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"Water Tariffs in Developing Countries: A case Study in Lima-Peru"

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Abstract

This paper is a collection of literature about urban water tariffs with a focus on developing countries. It sets up an analytical framework for evaluating tariff structures. The evaluation is based on the criteria: effectiveness, cost recovery, efficiency, equity and political feasibility. The most widely used models of water tariffs are analysed in depth presenting theoretical and empirical findings. This paper also contains a case study of metropolitan Lima in Peru that evaluates the situation of the water supply sector and the tariff system currently in use.

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Abbreviations

ADB	**A**sian **D**evelopment **B**ank
AOM	**A**poyo **O**pinion y **M**ercado
AWWA	**A**merican **W**ater **W**orks **A**ssociation
BID	**B**anco **I**nteramericano de **D**esarrollo
CPHEEO	**C**entral **P**ublic **H**ealth and **E**nvironment **E**ngineering **O**rganisation
DBT	**D**recreasing **B**lock **T**ariff
DGOS	**D**ireccion **G**eneral de **O**bras **S**anitarias
EPS	**E**mpresas **P**restadoras de **S**ervicios de **S**anemaiento *translation: sanitation service providers*
FAO	**F**ood and **A**griculture **O**rganization
FONAFE	**F**ondo **N**acional de **F**inanciameinto de la **A**ctividad **E**mpresarial del **E**stado *translation: national financial fund of governmental business activities*
IBT	**I**ncreasing **B**lock **T**ariffs
ICWE	**I**nternational **C**onference on **W**ater and **E**nvironment
INEI	**I**nstituto **N**acional de **E**stadistica e **I**nformatica
INRENA	**I**nstituto **N**acional de **RE**cursos **Na**turales *translation: national institute of natural resources*
IRT	**I**ncreasing **R**ate **T**ariffs
MMC	**M**illions **C**ubic **M**eter
MOP	**M**inisterio de **O**bras **P**ublicas de **C**hile
ODA	**O**fficial Development Assistance
OECD	**O**rganisation for **E**conomic **C**o-operation and **D**evelopment
O&M	**O**peration **&** **M**aintenance
PAI	**P**opulation **A**ction **I**nternational
SEDAPAL	**SE**rvicio **D**e **A**gua **P**otable y **A**lcantarillado de **L**ima *translation: Lima's drinking water and sewerage service*
SENAMHI	**SE**rvicio **NA**cional de **M**eteorologia e **HI**drologia del Peru.
SENAPA	**SE**rvicio **N**acional de **A**gua **P**otable y **A**lcantarillado-
SUNASS	**S**uperintendencia **N**acional de **S**ervicios de **S**aneamiento *translation: national superintendency of sanitation services*
UNDP	**U**nited **N**ations **D**evelopment **P**rogramme
UNEP	**U**nited **N**ations **E**nvironment **P**rogramme
UNSD	**U**nited **N**ations **S**tatistics **D**ivision
USAID	**U**nited **S**tates **A**gency of **I**nternational **D**evelopment
VMCS	**V**ice **M**inisterio de **C**onstruccion y **S**aneamiento *translation: vice ministry of construction and sanitation*
WHO	**W**orld **H**ealth **O**rganisation
WRI	**W**orld **R**esources **I**nstitute

