful for a man to be seen collecting the family's water supply.

Women's work: Women are expected to fetch water for the family, as well as cultivate crops, collect fuelwood, and maintain the home in Alemi, Uganda

8 The Cost of Obtaining Water



Households with Piped Water Connections

Households with piped water connections in East Africa use different systems to pay for their water. In the original study, nearly all piped households in the sample were paying **block** or **flat rates** for their water services (where households pay a single (usually monthly) fee irrespective of the amount of water they consume). In the repeat study, these types of rates were still found to be quite common across the region, including over 90 percent of piped households in Tanzania. A smaller, but significant number of households in DOW II pay a **proportional rate** based on their actual consumption levels. This type of fee-collection mechanism was documented for many of the piped urban and rural households in Kenya and for piped urban households in Uganda.

The Cost of Water in DOW I

During *Drawers of Water I* the average cost of water in urban centres was $0.77 pcm, with Uganda showing the highest value in the region ($0.8 pcm). The cost of water ranged from a minimum of $0.32 in Moshi, Tanzania, to $1.25 in Karuri, Kenya (Table 8.1). In the original study, White, Bradley and White were not particularly surprised at the relatively high values reported, and noted that "*the direct costs to customers for piped supplies in East African cities are somewhat higher than those for cities in the United States, where the mean is about $0.08 per cubic metre*" ($0.32 in 1997 values).

Table 8.1 Cost of Water for Households with Piped Connection (US$ per Cubic Metre) 1997

Country / Region	DOW I [a]	DOW II			
	Urban	Urban			Rural
		SS [b]	New [c]	All	New
Kenya	0.70	0.40	0.57	0.44	0.19
Tanzania	0.77	0.73	0.43	0.65	0.37
Uganda	0.80	0.81	0.78	0.80	--
East Africa	**0.77**	**0.64**	**0.57**	**0.63**	**0.26**

Note

a – The DOW I sample only included piped households in urban areas. Values from DOW I were converted into 1997 equivalent US Dollars using the US Dollar deflator

b – SS corresponds to 'same sites' as in the DOW I sample

c – 'New' corresponds to households with piped water connections located in sites previously classified as 'unpiped'. All direct comparisons between DOW I and DOW II are done using only the 'Same Sites' (SS) samples. This notes also applies to Table 8.2 (on page 68).

The Cost of Water in DOW II

In the repeat study, water was found to be less expensive in rural areas than urban areas (Table 8.1). The difference is significant, particularly in Kenya, with households in Kiambaa, Manyatta and Mutwot paying considerably less than those in Nairobi, and the lowest values across East Africa. Water was most expensive in urban areas in Uganda, where most households were paying flat rates of up to 15000 Ugandan Shillings per month (approximately US$14). Here the service was rather poor, with few hours of water delivery during the day, meaning that households were only able to draw a little water and were forced to use alternative (sometimes less hygienic) sources or pay private vendors. In fact, households paying flat rates paid on average 10 US Cents per cubic metre more than those with proportional rates, and were more likely to pay higher values when water was scarce – *"paying for air"* as some households described it. Despite an average value of US$0.58 in East Africa, the variation for this figure is quite large. Half of the households in the latest sample pay less than US$0.5 per cubic metre, while 40 percent of households pay between US$0.5-$1.00. The highest values (over US$1.5) are reported in Kamuli and Iganga in Uganda, and Changombe in Tanzania.

Independent water vendors play an increasingly important role in urban East Africa, delivering water to households who lack access to piped services – but at a price

International figures on the cost of water for piped households vary widely from place to place. According to information from the World Water Commission (Serageldin 1999[1]) on a 1998 survey on water cost, values (expressed in cubic metres) in industrialized countries vary from $0.31 in Canada to $2.16 in Germany. Some values in the range are UK $1.28, Finland $0.77, United States $0.40-0.80, and South Africa $0.45. Information for 1996 values in some developing countries include: Algeria $0.27-$0.57, Botswana $0.28-1.48, India $0.01-0.82, Sudan $0.08-0.10, **Tanzania $0.062-0.24, and Uganda $0.38-0.59**.

1 Serageldin, I. 1999. The Poor Pay Much More for Water...Use Much Less - Often Contaminated Press Release of the World Water Vision on 5 Aug 99. http://watervision.cdinet.com/pricerelease.html.

Changes in the Cost of Water

In real terms, the cost of water has decreased since 1966 in Kenya (almost 40 percent) and Tanzania (five percent), while in Uganda it has remained nearly the same. The remarkable change in Kenya is mostly due to a significant reduction of cost in Karuri, where a combination of public and private piped supplies now serve the population, although all Kenyan sites also reported reductions in water costs. In Dodoma, Tanzania, households experienced a decrease of almost 60 percent in water cost, but this decrease was out-weighed by increases in Changombe and Moshi. In Iganga, Uganda, water decreased from a reported $0.89 to $0.58, but likewise it increased in Temeke and Kamuli (Figure 8.1).

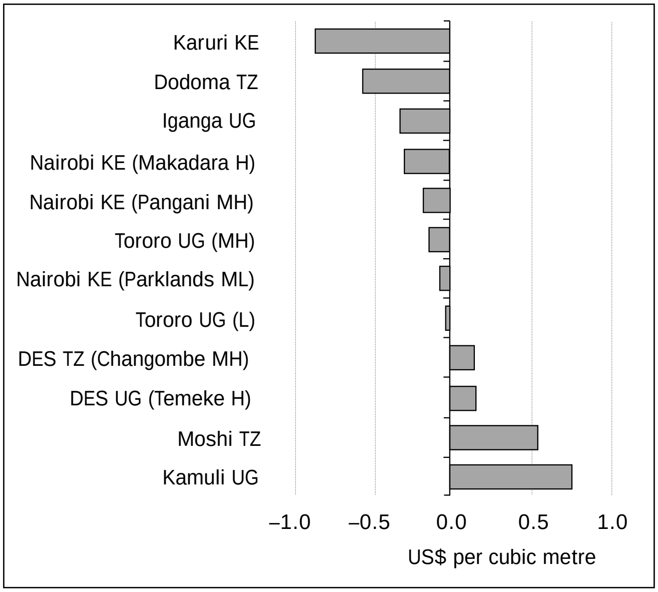


Figure 8.1 Direction and Magnitude of Change in the Cost of Water for Piped Households, DOW I-II

Note '0' represents no change in 1997 dollar value, with values less than '0' representing decreases in the cost of water and more than '0' represent increases in the cost.

Households without Piped Water Supply

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.

The cost faced by piped households is simply the fee paid to the service provider. The cost to unpiped households is more complex.

The social cost of obtaining water from unimproved sources, such as this example from Mukaa, Kenya, has increased since DOW I

Locked standpipe restricts access to water in Dodoma, Tanzania – DOW II

Energy expenditure was estimated in terms of calories 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). The gradient of land surface (going uphill or downhill) was also considered when estimating calories expenditure. Finally, one gram of maize meal (this being the basic staple in East Africa), yielding 3.5 Calories, was used as the unit of food to provide the energy requirements.

Converting these costs into a comparable cash value is difficult. In *Drawers of Water I*, 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'[2]. This method has been repeated in *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. 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.

2 For detailed information on how the values are derived, please refer to White, Bradley and White (1972). The methodology to estimate a cash price has a number of shortcomings, making its reliability open to discussion. 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.

The Cost of Water in the 1960s

In the original study, the average cost of water for unpiped households in East Africa was found to be US$0.82 pcm. Water was approximately 30 US cents less expensive for households living in rural areas compared to those living in cities. In the repeat study, despite the fact that the cost of water increased in both rural and urban areas, this difference was found to have doubled. During DOW I, water was less expensive in Uganda for both rural and urban households.

Table 8.2 Average Cost of Water for Unpiped Households (US$ per Cubic Metre)

Note: for explanation refer to notes on Table 8.1.

	Rural Areas		Urban Areas			Total	
	DOW I[*]	**DOW II[ss]**	**DOW I[*]**	**DOW II[ss]**	**DOWII[new]**	**DOW I[*]**	**DOW II**
Kenya	0.76	0.93	1.43	1.42	1.46	0.84	0.99
Tanzania	1.25	0.95	1.37	1.24	2.6	1.3	1.4
Uganda	0.52	0.71	0.68	1.45	2.5	0.57	1.3
East Africa	**0.74**	**0.84**	**1.06**	**1.41**	**2.46**	**0.82**	**1.22**

A vendor in Iganga, Uganda, selling water for five East African cents per *debe* – DOW I

The Cost of Water in the 1990s

In DOW II, all unpiped households in the sample paid an average of US$1.22 per cubic metre of water (Table 8.2). In general, water was less expensive in rural areas, where the average cost was US$0.84

pcm, with Uganda showing the lowest values of all. At site level, the lowest value was found in Mutwot, Kenya (US$0.16), and the highest value reported in Mukaa (US$2.14), also in Kenya. In the first case 80 percent of households draw most of their water from nearby sources, located within a radius of 150 metres, while 60 percent of households in Mukaa walk distances of 500 metres or more to get their water, thereby incurring a significant cost in terms of caloric expenditure.

Water is significantly more expensive to obtain in urban areas, particularly in Uganda. This is especially the case for households living in sites that were classed as 'piped' in DOW I, as many of those existing piped systems are now faulty and services are insufficient to cover the needs of a growing population. The average cost of water in these sites is US$2.46, with Kenya showing the lowest value of US$1.46. This aggregate value is affected by densely populated, low-income areas like Iganga, Uganda (US$3.15), and Changombe and Temeke in Dar es Salaam (US$3.68 and US$2.70, respectively). But the actual cost of water could be a lot higher depending on availability (or lack) of options. Values as high as US$6.53 per cubic metre were recorded for some households in Changombe and Temeke in Tanzania and Iganga, Uganda, reported a maximum of US$5.5 pcm.

Households living in sites that have remained unpiped since the original *Drawers of Water* pay an average of US$1.41 pcm. Households in Dodoma, Tanzania, pay the lowest cost per cubic metre (US$1.04) because of relatively short collection times at standpipes, while those in Iganga, Uganda pay the highest value (US$1.91) because of lengthy collection times and reliance on private vendors.

As might be expected, the cost of water is strongly related to the water source (Table 8.3). Vendors are the most expensive water source, whose prices range from a low of US$4.0 in urban areas that have remained unpiped to US$6.4 in rural areas. The lowest cost is generally for unprotected sources, like springs or seeps, with ranges between US$0.42 (in 'newly' unpiped urban sites) to US$0.88 in rural areas.

During the repeat study, a great diversity of water selling activities were in operation in Temeke, Tanzania, with an equally diverse range of prices. For example, the cost of a 20 litre jerrycan ranged from Tsh10 to 400 (0.82 to 33 dollars per cubic metre). Some boreholes charged about Tsh10 per 20 litres while mosques and churches sold rainwater stored in tanks for Tsh20 per 20 litres ($1.6 pcm). Most independent vendors operating during drought periods sold 20 litre jerrycans for Tsh100 ($8.2 pcm). Piped households paid a flat rate of Tsh 7,980 per month (US$13). This was considered very high, particularly given the irregular service received.

	Lowest		Highest	
Water source	US$ / pcm	Location	US$ / pcm	Location
Spring or seep	0.42	Urban	0.88	Rural
Well-hand pumped	0.47	Rural	1.90	Urban
Hydrant or standpipe	0.90	Rural	1.61	Urban
Vendor	4.03	Urban	6.44	Rural
Kiosk	1.21	Rural	2.47	Urban

Table 8.3 Range of Cost of Water by Type of Source, DOW II (1997 US$pcm)

The Changing Cost of Water

In Tororo, a piped urban site in Uganda, the charge for piped water was 616 Sh pcm (US$0.6 per cubic metre). A borehole served as the alternative source for those without piped supply, but was almost four times as expensive, as the cost of a 20 litre jerrycan was 50 Ugandan Shillings (US$2.3 pcm).

