QUANTITATIVE PERFORMANCE MEASUREMENTS FOR WATER SUPPLY DEVELOPMENT PROJECTS: APPLICATION IN RURAL ERITREA

Advanced Policy Analysis
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Executive Summary

Long recognized as a basic human necessity, safe drinking water was declared a human right last year by the United Nations Committee on Economic, Cultural and Social Rights (UNECSR). In Eritrea, approximately 60 percent of rural households do not enjoy this right, and expanding access to safe drinking water in rural areas remains a significant development challenge.

Expanding the use of quantitative performance measurements could assist the Eritrean government to maximize its limited resources for water supply investments. Appropriate project indicators could help the government to identify which investments best meet its water policy goals. Selecting performance measurements that are both appropriate to Eritrea's water policy objectives and relevant to potential international donors could also help to generate investments in the water supply sector.

To address this question of which performance measurements would be most appropriate in Eritrea, this analysis examines water supply data from the country's Debub region, case studies from other East African countries, and international agency water supply project evaluations. The analysis will consider measurements of four aspects of project performance:

- *Outputs*, or the tangible products that projects generate. In the case of water supply projects, outputs are usually physical in nature, e.g., wells, transmission pipes, or covering over freshwater springs.

- *Intermediate outcomes*, or the observable and measurable changes that result from the existence of outputs, e.g., lower bacterial levels, increased consumption of protected spring water, or a shorter distance from a village to a water source.

- *Final outcomes*, or the way people experience changes in their material lives because of intermediate outcomes, e.g., villagers are sick less frequently because of lower levels of bacterial contamination, or increase consumption because wells are located closer to villages.

- *Process*, or the way that a project is designed and implemented, e.g., the involvement of women in water supply management, or attention to the affordability of services for poor households.

The analysis concludes that **intermediate outcome measurements** – the observable and quantifiable changes that result from a project, such as increased water consumption – are the most likely to be both meaningful and measurable. These measurements address many key water supply development challenges that exist in rural Eritrea, such as increasing source protection and lowering bacteriological counts, decreasing the distance from villages to sources, and improving maintenance and reliability.

Final outcome measurements – indicators of a project's effects on people's material lives, such as health or household income – are central to water sector policy goals. It is difficult, however, to attribute *causality* of final outcomes to individual water projects through impact analysis. This is for two reasons: (a) necessary baseline data is often unavailable and (b) multiple explanatory factors make it difficult to model causality such that a significant impact can actually be demonstrated. Efforts to analyze whether changes in performance indicators can be attributed to individual projects should thus focus on the causal relationship between water projects and intermediate outcomes, for which modeling causality is less complex.

In contrast to outcomes, **output measurements** – those that measure a project's physical outputs, such as number of wells – will not necessarily tell an evaluator whether a project has achieved its policy goals. As such, performance evaluation should not rely solely on these measurements.

Finally, **process measurements** related to gender and equity should also be incorporated. Women's involvement in projects is often correlated with success on other outcome indicators, and can be shown through indicators such as representation of women on water committees. Equity and affordability measurements can indicate the degrees to which a project benefits poor households, an important consideration for projects that have a specific objective of improving water services to the poor.

This analysis offers three principal recommendations concerning the use of quantitative performance measurements for water projects in rural Eritrea:

1. Focus on intermediate outcomes, which are measurable, relevant to Eritrea's water supply needs and commonly used by international agencies. These include:
    - Distance to water source
    - Time spent collecting water
    - Protected source coverage
    - Percentage of facilities that are functional
    - Bacteriological count
    - Frequency of water testing
    - Total household consumption (for all water uses)
    - Use of improved sources for consumption of drinking water

2. Provide health outcome measurements, such as the number of households that suffered from water-related disease in a given time period, but focus efforts to analyze impact on the intermediate outcomes listed above. In order to perform impact analysis on any outcome, project design must allow for the comparison of treatment and control groups.

3. Include process measurements that reflect how and whether projects address gender and equity. These include the percentage of women on village water committees, and water costs as a percentage of total household consumption.

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Glossary

ADB	Asian Development Bank
AusAID	Australia's Overseas Development Agency
DALY	Disability-Adjusted Life Year
FAO	Food and Agricultural Organization (United Nations)
NEPAD	New Partnership for Africa
ODA	Overseas Development Agency (United Kingdom)
PRA	Participatory Rural Appraisal
UNCESCR	United Nations Committee on Economic, Cultural and Social Rights
UN-WSSD	United Nations World Summit on Sustainable Development
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization
WRD	Water Resources Department (Eritrea)
WSP	Water and Sanitation Program

Introduction

This analysis addresses the choice of quantitative performance measurements for rural water supply investments, with specific application for use in Eritrea. It was undertaken on behalf of the Eritrean Technical Exchange project, a collaborative initiative on the part of Eritrea's Ministry of Mines, Energy and Water Resources and the Environmental Energy Technology Division of the Lawrence Berkeley National Laboratory at the University of California.

In addressing which performance measures are appropriate for use in Eritrea, this analysis examines international agency water supply project evaluations from ten countries in Africa and Asia. These include projects supported by the Asian Development Bank (ADB), Australia's Overseas Aid Program (AusAID), the British Overseas Development Agency (ODA, now known as the Department for International Development or DFID), the United Nations Children's Fund (UNICEF), and the United States Agency for International Development (USAID). In addition, it analyzes water source data from Eritrea's Debub region, and draws on recent case studies of household water use in Kenya, Tanzania and Uganda.

While this analysis principally addresses performance measurements that could be used practically in rural Eritrea, the findings may have broader application in other countries and contexts. In some instances, the analysis concluded that certain measurements are not appropriate for use in rural water supply projects – particularly in regions where there are no piped water systems, as in rural Eritrea – but were included because of potential use in urban areas.

Section I of this analysis sets out the development challenges posed by inadequate rural water supply. Administrative data from Eritrea's Debub region are used to illustrate specific characteristics of the country's rural water sources, and to identify principal challenges to improving rural water supply. Section II addresses in greater detail the problem for analysis: what are performance measurements and how might their use benefit Eritrea's efforts to improve its rural water supply. This section defines different sets of performance measurements, and discusses criteria for selecting among these sets.

Section III provides an overview of the analysis, including its methodology and principal findings. Sections IV through VII each discuss a different set of performance measurements: outputs, intermediate outcomes, final outcomes and process indicators. Based on this analysis, section VIII offers recommendations for the use of performance measurements for rural water supply investments in Eritrea.

I. Background: Water Supply as a Development Challenge

Significance of Water Supply Policy

Long recognized as a basic human necessity, safe drinking water was declared a human right in 2002 by the United Nations Committee on Economic, Cultural and Social Rights (UNCECSR). In a General Comment from November 2002, the UN committee established that "the human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realization of other human rights." The statement continues, "an adequate amount of safe water is necessary to prevent death from dehydration, reduce the risk of water-related disease and provide for consumption, cooking, personal and domestic hygienic requirements."[1] (UNCECSR 2002)

Last year's UN's World Summit on Sustainable Development articulated the goal of halving the proportion of people who cannot reach or afford safe drinking water by the year 2015, as outlined in the UN Millennium Declaration. The provision of safe drinking water is also a priority of the New Partnership for Africa (NEPAD). This initiative calls for international partners to "provide access to potable domestic water, hygiene education and improved sanitation and waste management at the household level through initiatives to encourage public and private investment in water supply and sanitation." (UN-WSSD 2002)

As noted in the UNCECSR statement, clean water is an essential human requirement for a variety of reasons. The most basic link between water and health is the need for drinking water: human beings must drink a minimum amount of water for survival. In rural areas, community water sources are also used for other household uses, such as bathing, cleaning and washing.

In the developing world, unsafe drinking water and poor sanitation are the leading environmental contributors to the burden of disease, as measured in Disability-Adjusted Life Years (DALYs).[2] In other words, it is the leading **preventable** factor in the process of disease transmission. (WHO 2000c) Water contributes to disease primarily through two transmission patterns: (a) contaminated drinking water (which spreads typhoid, cholera, dysentery, and other diarrheal diseases), and (b) a shortage of clean, accessible

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[1] Other international agreements that articulate a human right to clean drinking water include the Convention on the Elimination of All Forms of Discrimination Against Women or CEDAW (1979), the Convention on the Rights of the Child (1989), and the Geneva Conventions III and IV (1949). (See UNESCR 2002, p. 16.)

[2] The environmental burden of disease measures the extent to which diseases are a result of environmental – and therefore preventable – factors. This burden is measured in terms of Disability-Adjusted Life Years, or DALYs. One DALY unit represents one healthy and productive life-year lost to disability or premature death. The higher the DALY figure, the greater the burden of disease from a given environmental factor. The DALY figure for water supply and sanitation among developing countries is 0.05, comparable in order of magnitude to the disease burden from occupational risks in the industrialized world. (See WHO 1997, WHO Working Group 2000)

water, which limits bathing and washing and in turn encourages infection. With four billion cases and 2.2 million deaths per year, diarrhea is the leading water-related global health problem. According to the World Health Organization (WHO), one child dies every 15 seconds from diarrheal diseases in the developing world. (WHO 2000a)

Water Supply Challenges in Eritrea

Throughout Africa, expanding households' access to safe water supplies is a significant development challenge, particularly in rural areas. In 2000, improved rural water supply coverage for the continent was 47 percent. This figure represents a slight improvement from 1990, when rural coverage was 44 percent. An estimated 256 million rural Africans lack access to a safe drinking water supply. (WHO 2000a)

Eritrea's rural water supply coverage is slightly below that of the continent as a whole. A 1994 survey conducted by the UN Food and Agricultural Organization (FAO) reported that 40 percent of Eritrea's rural population enjoyed access to protected water sources. In 2000, the WHO reported that rural water supply coverage was 42 percent. (FAO 1994, WHO 2000) As the table below shows, more than 80 percent of Eritrea' population lives in rural areas. Lower rural coverage rates, coupled with the bulk of the population living in rural areas, suggest that the need to improve water supply is most pressing in rural parts of the country.