Glossary

Aquifer	An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials from which groundwater can be usefully extracted using water well.
Block rate structure	A block rate structure is a tariff schedule with a provision for charging a different unit cost for various increasing or decreasing blocks of demand for water.
Capital cost	The Capital cost is the cost incurred on the purchase of land, buildings, construction and equipment to be used in the production of goods or the rendering of services.
Deadweight loss	Deadweight loss is the inefficiency caused by, for example, a tariff or monopoly pricing.
Cross-subsidy	Cross-subsidy is the improper assignment of costs among objects such that certain objects are overcosted while other cost objects are undercosted relative to the activity costs assigned.
Decreasing block tariff	A decreasing block tariff is a single tariff structure in which per-unit price of water decreases as the consumption increases.
Downstream	Downstream means literally away from the source of a stream or river.
Economic externality	An economic externality is an effect from one activity which has consequences for another activity but is not reflected in market prices (benefit or cost).
Environmental externality	An environmental externality occurs when the external benefit or cost generated, is related directly to the environment
Ferrulated-based charge	A ferrulated-based charge is a fixed charge tariff differentiated according to the diameter of the connection
Fixed charge	The fixed charge is the fixed component of a two part tariff structure.
Fixed charge tariff	A fixed charge tariffs is a single part tariff that applies the same price, without considering the consumption.
Fixed cost	The fixed cost is the sum of the business expenses that are not dependent on the activities of the business
Full cost	The full cost is the full economic cost with the addition of the environmental externalities. These costs have to be determined based on the damages caused.

Full cost recovery	Full cost recovery means to recover all of the costs associated with a water system, programme or service to ensure long-term sustainability
Full economic cost	The full economic cost is the sum of the full supply cost and the opportunity cost associated with other use of the same water resource and the economic externalities imposed on others as a result of the water consumption by a specific factor.
Full supply cost	The full supply cost is the cost associated with the supply of water to a consumer without consideration of the externalities or the alternatives uses of water
Full value	The full value is the economic value of water plus the intrinsic value.
Increasing block tariff	An increasing block tariff is a single part tariff structure in which per-unit price of water increases as the consumption increases.
Intrinsic value	The intrinsic value is the stewardships, bequest values, and pure existence values.
Income elasticity of demand	The income elasticity of demand measures the responsiveness of the demand of a good to the change in the income of the people demanding the good.
Marginal cost	The marginal cost is the change in total cost that arises when the quantity produced changes by one unit, i.e. it is the cost of producing one more unit of a good.
Marginal price	The marginal price is the price that is above the marginal cost but below the total or full cost which includes all overheads.
Marginal value	The marginal value is a value that holds true given particular constraints. It is the change in a value associated with a specific change in some independent variable, whether it is of that variable or of a dependent variable.
Micro metering	Micro metering is the concept of measuring by means of a meter, recording the quantity of water consumed.
Operation and maintenance cost	The operation and maintenance cost is the cost of maintenance and repair of real property, operation of utilities and provision of other services.
Price elasticity of demand	Price elasticity of demand is the responsiveness of the quantity demanded of a good or service to a change in its price.
Political feasibility	Political feasibility is defined as the extent to which officials and policy makers are willing to accept and support a particular piece of public policy.

Potable water	Potable water is water of sufficiently high quality that it can be consumed humans or used without risk of immediate or long term harm.
Riparian	A riparian zone or riparian area is the interface between land and a stream.
Single part tariff	A single part tariff is a tariff structure composed of only one charge or part.
Two-part tariff	A two-part tariff is a tariff structure composed of two charges or parts: a fixed charge and a volumetric charge.
Uniform volumetric tariff	A uniform volumetric tariff is a single tariff structure that applies a constant unit price for all metered volumetric units of water consumed.
Upstream	Upstream is the place from which the water in the river or stream originates.
Volumetric charge	The volumetric charge is the volumetric component of the two part tariff structure.
Volumetric tariff	A volumetric tariff is a tariff structure based on the volume of water consumed by the users.
(Water) utility	A (water) utility is an organization that maintains the infrastructure of a public water and sanitation service.

1 Introduction

1.1 Problem Statement

Water is a fundamental human necessity and the provision of potable water and sewerage services is an essential and integral part of human society dating back to as early as 3000 B.C. Mesopotamia. In the last decades, the world has been undergoing dramatic changes. While an information and communication revolution is underway and world markets are opening up, climatic conditions are shifting and human populations continue to rise, bringing new threats to water resources. Water management started to integrate common practices found in other economic and social sectors. As water is a scarce resource, pricing is increasingly seen as an adequate instrument of public policy. Water tariffs are one of the market-based approaches that can contribute to making water more accessible, healthier and more sustainable over the long term especially in developing countries.