The increase in the cost of water was not apparent in all the sites in the sample (Figure 8.2). For example, the rural sites of Alemi, Uganda, Kiambaa, Kenya , and Mkuu, Tanzania, experienced significant decreases in cost since 1966 (US$1.4, $0.6 and $0.5 respectively). The cost of water also decreased in Manyatta and Masii, although by a lower amount, while in Mutwot and Moi's (formerly Hoey's) Bridge, Kenya, it has remained almost at the same levels found in DOW I. This is not a universal trend, however, as the cost of water has increased significantly in five of the sites, especially in Mukaa, where water is almost one US Dollar more expensive than 30 years ago.

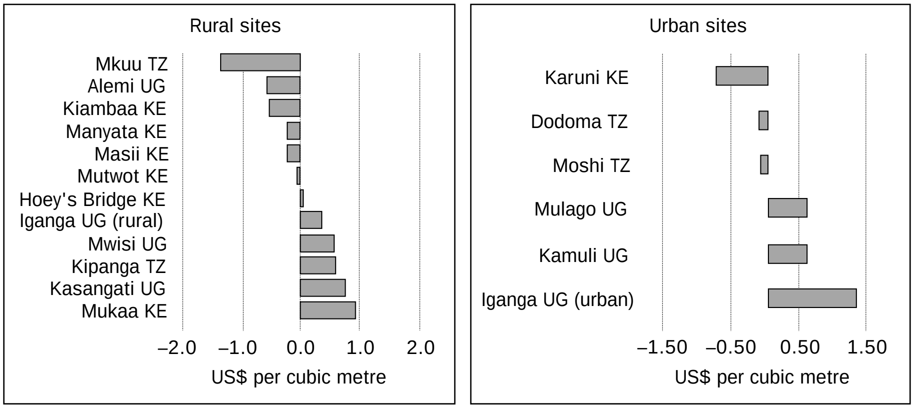


Figure 8.2 Direction and Magnitude of Change in Cost of Water for Unpiped sites (1997 US$ pcm)

Note

"0" represents no change in dollar value. Values less than "0" represent decreases in the cost of water and more than "0" represent increases in the cost. Magnitudes are expressed in US$ per cubic metre. Only 'same sites' are used in the comparison.

Thus, at the regional level, the average reduction in cost (approximately US$0.56) was not enough to compensate the average increase (approximately US$0.63). Households living in urban areas did not have the 'luck' of some of their rural counterparts. Only in Karuri, Kenya, was there a significant reduction in cost of water (equivalent to US$0.7), while Dodoma and Moshi, Tanzania, reported a slight decrease in cost. However, Mulago, Kamuli and Iganga, Uganda, experienced major increases in the cost of water of between 50 US Cents to one US Dollar per cubic metre.

Summarising from the previous sections, in the past 30 years the average cost of water in East Africa has (Figure 8.3):

- increased 10 US Cents (14%) for unpiped households in rural areas
- increased 30 US Cents (28%) for unpiped households in urban areas
- decreased 13 US Cents (20%) for piped households in urban areas

In addition, the relation of cost between unpiped households in rural areas and in cities or towns increased from a difference of 30 US Cents to 60 US Cents per cubic metre, reflecting the effects of growing population in urban areas and a subsequent increase in private and expensive water suppliers.

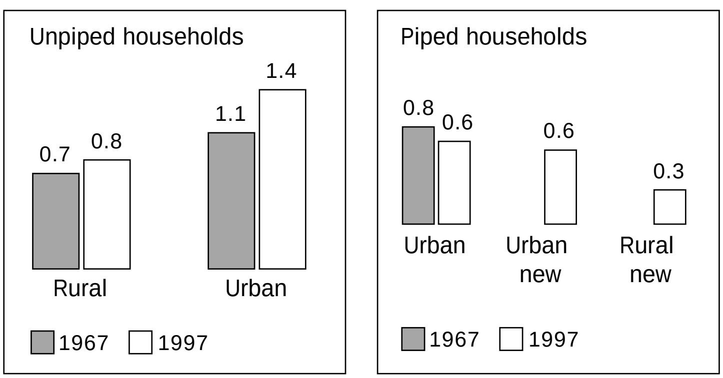
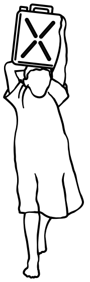


Figure 8.3 Summary: The Change of Cost of Water in East Africa (1997 US$ pcm)

Note only same sites as in DOW I are compared.

In *Drawers of Water I* the cost of water per cubic metre was on average $0.77 for piped households and $1.06 for unpiped households, a difference of 29 US Cents. In DOW II, this gap was found to be significantly larger. While piped households experienced decreases in their average cost of water to $0.64pcm, water cost increased for unpiped households to $1.41pcm. Hence, on average, unpiped households in urban areas pay 77 US Cents pcm more than households with piped connections. This figure obviously masks important variations. For example, households who obtain water from private vendors are likely to be paying US$3.5 pcm more than the cost of piped supply. But the trend is clear – once again the poor – and unconnected – pay more.

9 Water-Related Infectious Diseases, Sanitation, Hygiene Behaviour and the Determinants of Diarrhoea



The Health Aspects of Changing Water Use

The diseases related to water are numerous, diverse and severe, and can be reduced to some order by a classification developed in *Drawers of Water I* and subsequently widely adopted. This article reviews developments in thinking in relation to water-related infectious disease, describes the health implications of the changing use of water in DOW II as compared with the original study, and presents the specific data collected in the two studies on reported diarrhoeal disease and sanitation facilities, with an analysis of the key determinants of diarrhoea in the DOW II sites.

Classifying water-related infections

In *Drawers of Water I*, David Bradley and his colleagues proposed the classification of water-related infections according to their mode of transmission, rather than the type of organism that caused them or their effect on the patient.[1] This taxonomy of water-borne, water-washed, water-based and water-related insect vector groups was a new system of classification. The strength of Bradley's 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 Kolsky has noted, this system "has by and large set the agenda for thought about water interventions and diarrhoea for the last 20 years, precisely because it focused on the objects of such interventions."[2]

Bradley's system contains four classes of infectious diseases that are in some way related to water:

1 See Chapter 6, Costs and Benefits of Water: Health, in *Drawers of Water: Domestic Water Use in East Africa*, especially pp 162-176, in which the 'Classification of Infective Diseases Related to Water' is discussed.

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2 Kolsky, P. J. 1993. "Diarrhoeal Disease: Current Concepts and Future Challenges. Water, Sanitation and Diarrhoea: the limits of understanding." *Transactions of the Royal Society of Tropical Medicine and Hygiene* 87, Supplement 3: 43-46.

1. *Waterborne diseases* are the classic causes of water-related epidemics. In Sub-Saharan Africa, they include cholera and typhoid. These diseases are transmitted by consuming contaminated water.

2. *Water-washed diseases* are those that result from using insufficient quantities of water for personal or domestic hygiene. What matters most for these diseases is the quantity of water used, not its quality. Many are diseases of the skin and eyes, but, as is discussed in more detail below, diarrhoeal diseases are also frequently water-washed. The definition provided in *Drawers of Water* is those infections "whose incidence or severity can be reduced by augmenting the availability of water without improving its quality" (p. 169).

3. *Water-based diseases* are caused by pathogens that require aquatic organisms as hosts during some part of their life cycle. These diseases are transmitted through repeated contact with or ingestion of contaminated water, for example through bathing or washing clothes. The two main water-based diseases in sub-Saharan Africa are schistosomiasis and dracunculiasis (guinea worm disease).

4. Finally, diseases with *water-related insect vectors* are those that are spread by insects that breed in or near water, like malaria and onchocerciasis ('river blindness').

The one significant improvement made to the *Drawers of Water* categorisation was to consider it as a classification of transmission routes rather than diseases, because – as Bradley had recognised – some disease routes could be transmitted by more than one route.[3] This helped to focus interest on the transmission process itself, which is a particular concern to those who seek to control disease by environmental management rather than by immunization or the treatment of patients.

Because almost all the endemic diarrhoeal diseases that take such a heavy toll on health in sub-Saharan Africa are transmitted through the faecal-oral pathway and are very often water-washed, rather than

3 The improvement to the Bradley classification was suggested by Richard Feachem and further reinforced by Sandy Cairncross. For details see Feachem, R.G. 1977. Water Supplies for Low-Income Communities: Resource Allocation, Planning and Design for a Crisis Situation. In R.G. Feachem, M. McGarry and D. Mara, eds. *Water, Wastes and Health in Hot Climates*. London: John Wiley. See also Cairncross, S. 1996. Water Quality, Quantity, and Health. In J. Drangert et al., eds. Conference on Safe Water Environments. *Water and Environmental Studies Report* No. 24, Linköping University, Sweden.

waterborne, Richard Feachem (1977) and Sandy Cairncross (1996) proposed that the 'waterborne diseases' category be replaced with one for 'faecal-oral diseases' that can be either waterborne or water-washed. Skin and eye diseases that are strictly water-washed remain in a category of their own, as do water-based diseases and those with water-related insect vectors. Below are some of the common diseases in each class, using the combined Bradley-Feachem classification system (Bradley 1977; Feachem 1977).

1. *Faecal-oral* (may be waterborne or water-washed)	Low infective dose: cholera, typhoid High infective dose: diarrhoeal diseases, amoebic and bacillary dysentery, ascariasis, gastroenteritis, infectious hepatitis, paratyphoid, enteroviruses (some), and hookworm
2. *Water-washed* (strictly)	Skin and eye infections: trachoma, skin sepsis and ulcers, scabies, conjunctivitis, leprosy, yaws Other: insect and arachnid-borne typhus
3. *Water-based*	Penetrating skin: schistosomiasis (bilharzia) Ingested: dracunculiasis
4. *Water-related insect vectors*	Breeding in water: malaria, onchocerciasis, yellow fever, filariasis, dengue, and (some) arboviral infections Biting near water: trypanosomiasis (sleeping sickness)

Historically, there has been a great deal of emphasis on water and sanitation facility improvements to reduce the transmission of diarrhoeal diseases. In recent years, however, greater attention has been paid to the effects of hygiene behaviour rather than service improvements per se. While much of the *Drawers of Water II* project focused on assessing changes in domestic water use, the extensive nature of the research allowed for an analysis of the relative importance of different transmission routes, and thus the effectiveness of different policy interventions.

Improved water supplies tend to reduce transmission via faecal-oral and water-washed diseases. The former would arise through quality effects and the latter through quantity effects. Improved sanitation facilities reduce transmission through water-related insect-borne diseases, insofar as insect vectors would be less prevalent. Furthermore, the effects of personal hygiene programmes reduce transmission through water-washed diseases, and might also affect transmission through water-borne diseases if information obtained through the programme affects choice of water supply.

Sanitation facilities interrupt the transmission of much faecal–oral disease at its most important source by preventing human faecal contamination of water and soil. Epidemiological evidence suggests that sanitation is at least as effective in preventing disease as improved water supply. Often, however, it involves major behavioural changes and significant household cost. Sanitation is likely to be particularly effective in controlling worm infections. Policy makers and practitioners often think of sanitation in adult terms, but the safe disposal of children's faeces is of critical importance. Children are the main victims of diarrhoea and other faecal–oral disease, and also the most likely source of infection.

Reporting of diarrhoea

Diarrhoea is the most important public health problem affected by water and sanitation in East Africa and can be both waterborne and water-washed. Adequate quantities of safe water for consumption and its use to promote hygiene are complementary measures for protecting health. The quantity of water people use depends upon their ease of access to it. As DOW I and II have shown if water is available through a house or yard connection people will use large quantities for hygiene, but consumption decreases when water must be carried for more than a few minutes from a source to the household.

4 In their original study, White, Bradley and White included two questions about diarrhoea incidences in their household survey. They did not investigate latrine types and use or hygiene issues, which were new areas of investigation added to the DOW II study. Thus, comparison of the two datasets in this area is limited to the determinants and prevalence of diarrhoea. All additional observations are based upon findings from DOW II. This paper is based upon an article by Tumwine, J., J. Thompson, M. Katui-Katua, M. Mujwahuzi, N. Johnstone, E. Wood, and I. Porras. 2001. Diarrhoea and Effects of Alternative Water Sources, Sanitation and Hygiene Behaviour in East Africa. *Journal of Tropical Medicine and Hygiene* (under review).

