# Costing Improved Water Supply Systems for Low-Income Communities
# A Practical Manual

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**Abstract.** The aim of this paper is to present a practical manual prepared for the Department Public Health and Environment now Department for the Protection of the Human Environment of the World Health Organization (WHO) dealing with how to identify, collect, estimate and compare costs of the available technical options to provide access to safe drinking water in low-income communities. To cost an improved water supply technology, likely to secure access to safe drinking-water as defined by the WHO-UNICEF Joint Monitoring Programme for Water Supply and Sanitation, we rely on a bottom-up approach that disaggregates the technology process according to its essential components, singled out by an engineering description. Questionnaires have been developed to identify the main resources invested in a water supply project and to collect, at different disaggregation levels, four types of costs, namely: infrastructure, operation, maintenance and other relevant costs such as administration. Comparability of these different cost elements is achieved by discounting expenditures at different times to the same reference time. Eventually, full and unit cost indicators allowing least-cost analysis are derived from this cost-picture.

**Keywords:** water supply, sustainability, developing countries.

## 1. Introduction

The United Nations Millennium Declaration has confirmed the central role of water in sustainable development and in efforts to eradicate poverty. Increasing coverage in water supply is essential in overcoming poverty through reductions of water-related diseases.

In this paper we present a practical manual[1] on *Costing Improved Water Supply Systems for Low-income Communities* prepared for the Department Public Health and Environment of the World Health Organization (WHO), on how to identify, collect, estimate and compare costs of the available technical options to provide access to safe drinking water in low-income communities, namely rural and slum communities. This guidance document intends to contribute in a meaningful way to achieve one of the main targets of the Millennium Development Goals (MDG), namely to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation.

Although limited in scope to the process of costing safe water supply (WS) technologies, our methodology is intended to be part of a more comprehensive economic evaluation of basic services that are instrumental in fostering human development and quality of life in developing countries. In the context of this process, we have developed a methodology allowing identification and costing of the technical alternatives for performing least-cost analyses, in order to identify the best economic alternatives. For this purpose a practical manual has been conceived to facilitate and standardize the implementation of this methodology, aiming at improving the access to safe drinking-water in low-income communities. It explains, systematically, the process by which the relevant data should be collected and processed for costing improved drinking water sources, as defined by the WHO-UNICEF[2] Joint Monitoring Programme (JMP) for Water Supply and Sanitation (WS&S).

To successfully apply this method to actual projects, an Excel spreadsheet Costing Processor, has been developed, enabling a user-friendly collection and processing of the relevant information to assess a specific project, providing final conclusions for the decision makers.

**2. Improved WS technologies for low-income communities**

The essential components or "activities" of a water supply process in low-income communities are:

- **Water Source:** represents all the fresh water that comes from evaporation to precipitation. The types of water source are: surface water, groundwater and pluvial water.
- **Water Collection:** dug wells are common for the use of groundwater, while an intake with pumping facilities is required if the water is to be collected from a surface water source. A permanent roof is needed for collection of rainwater.
- **Water Conveyance:** water is normally conveyed by gravity or pumping. Dedicated structures carry the water from the water source to storage before treatment or water consumption.
- **Water Storage:** the reservoirs have a storage capacity for the anticipated water demand before treatment and distribution.
- **Water Treatment:** the more common method for water treatment includes sedimentation, aeration, filtration, demineralisation and disinfection.
- **Water Distribution:** the means of delivery of water to individual consumers varies. It may be piped or carried by various means of transport in containers.

Figure 1 shows how these activities of a water supply process can be combined to generate an actual water supply system for low-income communities.