Table 1: Urban and Rural Population and Water Supply Coverage in Eritrea[3]

Demographic Group	Population	Water Supply Coverage
Nationwide	3,851,000	46%
Rural	3,129,000	42%
Urban	722,000	63%

Source: WHO, 2000

The Water Resources Department (WRD), located within the Ministry of Mines, Energy and Water Resources (MMEWR), is responsible for management of Eritrea's water supplies. The WRD has 63 staff at the national level, including three staff members who focus on evaluation and monitoring. The WRD has an annual budget of 4.0 million Nakfa, or about USD $267,000.

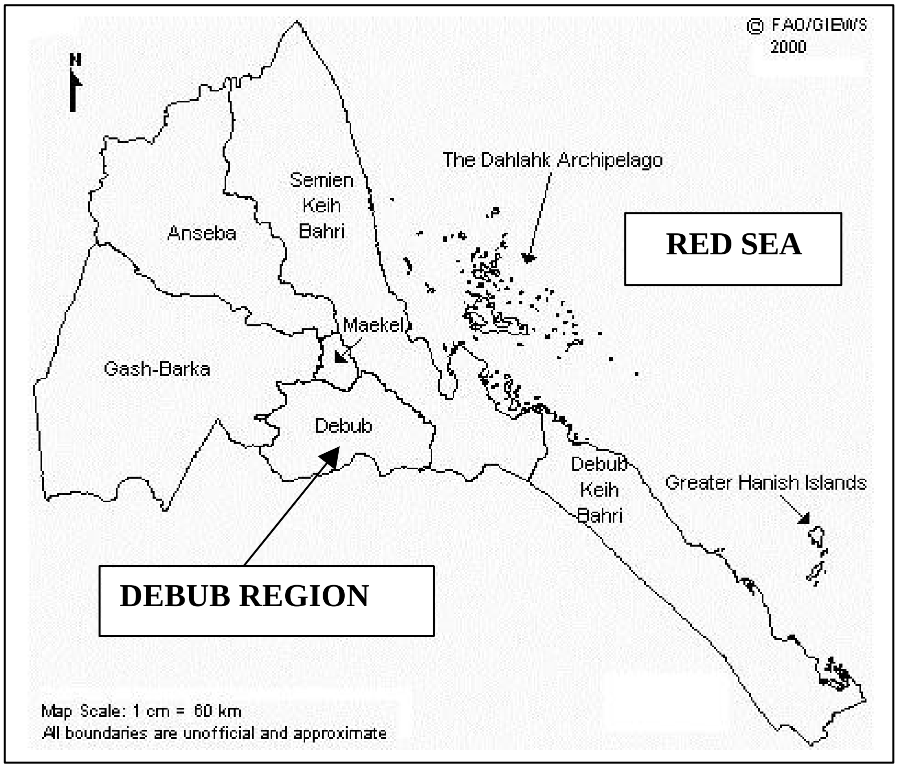
Implementation of local development projects falls under the Ministry of Local Government, which has between 10 and 25 staff members in each of Eritrea's six *zobas* or regions, administrative units akin to provinces. Water committees exist at the village level, composed of local residents. These committees are responsible for hiring a guard, who watches over the local water supply, and ensuring maintenance occurs when needed.

[3] These population figures reflect WHO estimates for the year 2000. Data from the University of Utrecht estimates Eritrea's nationwide population in mid-2000 to be just over four million. Whether the actual national population is closer to the WHO figure or the Utrecht figure, it remains that the vast majority of Eritreans lives in rural areas.

Case Study: Debub Region

Debub region is a semi-arid region in the southern part of Eritrea (see map below), encompassing parts of former Seraye and Akele Guzay provinces.[4] With more than one million residents, it is the most populous region in the country.[5]

Figure 1: Administrative Map of Eritrea



Source: FAO, 2000

While the western part of the country and the area along the Red Sea coast are hotter and drier than Debub, these regions are less populated and the majority of Eritreans live in regions with climate similar to that of Debub. Thus, while the data presented below is specific to Debub, we might expect many rural Eritreans to experience similar water supply challenges. For western and coastal regions, the obstacles to improving water supply would likely be greater, because of the more arid climate and lower population densities. (FAO 1994)

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[4] The 1997 constitution created new *zobas* or regions as part of a new administrative structure, replacing the provinces that had existed under Ethiopian rule. Climate information on Debub region is based on FAO data on the former provinces Seraye and Akele Guzay. (See Africa MapNet at http://www.africa-map.net/Eritrea%20Map%20-%20Country%20information.htm)

[5] Population estimate from University of Utrecht. Available via Internet at http://www.library.uu.nl/wesp/populstat/Africa/eritreap.htm.

Administrative data on water sources in Debub region illustrates the water supply challenges facing the country. These data come from a survey of 731 water sources in the region, conducted by the Water Resources Department.

- *Source types.* The table below shows the prevalence of different water source types in the Debub region. Nearly 80 percent of water sources rely on groundwater: just more than half of all water sources are hand-dug wells, and another one-quarter are boreholes, or machine-dug wells. While both sources rely on groundwater, boreholes are constructed using machines and are often given covering and a protective apron around the ground opening to guard against contamination, unlike hand-dug wells that are not necessarily protected.

Table 2: Frequency and Percentage of Water Sources, Debub Region

Source Type	Frequency	Percentage of Total
Hand-dug well	398	54%
Borehole	186	25%
River water	65	9%
Dam	38	5%
Pond	23	3%
Spring	15	2%
Water Point	5	1%
Reservoir	1	1%
All Sources	**731**	**100%**

Source: Water Resources Department, Eritrea

- *Protected and unprotected sources.* As part of its inventory of water sources, the Debub region data indicates whether a source is covered, one method to physically protect a site against contamination. About 38 percent of all water sources in the region are covered. The following table shows the breakdown of covered and uncovered sources by water source type.

Table 3: Frequency and Rates of Covering, by Water Source

Source Type	Covered	Uncovered	n/a	Total	Percentage Covered
Borehole	178	8	0	186	96%
Hand-dug well	99	297	2	398	25%
Reservoir	1	0	0	1	100%
River water	0	65	0	65	0%
Dam	0	38	0	38	0%
Pond	0	23	0	23	0%
Spring	0	15	0	15	0%
Water point	0	5	0	5	0%
All Sources	**278**	**451**	**2**	**731**	**38%**

Source: Water Resources Department, Eritrea

As these data show, machine-made boreholes are much more likely to be covered than other kinds of water sources.[6] Other types of sources – dams, ponds, rivers and springs – are entirely uncovered. It is not technically possible to protect some of these sources, such as rivers, against contamination. It is possible, though, to cover springs at their sources using man-made materials.

Covering, however, is only one method for protecting a water source. A separate WRD survey of 346 water sources nationwide identifies sources that are protected by fences and concrete aprons, those that use mechanical pumps instead of rope to draw water, and other characteristics of water sources. Like covering, aprons provide a physical barrier against contamination. Mechanical pumps provide protection because they eliminate the use of dipping buckets in the water collection process, which is a significant cause of source recontamination.

Regression analysis of these nationwide data shows that aprons and mechanical pumps are also significant determinants of water quality. In this sample, water quality was indicated by the coliform count, i.e., the number of bacterial organisms that are present in a 100-milliliter sample of water. More significantly, this analysis shows that the existence of a borehole has a powerful explanatory effect on the level of contamination of water supply sources – an effect that was an order of magnitude greater than any of the other protective measures taken. (See Appendix II.)

- *Functional and non-functional sources*. Out of 731 water sources in the region, 86 percent (601 sources) were functional and 14 percent (101 sources) were non-functional, i.e., they were not providing water to villagers. Sources were non-functional for a range of reasons – sources were reported broken, dried, salty, polluted by organic substances, or still under construction. As the table below shows, 57 of 186 boreholes, or 31 percent, were not functional. This percentage is higher than that for hand-dug wells, of which only 8 percent were non-functional.

Table 4: Percentage and Frequency of Non-Functional Sources, by Source Type

Water Source	Percentage Non-functional	Non-Functional Sources	Total Sources
Bore Hole	31%	57	186
Pond	22%	5	23
Water point	20%	1	5
Dam	11%	4	38
Hand-dug well	8%	33	398
River water	2%	1	65
Spring	0%	0	15
Reservoir	0%	0	1
All Sources	**14%**	**101**	**731**

Source: Water Resources Department, Eritrea

[6] The one exception is reservoirs, of which there is only 1 in this sample of 731 sources.