In addition to looking at changes in domestic water use, both *Drawers of Water* studies also examined issues related to water use, source type, hygiene behaviour, sanitation facilities and the prevalence of diarrhoea.[4] Respondents were asked to report the number of incidences of diarrhoea that had occurred in the household in the previous week and the previous 24 hours. While these were subjective questions, the range of interviewers and sites was great enough to permit hope that internal biases might cancel out if data were compared within and between the two studies.

In DOW II, there was considerable discrepancy between the three countries in terms of the percentage of households who responded that there had been at least one case of diarrhoea in the previous week, with Tanzania showing much lower rates (Figure 9.1).

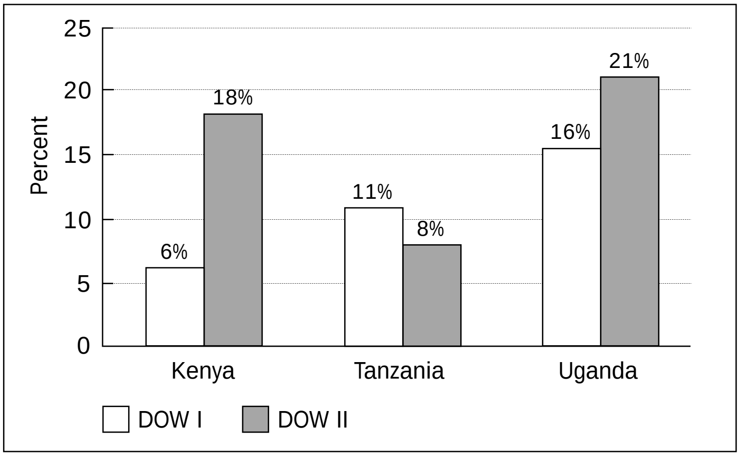


Figure 9.1 Reported Incidences of Diarrhoea in the Week Preceeding the Interview, DOW I & II (percentage of households)

The health effects of alternative water sources

In *Drawers of Water II* the likelihood of there being an incidence of diarrhoea in a particular household was found to be much greater for unpiped than piped households (Figure 9.2). However, it is important to look at this issue in more detail by examining the effects of alternative sources by type.

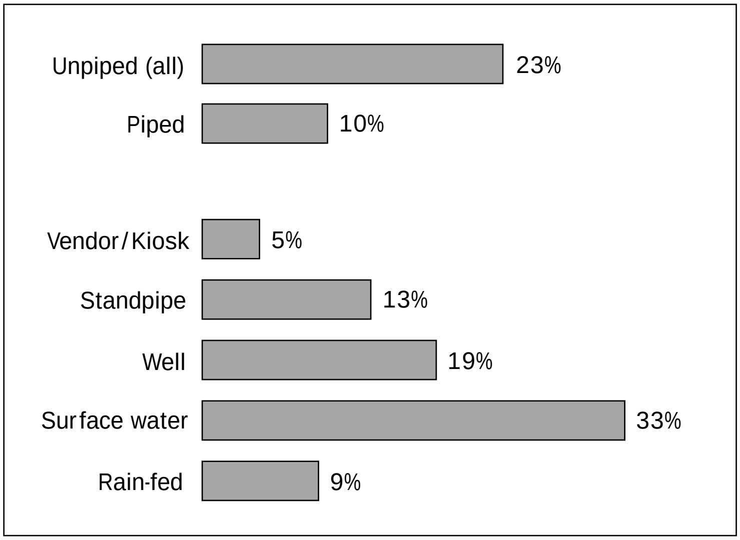


Figure 9.2 Reported Incidences of Diarrhoea by Source of Water, DOW II

The effect of alternative water sources is telling. Over 30 percent of households that rely on surface water as their primary source reported at least one case of diarrhoea in the last week. Households that rely on improved wells and standpipes were next, followed by those who rely on rain-fed sources. Vendors and indirect piped access appear to be the 'safest' sources. Indeed they appear to be somewhat safer than direct piped access (at least in terms of prevalence of diarrhoea), a finding at odds with results of some other studies that indicate that vendors usually sell water of dubious quality.[5] Regression analysis

5 See, for example, Oyemade, A, F.O. Omokhodion, Olawuyi J.F., Sridhar M.K. and Olaseha IO. 1998. Environmental and Hygiene Practices: Risk Factors for Diarrhoea Among Children of Nigerian Market Women. *Journal of Diarrhoeal Disease Research* 16(4): 241-7. The recent WHO / UNICEF Global Assessment also makes this point by classifying water from vendors as being 'not improved'. WHO and UNICEF. 2000. *Global Water Supply and Sanitation Assessment 2000 Report* Geneva: WHO / UNICEF Joint Monitoring Programme.

A child collecting water from a poorly maintained spring box in Kiambaa, Kenya

6 This is consistent with the findings of Manun'ebo, et al, who reported a significant association between diarrhoea prevalence and drinking water source. See Manun'ebo, M.N., Haggerty, P.A., Kalengaie, M., et al. 1994. Influence of Demographic, Socioeconomic and Environmental Variables on Childhood Diarrhoea in a Rural Area of Zaire. *Journal of Tropical Medicine and Hygiene* Vol. 97: 31-38.

demonstrated that unsafe surface sources (e.g., ponds, streams and unlined wells) increase the rate of diarrhoea by 1.9 percent.[6]

Caution is needed when suggesting a possible association between water source type and diarrhoea rates, however, as the effect may be subject to confounding by a number of factors, such as the physical location of the site (i.e., altitude and climatic conditions) and seasonal variations.

The health effects of alternative sanitation facilities, hygiene behaviour and socio-economic background

An attempt was made to gain an insight into the determinants of diarrhoea morbidity in households in East Africa. What has emerged is that these determinants are diverse. The type of sanitation facility appears to be an important factor (Figure 9.3). While 42.2 percent of the households without a toilet facility in the unpiped households reported at least one case of diarrhoea in the last week, the corresponding figure for those with unimproved pit latrines and Ventilated Improved Pit (VIP) latrines was 19.7 and 20 percent. The higher figure for the VIPs is somewhat surprising, but it must be noted that only five per cent of all sample households had VIPs.

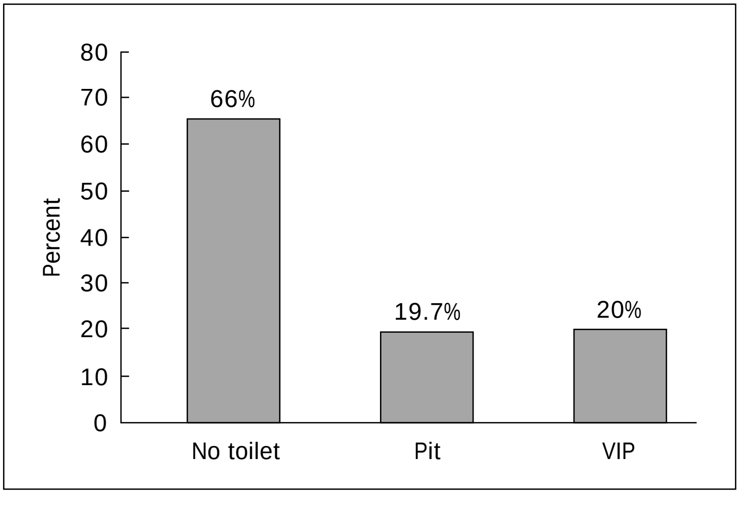


Figure 9.3 Reported Diarrhoea Incidences by Latrine Type, DOW II

In the piped sites, there were no households without access to a toilet facility. However 14 per cent of the households with a pit latrine reported at least one case of diarrhoea compared with only 7.4 per cent of the households with a flush toilet. However, flush toilet facilities are by no means universally preferable on personal health grounds.[7] Indeed, the multivariate regression analysis did not indicate that type of sanitation facility in and of itself was a statistically significant determinant of the prevalence of diarrhoea. Here again, some caution is required when drawing conclusions from these findings as the data on the effect of toilet type may be subject to confounding by the level of water supply service.

7 See Mara, D. 1996. *Low-Cost Urban Sanitation*. New York: John Wiley & Sons; and Cairncross, S. and Feachem, R. 1993. *Environmental Health Engineering in the Tropics*. New York: John Wiley & Sons.

What has clearly emerged is that hygiene-related factors are important determinants of diarrhoea in the study sites. While there is no single proxy for hygiene behaviour, regression analysis showed that the disposal of children's faeces, the amount of water used for household cleaning, and the level of education of the household head were important factors (Table 9.1):

Factor	Chi square	P value	Odds ratio	95% CI
Unsafe disposal of children's faeces	14.5	<0.001	2.73	1.55 – 4.80
Unsafe waste water disposal	36.5	<0.001	3.43	2.26 – 5.22
Faecal matter in toilet surroundings	7.9	0.005	2.60	1.26 – 4.04
Household has unpiped water supply	33.3	<0.001	2.40	1.76 – 3.29
Household located in rural area	60.8	<0.001	3.06	2.27 – 4.13
Household lacks latrine	47.6	<0.001	2.40	1.76 – 3.29

Table 9.1 Bivariate Analysis of the Factors Significantly Associated with Diarrhoea Morbidity, East Africa, DOW II

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

Simple pit latrines, such as this example from Moi's Bridge, Kenya, are a relatively effective form of sanitation in rural East Africa

While illustrative, the descriptive and bivariate data presented above tell us very little about the determinants of the prevalence of diarrhoea. For instance, many of the factors that appear to be closely related to the prevalence of diarrhoea are themselves highly correlated. As such, it is important to disentangle the separate influence of various factors. In order to do so, multivariate logistic analysis was used to examine this issue in more detail.

The independent variables used in the model included (expected signs in parentheses):

- Country of residence (Kenya, Tanzania or Uganda)
- Site location (rural or urban)
- Education level of head of household (to reflect socio-economic standing and 'awareness' of environmental health issues) (-)
- Size of household (+)
- Proportion of children in the household (+)
- Litres of water per household member used for cleaning (-)
- Disposal of children's faeces by 'burying in soil' or 'throwing in garden' (+)
- Using unimproved surface sources or wells (+)
- Use of unimproved toilet facilities (+)
- Observed evidence of faeces in the region of the sanitation facilities (+)

A number of the hypothesised relationships did not hold up well (Table 9.2). Perhaps most surprisingly, the variables for the type of toilet facilities and for the presence of faeces near the toilet were not significantly correlated with diarrhoea. However, a number of other variables did show strong associations of the expected sign. Most notably, the variables for per capita water use for cleaning and method of disposal of children's faeces were significant. In addition, use of unimproved water sources appears to be an important factor, as do level of education of the head of household and the size of household.

Table 9.2 Multivariate Analysis of the Determinants of Morbidity from Diarrhoea in East Africa, DOW II

Variable	Weighted Aggregate Elasticity
Country of residence (Uganda)	0.122**
Country of residence (Kenya)	0.227*
Per capita use of water for cleaning	–0.132*
Number of years of education of head of household	–0.374**
Obtained water from unimproved surface sources or wells	0.192***
Number of household members	0.370***
Unsafe disposal of children's faeces	0.253**

Note *sig. at 10% level, ** sig. at 5% level and *** sig. At 2.5%

In sum, the following relationships were found:

- Households with a 10 percent increase in the use of water for cleaning purposes will decrease the prevalence of diarrhoea by 1.3 percent.
- Unsafe disposal of children's faeces increases the prevalence by 25 percent.
- The relative risk of diarrhoea decreases by 3.7 percent for each 10 percent increase in the number of years of education attended.

The availability of water for personal hygiene, as described in Articles 2 and 3, remains an important factor. A comparison of the two data sets reveals a significant decline in mean daily per capita water use from 61.4 in DOW I to 39.6 litres in DOW II. This is a reflection of the almost universal decline in water use by households with piped connections. While water use in unpiped households increased by nearly 80 percent – from 11 to 19.7 lcd – use for piped households declined by over 48 percent, from 128 to 66 lcd. This decline in the amount of water available per person, especially in the urban areas in the region, means that people's health and hygiene are likely to be affected, as the box on local perceptions of the causes of water-related diseases in Alemi, Uganda, shows. When there is not enough water to go round, often there is less water available for cleaning utensils, washing hands after defecation or handling children's faeces, or cleaning the home and compound.