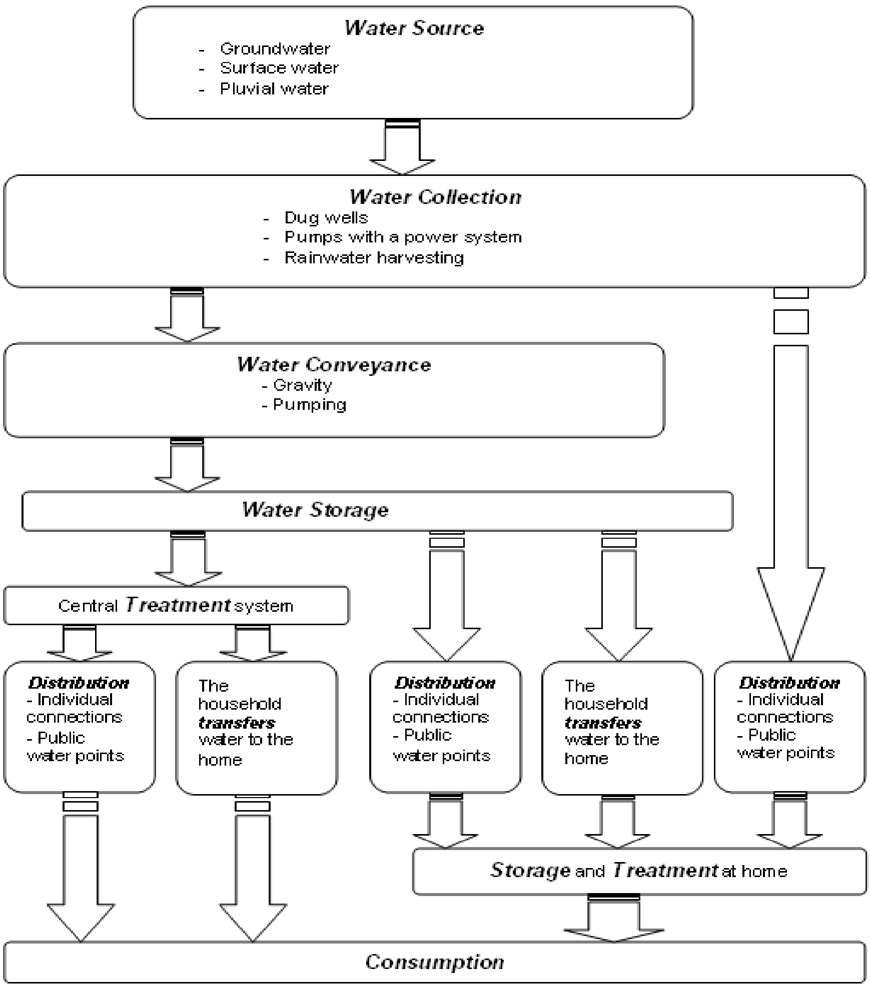


**Figure 1:** Activities of a water supply process

The WS technologies we consider are those compatible with the MDG WS&S target of improving the access to safe drinking water in low-income communities. To be operational, the WHO and UNICEF JMP for WS&S has defined drinking water as the water used for normal domestic purposes, including consumption and hygiene, and classified existing WS technologies as either “improved” or “unimproved”. The former are those technologies more likely to secure a safe supply of drinking water and, therefore, the technologies allowing achieving the MGD WS&S target.

These technologies include:

- Piped water into dwelling, plot or yard
- Public tap/standpipe
- Tube-well/borehole
- Protected dug well
- Protected spring
- Rainwater collection
- Bottle water may be considered improved only when the household uses water from an improved source for cooking and personal hygiene.

**3. Appropriate improved WS technologies**

Only some of the available improved WS technologies will be suited for use in the specific setting of a project. On the basis of local conditions, the use of some available technologies can be ruled out as they will be incompatible with prevailing constraints or entail unacceptable risks (for example: arsenic levels in groundwater).

Therefore, before tackling the costing of available technologies, it is important to identify all local risks and constraints and to discard all the technologies unable to overcome these constraints or posing unacceptable risks. The technologies that remain after this elimination process are referred to as “appropriate” for the project under assessment.

To identify the risks and constraints a WS project is faced with, it is useful to rely on a set of guiding criteria. The main screening criteria are those related to local resources, financial, economic, technical, environmental, institutional, cultural and social constraints as well as to health risks.

To select appropriate WS technologies according to these criteria, physical-technical as well as a socio-economic questionnaires have been designed to collect basic relevant data allowing testing the appropriateness of available WS technologies.

Figure 2 shows the selection process and guiding criteria that may serve as a useful tool or reference to help decision makers in the identification and selection of the most appropriate WS technology in rural areas. This selection process is particularly useful when there is no formal water supply technology in the community under consideration. In some cases any existing water supply technology can influence the selection of the appropriate technology in ways that the process cannot fully capture. It is important to consider existing or planned water supply technologies in neighbouring areas because these alternatives may enable the community to reduce its costs below what they would otherwise be.

**4. Costing rationale**

The primary intent of economic costing is to develop an economic value of the opportunity cost of providing a given WS service to the national economy. In practice, there are three principles to follow in preparing estimates of economic costs:

- All relevant costs to the economy, regardless of who (utility, households, Government, etc.) incurs them, must be included.
- Each cost must be properly evaluated using economic prices representing the national opportunity costs of the resources invested in the WS project. To correct distorted prices, “shadow factors” must be used, in particular for unskilled labour wages, foreign exchange for imports and the interest rate.
- The assumptions used for costing different technologies must be mutually consistent and comparable.