1.2 Objectives

The objectives of this paper are to give an overview over the economic and social situation of water and to explore and analyse the most important types of water tariffs used for residential consumers. Further, the most appropriate and functional water tariffs structures are identified by applying criteria such as effectiveness, cost recovery, efficiency, equity and political feasibility. Finally, the water sector and the tariff structure in Lima-Peru are evaluated using the framework set up in this paper.

1.3 Structure

This paper is comprised by three parts. The first part (chapter 2: Analytical Framework) introduces the analytical framework of the three dimensions of water: water as a natural resource, water as an economic good and water as a social good. The definition of water tariffs is given as well as the criteria that will be used to evaluate the tariffs. The second part of this paper (chapter 3: Water Tariff Structures) illustrates the most important models of water tariff structures that are used in the water sector. Each tariff is evaluated theoretically and empirically based on the criteria stated in the first part. To give an overview of their performance in practice, for each type of tariff, real world examples are given from (mostly) developing countries. The third part of this paper (chapter 4: Case Study: Lima) presents a case study evaluating the water sector and the tariff system used in the city of Lima-Peru.

2 Analytical Framework

A collection of data from different sources is being used to develop the analytical framework of water. This framework then will be used to evaluate the water tariff types in chapter 3 Water Tariff Structures.

2.1 Dimensions of Water

When water started to come into the focus of economists, it was only viewed as a natural resource. Over time new views of water have been defined. In this paper this views are called dimensions. There are three dimensions of water:

- as a natural Resource
- as an Economic Good
- as a Social Good

2.1.1 Water as a Natural Resource

This dimension describes the view of water as a natural resource. It's availability, distribution, characteristics and uses.

2.1.1.1 World Water Supply

Quantitatively, According to UNEP (2002), the total amount of water on the Earth is 1400 million km³ approximately. About 97.5% of this amount is saltwater and only 2.5% or about 35 million km³ is fresh water. The greater portion of freshwater (around 69%) is in the form of ice. Around 30% exists as fresh groundwater. Only about 0.3% of the total amount of fresh water on the earth is concentrated in lakes, rivers, soil moisture and relatively shallow groundwater basins where it is most easily accessible for economic needs and extremely vital for water ecosystems.

According to UNSD (1997), a key characteristic of the world's freshwater resource is its uneven distribution and variability in respect to time and space, which is dictated by climate conditions. They range from arid deserts, with almost no rainfall, to the most humid regions, which can receive several metres of rainfall a year.

According to FAO (2003), the total water resources in the world are estimated in the order of 43 750 km³/year, distributed throughout the world according to the patchwork of climates and physiographic structures. At the continental level, America has the largest share of the world's total freshwater resources with 45%, followed by Asia with 28%, Europe with 15.5% and Africa with 9%. In terms of resources per inhabitant in each continent, America has 24 000 m³/year, Europe 9 300 m³/year, Africa 5 000 m³/year and Asia 3 400.1 m³/year. Nine countries are the world leaders in terms of internal water resources, accounting for 60 % of the world's natural freshwater (Table 1). The water poor countries are usually the smallest (islands) and arid ones (Table 2).

Water rich countries

FAO Code	Country	Average precipitation 1961-1990 (km^3/year)	Internal resources: surface (km^3/year)	Internal resources: groundwater (km^3/year)	Internal resources: overlap (km^3/year)	Internal resources: total (km^3/year)	External resources: natural (km^3/year)	External resources: actual (km^3/year)	Total resources: natural (km^3/year)	Total resources: actual (km^3/year)	IRWR/inhab. (m^3/year)
21	Brazil	15 236	5 418	1 874	1 874	5 418	2 815	2 815	8 233	8 233	31 795
185	Russian Federation	7 855	4 037	788	512	4 313	195	195	4 507	4 507	29 642
33	Canada	5 352	2 840	370	360	2 850	52	52	2 902	2 902	92 662
101	Indonesia	5 147	2 793	455	410	2 838	0	0	2 838	2 838	13 381
41	China, Mainland	5 995	2 712	829	728	2 812	17	17	2 830	2 830	2 245
44	Colombia	2 975	2 112	510	510	2 112	20	20	2 132	2 132	50 160
231	United States of America (Cont.)	5 800	1 862	1 300	1 162	2 000	71	71	2 071	2 071	7 153
170	Peru	1 919	1 616	303	303	1 616	297	297	1 913	1 913	62 973
100	India	3 559	1 222	419	380	1 261	647	636	1 908	1 897	1 249