Despite the increase in the amount of water available per capita in unpiped households, the new figure (19.5 lcd) is hardly adequate. In fact, the repeat study has shown that unpiped households suffer lower hygiene levels as a result of not having access to reliable piped water supplies. For example, the unpiped households use less than half the amount of water used by households with piped connections, for bathing, washing dishes and clothes and house cleaning. Yet recent studies have demonstrated that many diarrhoeal diseases can be prevented or reduced by improving water related hygiene behaviour. [8]

It appears that there is association between prevalence of diarrhoea, water used for cleaning (which is linked to access to water sources)

Local Perceptions of the Causes of Water-Related Diseases in Alemi, Uganda

In Alemi, a remote, rural site in northern Uganda, 32 out of 40 sample households (80 percent) reported at least one case of diarrhoea in the previous week, and 11 households reported at least two cases in the previous 24 hours. This was the highest level recorded among the 34 *Drawers of Water* field sites and significantly higher than the mean for the study. The reasons for this high rate of diarrhoea morbidity are complex, but low per capita use (15.7 lcd) of poor quality water is clearly a contributing factor. So too is the lack of improved latrines, as only eight out of 40 sample households (20 percent) possess their own latrines, only one of which is an improved VIP latrine. This shortage of latrines leads people to dispose of children's and adults' faecal matter either by burying it or throwing it in kitchen gardens in or near family compounds.

Local women's understanding of the relationship between water, waste and hygiene in Alemi is sophisticated, if not always scientifically accurate. They attribute a number of diseases, including diarrhoea, schistosomiasis, skin infections and backache, to the collection and use of water from open, unimproved, often seasonal sources. They also believe there is an association between measles and contaminated water. Moreover, they think that walking in stagnant water and passing through bushes covered with dew causes skin rashes and boils.

The women also recognise the seasonal dimensions of water-related diseases. They reported that waterborne and water-washed infections such as diarrhoea and skin rashes were not common during the dry season, but very common during the wet months of April and May.

The women also feel that the high prevalence of diarrhoea at Alemi is due in part to low latrine coverage and to the use of water sources that are exposed to contamination by animal and human excreta. Diarrhoea, skin rashes and cholera are also attributed to dirty latrines. In addition, they say that flies from latrines contaminate food, subsequently leading to diarrhoea and cholera.

Skin infections and schistosomiasis, which were found to be very common in Alemi during the original study because of water scarcity and infrequent bathing, were less common in DOW II because of an increase in the availability of drugs and medical treatment. From the women's perspective, skin rashes and persistent itching are associated with water scarcity and poor hygiene, as shortages of supply prevent them from washing clothes regularly, smearing the floors of houses with cow dung (a process that requires water) and bathing frequently.

and hygiene practices such as disposal of children's faeces. This study also demonstrates that households with a piped water connection use significantly more water for cleaning (laundering, washing clothes, bathing and personal hygiene) than those without.[9] Indeed factors such as the characteristics of sanitation facilities and hygiene behaviour appear to be important determinants of diarrhoea prevalence, a finding consistent with several recent reviews.[10]

Disease Classification and Changes in Water Us

It was found that the changing water use scene and its associated changes (and in some cases unchanging features) in water-related infectious disease problems, including diarrhoea, map well onto the four-category DOW I classification described above. Thus changes in the quantity of water used will primarily influence the water-washed transmission of disease. Furthermore, the potential and actual changes in water quality will be reflected in the incidence of water-borne transmission in the strict sense.

Since DOW I the main change in water-based disease has been the virtual eradication of Guinea worm (dracunculiasis) from Africa outside the Sudan. The one site where this may have had a direct effect is Alemi in Central Uganda, which was formerly in the Guinea worm endemic area and had sufficiently poor quality water sources that it may have earlier suffered from Guinea worm even though it was not observed during the DOW I survey.[11]

The move towards intermittency of piped water service (Article 6) is generating major household storage container use with an increased risk of Aëdes breeding, with implications for arbovirus transmission and especially increased vulnerability to dengue. Thus, there is a move of Category IV of water-related disease: water-related insect vectors, from spilled water around sources breeding anophelines that transmit malaria, to peridomestic *Aëdes* breeding in man-made containers with a threat of virus fevers.

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

Software versus hardware solutions

Since the publication of *Drawers of Water* in 1972, research on the effects of water supply on health has fairly consistently concluded that increasing the quantity of water used in the household is more important than improving its quality. Because faecal-oral diseases have multiple transmission routes – hands, food, and utensils, 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 probable that all aspects of hygiene, from bathing to laundry to washing of hands, food, and dishes, will suffer. A typical observation is that of Cairncross, who commented, "...an increasing weight of evidence, much of it from rural Africa, has accumulated that the endemic paediatric diarrhoeas of poor communities are largely water-washed, as they are not substantially affected by water quality improvements when hygiene and access to water are unchanged."[12]

The findings of this study supports the view that daily access to at least a few litres of water per person beyond the minimum required for physical survival is a prerequisite for achieving major, sustained improvements in hygiene practices. The WHO's recommended standard of 20 litres/person/day assumes this to be the case.[13] At the same time, it seems equally logical that, since almost all households have access to some water for hygiene, more effective use of that water should cause some reduction in the transmission of faecal-oral diseases.

Since the amounts of water used for cleaning and disposal of children's faeces are likely to be closely linked to access to water sources, it is difficult to draw firm policy conclusions regarding the separate effects of hardware and software solutions. However, the results strongly suggest that software (hygiene behaviour education) is an important complement to hardware (increased access to improved water and sanitation facilities), when seeking to reduce diarrhoeal morbidity rates. Thus, while there is a clear and pressing need for increased levels of investment in water and sanitation facilities in East Africa, these improvements must be accompanied by hygiene programmes or some of the environmental health benefits will be lost.

9 This is similar to findings reported by Cairncross and Cliff in two villages in Mueda, Mozambique, who found that households with a centrally located water source used an average of 11.1 lcd, while those relying on a distant source averaged only 4.1 lcd. More than half of the additional water was used for bathing adults and children. Water for bathing children, nearly nonexistent when the water source was distant, rose to 13 percent of the total when more easily accessible. See Cairncross, S. and Cliff, J.L. 1987. Water Use and Health in Mueda, Mozambique. *Transactions of the Royal Society of Medicine and Hygiene* 81: 51-54.

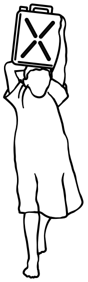
10 See Esrey, S. 1996. op cit., Kolsky, P.J. 1993. op cit, and Varley, R.C.G., Tarvid, J. and Chao, D.N.W. 1998. A Reassessment of the Cost-Effectiveness of Water and Sanitation Interventions in Programmes for Controlling Childhood Diarrhoea. *Bulletin of the World Health Organisation* 76 (6): 617-631.

11 David Bradley, personal communication.

12 Cairncross, S. 1988. Domestic Water Supply in Rural Africa. In D. Rimmer, ed. *Rural Transformation in Tropical Africa*. London: Belhaven.

13 WHO and UNICEF. 2000. Global Water Supply and Sanitation Assessment 2000 Report. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP). Geneva: WHO and New York: UNICEF. According to *Drawers of Water I*, the minimum water intake required for survival in tropical areas is estimated at 1.8-3.0 litres per person per day.

10 The Natural Environment, Household Choice and Water and Sanitation Services in East Africa



Introduction

In this article the links between some of the social and ethical dimensions of the provision of water and sanitation services and the natural environment in East Africa are examined, with reference to the lessons emerging from the *Drawers of Water* research.[1] The environmental dimensions arise from the fact that water sources are often non-excludable and that water and sanitation service provision affects, and is affected by, negative environmental and health externalities. The social and ethical dimensions arise from the fact that society may attach value to an individual household's water consumption and to access to sanitation facilities above and beyond the private household's (resource-constrained) demand.[2]

The focus is on the direct domestic use of water for consumption (drinking and cooking) for those households that do not have access to piped facilities. In such cases the links between the private consumptive uses of the environment and its associated public environmental benefits is often more complex than for water used for amenity uses or which is obtained from piped sources. In the case of water used by unpiped households for consumptive purposes, the public environmental good is also a private economic good (if not always a commodity) to be consumed.[3]

Second, the distinction is perhaps more important from a social and ethical perspective. Unlike many other environmental resources, access to improved water supply and sanitation facilities is a public concern not only because of the more traditional concerns of non-excludability (in which access can not be limited) and environmental externalities (in which quality is inadequate), but also because such access is a precondition for full participation in society, and even survival. As such, it is a *basic need* and, as with all basic needs, society attaches a value to personal consumption patterns, even in the absence of negative environmental externalities and non-excludability of resource use.[4]

To begin, the environmental and ethical aspects of the public nature of water and sanitation provision are reviewed briefly. This is followed by a review of the consequences of not having access to piped water services in terms of financial costs of water, inconvenience (distance and time), the costs of collection, and health costs (in terms of diarrhoea rates). It is argued that 'choice' means something very different for such households than is usually meant by the term. The article closes with a brief discussion of policy implications.

The 'Public' Dimensions of Water and Sanitation Service Provision

As noted above, environmental market failures are common in the provision of water and sanitation services. Many sources of water are excludable and have been for a considerable time, while in other cases it may be prohibitively costly (or technically unfeasible) to restrict access in any way. In such cases water use will be unregulated and the source is an open access resource. In other cases water resources may have been held in common, with custom and tradition determining access through collective decision-making and the effective and efficient institutional arrangements of local organisations. This is still true in many regions of developing countries, including East Africa.[5] In some areas, however, changes in economic conditions, tenure arrangements or demographic shifts may have corroded this web of social relations, resulting in conditions of non-excludability.

Full or partial non-excludability results in an excessive level of consumption. Households will have no incentive to bear in mind the additional costs of water consumption on other users as scarcity increases. This is particularly important for groundwater, although it also affects some surface waters, wells and even public standpipes. If network water is not priced appropriately – as is the case in the majority of systems in developing countries – users will treat even piped supplies as open access resources. Even if it is priced appropriately, if supply is intermittent (and uncertain) then individual users may engage in a competitive "race" to fill up their storage tanks before others do so. As we have seen all of these conditions exist in East Africa.

The difficulties involved in restricting access to water resources have contributed to decreasing availability of water resources for many households. At the global level, current trends indicate that the level of per capita available water resources is likely to continue to fall for the foreseeable future, with an estimated 250 million people living in areas under high water stress by 2020.[6] Some of the worst affected areas are in Sub-Saharan Africa. Of the three countries surveyed, Kenya faces the highest degree of water stress, but resources in some regions in all three countries are constrained.[7]

The low quality of water on which households depend is often an equally pressing concern, with high incidences of a variety of water-borne and water-washed diseases, as described in Article 9. Negative environmental externalities associated with use of inadequate sanitation services are often very important contributors, with both surface and groundwater affected. With an estimated 1.1 billion households in developing countries in 2000 not having access to 'improved' drinking water supply and 2.4 billion households not having access to 'improved' sanitation facilities, the problem is clearly pressing.[8]

The health consequences are considerable. According to the most recent WHO/UNICEF *Global Water Supply and Sanitation Assessment*, there are four billion cases of diarrhoea each year with 2.2 million deaths, most of which are children under the age of five.[9] Intestinal parasites such as roundworm and hookworm infect large proportions of the population of the developing world. Depending upon the severity of the infection they can lead to malnutrition, retarded growth and, perhaps, anaemia. A total of six million people are blind from trachoma. Other health concerns related to water and sanitation include schistosomiasis, cholera and typhoid.[10] In many cases the adverse health effects of low water quality, inadequate water quantity and poor sanitation facilities are synergistic. The incidence of many of these diseases can be reduced through changing hygiene behaviour, including use of adequate amounts of water for washing, bathing and cleaning.[11]

The effects of many of those diseases listed above are borne by the wider community and not just by the household directly affected. These zones of infectious disease transmission have been described as the 'public' and 'domestic domains'.[12] Households may well recognise the adverse health effects of these diseases in the domestic domain and, if they can afford to do so, adjust their water supply and sanitation provision patterns accordingly. However, they may not consider the external benefits of their own improved health to the health of the wider community. For instance, a household might choose to use a simple pit latrine that is perfectly sanitary in terms of immediate environmental consequences. Depending on hydrogeologic conditions, however, it may result in externalities by contaminating the groundwater supply of the community. Even if the household itself draws water from this supply, there will still tend to be excess contamination since the household's cost of avoiding this contamination is likely to be greater than the household's expected benefit from better quality groundwater arising from their own efforts.