The proposed method of identifying, collecting and analysing cost data of appropriate WS technologies relies on a bottom-up approach that disaggregates the WS process according to the main activities described in section 2. For each activity we consider four types of costs.

- **Investment costs** include those costs that can be identified in the construction of infrastructures, such as: preliminary studies, equipment, local material, imported material, workers, other investment costs and contingencies.
- **Operation costs** comprise all expenditures that are required to keep a system in operation. They include expenses for personnel, chemicals, electricity, fuels, materials, office supplies and building rents.
- **Maintenance costs** comprise all expenditures that are required to keep a system in good condition while it is operated. They include all the expenses for running maintenance plans and repair interventions of infrastructures, equipments and vehicles.
- **Other relevant costs** encompass the operational costs of a WS technology reflecting the correct functioning of the system; in this context the most important are: administrative costs of the system, training costs, promotional and educational costs.

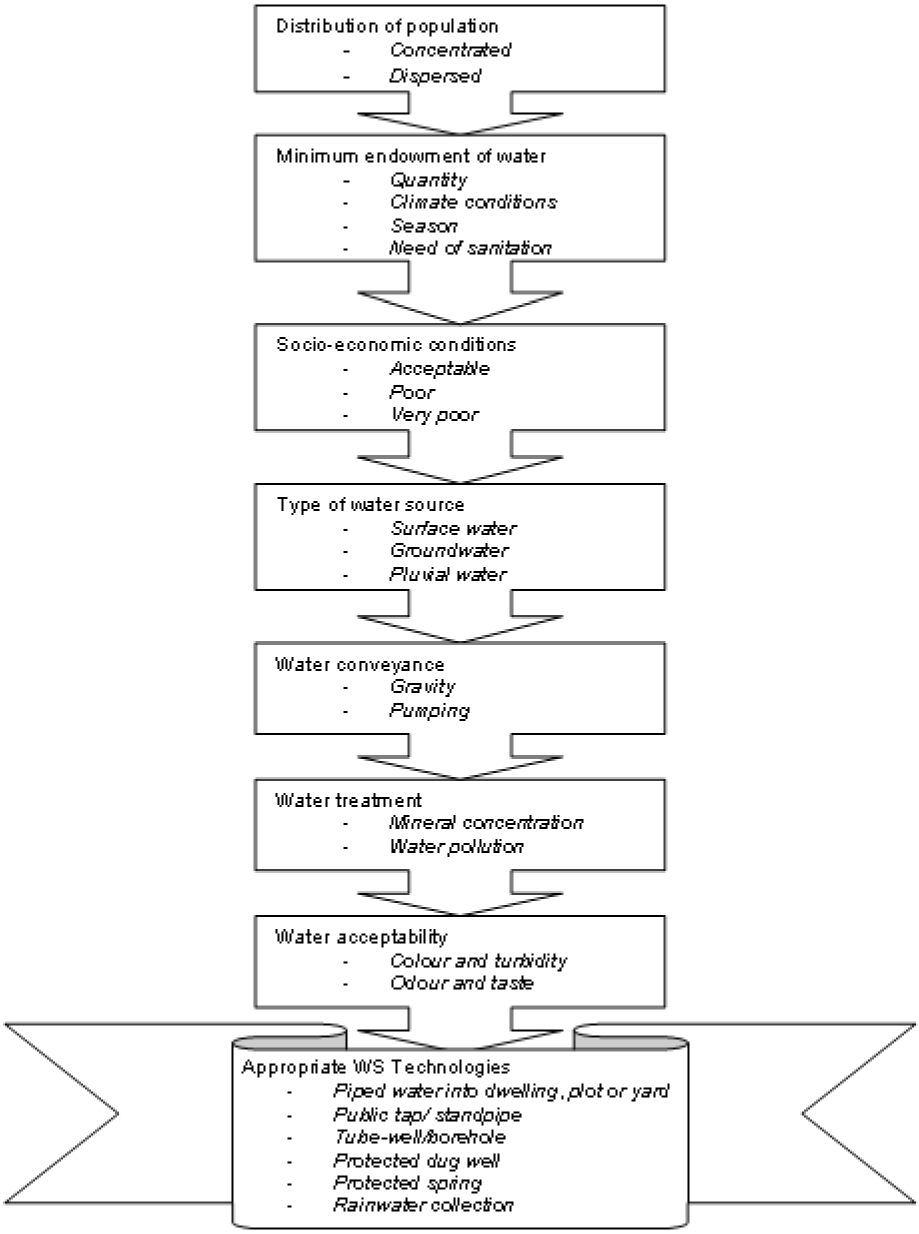


**Figure 2:** Screening process to select appropriate improved water supply technologies in low-income communities

All WS technologies involve costs that occur at different points in time, some annually, like operational costs, others less regularly, like maintenance and replacement costs, some only once, like the installation of heavy infrastructure. To make these different sequences of costs comparable and to consolidate all these costs it is necessary to bring expenditures at different times to values at the same reference time.

The costs comparability of different WS projects is achieved by computing the present value of each economic cost component of a project, using a common discount rate reflecting the opportunity cost of capital and by consolidating all these discounted costs in a Full Cost Present Value (*FCPV*) of the project. This calculation is performed using the following formula:

$$FCPV = \sum_{t=1}^{T} \frac{(C_t + O_t + M_t + OC_t)}{(1+i)^{t-1}},$$

with:

$C_t$ the economic construction costs incurred in year $t$,

$O_t$ the economic operation costs incurred in year $t$,

$M_t$ the economic maintenance costs incurred in year $t$,

$OC_t$ the other economic relevant costs incurred in year $t$,

$i$ the annual opportunity cost of capital (here assumed to be constant) used as discount rate,

$T$ the design lifetime of the project (in years).

Notice that, by discounting costs incurred in year $t$ for a period of $t-1$ years, we implicitly assume that annual costs all occur at the beginning of the year.

When the level of services provided by the appropriate WS technologies varies in time and across technologies, *FCPV* is not the most suitable indicators to use for least-cost comparisons because its value varies according to the level of services provided. In these situations, a service or production indicator of the WS system is needed. Using such an indicator, it is possible to compute a cost measure per unit of service provided during a year.