Thus, while machine-made boreholes provide a much greater level of protection against contamination, they also require more attention and maintenance if they are to be kept in working condition. This is largely the result of mechanical breakdown, something that hand-dug wells experienced far less frequently, as the following table shows:

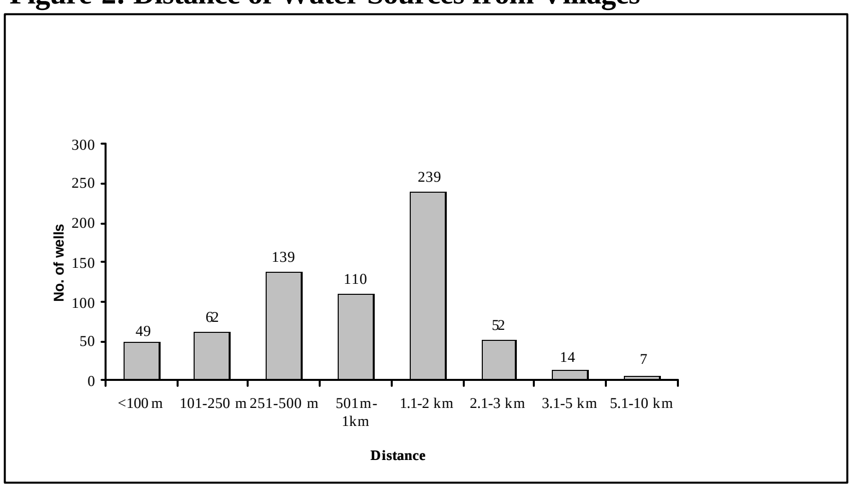
Table 5: Causes of Non-Functional Water Sources

Cause of Non-Functional Status	Boreholes (frequency)	Boreholes (% of all non-functional boreholes)	Hand-dug Wells (frequency)	Hand-dug wells (% of all non-functional boreholes)
Broken	45	79%	7	21%
Dried	8	14%	10	30%
Salty	1	2%	1	3%
Organic Polluted	0	0%	4	12%
Under Construction	3	5%	11	33%
Total	**57**	**100%**	**33**	**100%**

Source: Water Resources Department, Eritrea

- *Distance to source*. As Figure 2 shows below, distance to the 731 water sources from villages varied within the region. A significant percentage of sources – 46 percent – were located further than one kilometer from water users. The WHO uses this distance of one kilometer as an upper bound for what constitutes "reasonable" access to household water supply. (IIED 2002) A large percentage of wells are further from Debub region villages than this upper bound, which depicts a significant challenge facing Eritrea: increasing the accessibility of household-use water sources.

Figure 2: Distance of Water Sources from Villages



Source: Water Resources Department, Eritrea

Data from other countries suggest that rural water sources are often closer to villages than 1,000 meters. A 2001 study of 13 rural sites in Kenya, Tanzania and Uganda showed an average distance of 466 meters from water source to village. (IIED 2001, Mujwahuzi 2001, Tumwine 2001) As targets for water supply improvements in their national poverty reduction strategy papers, Uganda sets a target of sources less than 500 meters from users; Burkina Faso sets a target of 300 meters or less. (DFID 2002) While 1,000 meters may therefore seem like a conservative target, given the distance figures from Debub region, it is a realistic one for Eritrea, at least in the near future.

In summary, the data from Debub indicates that there are several challenges to improving rural water supply in Eritrea, including:

- Increasing protected source coverage
- Repairing and maintaining non-functional sources, particularly boreholes
- Decreasing distance from water sources to village users

II. Problem for Analysis

Performance measurements are often used in two ways. First, they are used to monitor and evaluate project implementation, to determine whether a project is achieving its stated objectives. This is a descriptive exercise, in which changes in the value of quantitative indicator can be observed and measured, but not attributed to the project itself. Second, performance measurements can be used to analyze project impact, whereby statistical analysis would indicate whether changes in specific performance measurements could be attributed to a specific project. Impact analysis seeks to demonstrate a causal relationship between a project and the changes in performance indicators that are observed through monitoring and evaluation.

Conceptualizing Performance Measurement

One way to conceptualize what "performance" of a water supply project (or any other kind of development project) constitutes is as follows:

Input → Output → Intermediate Outcome → Final Outcome

- *Inputs* are the resources that are used to design and implement the project, e.g., staff members, drilling equipment, statistical software, funding.
- *Outputs* are the tangible products that projects generate. In the case of water supply projects, outputs are usually physical in nature, e.g., wells, transmission pipes, covering over freshwater springs.
- *Intermediate Outcomes* are the observable and measurable changes that result from the existence of these outputs, e.g., lower bacterial levels, increased consumption of protected spring water, shorter distances from a village to a water source.
- *Final Outcomes* are the way people experience changes in their material lives because of intermediate outcomes, e.g., sick less frequently from water-related disease, increased consumption because of less time spent on collecting water. (WSP 2002, DFID 2002)

In addition to the stages of this cycle, the *process* through which a water project is designed and implemented can itself influence performance. As such, this report will discuss the use of process indicators as well measurements of outputs, intermediate outcomes and final outcomes.

Why Performance Measurement?

If it had unlimited resources, the Eritrean government could undertake a range of investments to improve its rural water supply. It could, for instance, increase the number of protected water sources, through investment in new boreholes or upgrading existing sources, primarily hand-dug wells. It could allocate resources toward regular maintenance (e.g, of pumps), or provision of materials (e.g., buckets and rope), in order to improve water production. It could disinfect drinking water, from both protected and unprotected sources, through methods such as chlorination, slow sand filtration or ultraviolet disinfection. Investments might also seek to strengthen the management of water resources, either at the village level through local water committees or at the national level through the Water Resources Department.

Resources for undertaking these different kinds of projects, however, are extremely limited. There is only a small number of government staff available to design and implement water projects. Furthermore, development projects, particularly in rural parts of the country, rely heavily on investments by international donor agencies. In short, scarcity of resources dictates that decisions regarding alternative water supply investments carefully consider how different investments are likely to perform. Performance measurements can help managers to make these decisions through their use in monitoring and evaluation and impact analysis.

When used in monitoring and evaluation, performance measurements can indicate whether a project is fulfilling its policy objectives, for instance, "to ensure that the people of Eritrea receive fair and appropriate distribution of water services."[7] First, they assist project managers to monitor system performance, so that they could make changes or improvements to projects while they are still being implemented. Second, they provide information that can be used to evaluate program results. Implementing and funding agencies often conduct such *post-hoc* evaluations after project completion to determine how project resources were utilized and whether the project achieved its objectives by comparing performance measurements against targets set at the start of the program. Selecting performance measurements that are both appropriate to Eritrea's water policy objectives and relevant to potential international donors could improve the government's ability to gain support for investments in this sector.

In addition, performance measurements can also be used to conduct impact analysis of a project. Unlike monitoring and evaluation, impact analysis seeks to attribute a causal relationship between project activities and specific outcomes, through statistical analysis techniques. In order to perform impact analysis, project design must allow for the comparison of treatment and control groups, i.e., between households that receive improved water services and other households that do not.[8]

As this analysis will discuss, however, it may be difficult to attribute impact to water supply programs for changes in the final outcome measurements – particularly health status – that most directly reflect the policy goals of water supply projects. For this reason, many of the agency evaluations that were examined in this study used

[7] See PFDJ National Charter, 1994.

[8] While this analysis does not specific address methodologies for impact analysis, it should be noted that there are ways to design projects such that treatment and control groups exist, while not unnecessarily preventing certain households or villages from receiving a new service. Given that project resources are limited, for instance, water source improvements could take place in two waves, with one set of villages receiving project services before the second set. If impact analysis is conducted at the completion of the first project wave, the second set of villages serves as a control group for the purpose of impact analysis, even though residents ultimately receive the same services.

intermediate outcome measurements, such as change in water quantity or quality, as proxies for health impact. The causal relationship between water projects and these intermediate outcomes is less complex than for final outcomes such as health, which increases the likelihood that evaluators could identify a significant impact from a given project.

Selecting Performance Measurements

There are numerous quantitative performance measurements that could be used for any given water supply investment. Depending on what type of project is conducted, and the development context in which the project takes place, some indicators will be more appropriate than others. In order to evaluate which measurements would be beneficial in rural Eritrea, this analysis used three criteria:

1. Are the measurements relevant to Eritrea's rural water supply needs (i.e., increasing source protection, decreasing distance to sources and improving reliability)?
2. Are they feasible, given available data and opportunities for collecting new data?
3. Are they used and understood by international agencies that fund and implement water supply projects?

The data from Debub region suggests that Eritrea's main water supply challenges include increasing access (particularly in terms of decreasing distance) to water supplies, increasing the coverage rates and the number of protected water sources, and ensuring that protected sources are maintained adequately so that they remain functional.[9] In evaluating whether projects are alleviating these problems, WRD officials currently use several performance indicators, including:

- Is a water committee in place? Has it hired and trained a guard and technician for the local water supply?
- What is the specific quantity of water delivered, i.e., the capacity of water sources?
- Does the construction meet national standards? Are there sufficient financial and energy resources to keep the pumps operational?
- Are water fees being collected?

[9] In its statement on the right to safe drinking water, the UNCESCR identifies key elements of water supply policy – availability, quality, accessibility, and affordability – that reflect needs similar to those that exist in Eritrea.