Thus, water and sanitation have strong 'public' environmental attributes since: (i) water resources are often non-excludable; (ii) use of inadequate sanitation facilities can result in negative environmental and health externalities; and (iii) consumption of water of poor quality (or in inadequate quantity) can generate negative health externalities. At the same time, water and sanitation are also necessities. In strict economic terms this is reflected in the fact that estimated income elasticities for water demand are consistently less than one (Article 2).[13]

As noted above, a much more fundamental case is also often made with many arguing that access to adequate water supply and sanitation facilities is a 'basic need'. This is a controversial area, with the term itself being a subject of intense debate.[14] At its core, the notion of a basic need draws upon the distinction between negative and positive freedom, with some goods being preconditions for "the ability of a person to function."[15] The basket of goods and services that are considered to belong in this category will vary across societies and over time.[16] A strong case can be made for the inclusion of water and sanitation services under this category. Most fundamentally, a basic level of water consumption for drinking purposes is a precondition for survival itself.[17] Access to sanitation facilities, while less pressing in strict physiological terms, is nonetheless fundamental to meaningful participation in most societies. Thus, at one level, consumption is non-discretionary, since households do not 'choose' to consume water for drinking and cooking purposes, but are physiologically required to do so. These have been labelled as 'primary' or 'positive rights goods' in the literature.[18] The latter term underscores the point that private consumption of water and private access to sanitation facilities has public ethical dimensions. Unlike some other 'goods' that can be classified as positive rights goods, however, consumers of water and sanitation services can affect each other's consumption possibilities and broader welfare directly in the public domain. This is due to the non-excludable nature of some water sources and the negative environmental and health externalities that exist and which have been discussed above. It is the joint existence of these two 'public' elements – the environmental and the ethical – of water and sanitation services that has made public policy in the area such a fraught exercise.

The key point is that inadequate access to a basic need that is also potentially degradable and exhaustible can constrain a household's choices to such an extent that the choice itself can hardly be considered an exercise of freedom in any sense. In practice, household members are forced to choose between bearing costs in terms of potential ill health, use of extremely scarce financial resources (and thus other non-discretionary consumption), or through large expenditures of time and effort. In order to provide the context for this discussion it is first necessary to review water consumption rates and levels of access to piped facilities in the *Drawers of Water* sites.

Water Consumption Rates and Access to Network Water and Sanitation Facilities

Not surprisingly, the DOW II survey revealed that water consumption rates differ markedly between piped and unpiped households. Mean water consumption for those with access to piped facilities is 60 litres per capita per day, but for unpiped households it is just 19.7 lcd. These figures are at the very low end of international consumption rates. For instance, a survey of urban and rural 'recorded' domestic water consumption rates reported only two countries (Bangladesh and Burma) with comparable rates.[19] Moreover, the figure for unpiped households is only marginally higher than figures usually used as indicative of basic human requirements. For instance, the US Agency for International Development uses a guideline figure of 15-20 lcd for disaster relief projects involving 'populations at risk'.[20] A total of 230 households in the DOW II survey have average daily per capita water use of less than 15 lcd. Tanzania's *National Water Policy* recommends that rural households have access to at least 25 lcd, a level currently not being met by a majority of unpiped rural households.[21]

Freedom of choice? Inadequate access to water can constrain a household's choices

More relevant to this discussion are the figures for water consumption by type of use since water consumption per se is not a basic need, but water consumption for some very specific purposes clearly is (Article 2). Indeed, while some uses of water may be considered basic needs (e.g. drinking and cooking water) it is clear that others may even be considered luxury goods (e.g. non-food gardening, car washing, swimming pools). This highlights the 'instrumental' nature of water as a positive right good. In effect, it is really an input through which the positive right (a reasonable standard of health) can be realised.

Fortunately in the survey, data were collected on water consumption by use (e.g. drinking and cooking, personal hygiene, laundering and washing, flushing toilet, garden). Article 2 in this monograph provides data on water consumption by type of use for piped and unpiped households. The average consumption rate for drinking and cooking combined is approximately four lcd in DOW II. However, 339 households reported drinking water consumption rates less than the three lcd figure recommended in the aforementioned USAID guidelines.

In general, however, there was remarkably little variation in consumption rates across groups of households. The 'non-discretionary' nature of consumption for drinking and cooking is revealed by the similarity of the figures irrespective of whether or not they have access to a piped connection. Indeed, much of the difference for the aggregate figures can be explained by flushing toilets, although the figure given (19 lcd) is based on a small sub-sample of only 104 households. Nonetheless, the discrepancies between consumption rates for bathing and personal hygiene, which can also have strong influences on the prevalence of negative health effects (and externalities), are also quite large.

Not surprisingly, consumption of water for drinking and cooking appears to be non-discretionary. Households consume approximately the same amount for these uses, irrespective of conditions. However, since the characteristics associated with alternative sources of water are very different, not having access to piped water can have significant financial, inconvenience and health implications even if consumption levels are approximately the same.

The Welfare Implications of Not Having Access to Piped Facilities

The evidence elsewhere in this report (see especially Articles 2, 4 and 6) indicated that households do not appear to bear the costs of non-access to piped facilities mainly in terms of reduced consumption of drinking and cooking water. This is not surprising since as a necessity households are required to consume a minimum amount for survival. The choice that they face is not primarily about how much to consume, but rather about their source of consumption. Due to the very different implications of consumption from different sources, however, the costs of their choices manifest themselves in very different ways. In this section, we will review how households bear the costs of not having access to piped facilities through ill health, financial costs, and/or inconvenience. All of these factors derive in large part from the public (in the environmental sense) nature of water and sanitation. Ill health can be attributed in part to the existence of externalities and non-excludability (increasing water scarcity). Inconvenience costs can also be partly attributed to scarcity. They can also be attributed to externalities that have affected more convenient sources. The same can be said of financial costs, although other factors are clearly also at play.

Data on the distance travelled and time spent to collect water (Article 7), the financial cost of water (Article 8) and the incidence of diarrhoea (Article 9) can be compared for households which opt (or are required) to use different classes of alternative source (rain-fed cisterns, surface waters, wells, indirect piped water from communal buildings or from neighbours, hydrants and standpipes, and vendors and kiosks). Most households without access to a piped connection will obtain their water from a number of these alternative sources. In some cases this will reflect the different uses to which the water is put. In other cases it may a function of seasonal factors. In still other cases it may reflect economic factors, as relative prices and other factors change. However, in the course of the survey, households were requested to designate a primary source. The largest group (219 households) used surface waters, followed by wells (113), vendors and kiosks (65), hydrants and standpipes (53), 'other' sources (23), indirect access to piped supplies through neighbours (20), and rain-fed water (11).

In Figure 10.1 the financial effects of non-connection are compared by type of 'primary' source. Not surprisingly, those who rely upon surface waters pay the least. Those who rely upon rainwater and wells are next, followed by standpipes and indirect piped (neighbours or communal building). Vendors and kiosks are by far the most expensive sources, with average costs more than double the price of more convenient direct "piped" water access.

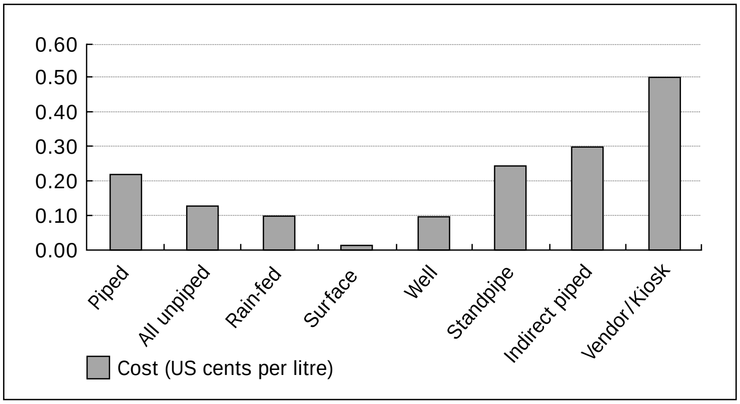


Figure 10.1 The Financial Cost of Alternative Sources, DOW II (1997 US Cents per Litre)

In terms of 'convenience' a rather different picture emerges, with vendors and kiosks being relatively close to the home (an average of just under 200 metres), while surface waters are further removed (over 400 metres, with 45 households over one kilometre distance to their primary source) (Figure 10.2). Wells and standpipes are at an intermediate distance, while indirect piped access and rain-fed catchments are the closest of all. Not surprisingly, a similar picture emerges in terms of time for collection, although congestion at some types of sources (particularly standpipes) means that considerably more time is required than the distance would imply. Indeed, as discussed in Article 7, a comparison of DOW I and DOW II indicates that time spent is increasing much more rapidly than distance travelled, indicating that congestion is worsening, perhaps due to increased unreliability of supply as well as increased population density.

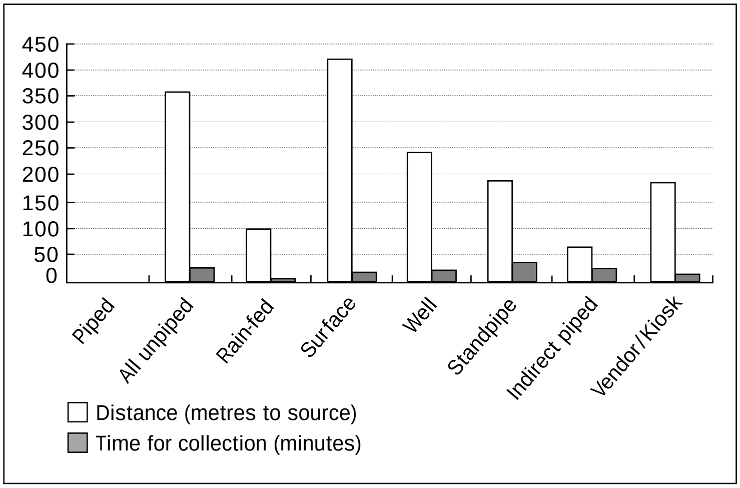


Figure 10.2 The 'Inconvenience' Costs of Alternative Sources, DOW II

Since these figures are equal to time required per individual trip, the 36 minutes required per trip on average for collection from a hydrant or standpipe means that a large proportion of the day can be spent collecting water. The "opportunity cost" of this time may dwarf any financial expenditures, and thus households clearly have incentives to trade off time against financial savings.

Perhaps more important are the health effects. Figure 10.3 compares source types with incidences of diarrhoea per household. In this case, almost 30 percent of households that relied upon surface water as their primary source reported at least one case of diarrhoea in the last week. Households that relied upon wells and standpipes were next, followed by those who relied upon rain-fed sources. Vendors and indirect piped access appeared to be the 'safest' sources. Indeed they appeared to be somewhat safer than direct piped access.