In particular, when the WS facility is not utilized at full capacity upon construction, but use increases gradually over time to meet the designed level of services only after a number of years, an appropriate definition of a unit cost is provided by the so-called Average Incremental Cost (*AIC*), based on the following formula:

$$AIC = \frac{FCPV}{\sum_{t=1}^{T} \frac{Q_t}{(1+i)^{t-1}}},$$

where $Q_t$ stands for the annual level of services provided in year *t*. This formula provides a unit cost calculated by dividing the *FCPV* of the WS system with a measure of its life cycle production. Life cycle production is computed by valuing the services provided in the future less than those produced at the present time, just as costs incurred in the future have a lower present value than those incurred at the present time. This way of measuring the life cycle production of a WS system that is operated over time in a non-stationary way, expresses the present value of the life cycle production if the value of the services provided is constant in time.

To quantify the service or production of a WS system in each year $t$ of its life cycle, we consider three alternative indicators, namely:

- the size of the population served, denoted by $P_t$;
- the number of household water connections, denoted by $H_t$;
- the quantity of water supplied, denoted by $Q_t$.

For designing consistent scenarios of these production indicators, we start by specifying independent scenarios with respect to the population served and to the following two other variables:

- the average size of the household served, denoted by $N_t$;
- the average per capita consumption of water of the population served, denoted by $q_t$.

These two last variables allow deriving consistent scenarios of the number of household water connections and of the quantity of water supplied from the population served scenario, simply by dividing $P_t$ by $N_t$ and multiplying $P_t$ by $q_t$, respectively.

We model the development scenario of variables $P_t$, $N_t$ and $q_t$ by means of the following formula:

$$X_t = X_1 + (X_{\theta+1} - X_1)F(t-1;\alpha,\beta,\theta),$$

where $X_t$ denotes the variable to be modelled, $X_1$ its initial value at the starting date of the WS system use (beginning of year $t=1$), $X_{\theta+1}$ its final value (beginning of year $t=\theta+1$), corresponding to the full capacity use of the WS system , reached after $\theta \le T$ full years of the $T$ full years project life cycle, and $F(\tau;\alpha,\beta,\theta)$ a beta cumulative distribution function of the continuous time variable $\tau$ defined on interval $[0;\theta]$. This function expresses the shape of the time trend followed by variable $X_t$ to reach after $\theta$ full years its final value $X_{\theta+1}$ from its initial value $X_1$. Therefore, it depicts a growth scenario if $X_1 < X_{\theta+1}$, a decline scenario if $X_1 > X_{\theta+1}$ and a steady scenario if $X_1 = X_{\theta+1}$.