This process already provides information to water supply administrators that can be used to evaluate water projects. Among other information, existing administrative data provides baseline coverage rates, status of water sources (functional/non-functional), forms of protection (e.g., covering, aprons), type of pumps used, distance from villages to water sources; and levels and forms of water payments. This makes for a solid base from which the WRD could further develop its use of performance measurements.

III. Overview of Analysis

The objective of this analysis is to consider which performance measures could assist in evaluating rural water supply investments in Eritrea. This analysis examines international agency water supply project evaluations from ten African and Asian countries: China, Ethiopia, Gambia, Indonesia, Laos, Malaysia, Philippines, Sierra Leone, Sri Lanka and Uganda. These projects were supported by the Asian Development Bank (ADB), Australia's Overseas Aid Program (AusAID), the British Overseas Development Agency (ODA, now known as the Department for International Development or DFID), the United Nations Children's Fund (UNICEF), and the United States Agency for International Development (USAID). In addition, the analysis draws on data from recent case studies of household water use in Kenya, Tanzania and Uganda.

Intermediate Outcome Measurements

- Distance to water source
- Queue time for collecting water
- Protected source coverage
- Functioning facilities
- Bacteriological count
- Frequency of water testing
- Total household consumption

Water supply indicators that measure **intermediate outcomes** are the most likely to be both measurable and relevant to rural water policy goals. This is the principal reason that international agencies tend to focus on intermediate outcome measurements in program evaluation. As such, much of this analysis will focus on indicators within this set that could be used in Eritrea.

Final outcome indicators, particularly those related to health, are central to water supply project goals and should be included in descriptive analysis of project results when possible. Attributing impact to changes in these measurements, however, is difficult for two reasons: (a) necessary baseline data is often unavailable and (b) multiple explanatory factors make it difficult to model causality such that a significant impact can actually be demonstrated.

Final Outcome Measurements

- Incidence of water-related disease
- Change in household income or consumption

Output Measurements

- Number of facilities (e.g., wells, filtration systems) constructed

In contrast to outcome measurements, **output measurements** will not necessarily tell an evaluator whether a project has achieved its policy goals, i.e., whether it has generated a change in water supply institutions or processes that will go on to affect users' lives.

Process Measurements

- Women's participation on village water committees
- Poor versus non-poor coverage rates
- Water costs as a percentage of total household consumption

In addition, this analysis will also consider the use of **process measurements**, such as indicators related to gender and poverty status. Gender performance measurements can indicate the extent to which women are involved in a project's design and implementation, a characteristic that is often correlated with success on other outcome indicators. Poverty status or equity measurements can indicate the degrees to which a project benefits poor versus non-poor households. This is important to consider for projects that have a specific objective of improving water services to the poor.

Sections IV through VI of this analysis will address measurements of the final three stages of the performance cycle: outputs, intermediate outcomes and final outcomes. Section VII will address aspects of the process through which projects perform, with particular attention to gender and equity indicators.

IV. Output Indicators

This section discusses using **project outputs** as performance measures. *Outputs* are the tangible products that projects generate. In the case of water supply projects, outputs are usually physical in nature. Measuring the number of physical outputs of a project – such as wells, protected springs or household connections – is easily achieved, but does not necessarily provide a good indication of whether a project has achieved its policy goals.

A borehole rehabilitation project conducted by ODA in Uganda illustrates this shortcoming. Monitoring and evaluation of this project emphasized the number of facilities (new wells, in this case) provided as a performance measurement. In Uganda, the implementing agency (UK-based Water Aid) principally assessed project performance based on the number of wells dug, i.e., an output measurement, rather than the water quality levels in these wells, or consumption of water from these wells, i.e., outcome measurements.

ODA evaluators considered this project largely unsuccessful, despite far surpassing the number of boreholes targeted for provision, because these facilities did not ultimately increase water consumption, one of the project's main objectives. This outcome was not realized in part because the project did not decrease the distance to water sources for enough villagers (the new wells were no closer than traditional water sources). It also was in part because of poor maintenance of project wells, such that nearly 40 percent of the wells were non-functional by the time of the evaluation. As a result, the project fell short of fulfilling its policy goal, which was to provide selected communities in three districts of eastern Uganda with access to a clean and reliable domestic water supply.

This does not mean that project administrators should not keep count of the number of actual water supply facilities and other physical outputs that a project generates. Rather, it suggests that these figures should not be relied upon as the principal measurements of a project's performance. Instead, as this analysis will address next, performance measurements should largely comprise project outcomes, i.e., the changes in water supply services that result from the generation of physical outputs.

V. Intermediate Outcome Measurements

This section addresses potential measurements of project performance that focus on **intermediate outcomes**. *Intermediate outcomes* are the observable and measurable changes that result from the existence of physical outputs. The following chart provides a few examples:

Output	Intermediate Outcome
Ultraviolet disinfection systems	Lower bacteria levels
Covering over springs	Increased percentage of protected water sources
Hygiene education pamphlets	More frequent bathing and washing

This analysis considers three sets of potential intermediate outcomes: service delivery outcomes, water quality outcomes and consumption outcomes. It will draw upon data from in international agency evaluations of water supply projects, as well as case studies of household water consumption in Kenya, Tanzania and Uganda.

Service Delivery

This first set of indicators measures **water service delivery outcomes**, or the "supply side" of water systems. This analysis will discuss five service delivery outcome measurements: (a) distance to source, (b) time spent collecting water, (c) protected source coverage, (d) functioning facilities and (e) hours of service per day.

These indicators reflect changes in rural water services that are dependent primarily on the agency or organization responsible for supplying water. Implementing agencies, though, may employ varying degrees of public consultation in the design of water supply projects, which allow for an element of demand-side influence in decisions about water service delivery. For instance, decisions on well locations made in consultation with communities might result in a decreased distance to water sources from villages.

- *Distance to source*. This is a measurement of the average distance that household users must travel to reach the water source. In rural areas where there is no piped water supply, collecting water involves carrying it from the source, just as households – or, more accurately, women in households – have done for generations. (IIED 2002) In his study of water use in rural Kenya, Peter Kimuyu concludes "proximity to a water source is the main reason for choosing a source in both [wet and dry] seasons."[10] (Kimuyu 1998)

[10] In the study, regression analysis of potential explanatory variables on the choice of water source supported this conclusion. In addition to the distance to the water source, the regression model used in this study included as independent variables: household size, proportion of females in household, female household head, daily water use, household expenditure and reasoning ability score (a proxy for human capital attributes). Water sources examined in household decision-making were boreholes and wells, rivers, piped sources and roof catchments. The negative effect of distance on choice of a source was significant at the 95 percent level for rivers, piped sources and roof catchments. This suggests that villagers consider distance an important factor when making choices of where to draw their water. (See Kimuyu 1998, ch. 4)

International agency evaluations also noted that closer sources were correlated with increased water consumption. A project that ODA conducted in Sierra Leone showed that newly dug wells cut down on the distance women traveled to collect water. There wells were an important water source during the dry season, when many natural sources dry up and women would otherwise be forced further afield to draw water for their households. As noted in the previous section, another ODA project in Uganda did not achieve its policy objectives in part because the new wells did not decrease the distance over which water was collected. In this case, the poor showing on this outcome measurement indicated a significant weakness in the project's performance.

- *Time spent collecting water*. There was evidence in agency evaluations and case studies that water supply improvements can decrease the time needed for drawing water. This indicator could be broken down into two components: reduced travel time to a water source, and reduced wait time at the water source. The first component is correlated with distance to the water source. The second component, queue time at the water source, may vary depending on the type of source. For instance, the case study of household water consumption in Tanzania reported that total time for collecting water reflected queue length, not only distance to the source:

Table 6: Water Collection Times in Tanzania, by Water Source

Water Source	Distance (meters)	Time (minutes RT)
Neighbor	37	12
Public Buildings	54	95
Reservoir	114	25
Kiosk	158	40
Standpipe	230	44
Stream / River	1,100	58

Source: Mujwahuzi, 2001

As this table shows, while time for collecting water generally increases with distance, there can be exceptions. Users who drew water at nearby public building such as churches, mosques and government buildings faced a long wait time, which created a total trip of more than 90 minutes. (Mujwahuzi 2001) Similarly, users who collected water at kiosks and standpipes faced a time cost that appears disproportionately larger than those who collected water at reservoirs, if we consider just the distance to the sources. We can surmise this is the product of longer queue times, though the data does not provide this breakdown explicitly.

- *Protected source household coverage*. This is a measurement of the percentage of households that enjoy access to protected or improved water sources. These are sources that attempt to prevent contamination of household-use water, often through physical means, such as aprons or covering. As discussed earlier, mechanical pumps also protect water sources, by eliminating the possibility of recontamination through the use of dipping buckets. Coverage figures in Eritrea can be calculated from the

Water Resources Department's existing administrative data, which provides information concerning protection at each source.

Coverage indicates that water users have access to protected source, which is a positive service delivery outcome. On its own, though, this measurement does not indicate the level of contamination in these sources, only that steps have been taken to decrease contamination. It also does not show the extent to which households consume water from these protected sources, only that these sources are available to them. This analysis will address measurements of both these outcomes in later sections.

- *Functioning facilities*. This indicator measures the number or, more commonly, the percentage of facilities (e.g., rehabilitated wells) functioning properly after the completion of a project. The project evaluations reviewed for this analysis were generally conducted between one and three years after project completion. If a high percentage of facilities are not functional so soon after project completion, then water users are not realizing the potential benefits of a project. This challenge is evident in Eritrea, given the data from the Debub region that shows 25 percent of boreholes are now not functional, in many cases because of broken mechanical pumps.