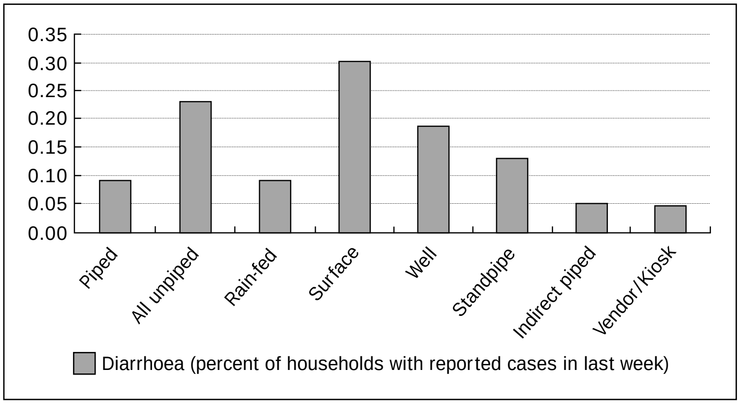


Figure 10.3 The Health Effects of 'Alternative' Sources

Conclusions

Two broad lessons can be drawn from this comparative discussion. First, unpiped households are generally worse off than piped households in terms of inconvenience and health and hygiene effects. However, it is significant that the latter effect is not true for those who rely upon vendors. In terms of financial effects, there is some ambiguity since many households have access to 'free' sources (or must rely upon 'free' sources during some part of the year). Second, there is a trade-off between alternative sources, with the less costly sources in financial terms having the highest inconvenience (standpipes and surface waters) and health (unimproved surface waters) costs. As noted above, all of these adverse welfare effects derive in part from the public environmental nature of the resource.

Thus, households appear to face a 'choice' between bearing the costs of non-access in financial terms (thus reducing already scarce disposable income) or bearing the costs in terms of inconvenience and health effects. Not surprisingly, it would appear that this choice is partly a function of relative wealth. Relatively poorer unconnected households tend to rely disproportionately upon 'free sources', such as unimproved surface waters. Indeed, further (unreported) econometric evidence reveals that relative wealth is the most significant factor in determining the use of vendors or kiosks amongst unpiped households. A ten percent increase in the ranking of relative wealth results in a 5.4 percent increase in the likelihood of using a vendor or kiosk rather than another source of water.

Endnotes

1 This article is drawn from Johnstone, J., J. Thompson, M. Katui-Katua, M.R. Mujwahuzi, J.K. Tumwine, E. Wood and I T. Porras. 2002. Environmental and Ethical Dimensions of the Provision of a Basic Need: Water and Sanitation Services in East Africa. In D. Bromley and J. Paavola, eds. *Economics, Ethics and Environmental Policy: Contested Choices*. Oxford: Basil Blackwell; and from Thompson, J. I.T. Porras, J.K. Tumwine, M.R. Mujwahuzi, M. Katui-Katua, and N. Johnstone. 2000. Waiting at the Tap: Changes in Urban Water Use in East Africa over Three Decades. *Environment and Urbanization* 12 (2): 37-52.

2 Water and sanitation services also have public attributes arising from the fact that the delivery of some kinds of services has natural monopoly characteristics, with economies of scale being very important. These issues will only be raised parenthetically.

3 Dasgupta, P. 1997. Environmental and Resource Economics in the World of the Poor. *RFF Discussion Paper*. Washington, DC: Resources for the Future.

4 Water and sanitation facilities have been described not only as 'basic needs' but also as 'merit' or 'beneficial goods'. This implies that society as a whole values private consumption by individuals above and beyond those benefits reflected by personal preferences and external health and environmental benefits. See Mody, A., ed. 1996. *Infrastructure Delivery: Private Initiative and the Public Good*. Washington, DC: Economic Development Institute, The World Bank; and Frances, R. 1997. *PSP in the Water and Sanitation Sector*. DFID Occasional Paper No. 3. London: UK Department for International Development.

5 For more on collective action and common property resource management, see Meinzen-Dick, R., A. Knox, and M Di Gregorio, eds. 2001. *Collective Action, Property Rights, and Devolution of Natural Resource Management: Exchange of Knowledge and Implications for Policy*. Feldafing, Germany: Zentralstelle für Ernährung und Landwirtschaft, Food and Agriculture Development Centre. Ostrom, E., R. Gardner, and J Walker, eds. 1994. *Rules, Games, and Common-Pool Resources*. Ann Arbor: University of Michigan Press; Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press; and Berkes, F. ed. 1989. *Common Property Resources: Ecology and Community-Based Sustainable Development*. London: Belhaven Press.

6 Water stress is considered high when the ratio of withdrawals (minus wastewater returns) to renewable resources exceeds 0.4.

7 According to the World Resources Institute, annual withdrawals are 10 percent of water resources in Kenya, but only 1 percent in Uganda and Tanzania. However, national figures are of little practical relevance. See WRI. 2000. *World Resources 2000-01*. Washington, DC: World Resources Institute.

8 For details, see WHO and UNICEF. 2000. Global Water Supply and Sanitation Assessment 2000 Report. WHO / UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP). Geneva: WHO and New York: UNICEF. According to WHO / UNICEF criteria, 'improved' water supply includes household connections, public standpipes, boreholes, protected wells and springs, and rainwater. 'Improved' sanitation includes public sewer connections, septic systems, pour-flush latrines, simple pit latrines and ventilated improved latrines.

9 WHO and UNICEF. 2000. op cit.

10 Hardoy, J.E., D. Mitlin and D. Satterthwaite. 2001. *Environmental Problems in an Urbanising World: Local Solutions for Cities in Africa, Asia and Latin America*. London: Earthscan.

11 Esrey, S.A. 1996. Water, Waste and Well-Being: A Multicountry Study. *American Journal of Epidemiology* 143(6): 608-623.

12 The 'domestic domain' is the area normally occupied by and under the control of a household, while the 'public domain' includes public places of work, schooling, commerce and recreation, as well as streets and fields. For a discussion on the distinction between the transmission of infectious diseases within the domestic and the public domains, see Cairncross, S., et al. 116. The Public and Domestic Domains in the Transmission of Disease. *Tropical Medicine and International Health*. 1(1): 27-34.

13 A recent review of a number of country-level studies of water demand in developing countries

estimated income elasticities ranging from 0.0 to 0.4 (Bahl, R.W. and J.F. Linn. 1992. *Urban Public Finance in Developing Countries*. Oxford: Oxford University Press). However, it should be emphasised that if the nature of the service provided by the good changes with income then the demand function may exhibit changing elasticities. For instance, higher-income households in which a significant portion of water is used for recreation and aesthetic purposes (e.g., non-productive gardening and car-washing) may have highly price-responsive demand. Thus, not surprisingly it has been found that the price elasticity of demand for water differs with income levels, with elasticities being much lower for poorer households. Bahl and Linn, ibid. See also Bhatia, R., R. Cestti and J. Winpenny. 1995. *Water Conservation and Reallocation: Best Practice in Improving Economic Efficiency and Environmental Quality*. New York: UNDP / World Bank Water and Sanitation Program) who report a range of estimated income elasticities from 0.15 to 0.78 from seven studies.

14 Sen, A. 1985. *Commodities and Capabilities*. Amsterdam: North-Holland.

15 Berlin, I. 1969. *Four Essays on Liberty*. Oxford: Oxford University Press.

16 Helm, D. 1986. The Economic Borders of the State. *Oxford Review of Economic Policy*. 2(2): i-xxiv.

17 Fass, S.M. 1993. Water and Poverty: Implications for Water Planning. *Water Resources Research* 29(7): 1975-1981.

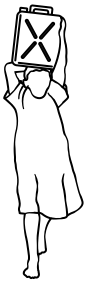
18 Dasgupta, P. 1986. Positive Freedom, Markets and the Welfare State. *Oxford Review of Economic Policy* 2 (2): 25-36.

19 Nickum J. and W. Easter. 1994. *Metropolitan Water Use Conflicts in Asia and the Pacific*. Boulder, CO: Westview Press.

20 USAID. 2000. *Field Operations Guide: Version 3.0*. Washington, DC: United States Agency for International Development

21 Government of Tanzania. 2001. *National Water Policy* (Draft August 2001). Dar es Salaam: Ministry of Water and Livestock Development, The United Republic of Tanzania.

11 Policy and Institutional Lessons



Introduction

This final article addresses some of the key policy and institutional lessons emerging from this cross-sectional, longitudinal analysis of the *Drawers of Water* sites. Changes in domestic water use and environmental health documented in this report reveal a complex picture of improvement, decline and stasis. This image offers possibilities of hope, while leaving much cause for concern. For every Mathare Valley, a large squatter settlement on the fringes of Nairobi where per capita water use has trebled in three decades, there is a Temeke, a low-income quarter of Dar es Salaam, where it has declined by the same order of magnitude over the same period. And even in those sites where considerable improvements in domestic water use have been made, the actual amount available per capita frequently remains well below the minimum standards suggested by national governments and international bodies.[1]

In the span of only three decades, the population of East Africa has gone from roughly 32 million to over 83 million people, an unprecedented increase of nearly 260 percent. Much of that increase has occurred in the towns and cities, such as Karuri, Makadara and Pangani in Kenya, Moshi, Dodoma and Changombe in Tanzania, and Iganga, Kamuli and Tororo in Uganda. With this rapid growth in population has come an equally rapid increase in demand for water and other environmental health services. Clearly, with the region's population projected to rise rapidly in the short to medium-term, radical changes in both policy and practice will be needed if these demands are to be met.

1 Unlike water quality standards for which there are accepted guidelines and specific targets, no universally agreed guidelines or standards have been established for water quantity (i.e., the minimum daily water allowance or requirement needed per capita). The recent WHO / UNICEF *Global Assessment on Water Supply and Sanitation Assessment 2000 Report* defines 'reasonable access' as a minimum of 20 litres of water per person per day from a source within one kilometre of the user's dwelling. Other authorities suggest significantly higher quantities and / or shorter distances to the source. Officials at the Second World Water Forum and Inter-Ministerial Meeting held in The Hague, The Netherlands, in March 2000 failed to address this matter, as they did the contentious call to make water a 'basic human right'. See Lane, J. 2000. Perspective: The 2nd World Water Forum at The Hague, March 2000. *Water Policy* 2 (6): 465-467.

It is worth reviewing some of the key findings and their policy implications here, before turning attention to the remaining institutional issues.

Changes in Water Use and Their Relation to Health and Disease

The striking changes observed in water delivery and use between the two *Drawers of Water* studies are, first, the increase in per capita water use by those without piped supplies – nearly double the amount of 30 years ago – and second, the intermittent nature and unreliability of piped supplies (Articles 3, 4 and 5). Third, some have moved from unpiped to piped facilities, while a smaller, but still substantial number of households have lost their piped supplies and have had to seek alternative sources (Articles 6 and 7). These affect both access to water and the quality of water used. Finally, the availability of simple facilities for the disposal of excreta appears to have increased (quantitative observations were not recorded in DOW I so that the change cannot be measured but the current coverage by excreta disposal facilities is very high compared with the past, particularly for Africa) (Article 9).

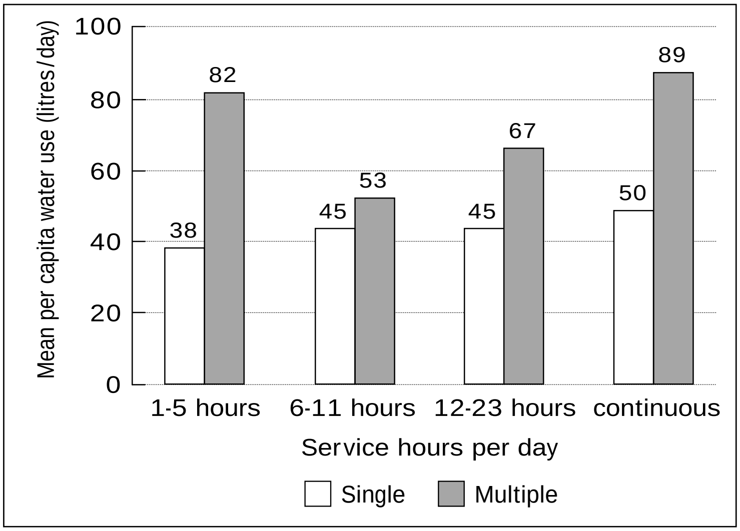
Large rainwater catchment tank funded by an external development agency and built through a local self-help scheme, Moi's Bridge, Kenya

The near doubling of mean daily per capita water use by those households carrying water has the potential to substantially increase health by reducing the water-washed transmission of infections. Observations on all water users in the DOW II study indicated that (with rare and specific exceptions where livestock are watered or beer is brewed commercially from the domestic supply), once the consumption for drinking and cooking is satisfied by a limited and relatively invariable amount (about four lcd), almost all the remainder is used for personal hygiene or cleaning utensils and house, so that a rise in water use is primarily an increase in water volume available for hygienic purposes (Article 2). However, a large and increasing body of evidence at the household, community and national level indicates that without hygiene education to, for example, encourage hand-washing with soap after defecation, the health benefits that can be derived from improved water availability will not materialise. It follows that while the rise in per capita use of water by unpiped households is very welcome, it must be backed up by adequate hygiene education.