As regards the profile of this time trend, it is determined by the value of parameters $\alpha$ and $\beta$ which rule the shape of a beta cumulative distribution function and of its underlying density function expressing the instantaneous rate of change (speed) of this time trend. By choosing appropriate values of these positive parameters $\alpha$ and $\beta$, a wide range of time trend profiles can be generated.

For WS projects that are fully utilized upon construction, costs comparisons through *FCPV* can be replaced by a costing criterion of easier interpretation, namely the Full Annual Equivalent Cost (*FAEC*), defined as the constant annuity to be paid during the project life cycle of *T* years to refund the full cost of the project at an opportunity cost of capital $i$. This equivalence is stated by the following formula:

$$\sum_{t=1}^{T} \frac{FAEC}{(1+i)^{t-1}} = FCPV \quad \Rightarrow \quad FAEC = FCPV \frac{i(1+i)^{T-1}}{(1+i)^{T}-1}.$$

Defining an average unit cost is also easier when the WS system is utilized at full capacity as soon as it is built. Such a unit cost is calculated by dividing the *FAEC* of the system by the annual production at full capacity. This Unit Annual Equivalent Cost is therefore defined as: $UAEC = FAEC/Q$, where $Q$ stands for the annual level of services provided at full capacity.

For a project designed to provide drinking water to a growing population or to a growing water demand, the *UAEC* criterion understates the cost of producing a unit of service by an amount determined by the time-shape of unused production capacity. Therefore, the difference between *UAEC* and *AIC* will assess the opportunity cost of spare capacity during the design lifetime of the project.

## 5. The water supply costing processor

Any attempt at costing a WS project should address the following practical issues:

- Outlining a project scenario.
- Identifying the local risks and constraints faced by the project.
- Selecting the appropriate improved WS technologies compatible with the identified risks and constraints.
- Identifying and collecting the relevant quantitative data allowing calibrating the level of WS services to be provided and to assess the life-cycle economic cost of the project for any identified appropriate WS technology.
- Computing consolidated cost indicators for any identified appropriate technology in order to perform least-cost analysis allowing identifying the best economic technologies.

To tackle the two last complex issues of this costing process, an Excel spreadsheet, referred to as a **Water Supply Costing Processor (WSCP)**, has been developed, enabling a user-friendly identification, collection and processing of the relevant quantitative information to assess a specific WS project.

Preliminary to the use of this processor, the practitioner (the appropriate person to fill in the spreadsheet is a sanitary engineer) should identify the sources of data among: local authorities, municipal or city offices, secretaries or ministries of public works. All these agencies have engineering work-studies audited by multilateral organizations, such as the World Bank, the Inter-American Development Bank, the Asian Development Bank or the African Development Bank. Regarding to the expenses in promotion and hygiene education, one should consult these institutions and the Health Secretary or Ministry of Health of the country. When these public sources cannot provide the necessary data one can resort to other private sources, such as construction firms, consulting firms, or anyone who has participated in the construction or pre-studies related to WS technologies in the rural communities.

In what follows we shall briefly present this tool, using an illustrative case study, namely a rural WS project intended to provide potable water to the population of Guantánamo, located in Peru (Department of San Martín), carried out by a local consultant[3] to test and assess a former version of our guidance manual and WSCP.

The WSCP costing of a WS project starts with the choice of an improved WS technology and the design of its use over its life cycle. This first task is performed by inputting in a **Scenario design** sheet:

- The choice of an **improved WS technology** and its **design lifetime**.
- The **time trend shape** of each of the quantitative indicators used to design the life cycle production growth of the WS system, with the corresponding values of the three parameters used to quantify these trend profiles, namely: the **initial value** of the indicator (at the starting date of the WS system use), its **design value** (corresponding to the full capacity use of the WS system) and the **trend duration** (number of full years to reach the design value).