  In Sierra Leone, for instance, the use of this performance measurement indicated a weakness of the project: maintaining necessary supplies at well sites. The ODA project sought to improve village health by constructing new hand-dug wells, and was evaluated in 1991 after 11 years of operation. It was then found that the 42 percent of all project wells were no longer functional, primarily because they lacked ropes and/or buckets. The implementing agency, CARE International, had initially provided these materials in setting up the well projects, and as a result there was some resistance on the part of local user committees to purchase replacements on their own. In addition, easy access to alternative water sources led well users to simply revert back to unprotected sources, rather than to purchase ropes and buckets (or call on the water committee to make such purchases).

  In this case, both water suppliers and village users contributed to the high level of non-functioning wells. Most non-functional wells (90 percent of them) were located in villages that did not receive hygiene education, suggesting that there was correlation between knowledge of water-related disease and maintenance of these new water sources.

- *Hours of service per day*. This measurement shows the level of "intermittency," or the frequency with which water services are not available to users. Among the agency evaluations, this measurement was provided for projects that provide piped water service, but it was not used in unpiped projects. In two cases where intermittency was a problem (ADB projects in the Philippines and Sri Lanka), breaks in service were attributed to an increasing number of users, limited water supply and lack of resources put toward operation and maintenance. Except in cases where water supply diminishes to the point where it must be rationed, this outcome measurement may be inappropriate for rural Eritrea, where piped water systems do not exist.

Summary. Measuring water service delivery outcomes can indicate whether a water investment is achieving its policy objectives. At least four performance measurements are appropriate for use in rural Eritrea: (1) distance to source, (2) protected source coverage, (3) percentage of functioning facilities and (4) queue time for drawing water. The first three of these indicators use administrative data that already exists within the Water Resources Department; the fourth would require additional data to be collected. All four address significant water supply challenges, as demonstrated in the Debub region case study.

Water Quality

A second set of performance indicators is **water supply quality** measurements. These indicators generally measure the bacteriological content of water – a characteristic that is closely associated with the transmission of water-related diseases.

Because bacteriological content is linked to the construction and maintenance of a water source, at first glance it also appears to be largely a function of the supply side. In rural water systems, though, households can also affect water supply quality through their consumption and sanitation practices. In this sense, some of these indicators reflect the performance both of supply and demand sides, i.e., water providers and users.

The water quality performance indicators that are analyzed in this section include (a) bacteriological counts, (b) frequency of water testing, (c) user perceptions of water quality and (d) turbidity.

- *Bacteriological counts*. Bacteriological tests can indicate the levels of *E. coli* or other coliform bacteria in the water, using the number of organisms per 100 milliliters of water as a metric.[11] These counts serve as proxies for broader contamination of water supplies: a high coliform count would indicate that fecal matter has contaminated the source, a sign that there could be other harmful microbiological contaminants. (Gadgil 1998)

  As this analysis will discuss, it remains difficult to demonstrate a significant impact of water supply improvements on health outcomes. But there is general agreement that the bacteriological content of water plays a role in the "causal network" of water-related diseases. As such, bacteriological counts are sometimes used as a proxy for health impact. These tests can be conducted at the water source using portable test

[11] The WHO recommends that there be less than one organism per 100 milliliters, although it does not formally set this as a standard. While in theory just one organism can cause illness, in practice a person might consume many without getting sick. This depends in part on body size, age and general health status; children and the elderly are the most likely to become sick from ingesting water-borne bacteria. (See Gadgil 1998)

kits, which could facilitate testing in rural areas where laboratories are not available to analyze water quality.

Water from unpiped sources, even improved ones such as boreholes or streams, may diminish in quality (i.e., become re-contaminated) during transportation and storage for household use. Measures of on-site bacteriological levels would not reflect any degradation of water quality that takes place after water is drawn from the source. However, none of the agency evaluations included in this analysis used contamination level *at the household* as an outcome measurement, likely because of the difficulty in obtaining accurate data for evaluation.[12]

- *Frequency of water quality testing.* Contamination of water supply can occur even after an investment is made to improve water quality. Improper disposal of human and animal wastes, for example, can seep back into groundwater or freshwater sources, re-contaminating sources that have already been protected. Testing water sources on a regular basis can help to ensure that recontamination does not occur.

  An ADB project in the Philippines showed that bacteriological testing was only conducted after users reported sickness. This approach to testing might not address ongoing needs to identify whether recontamination of a protected water source has occurred. In the Philippines case, national standards called for water supply quality to be tested, but this regulation was not enforced.

- *User perceptions of water quality.* Some evaluations reported user ratings of water quality, which are generally based on color, smell and taste. In some cases, these criteria may coincide with microbiological contamination. In Sierra Leone, for instance, the project evaluation showed that villagers could accurately identify which wells and traditional sources were contaminated, as evidenced by higher rates of diarrheal disease associated with their usage. Feedback from water users may therefore provide some indication of water contamination, which could be particularly valuable when regular testing is not conducted.

- *Turbidity.* Testing for turbidity or silt content is a necessary step for some water supply investments, particularly those that intend to disinfect or filter water before consumption. For instance, in an ADB-funded project in Laos to install piped connections in provincial towns, contractors did not carefully examine hydrological conditions. Instead, they applied a standard technical model in all four sites. This lack of attention to heterogeneity among project sites' hydrology ultimately contributed to the project's failure. Because of the local conditions, silt levels in the water were too high for it to be consumed as drinking water (i.e., the infiltration gallery was ineffective in removing silt). Generally, however, turbidity is not a

[12] The International Christian Support-Fund (ICS), in conjunction with researchers at the University of California and Harvard University, are developing a project in rural Kenya that will measure bacteriological counts at the household as well as at the source, in order to determine whether transporting water results in significant recontamination.

performance measurement used in water supply projects, because it is not part of the causal chain that can lead to water-related disease or health improvements.

Summary: While bacteriological counts are an important performance measurement for water quality, the frequency of testing is also a relevant measurement that should be considered, if tests are used at all. If low-cost methods for testing water are available, the WRD should make use of them. User perceptions of water quality can also provide information about contaminated sources, which could be valuable if regular testing is not possible. This information could be gathered formally through household surveys or informally through conversations between water committee members and villagers who utilize the water supplies.

Household Consumption

A third set of intermediate outcomes that are used as performance measurements concern **household water consumption**. These indicators reflect the demand response of household water users to the provision of new water sources or services.

One reason to measure these changes in consumption is that the action of consuming water – particularly through drinking and bathing – is what actually generates benefits or costs to water users. In addition, in recent years international agencies have emphasized the importance of generating a demand response in water projects, i.e., projects in which the services provided are appropriate to the value that beneficiaries place on those services. Funding agencies are thus often interested in seeing that households respond to new services through their behavior as water consumers. (Garn 1993, Varley 1996)

Consumption outcomes are also important because there may be external benefits associated with increased use of protected water sources. For instance, reliance on protected sources and increased consumption for bathing and washing could reduce water-related disease within a household, providing a benefit for other households in the form of lower exposure to these communicable diseases. (Whittington and Swarna 1994) Demand-side performance measurements for consumption outcomes include (a) total household consumption, (b) consumption for drinking and cooking from protected sources, (c) consumption for drinking and cooking from unprotected sources, (d) consumption for bathing and washing and (e) consumption for other uses, such as gardens and livestock.

- *Total household consumption*. This indicator measures total household water consumption, in terms of liters/capita/day. Change in consumption levels indicates an increase or decrease in overall household demand for water, i.e., that there was a positive demand response to the water supply investment. One benefit of increased total consumption is that more water is consumed for bathing, washing and other hygiene-promoting activities. This can have positive health effects by mitigating the conditions through which water-related diseases are often transmitted. (Gadgil 1998, WHO 2000)

In unpiped systems, where there are no meters to measure water consumption at the source, a household survey could be administered in order to measure the actual consumption levels of households. Using this survey, however, would make this a resource-intensive indicator. Alternatively, AusAID's 1999 evaluation of water supply investments in Indonesia used participatory rural appraisal (PRA) to estimate household consumption changes.[13] This approach revealed that households increased their water consumption between 200 and 500 percent, a significant outcome.

A primary objective of the ODA-funded borehole rehabilitation project in Uganda, discussed in previous sections, was to increase the quantity of clean water to project villages. Through focus group discussions with villagers, project evaluators concluded that total consumption varied among households. While villagers who live close to the wells consumed 30 to 40 L/cap/day, households located further from well sites consumed as little as 7.5 L/cap/day.[14] In this case, total consumption measurements revealed that there was significant heterogeneity within villages, and that not all households exhibited the same demand response to the project. An additional reason to measure total consumption is therefore to determine whether different households exhibit heterogeneity in consumption, i.e., whether they respond differently to the same project in terms of demand for new water services.

- *Consumption for drinking and cooking from protected sources*. Household water consumption may be divided further into two demand components: demand for drinking and cooking water, and demand for washing and cleaning water. Demand for drinking and cooking water tends to be relatively inelastic, because of basic human needs to consume a minimal amount of drinking water. (Whittington and Swarna 1994) The figures in Table 7, drawn from a case study of household water supply in Uganda, illustrate the difference in these two demand functions.