That some households in sites that were previously receiving piped supplies no longer do so is a more sinister change and must have required some coping with by those affected (Article 6). There may be health consequences of lower use for the few who now use polluted, unimproved, surface sources (Article 7). Moreover, there is the increased burden of paying for water from vendors or using time and funds to visit kiosks for water (Articles 7 and 8).

A larger-scale change has been the shift to intermittency in water availability to users with piped supplies. While intermittent supplies were so rare as to be practically ignored in DOW I, Article 6 shows that in DOW II 44 percent suffer from intermittent service and 20 percent of households have less than six hours of water service daily. While intermittency does not appear to reduce use, when controlled for the number of taps in the house, except among those with a single tap, it may in some way relate to the generally lower volume of use by those with piped supplies (Figure 11.1).

Figure 11.1 Intermittent supplies, number of taps in house and mean per capita water use (litres per day)



Intermittency poses two more substantial threats to health. First, it creates the need for water storage. This was of course the case for families with unpiped water but their volume use is low and the journeys to fetch water are planned so that storage volume is limited and water is often completely emptied from the storage vessel. By contrast, larger volume users of piped supplies require greater storage volumes – which need to be still greater when the supply is unreliable as well as intermittent. There is a move towards larger volume storage and the less impoverished may purchase large containers and electric pumps so as to restore continuous water supply at the point of use. But such storage vessels may not be completely emptied. There will therefore be a great increase in sites appropriate for the proliferation of container-breeding mosquitoes, particularly of the genus *Aëdes*. The stage is then set for increased transmission of dengue in particular. Fortunately large container-breeding vectors of malaria are effectively confined to the Indian sub-continent (*Anopheles stephensi*), but *Aëdes aegyptic* is cosmopolitan in the tropics and *A. albopic* is spreading. There could be real concern that the situation with dengue and its complications could develop to resemble Thailand and other parts of Southeast Asia. This, however, is more a matter of concern for the future than the present, where increasing reliance on containers to bridge the gaps in piped water availability has occurred, and as these containers get larger they are less likely to be completely emptied on a daily basis.

A further problem with in-house storage is contamination after the water has left the pipe. This undoubtedly occurs, as evidenced by bacteriological study of the contents of water storage containers in unpiped households in other areas. However, there remains some doubt over the epidemiological importance of water contaminated within the household. Would this merely add a little to circulation of the same organisms from person to person by a direct faecal-oral route that omits the dilution into the water supply? This is rather unclear, but attention to the quality and pattern of water storage is of increasing importance in the face of interrupted piped water services.

Intermittent flow in water pipes to households has the further and different hazard that during periods when they are empty there may be leakage of highly contaminated water into the pipes. Stories of visibly dirty or sediment-laden flow after such periods are common. When this is the case there may be little danger of the water being consumed, as households report rejecting turbid-looking water, but there may be other occasions when no visible evidence of contamination is present. The hazard is well known, but its epidemiological importance in the environments studied is unclear. As the systematic measurement of microbiological contaminant levels of the water supplies and storage vessels was beyond the scope of both *Drawers of Water* studies, it may be some time before this issue is resolved.

Changes in Access to Water and Their Relation to Meeting Basic Needs

As noted in Article 10, access to adequate water and sanitation is often defined as a basic need. While the precise basket of goods and services to be classed as basic needs is necessarily contextual, the case for the inclusion of water in this basket is very strong. This is particularly true in areas where the 'public' environmental resource has been degraded. Households cannot rely upon unimproved surface sources or wells as an appropriate substitute. Indeed many countries have codified the 'right' to clean water. Thus, a very different set of issues emerges relative to those associated with many other kinds of environmental resources, where issues of preference are the main concern. Some of these issues are ethical, insofar as a strong case can be made for the social value of personal consumption, even in the absence of externalities and non-excludability.

This much is relatively uncontroversial. Where controversy does arise is when this 'right' is converted into practical priorities and policy measures. In particular, it is becoming increasingly clear that universal access to piped water and sanitation services is not a feasible policy objective in many countries, including those of East Africa, at least for the foreseeable future (Kenya's latest national water policy aims to provide all households with access to safe, potable water system within a two km radius of the home by the year 2010). Nor should universal access to standardised services necessarily be a policy objective, particularly in rural areas where costs can differ markedly and where the implications of not having access can be so different (a point argued in the original *Drawers of Water* study). Indeed, a focus on universal coverage to network facilities in many cases has retarded access to reasonable services for the majority of households in East Africa. In many urban areas it has resulted in a dual system where a small minority of (usually wealthy) households have access to high-quality services, and the large (usually poor) majority have to fend for themselves by whatever means possible. In fact, many of the surveyed households in the study sites that previously had access to piped facilities no longer do so due to widespread deterioration of infrastructure (Articles 3 and 5).

In a sense, the objective of universal access to standardised high-quality services has contributed to a situation throughout Sub-Saharan Africa where a minority of households have access to (subsidised) water used in large part for non-essential purposes (including several high-income communities included in this study), while a majority of households are faced with a choice between a set of unsatisfactory alternative sources for water used to fulfil basic needs. As a consequence, the 'basic needs' of many households are being left unmet. Some households have access to low-cost, convenient and relatively safe water that is mainly used for 'discretionary' purposes, while other households are being forced to seek out more expensive, inconvenient or unsafe alternative sources to satisfy their basic physiological and health requirements.

Clearly, classifying a good or service as a 'basic need' does not imply that there need be state provision of a homogeneous good to all households. The good itself is merely an instrument through which the basic need is met. Rather than providing the good, the state can be a guarantor of its provision. The public policy objective should be to ensure that households are not forced to make the 'tragic' choices that they are making in many parts of East Africa at present. In the area of water and sanitation, this can mean a choice between using up a poor household's scarce financial resources, expending vast amounts of time and effort, and risking its members' own health. Indeed, in participatory surveys undertaken as part of the DOW II research, a number of households emphasised that they did not see their decision about which alternative source to use as a choice at all. They had no other option.

From a public policy perspective relaxing the constraints on this 'choice' of water source means reducing the financial cost of vendor water, the inconvenience costs of public standpipes or kiosks or improving the quality of local water bodies. The latter is, of course, a desirable long-term objective for both environmental and social reasons. Precarious environmental conditions (in terms of both scarcity and quality) are sharpening the ethical dilemmas associated with water provision. In some areas improved sanitation facilities can be an effective means to increase the availability of safe water sources. In order to ensure that households have access to affordable clean water in a reasonable timeframe, however, the first two options are of greater significance.

One area that is receiving increased attention is the use of small-scale private entrepreneurs and community-based organisations in the provision of both vended water and public standpipes. They are emerging between the cracks of failed delivery systems involving much greater investment requirements. In some cases they have even played a role in developing and managing small-scale infrastructure for service delivery. They often provide levels of service that better reflect the underlying demand of households served, and the level of maintenance, which is likely to be sustainable.

Vended water has not usually been seen as part of the solution to bridging the deficit in access to affordable drinking water. On the basis of the financial costs cited in Articles 8 and 10, this view may be warranted since their cost would appear to indicate that they are an inefficient means of water delivery. However, in many cases the financial costs may be a reflection of rents arising from local monopolies. Alternatively, the high costs may reflect the risks associated with provision of a service that is not sanctioned officially. Where provision is competitive and legal, costs are often lower. Indeed, recognising their own capacity constraints many public utilities have started to sell water to vendors for distribution in poorer neighbourhoods. Given that this also allows for better control of water quality, formalisation of the role of vendors may be an important step toward helping households meet basic requirements for the foreseeable future.

Public standpipes are clearly going to be important in helping households to meet such requirements as well, a point argued by White, Bradley and White some three decades ago. While initiatives pursued by development agencies, non-governmental organisations (NGOs) and community-based organisations (CBOs) have long focused on the provision of standpipes, there is room for institutional innovation in this area as well. In many cases problems arise with operation and maintenance, with many facilities falling into disrepair. This problem can be obviated by giving the managers of the water points a direct commercial stake in their upkeep through, for example, the franchising of kiosks and other innovative concessions. Allowing local community-based organisations to derive commercial benefits from operation and maintenance (and even investment) is also becoming more common. In all cases it is clear that efforts need to be made (through regulations and incentives) to ensure that such water points remain open as long as possible, since waiting times can exceed travel times.

Changes in Institutional Arrangements and Their Implications for Future Service Delivery

The 30 years between the first and second *Drawers of Water* studies witnessed a number of important institutional and policy shifts at both national and international levels, which have had a profound effect on people's access to efficient, effective and equitable water and health services. Many of these shifts have been chronicled in a set of country-level policy histories that were specially commissioned for this project. These indicate that the quality of water and health services have been influenced by a combination of factors, including the increasing privatisation of water and health service delivery and financing, and a growing importance of NGOs and CBOs.

Privatisation of water and health services in East Africa has taken place on a grand scale since in the Structural Adjustment era of the 1980s (which, interestingly, coincided with the 'Water Decade'), but not in ways that fit easily with World Bank or IMF prescriptions. NGOs and CBOs – not primarily profit-making entrepreneurs – play an increasing role in service provision. Moreover, the links between the voluntary sector and the state are becoming more, not less, important for service provision. Significant parts of water and environmental health services would grind to a halt in Kenya, Tanzania and Uganda if voluntary agencies did not have access to state-provided resources. In fact, much grassroots mobilisation of resources (often 'in-kind' contributions of labour and materials) aims at attracting state support. Similarly, many voluntary organisations are run by or through ex-state employees. This straddling between the state and civil society is a key feature of privatisation of water and health service provision in the region. Finally, donors play a growing political and financial role in the water and health sectors. State services depend increasingly on donor resources, particularly in Tanzania and Uganda. The voluntary sector is also driven by donor funds (and donor priorities) to a significant degree. An important facet of privatisation of water and environmental health service provision in East Africa is therefore not just the increasing role of the voluntary sector, but also the continued centrality of the state – and foreign donors.

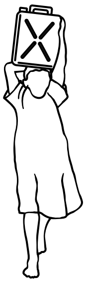
It is perhaps surprising that these trends are common to all three countries since each has followed a very different political trajectory since the heady days of the first East African Community in the 1960s. But past differences between them in the way water and environmental health services were provided are fast disappearing. Today, the societal arrangements for service provision are converging under the pressure of political and economic forces that originate both from outside (dependence on donors and global markets) and from inside (social differentiation and political struggles).

In the short term, the most certain implication of these trends is that the role of the state and external support agencies is crucial for improving water and environmental health services in East Africa. Not only because state-provided services are significant in themselves, but also because without links to the state and donors, many voluntary sector services would cease to function. Experience from Uganda when the state collapsed during the civil unrest shows both the considerable resilience of the voluntary sector (expansion in operations) and its limitations (widening inequality in access and drastically reduced quality of services).

The long-term implications of ‘privatisation’ for service provision are much more difficult to assess. The optimistic view is that we are witnessing a strengthening of civil society, leading to democratisation that will make the state more transparent, accountable and efficient. Democratisation and the successful implementation of market liberalisation and structural reform programmes will also promote economic growth. The state, in turn, will establish the enabling environment that allows the both the voluntary sector and private enterprise to flourish. Sustainability of services will then be secured. The pessimistic view is that the location of NGOs and CBOs in civil society tells us little about the values and constituencies they represent and therefore little about how they operate vis-à-vis the state or their members. In fact, their close links to local elites and their dependence on patronage from the state and donors make their role in fostering ‘grassroots democracy’ ambiguous. Moreover, the long-term prospects for economic growth, which is a precondition for any domestically supported, demand-responsive provision of services, are also in doubt. Thus, the sustainability of many water and environmental health services is likely to continue to depend on uncertain donor support for the foreseeable future.