The WS project of Guantánamo-San Martín was designed to provide drinking water to a population of 50 families, by transporting through one collector, water taken from a river located in a gorge, to sedimentation first and later to a slow sand filter and a reservoir. From the reservoir, a line of adduction transports the water into the distribution network and to the domiciliary sinks. The initial population benefiting from this project was estimated at 300 inhabitants (6 inhabitants per family) but the infrastructure was laid out to supply water to a design population of 408 inhabitants reached after 7 full years of growth at an average annual rate of 4.5% (historical growth rate of the decade 1993-2003). The expected utility life of the system was estimated to 20 years. Consequently, from a menu of improved WS technologies a PIPED WATER INTO DWELLING, PLOT OR YARD was selected for costing over a design lifetime of 20 years and, from a menu of pre-programmed time trend shapes a SYMMETRICAL S-SHAPED ( $\alpha = \beta = 2$) trend was selected to design the trend scenario of the population served by the project, supposed to grow in 7 full years from an initial size of 300 inhabitants to a design size of 408 inhabitants. Once these data inputted, the WSCP display the time trend scenario of the WS project use in numerical as well as in graphical form, as shown by Figure 3.

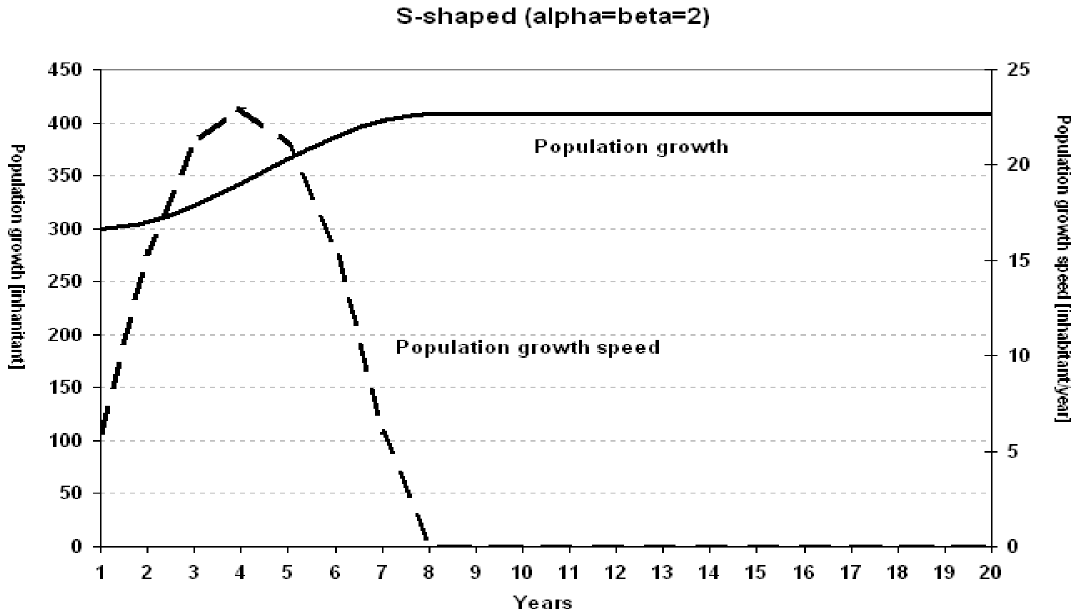


**Figure 3:** Growth scenario of the population of users for the Guantánamo-San Martín water supply project

The second step in costing a WS project with the WSCP consists in identifying the main resources invested in the project. To help identifying what inputs are necessary for implementing a particular WS project, a set of questionnaires encompassing all the activities potentially involved in implementing an improved WS technology have been designed. These costing questionnaires, implemented in the WSCP, are based on the typology of costs described in section 4. According to this typology, costs are first distinguished depending on whether they are incurred to set up the WS infrastructure or to maintain and operate the infrastructure during its lifetime. These cost categories are than crossed with a typology of the kind of economic resources invested into these activities, to generate a series of costing questionnaires describing the use of a given resource according to three levels of aggregation, namely:

- an **item level** corresponding to the technologies that can be used to perform each single activity describing, in section 2, an improved WS technology option from a technical point of view;
- a **sub-item level** corresponding to the particular technical device that can be used to practically implement a technology;
- an **input level** that breakdowns the sub-item description of a technical device according to the more detailed level at which cost data can be collected.

Once the resources involved in the realization of a WS project have been identified, the next step consists in looking for the data sources essential for quantifying the resources invested in the WS project. According to the available data sources, this quantification can be performed at a disaggregated level (input level breakdown) or at a more aggregated level (sub-item, item or activity breakdown).

- The use of the disaggregated level option, programmed in the costing questionnaire sheets of the WSCP, requires inputting a physical measurement of the invested resources described at the input level breakdown. This level of disaggregation is recommended in order to provide insight and transparency into the process of valuing economic resources in monetary terms, and eventually enabling cost portability to other settings.
- The sub-item, item or activity aggregation level option has been devised for those situations where historical or bid data sources lack detailed information for performing a costing at a disaggregated level. In such a case only the monetary value of a cost component at a sub-item, item or activity level is required.