Table 7: Water Consumption in Rural Piped and Unpiped Households, Uganda

Water Use	**Rural Piped Consumption (L/cap/day)**	**Rural Unpiped Consumption (L/cap/day)**
Drinking and Cooking	3.4	3.7
Bathing	22.1	5.8
Washing and Cleaning	22.7	6.3
Total	48.2	15.8

Source: Tumwine, 2001

These data from rural Uganda suggests that household consumption for drinking and cooking is relatively fixed: in this case, average consumption for drinking and cooking was virtually the same among all rural households, even though accessing water is far more difficult for unpiped households. In contrast, the amount of water used for bathing, washing and cleaning is significantly lower among unpiped

[13] PRA methodology relies on structured community forums to collect data and elicit feedback from villagers who use project facilities. In late 1998, AusAID conducted the PRA in 10 villages that were part of this program, and used the study's findings to inform the project evaluation that took place in early 1999.
[14] The WHO recommends that household water consumption be at least 20 L/cap/day.

households than among piped households. In other words, households need to consume at least a minimum amount of water in drinking and cooking for their basic needs, while consumption for other household uses could be more variable. A similar trend is evident in the case study of household water use in rural Tanzania.[15]

Given that consumption levels for drinking and cooking will likely remain relatively constant before and after the project, it is more useful to examine whether water users switch over to protected sources to fulfill this consumption total, once these sources become available. Thus, an evaluation could use a simple "yes / no" variable for measuring this change at the household level, i.e., "did the household switch over to the protected source for drinking and cooking uses?" rather than measuring the quantity actually consumed.

- *Consumption for drinking and cooking from unprotected sources*. Alternatively, this performance measurement could be used to show change in the consumption of drinking water from unprotected sources. The logic of this indicator is that it quantifies the problem that many water projects intend to address, i.e., consumption of unsafe drinking water. In AusAID's Indonesia project, both measurements (consumption from protected and unprotected sources) were tracked, and the evaluation found that there was a 50 percent reduction in water use from unprotected sources. The evaluation reported this as a proxy for health improvement.

  Given the proposition that demand for drinking and cooking purposes is relatively inelastic, there is duplication between this indicator and the previous one (drinking/cooking consumption from protected sources). In other words, if consumption from protected sources for drinking use increases, there should be a corresponding decrease in consumption from unprotected sources, and vice-versa. As such, it may not necessary to use both these measurements, in which case project evaluators should choose the indicator for which household survey data is most likely to be reliable.

- *Consumption for bathing, washing and cleaning*. Increased water use for bathing and washing is considered an important factor in combating water-washed diseases (i.e., diseases that are related to poor hygienic conditions). (Gadgil 1998, WHO 2000) This outcome, however, was not explicitly measured among project evaluations used in this analysis. Some evaluations reported the direction of change in consumption for bathing and washing uses, i.e., whether there was an increase, a decrease, or whether consumption remained the same. The case studies from East Africa reported some washing and bathing activity at the water site itself (for sources such as rivers, streams and ponds), which would complicate efforts to measure the quantity consumed for these purposes, even if household surveys were used.

[15] In the Tanzania case study, piped consumption was 4.7 L/cap/day for drinking and cooking and 46 L/cap/day for bathing and washing. Rural unpiped consumption was 2.7 L/cap/day for drinking and cooking and 12 L/cap/day for bathing and washing. As in Uganda, these figures show greater elasticity in the demand for water for bathing and washing.

In addition, given that demand for water for washing and cleaning is relatively elastic, an increase in overall consumption would likely reflect an increase in water used for washing and bathing (as opposed to drinking and cooking).[16] In this case, a separate measurement for bathing, washing and cleaning may not be necessary, if total consumption is already being measured.

- *Consumption for other uses.* In addition to drinking, cooking, bathing and washing, households may use water for gardening, livestock or other uses. Measurements of these other uses were not included among water supply project evaluations. The Uganda case study showed rural households use a significant amount of water (2.7 L/cap/day, nearly as much as is used in drinking and cooking) for livestock, and a small amount for gardens. These results were not evident in the Tanzania case study.

Summary: Total consumption should be included among a project's performance measurements, so long as it is feasible either to collect data through household surveys or estimates through PRA methods. Evaluations should also track whether water users switch from unprotected to protected sources for drinking and cooking purposes. Changes in consumption of water for bathing, washing and cleaning will likely be reflected in overall consumption levels, reducing the need to measure consumption for these uses separately. Nonetheless, if a household survey is used to collect data on total water consumption, the marginal costs of additional questions concerning quantities for specific uses is minimal, so these data could be collected as well.

[16] This is borne out by the Uganda consumption figures shown earlier, in which the large increase in total consumption from unpiped to piped households was largely attributable to an increase in water used for bathing, washing and cleaning.

VI. Final Outcome Measurements

This section will examine the use of **final outcome measurements** for water supply projects. *Final outcomes* are the way people experience changes in their material lives because of intermediate outcomes. For instance, they may experience being sick less frequently because of lower levels of bacterial contamination, or might enjoy gains in household livelihood because of less time spent on collecting water.

In the water supply sector, investments are generally anticipated to have an impact on the health of project beneficiaries, i.e., the people who use the water supply services that are provided. In addition, some sector literature proposes that water supply investments may have an impact on household livelihood, by increasing the income and consumption levels of households that receive new water services. As this analysis discusses, while quantitative health outcomes can be reported, it may be difficult to measure or put into monetary terms livelihood gains from water projects.

Additionally, it is difficult to demonstrate a statistically significant impact of water projects on both health or livelihood variables. For this reason, these final outcome measurements are more easily used in descriptive evaluations of water supply investments, rather than in project impact analyses.

Health Outcomes

Water supply investments are often undertaken with the goal of improving health conditions of villagers who receive the improved water services. In particular, young children who are most susceptible to water-related disease may benefit from improvements in water supply, as well as hygiene and sanitation. A common health outcome measurement is the percentage of household members who experienced diarrhea or other water-related illnesses within the past two weeks.

It is generally accepted that water supply is an important link in the "causal network" for many diseases and, as a final outcome measurement, health status is central to the policy objectives of most water projects.[17] (WHO 2000b) On the other hand, it is unlikely that evaluators would be able show a statistically significant impact of a single project on health outcomes of water users.

[17] The path of water-related transmission is characterized as an interrelated network of causal factors, rather than a discrete causal chain. Distal causes (e.g., scarcity of resources to construct new wells) contribute to proximal causes (e.g., reliance on closer, but unprotected, water supply). These proximal factors lead to disease. Scientific evidence may not allow evaluators to quantify all the factors in this causal network in a way that would allow for meaningful impact analysis of water supply projects on health status. (See WHO 2000b)

While it is often possible to measure changes in health status as a final outcome of a project, is has proven to be extremely difficult for analysts to attribute significant *impacts* from water supply projects on beneficiaries' health. This is largely because of two factors:

1. Baseline data concerning the health status of project beneficiaries are often missing or insufficient to conduct a rigorous impact analysis.

2. In addition to water supply, there are a host of other factors that could potentially explain changes in health status, e.g., health education, hygiene practices, presence of health clinic, etc. This has presented a significant challenge to project evaluators who seek to model causality with respect to health status.

As such, international agencies tend to use health indicators in descriptive analyses (e.g., report a decrease in the prevalence of water-related diseases) but avoid impact analysis with respect to health (e.g., report a causal effect of a project on households' health). In other words, although pre- and post-project health status data may be reported, the evaluations reviewed in this analysis did not seek to attribute changes in these indicators to any single project.

Several of the ADB projects, for instance, had a stated objective to decrease the incidence of water-related disease but did not attempt to show a causal relationship with changes in health outcome measurements. A 1999 evaluation of ADB project's in Indonesia showed no attempt to collect household data or information on the health status of water users. Instead, evaluators assumed that an improved water supply – in terms of both quantity and quality – would improve the health status of water users, but that it would difficult to show this impact within any single project. "It was observed," the report stated, "that overall, with better access to safe and potable water supply, the health status of the community has improved significantly with the before-project situation."

In a 2002 ADB regional evaluation of water projects, the agency used proxies for health impact, e.g., water consumption and service delivery outcomes. Evaluators made this decision in large part because there was no pre-project data that could provide a baseline for impact analysis. The evaluation of ODA's project in Sierra Leone similarly concluded that it is "extremely difficult, if not impossible, to quantify directly the health benefits of a rural water supply and sanitation project" through impact analysis, for two reasons. First, baseline data on health status is not very reliable and difficult to collect. Second, there exist many other potential explanatory factors besides water supply (e.g., nutrition, school health programs, availability of oral rehydration tablets, etc.) that could explain changes in health indicators. Given these challenges, the evaluation examined changes in the use and function of water supply facilities as proxies for health impact.

Household Livelihood

Some literature on water supply projects also contends that these investments may generate livelihood outcomes, i.e., increases in household consumption or income. (Nicol 2000) This hypothesis is based in part on the premise that water supply investments – particularly the construction or upgrade of water sources – will decrease the time needed to collect water, which could then be put to other productive uses, as well as decrease other barriers to overcoming poverty.[18]

On its own, however, time saved does not necessarily generate a measurable change in household consumption or income. As such, agency evaluations generally did not attempt to monetize the benefits from saved time, i.e., provide an economic value for this time saved. For example, AusAID's evaluation of its project in eastern Indonesia used time saved in collecting water as a performance indicator. Participatory rural appraisal findings showed that there was time saved from the project – 18 minutes per day, on average. However, the evaluation did not attempt to monetize time saved in terms of livelihood benefits to households, it simply asserted that such benefits were positive.