Whatever view proves to be correct, what is clear is that the lessons emerging from *Drawers of Water II* suggest that a new vision of improved access to and use of water and environmental health services in Africa will require a combination of innovative policies and flexible funding arrangements in order to address the water, and with it, the health and hygiene needs of poor people in both rural and urban communities. It will also require strengthened public and private organisations to develop, operate and maintain water systems and services sustainably, and new partnerships between the state, the private sector and civil society that promote market-based water development while creating co-operative management arrangements that work for people and the environment.

Appendix



Piped Households (Same Sites Only)

	Percent of Households		Average Number of Years of Education		Average Daily Per Capita Water Use (litres)		Average Total Water Use in Household Per Day (litres)		Average Daily Cost of Water (1997 US$ pcm)		Receive 24-hour Supply (% households)		Principal Alternative Source if Piped System Breaks		Reported Diarrhoea Incidence During the Previous Week (% households)	
	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I
Kenya	27.8	22.8	12.0	10.6	47.4	121.6	240	934	0.40	0.70	80	87.5	Kiosk	Well	12.4	0
Tanzania	46.1	50.3	14.1	9.8	80.2	141.8	442	667	0.73	0.77	32.5	100	Vendor	Rain	3.1	5.7
Uganda	26.1	26.9	14.4	10.0	64.7	108.3	398	551	0.81	0.80	72.5	100	Well	Rain	9.9	2.4
Total (percent)	100	100	13.6	10.0	65.8	128.1	368	691	0.64	0.77	55.7	97			7.4	3.5
Total (obs)	**349**	**312**														
By Site (all urban)																
Karuri, Kenya	6.0	4.8	12.0	14.1	28.4	28.5	148	193	0.41	1.25	24	0	Kiosk	Well	9.5	0
Moshi, Tanzania	5.2	8.0	11.2	8.8	40.7	108.2	222	778	0.87	0.32	0	96	Spring	Spring	11.1	4.0
Dodoma, Tanzania	10.0	15.1	13.8	8.6	62.1	72.1	366	474	0.41	0.95	11.4	100	Other	Rain	2.9	10.6
Iganga, Uganda	1.4	6.1	10.4	7.4	34.2	78.7	273	389	0.58	0.89	0	100	Kiosk	Rain	0.0	0.0
Kamuli, Uganda	5.4	7.4	12.7	9.8	32.4	76.2	177	399	1.82	1.06	0	100	Well	Rain	21.1	4.3
Tororo, Uganda - L	11.2	8.7	15.7	12.8	110.7	160.9	692	843	0.57	0.59	97	100	Other	Rain	5.1	0.0
Tororo, Uganda - MH	8.0	4.8	14.4	8.3	27.8	100.1	160	465	0.57	0.69	100	100	Reservoir	Rain	10.7	6.7
Nairobi, Kenya - Parklands, ML	7.4	5.1	13.3	10.3	60.9	176.9	334	1165	0.46	0.53	100	100	Kiosk	Well	7.7	0.0
Nairobi, Kenya - Pangani, MH	8.6	9.6	11.9	9.9	52.9	167.3	274	1237	0.39	0.56	93	100	Well	Stream	3.3	0.0
Nairobi, Kenya - Makadara, H	5.7	3.2	10.6	7.3	41.6	26.3	162	934	0.30	0.58	90	100	Vendor	Hydrant	35.0	0.0
DeS, Tanzania - Oyster Bay, L	8.6	9.9	17.2	14.0	164.3	243.9	791	925			70	100	Vendor	Well	6.7	6.5
DeS, Tanzania - Upanga, ML	8.6	8.3	14.7	9.4	n/a	157.7	n/a	637			73	100	Vendor	Stream	0.0	3.8
DeS, Tanzania - Changombe, MH	8.0	7.1	14.7	9.4	43.7	161.1	431	541	0.97	0.81	11	100	Vendor	Spring	0.0	0.0
DeS, Tanzania - Temeke, H	5.7	1.9	12.6	6.8	64.4	153.5	264	1157	1.01	0.83	10	100	Vendor	Hydrant	0.0	0.0

Note: DeS – Dar es Salaam

L – Low density population; ML – Medium-Low; M – Medium; MH – Medium-High; H – High

For urban households with piped connections, the density of housing was taken as a measure of material wealth

Unpiped Households (Same Sites Only)

	Percent of Households		Average Number of Years of Education		Average Equipment Index		Average Per Capita (Water Use) (litres) Per Day		Average Cost (1997 US$ pcm)		Principal Water Source		Average Time per Trip (Minutes)		Average Distance to Water Source (metres)		Average Number of Trips		Reported Diarrhoea Incidence During Previous Week (% households)	
	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I	DOW II	DOW I
Urban Households																				
Kenya	12.1	18.3	10.0	0.3	12.5	3.1	22.9	11.3	1.42	1.43	Kiosk	Hydrant	33.1	11.0	400.3	384.0	3.4	2.9	0.0	26.3
Tanzania	18.2	34.6	8.4	5.8	7.3	4.0	25.1	17.8	1.24	1.37	Hydrant, Kiosk	Hydrant	34.4	13.9	152.6	236.5	3.8	3.1	22.2	13.9
Uganda	69.7	47.1	9.9	5.1	6.2	5.7	23.5	14.3	1.45	0.68	Hydrant, Well	Hydrant	15.2	6.1	182.6	177.2	4.1	2.2	14.5	18.4
Total	100	100	9.7	4.9	7.2	4.8	23.7	15.4	1.41	1.06			21.4	9.3	204.2	222.4	4.0	2.6	14.1	18.3
Total (obs)	**99.0**	**104.0**																		
Rural Households																				
Kenya	45.2	46.6	9.9	4.9	7.3	3.3	22.3	8.2	0.93	0.76	Spring, stream	Spring, stream	24.9	17.6	445.5	554.9	4.4	2.6	22.1	23.8
Tanzania	13.9	15.0	4.7	4.7	4.1	3.3	16.0	10.1	0.95	1.25	Spring, stream	Reservoir, Hydrant	44.7	17.8	769.4	569.4	3.7	2.9	21.7	32.6
Uganda	40.9	38.4	7.4	3.3	5.8	3.7	14.8	11.5	0.71	0.52	Spring, stream	Spring, well	18.9	12.9	381.2	343.6	3.2	2.3	37.8	26.3
Total	100.0	100.0	8.2	4.3	6.2	3.4	18.3	9.7	0.84	0.74			25.3	15.8	466.0	477.3	3.8	2.5	28.5	26.1
Total (obs)	**330**	**307**																		
Urban Sites																				
Karuri, Kenya	11.1	9.6	10.3	7.6	13.0	4.0	22.3	9.3	1.16	1.87	Kiosk	Hydrant	36.1	13.5	436.6	288.0	3.7	2.9	0.0	10.0
Nairobi, Kenya-Mathare Valley	1.0	8.7	7.0	0.3	7.0	3.1	29.8	11.3	4.29	0.93	Vendor	Hydrant	0.0	11.0	0.0	384.0	0.0	2.9	0.0	44.4
Moshi, Tanzania	6.1	14.4	8.0	7.8	8.7	6.1	19.3	13.3	1.65	1.74	Kiosk	Hydrant	33.2	9.3	118.3	270.1	4.2	2.9	0.0	13.3
Dodoma, Tanzania	12.1	20.2	8.6	4.3	6.7	2.6	28.3	21.0	1.04	1.14	Other, Neighbour	Hydrant	35.1	20.7	171.3	186.2	3.6	3.5	33.3	14.3
Iganga, Uganda	31.3	17.3	9.3	4.9	5.5	5.7	22.2	13.8	1.91	0.68	Hydrant	Hydrant	14.7	3.7	117.4	114.9	3.1	1.5	19.4	11.1
Kamuli, Uganda	26.3	15.4	8.9	4.4	5.1	5.9	25.8	16.0	0.77	0.20	Well	Hydrant	16.4	5.9	293.7	221.9	4.2	1.3	7.7	37.5
Mulago, Uganda	12.1	14.4	13.9	6.1	10.6	5.3	21.6	13.1	1.77	1.21	Hydrant	Spring	13.7	9.9	104.5	233.5	6.6	4.1	16.7	6.7
Total	**100.0**	**100.0**	**9.7**	**5.2**	**7.2**	**4.7**	**23.7**	**14.8**	**1.41**	**1.06**			**21.4**	**9.8**	**204.2**	**230.2**	**4.0**	**2.6**	**14.1**	**18.3**
Rural Sites																				
Kiambaa, Kenya	6.4	6.2	9.1	7.1	10.3	3.5	24.6	11.1	0.88	1.39	Well	Spring	19.5		513.0	811.3	3.9	2.6	4.8	0.0
Mukaa, Kenya	9.7	7.5	10.1	4.8	5.9	3.3	9.3	8.2	2.14	1.23	Spring	Stream	26.1	25.9	637.4	1012.9	2.9	2.5	12.5	13.0
Masii, Kenya	9.1	7.8	11.2	5.0	6.1	2.8	12.0	6.9	0.75	0.97	Reservoir	Stream	30.5	25.1	636.5	1007.1	2.8	3.3	50.0	100.0
Manyata, Kenya	2.4	5.5	10.6	5.4	8.6	3.6	29.8	10.4	0.88	1.11	Spring, Stream	Spring, Stream	20.8	16.1	242.2	305.9	5.9	3.4	50.0	29.4
Moi's (Hoey's) Bridge, Kenya	9.7	9.8	10.2	3.2	8.7	3.1	45.3	6.1	0.28	0.22	Well	Spring, Stream	36.8	13.1	370.2	249.9	7.8	1.9	0.0	6.7
Mutwot, Kenya	7.9	9.8	8.2	4.1	5.6	3.5	20.5	7.7	0.16	0.21	Well, other	Well, Hydrant	7.3	11.7	98.0	205.1	4.5	2.2	34.6	0.0
Mkuu, Tanzania	3.3	7.8	6.7	6.6	6.8	4.4	14.2	7.8	0.59	1.95	Hydrant	Hydrant	31.2	28.6	342.8	1015.5	3.9	3.0	18.2	12.5
Kipanga, Tanzania	10.6	7.2	4.1	2.6	3.2	2.0	16.6	12.7	1.06	0.48	Stream	Reservoir	49.2	4.8	903.5	34.2	3.6	2.7	22.9	54.5
Alemi (Ayer), Uganda	12.1	12.1	5.9	3.3	4.8	3.0	15.7	17.6	0.62	1.18	Spring	Well	25.3	13.3	459.5	423.2	4.0	2.7	80.0	62.2
Iganga, Uganda	9.1	9.1	6.3	3.9	5.1	4.2	15.5	12.7	0.45	0.09	Spring, Well	Spring	22.8	6.7	442.3	191.2	3.4	1.8	30.0	10.7
Mwisi, Uganda	10.6	8.5	7.4	2.0	4.7	2.4	9.1	4.5	0.64	0.09	Spring	Spring	15.3	20.9	368.4	328.7	2.0	2.0	14.3	11.5
Kasangati, Uganda	9.1	8.8	10.6	4.0	8.9	5.2	19.5	8.8	1.20	0.48	Spring, Well	Spring	9.9	10.8	200.7	414.7	3.4	2.9	16.7	7.4
Total	**100.0**	**100.0**	**8.2**	**4.2**	**6.2**	**3.4**	**18.3**	**9.7**	**0.84**	**0.74**			**25.3**	**15.8**	**466.0**	**483.7**	**3.8**	**2.5**	**28.5**	**26.1**

Note: Equipment Index – A measure of relative wealth based upon an index of observable physical equipment and tools was used as a partial surrogate of income in unpiped households