For the Guantánamo-San Martín WS project, in particular, investment costs for local material have been quantified at a disaggregated level while the available data sources did allow assessing investment costs for labour only at a more aggregated level of total wage cost paid at a sub-item or item level. Likewise, maintenance and operation costs for local materials and labour were reported at an aggregated level, whereas the separation for labour costs between maintenance and operation was prevented because the same person was appointed for both tasks.

The final step in costing a WS project consists in valuing and discounting the quantified invested resources, using prices that represent the national opportunity costs of these resources (economic costing). To perform this task an **Economic pricing** sheet has been designed to input the relevant information for performing an economic costing of the resources invested in the WS project. This information is represented by:

- the **currency** used to value in monetary terms any cost component of the project;
- the **reference date** at which all the cost components of the project shall be valued and consolidated;
- the **real annual discount rate** used to compute the present value, at the reference date, of each cost component of the project as well as the present value of the project life cycle production;
- the **shadow factors** of those resources whose actual prices may not reflect their scarcities within the national economy because they significantly differ from competitive market prices. They express the ratio of an economic or shadow price to its actual (non-competitive market) price, allowing converting an actual, non-competitive price, into a virtual competitive price.
- The series of past **consumer price index** values necessary to transform, when used, historical cost data into cost values at the reference date.

The economic cost of the Guantánamo-San Martín WS project has been valued in Peruvian currency (Soles) at the shadow prices of December 1st, 2006, by using a real annual discount rate of 11%, and a shadow factor for unskilled labour of 0.49. No imported equipments or materials were used. The monthly series of the consumer price index was used to convert the investment cost components, inputted in the costing questionnaire sheets at the historical values of January 2003, to the Soles value of the reference date of December 1st, 2006, conventionally chosen as the starting date of the WS system use.

Once all the input data sheets have been provided with the relevant information, the WSCP compute for the WS project the consolidated cost indicators defined in section 4, namely:

- the **Full Cost Present Value (FCPV),** at the reference date, of the WS project broken down by its main components;
- the **Full Annual Equivalent Cost (FAEC)** of the WS project broken down by its main components;
- the **Average Incremental Cost (AIC)**;
- the **Unit Annual Equivalent Cost (UAEC)**.

These cost indicators are displayed in a series of **Costing summary** sheets, designed for costing the whole WS project as well as each of its activities.

**Costing Questionnaire**
*Water Supply*

*Selected improved technology:* *PIPED WATER INTO DWELLING, PLOT OR YARD*
*Currency and day of actualization:* **Soles of 01.12.2006**

| TOTAL COST TYPOLOGY | FULL COST | | | UNIT COST PER | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | FCPV | | FAEC | INHABITANT | | HOUSEHOLD | | litre/inhab./day WATER SUPPLY | |
| | [Soles] | [%] | [Soles/year] | AIC [Soles/year] | UAEC [Soles/year] | AIC [Soles/year] | UAEC [Soles/year] | AIC [Soles/year] | UAEC [Soles/year] |
| **TOTAL INVESTMENT COSTS** | **187'039.60** | **74.4** | **21'160.02** | **57.65** | **51.86** | **N/A** | **N/A** | **N/A** | **N/A** |
| Local Materials | 96'281.09 | 38.3 | 10'892.40 | 29.68 | 26.70 | N/A | N/A | N/A | N/A |
| Imported Materials | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Local Equipments | 113.17 | 0.05 | 12.80 | 0.03 | 0.03 | N/A | N/A | N/A | N/A |
| Imported Equipments | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Local Labour | 45'495.67 | 18.1 | 5'146.98 | 14.02 | 12.62 | N/A | N/A | N/A | N/A |
| Other investment costs | 45'149.67 | 18.0 | 5'107.84 | 13.92 | 12.52 | N/A | N/A | N/A | N/A |
| **TOTAL CONTINGENCIES COSTS** | **-** | **0.0** | **-** | **-** | **-** | **N/A** | **N/A** | **N/A** | **N/A** |
| Incidental costs | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| **TOTAL MAINTENANCE COSTS** | **30'575.12** | **12.2** | **3'459.00** | **9.42** | **8.48** | **N/A** | **N/A** | **N/A** | **N/A** |
| Local Materials | 18'208.95 | 7.2 | 2'060.00 | 5.61 | 5.05 | N/A | N/A | N/A | N/A |
| Imported Materials | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Local Equipments | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Imported Equipments | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Local Labour | 12'366.17 | 4.9 | 1'399.00 | 3.81 | 3.43 | N/A | N/A | N/A | N/A |
| **TOTAL OPERATION COSTS** | **13'126.35** | **5.2** | **1'485.00** | **4.05** | **3.64** | **N/A** | **N/A** | **N/A** | **N/A** |
| Local Materials | 751.34 | 0.3 | 85.00 | 0.23 | 0.21 | N/A | N/A | N/A | N/A |
| Imported Materials | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Local Power Services | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Imported Power Services | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Local Labour | 12'375.01 | 4.9 | 1'400.00 | 3.81 | 3.43 | N/A | N/A | N/A | N/A |
| **TOTAL OTHER RELEVANT COSTS** | **20'683.95** | **8.2** | **2'340.00** | **6.38** | **5.74** | **N/A** | **N/A** | **N/A** | **N/A** |
| Administration | 20'683.95 | 8.2 | 2'340.00 | 6.38 | 5.74 | N/A | N/A | N/A | N/A |
| Training | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| Promotion & Education | - | 0.0 | - | - | - | N/A | N/A | N/A | N/A |
| TOTAL COST | 251'425.02 | 100 | 28'444.02 | 77.49 | 69.72 | N/A | N/A | N/A | N/A |