More commonly, evaluators concluded that there was little evidence that saved time was associated with an observable increase in household consumption or income. The evaluation of ODA's Sierra Leone project noted that this was in part the case because so few opportunities for income generation existed in rural areas of the country to begin with. This conclusion may be particularly relevant for rural Eritrea, where there are also few opportunities for residents to make use of time savings in ways that would create observable change in household consumption.

This should not, however, diminish the importance of time saved itself as an outcome measurement. Qualitative analysis in the AusAID evaluation showed that women generally valued having to spend less time (and physical energy) collecting water, even if there was no clear link between this time savings and a measurable change in household income.

[18] For instance, according to the livelihood approach, time saved collecting water might allow for more income-generating activity, or other non-market activities that increase consumption, such as household gardening. To the extent that children are engaged in water collection, it might also allow them to spend less time drawing water and more time on educational activities. Alternatively, a social analysis of this measurement might conclude that women do value the time they spend collecting water, even if it represents an economic opportunity cost, because it creates a female-controlled social space that is not available to them in the household itself.

Summary: It is difficult to demonstrate a statistically significant impact of water supply projects on health or livelihood variables. International development agencies instead generally use proxies in project assessments, such as changes in the quantity and quality of water supply as proxies for health impact. Nonetheless, health outcomes are central to most water supply projects, and are thus measured and reported as part of project monitoring and evaluation, even if a causal relationship with the project cannot be demonstrated.

VII. Process Measurements

The final set of performance measurements that this analysis will consider are **process measurements**, such as indicators related to gender and poverty status. Gender performance measurements can indicate the extent to which women are involved in a project's design and implementation, a characteristic that is often correlated with success on other outcome indicators. Equity and affordability measurements can indicate the degree to which poor households benefit from water supply investments. This is important to consider for projects that have a specific objective of improving water services to the poor.

Gender

In most countries, women collect water for use in the household. Their involvement in project design and management can be an important contributing factor to project success because, as the principal water drawers, women have firsthand information about water sources that is needed for sound operation and maintenance. This is one reason that some agencies have found a lack of women's involvement to be correlated with project failure. AusAID describes this problem in its gender guidelines for water supply projects: "in many cases WSS [water supply and sanitation] facilities have failed because not all members of the community, and particularly women, were fully involved or fully committed to the project." (AusAID 2000)

For this reason, international agencies may note process standards for gender in their evaluations of water supply investments. Two process measurements that were used were (a) the percentage of women on water user committees, and (b) the percentage of women who served as heads of these committees.

- *The percentage of women among village water committees*. This measurement shows the extent to which women are involved in regular operations and management of village water supplies. A USAID project in Ethiopia to rehabilitate wells noted that there was, by design, an even gender balance on water committees (three women and three men, selected by their communities). Evaluators concluded that this balance allowed for "proper representation" of women's interests and knowledge in selecting water sites for rehabilitation.

  ODA's Sierra Leone project evaluation showed that the involvement of women was important to increasing project sustainability and achieving positive consumption and service delivery outcomes. When women (particularly female elders) were represented on village well committees, they were well positioned to use their social authority to influence the behavior of younger women, e.g., through home visits to encourage better hygiene and safe water use. Similarly, it made a difference to include women as trainers for hygiene education programs, because they were better positioned to reach a female audience – the bulk of household water users.

- *Percentage of women among water committee leadership*. The evaluation of AusAID's project in eastern Indonesia concluded that women were active participants in project design and management – as project staff members, user group committee members and health educators – but not well represented among water committee leaderships. Women made up 38 percent of user group volunteers, but only 3 percent of user group heads.

  As a result, the evaluation concluded, "the project had no discernible impact on traditional decision-making in the community." This did not mean that women did not benefit from the projects: evaluators concluded that the health benefits and saved time in water collection were felt in women's lives. It did not, however, mark a change in women's decision-making status within the project villages such that, as a group, women would be empowered in subsequent development decisions that faced their communities.

Equity and Affordability

Many of the projects included in this analysis sought to improve water services to the poor, as part of a broader national goal of alleviating poverty through development projects. Given this objective, it is relevant to examine project outcomes through the lens of equity, e.g., whether project beneficiaries include both poor and non-poor households, or whether the size of benefits differs between poor and non-poor recipients. In addition, the affordability of water may be a relevant policy concern, particularly if the project serves a largely poor population. Two performance measurements could indicate whether a project is fulfilling its equity or poverty objectives: (a) a comparison of poor versus non-poor coverage rates, and (b) water costs as a percentage of total household consumption or income.

- *Poor versus non-poor coverage rates*. This measurement addresses the first equity question posed above, i.e., whether the rate at which poor households benefit from water supply investments is comparable to the rate among the non-poor. In communities where socioeconomic heterogeneity exists, this indicator would require the use of household surveys to determine consumption levels (i.e., to indicate whether they are poor or non-poor) as well as beneficiary status.

  The ADB used this approach in evaluating a project in Sri Lanka that provided in-house piped connections. Using data from a survey administered to 100 households, evaluators concluded that poor households had received connections through the project, which satisfied the objective of providing service to the poor. This survey, however, did not reveal the magnitude of these benefits and how they compared to that of non-poor beneficiaries. It was used principally to determine the poverty status of households, and whether they had received piped water services through the project.

- *Water costs as percentage of household income or consumption*. This measurement indicates the affordability of water. The higher the percentage, the greater the burden that water consumption is for the household. For the purposes of this analysis, we will consider changes in this measurement as indicating whether water is becoming more or less affordable, rather than recommending a specific percentage above which water becomes "unaffordable."[19]

One ADB project in Indonesia used this measurement to indicate affordability. This project, which provided household piped connections in rural small towns, had set as its target water costs no greater than 3 percent of household income. ADB evaluators found that performance varied among project sites, with costs as high as 7 percent of household income in some areas, as many water districts increased water tariffs designed in response to Indonesia's 1998 financial crisis. This outcome likely contributed to a disproportionate share of project benefits going to non-poor households, meaning that the project did not fully meet the Indonesian government's stated policy objective of providing safe water supply to low-income households.

Table 8 shows average water costs in 89 villages in Debub region. The reported standard deviations depict significant variance in costs among villages. The form of payment is also different among rural communities. Some villagers pay monthly flat fees while others pay based on the quantity of water they consume. While many pay fees in cash, for others payment is in-kind and takes the form agricultural products.

Table 8: Water Costs in Debub Region

	In-kind costs (kg/HH/month)	Cash price (NKF/jerrican)	Cash price (NKF/HH/month)
Number of villages	25	31	33
Mean water cost	2.48	0.14	2.10
Standard deviation	1.29	0.10	1.35

Source: Water Resources Department, Eritrea

Given that these costs differ among villages, tracking costs as a percentage of household consumption could provide valuable information on whether a project affects the affordability of water.[20] This would be relevant information for policy-makers even if the rural population is relatively homogenous in terms of poverty status and income levels, given that the water costs faced do vary among villages.

Household surveys could be used in order to determine precisely household consumption and water costs, although other qualitative methodologies (such as PRA) could be used to estimate these figures in order to show change over time. Past attempts to collect data have proven difficult, however, because of villagers' reticence to reveal this information. Alternatively, village administrative units collect data on

[19] Whittington and Swarna cite a traditionally used benchmark for affordability, by which households in the developing world were expected to spend 3 to 5 percent of their total income on water. In practice, the authors contend, water users may be willing to pay higher percentages for improved services, such as in-house piped connections. (Whittington and Swarna 1994)

[20] Using monthly household consumption instead of income is preferable because it would smooth out seasonal income fluctuations that often characterizes rural economies in developing countries. Consumption levels more consistent, and thus are more reliable indicators of household standard of living.

the mean consumption or income among village households. These data could be used to show affordability for the average household, and tracked to examine change over time.

Summary: Process measurements for gender, such as the percentage of women on water committees, can indicate whether the information about water supply needs that women possess is being incorporated into water management decisions. Administrative data should be available for this measurement, such that it is highly feasible. Measuring water costs as a percentage of monthly household consumption could allow policy-makers to determine whether an investment affects the affordability of water. While it may not be feasible to measure this outcome quantitatively with household survey data, it could be estimated qualitatively, or calculated using the mean household income among households in a village.

VIII. Recommendations

This analysis offers three principal recommendations concerning the use of quantitative performance measurements for water projects in rural Eritrea. These are:

1. **Focus on intermediate outcomes, which are meaningful, measurable and commonly used by international agencies.**

   - Among service delivery outcomes, four performance measurements are most appropriate: (1) distance to source, (2) queue time for collecting water, (3) protected source coverage and (4) percentage of facilities that are functional. These address key development challenges facing the country's water supply sector, and make use of administrative data that already exists within the Water Resources Department. Hours of service per day is an appropriate indicator for piped systems in urban areas, but not for rural areas where unpiped systems are the norm.

   - While bacteriological counts are an important performance measurement for water quality, the frequency of testing is also a relevant measurement that should be considered, if tests are used at all. User perceptions of water quality can also provide information about contaminated sources, which could be valuable if regular testing is not possible.