| | [year-INHABITANT] | [year-HOUSEHOLD] | [year-litre/inhab./day] |
|---|---|---|---|
| PRESENT VALUE OF LIFE-CYCLE PRODUCTION | 3'244 | N/A | N/A |
| FULL CAPACITY PRODUCTION | 408 | N/A | N/A |

Costing Summary

**Figure 4:** Costing summary of the Guantánamo-San Martín water supply project

As shown by Figure 4, the full cost present value (*FCPV*) of the Guantánamo-San Martin WS project is evaluated, at December 1st, 2006, to 251'425 Soles from which 75% are due to investment costs, 0% to contingencies costs, 12% to maintenance costs, 5% to operational costs and 8% to administrative costs. This FCPV is converted into an average incremental cost (AIC) by dividing the *FCPV* with the present value of life cycle production evaluated to 3'244 actualized year-inhabitant. This leads to an average incremental cost (AIC) of 78 Soles/year per inhabitant.

To assess the cost of spare capacity, a unit cost at full capacity is computed by dividing the full annual equivalent cost (*FAEC*) of 28'444 Soles/year by the system production at full capacity evaluated to 408 year-inhabitant. The ensuing unit annual equivalent cost (*UAEC*) is of 70 Soles/year per inhabitant. Compared to the former AIC, these figures lead to a spare capacity loss of 8 Soles/year per inhabitant.

**6. Field tests**

To assess in real settings, the scope and the limits of our costing method a series of field tests have been designed and performed in selected countries through local practitioners. A first testing and assessment of the method, reported in our manual, was commissioned to a local consultant from Peru[3]. A second large scale testing opportunity was provided by a series of capacity building activities, organized by the WHO Department for the Protection of Human Environment[4,5] with a special grant support of the U.S.A. Department of State. Within these activities, attended by participants from six countries in the WHO regions of South East Asia and the Western Pacific (Cambodia, Indonesia, Lao PDR, Philippines, Thailand and Viet Nam), protocols were developed to apply the method and test it on thirteen actual case studies selected in the participants' countries.

The synthesis of these case study experiences has confirmed the valuable interest of our practical manual and Excel costing processor for the planning and design of WS projects in low income communities. Indeed, although the local conditions of a WS project often provide overriding arguments in favour of a single technological option, within that option the different components can be carried out according to different economic alternatives deserving an insightful cost analysis. Still, a successful implementation of the method requires a multi-disciplinary team and the creation of a partnership between sanitary engineers, economists and economic institutions.

**7. Conclusions**

In its present form our costing method does only account for market costs without taking in proper consideration non-market costs and benefits that can favour some technological options from a more encompassing socio-economic point of view. Therefore, it should be seen as a first step in the process of assessing WS projects from a sustainable development perspective. Assessing WS projects from such an enlarged perspective calls for an extension of our costing method to a more comprehensive framework allowing to compare all the socially scarce resources invested into the project to the complete set of project outcomes contributing to improve the quality of life of project beneficiaries. It is in such direction that we carry on our research.

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