   - Total consumption should be included among a project's performance measurements, if it is feasible either to collect data through household surveys other methods. If a household survey is already bring conducted to collect data on total consumption, it should also collect data on consumption breakdowns by use (e.g., drinking, bathing, gardening, etc) and by source. Examining these data will also indicate whether households switch from unprotected to protected sources for drinking and cooking purposes.

2. **Provide health outcome measurements, if easily collected, but focus efforts to analyze *impact* on the intermediate outcomes listed above.**

   - Health outcomes are central to most water supply projects, and are thus included in project monitoring and evaluation. A relationship between water supply and disease is widely acknowledged, even if a causal relationship cannot be easily demonstrated. As such, measuring the incidence of water-related disease before and after a project also provides information that is relevant to water policy objectives and of interest to international agencies. If this information is not curenrtly collected by village administration or national health agencies, the Water Resrouces Department should collect it as part of the monitoring and evaluation of its water projects.

   - It remains difficult to demonstrate a statistically significant impact of water supply projects on health or livelihood variables. International development agencies instead generally use proxies in project assessments, such as changes in the quantity and quality of water supply for health impact. Efforts to analyze project *impact* should focus on determining whether there is a causal relationship between water projects and these intermediate outcomes.

- Project design must allow for a comparison between treatment and control groups, in order for impact analysis to be conducted on any outcome measurements.

3. Include process measurements that reflect how and whether projects address gender and affordability.

- Process measurements for gender, such as the percentage of women on water committees, can indicate whether the information about water supply needs that women possess is being incorporated into water management decisions. Administrative data should be available for this measurement, so it is highly feasible.

- Measuring water costs as a percentage of monthly household consumption could allow policy-makers to determine whether an investment affects the affordability of water. While it may not be feasible to measure this outcome quantitatively with households survey data, it could be estimated qualitatively or through average income within villages, which could serve as an adequate indicator of whether affordability changes over time.

Appendix I: Example of survey questions that could be used to collect data needed for performance measurements.

The following list of questions indicates data that the Water Resources Department does not regularly collect and which would be needed to utilize many of the performance measurements discussed in this paper. This list is meant to illustrate sample questions that could be asked in household village surveys, with the assumption that WRD would identify the most appropriate format and wording for such a survey.

The questions are separated into those related to **administrative data**, which is information that could be collected directly from water committees, village administration or other government departments, and **household data**, which would require a survey or other method to collect information directly from village households.

Administrative Data from WRD or Village Water Committees

1. How many people are on the water committee? How many are women?

2. What is the average wait time at the source for water users?

3. How much does water cost per household?

4. (*If coliform test is conducted*) What is the coliform count?

5. (*If coliform test is conducted*) How often is this test conducted?

Administrative Data from Village Administration

1. What is the average household income or level of consumption in the village?

New Household Data

1. How many people are in your household?

2. How much water does your household use per day?

3. How much of this water is used for each purpose:
    a. Drinking and cooking
    b. Bathing
    c. Washing and cleaning
    d. Livestock
    e. Garden
    f. Other (specify)

4. What is your primary source for each water use?
    a. Drinking and cooking
    b. Bathing

c. Washing and cleaning
d. Livestock
e. Garden
f. Other (specify)

5. Do you disinfect or purify water before using it?

6. If yes, for what uses?

7. If yes, how do you disinfect or purify the water?
    a. Boiling
    b. Chlorine tablets
    c. Other

8. Do you have to wait in line at the water source?
    a. No
    b. Yes, for a short time
    c. Yes, for a long time

9. Has anyone in the household experienced diarrhea in the last 14 days?*
    a. If so, what age?

* This question can be included in a household survey if this information is not already available through the government's health agency or the village administration.

Appendix II: Results of regression analysis of determinants of ln coliform count.

The following table shows results for a linear regression of water source characteristics on the natural log of coliform count, using data from 346 water sources nationwide. The model included five independent dummy variables for which a value of '1' represented the presence of a specific source characteristic:

- Source is a borehole
- Source has covering
- Source has a protective apron
- Source is fenced
- Source uses a mechanical hand pump

The base case for this analysis was a site that was not a borehole, and did not have any of the four protective characteristics.

Level of Significance		Unstandardized Coefficients	Standard Error	Standardized Coefficients	t-statistic	P-value
		B		Beta		
	(Constant)	4.29	0.20		21.01	0.000
99%	Borehole = 1	-3.11	0.34	-0.48	-9.12	0.000
99%	Covered = 1	-1.40	0.35	-0.21	-4.05	0.000
99%	Apron = 1	-1.07	0.29	-0.14	-3.67	0.000
	Fenced = 1	0.40	0.33	0.05	1.22	0.222
95%	Pump = 1	-0.67	0.33	-0.11	-2.02	0.044
	Dependent Variable: LOGCOLI					

As these results show, the presence of boreholes, covering, aprons and mechanical pumps had a negative effect on ln coliform that was significant at a 95 percent level of confidence or better, albeit with large standard errors. The beta coefficient on these variables can be used to estimate the magnitude of each characteristic's effect, by raising e to the power of beta. For instance, $e^{3.1} = 22$, indicating that a value of 1 for dummy variable (i.e., the source is a borehole) decreases the coliform count by 22 times over what would be the case if this variable was 0 (i.e., not a borehole).

Coliform counts among all water sources in the sample ranged from less than 1 organism to 1,000 organisms per 100 milliliters of water. The extent of this range suggests that it would be possible for the presence of a borehole to have an effect of this large magnitude on the actual contamination in a water source, as measured by the number of bacterial organisms present per 100 milliliters of water.

Appendix III: International Agency Evaluation Data Set

Agency	ADB	ADB	ADB	ADB	AusAID
Type of Report	Impact Evaluation Study	Project Performance Audit Report	Project Performance Audit Report	Impact Evaluation Study	Quality Assurance Series
Country / Region	Asia Regional (China, Malaysia, Philippines, Sri Lanka)	Indonesia	Laos	Indonesia	Indonesia
Project Goals	Increase access to safe water; health improvements.	Improve health status; provide water supply to underdeveloped areas and lower-income households	Improve health and support economic growth in provincial towns through water supply improvements	Improved health and productivity of the population	Improve access to water supply, with emphasis on lower-income communities in rural areas
Project Dates	1983-1999 (Multiple projects in the four countries)	1991-1996	1991-1997	1974-1999 (Multiple projects over that time period)	1991-1996
Publication Date	December 2002	November 2001	December 2000	September 1999	November 1999
Performance Measurements Used	➢ Total HH water consumption ➢ User satisfaction ratings ➢ Incidence of diarrhea ➢ Frequency of water testing ➢ Hrs service/day ➢ HH piped coverage ➢ Water costs as % of HH income ➢ Poor vs non-poor coverage rates	➢ Levels of bacterial contamination ➢ Child mortality rates ➢ HH coverage ➢ % functioning facilities ➢ Water costs as % of HH income ➢ Public participation in the project	➢ Incidence of dysentery, cholera ➢ % of sites that meet national quality standards ➢ Hrs service/day ➢ % functioning facilities	➢ Total HH water consumption ➢ Drinking / cooking consumption ➢ Distance to sources ➢ HH coverage ➢ Water costs as % of HH income ➢ Time saved collecting water ➢ Poor vs non-poor coverage rates	➢ Total HH water consumption ➢ Drinking / cooking consumption (from protected vs unprotected sources) ➢ Incidence of diarrhea, cholera ➢ Water user quality ratings ➢ Collection time saved ➢ Water costs as % of HH income ➢ Women's participation in water committees, project implementation ➢ Women's representation among water committee heads

Agency	ODA	ODA	UNICEF	USAID	USAID
Type of Report	Evaluation Report	Evaluation Report	Evaluation of Programme of Cooperation	Final Project Report	Strategic Report
Country / Region	Uganda	Sierra Leone	The Gambia	Ethiopia	Latin America Regional
Project Goals	Provide clean and reliable water supply through borehole rehabilitation	Reduce mortality caused by water-related diseases	Increase water supply coverage; contribute to decreased incidence of diarrhea mortality		Improve management capacity of local water committees
Project Dates	1989-1992	1980-1991	1983-2002 (Multiple projects reviewed in the evaluation)		1990-2001 (Multiple projects included in repor
Publication Date	1992	February 1993	March 2002	2002	December 2002
Performance Measurements Used	➢ Total HH water consumption ➢ Consumption from improved sources ➢ Consumption for washing / bathing ➢ Distance to source ➢ HH coverage ➢ % functioning facilities ➢ Time saved in collecting water ➢ Time spent in queue at water source	➢ Total HH water consumption ➢ Consumption from improved sources ➢ Consumption from traditional sources ➢ Levels of bacterial contamination ➢ Water user quality ratings ➢ Distance to source ➢ % functioning facilities ➢ % sites that meet quality standards ➢ Time saved collecting water	➢ Consumption from improved sources ➢ Consumption for drinking / cooking ➢ Levels of bacterial contamination ➢ % of sites that meet quality standards ➢ HH coverage ➢ Role of women in project management	➢ Total HH water consumption ➢ Capacity of wells ➢ % functioning facilities ➢ Women's participation on village water committees ➢ Time saved collecting water	➢ HH coverage ➢ % functioning facilitie

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