Source: FAO 2003.
Table 1: Water Rich Countries

Water poor countries

FAO Code	Country	Average precipitation 1961-1990 (km^3/year)	Internal resources: surface (km^3/year)	Internal resources: groundwater (km^3/year)	Internal resources: overlap (km^3/year)	Internal resources: total (km^3/year)	External resources: natural (km^3/year)	External resources: actual (km^3/year)	Total resources: natural (km^3/year)	Total resources: actual (km^3/year)
105	Israel	9.16	0.25	0.50	0.00	0.75	0.92	0.92	1.67	1.67
112	Jordan	9.93	0.40	0.50	0.22	0.68	0.20	0.20	0.88	0.88
124	Libyan Arab Jamahiriya	98.53	0.20	0.50	0.10	0.60	0.00	0.00	0.60	0.60
136	Mauritania	94.66	0.10	0.30	0.00	0.40	11.00	11.00	11.40	11.40
35	Cape Verde	1.70	0.18	0.12	0.00	0.30	0.00	0.00	0.30	0.30
72	Djibouti	5.12	0.30	0.02	0.02	0.30	0.00	0.00	0.30	0.30
225	United Arab Emirates	6.53	0.15	0.12	0.12	0.15	0.00	0.00	0.15	0.15
179	Qatar	0.81	0.00	0.05	0.00	0.05	0.00	0.00	0.05	0.05
134	Malta	0.12	0.00	0.05	0.00	0.05	0.00	0.00	0.05	0.05
76	Gaza Strip (Palestinian Authority)	0.00	0.00	0.05	0.00	0.05	0.01	0.01	0.06	0.06
13	Bahrain	0.06	0.00	0.00	0.00	0.00	0.11	0.11	0.12	0.12
118	Kuwait	2.16	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02

Source: FAO 2003.
Table 2: Water Poor Countries

SHIKLOMANOV (2000, p 24), states that due to rapid global population growth between 1970 and 1994, the potential water availability for the earth's population decreased from 12900 m³ to 7600 m³ per year per person. The greatest reduction in annual per capita water supply took place in Africa (by 64%), Asia (by 50%), and South America (by 41%). Water supply in Europe decreased for the same period only by 16%. The global average of per capita freshwater availability is reducing by 5% every year due to population increase and pollution.

According to WRI (1999), water availability on the basis of global per capita figures provides a false picture. In some cases water is not where it is wanted and in other cases, there is too much water in the wrong place at the wrong time. About 20% of the global annual rain runoff each year occurs in the Amazon basin, a vast region inhabited by somewhat more than 10 million people, only a tiny fraction of the World's population. According to PAI (1999) in 1995 the estimated amount of renewable freshwater available per capita on an annual basis ranges from over 600,000 m³ in Iceland to less than 100 m³ per person in Kuwait, Malta and Qatar.

VAN DER ZAAG and SAVENIJE (2006, p 10) present certain characteristics of water that makes it a special natural resource, these are as follows:

Water is Essential. There is no life without water, no economic production, no environment. There is no human activity that does not depend on water. It is a vital resource.

Water is Non-Substitutable. Economic theory is based on the existence of choice. However, as there is no alternative to water, there is no choice. The only exception is coastal cities that could afford to produce fresh water from seawater through desalinisation.

Water is Finite. The amount of water available is limited by the amount of water that circulates through the atmosphere on an annual basis. All the water stems from the rainfall. The amount of rainfall that falls on the continents is finite.

Water is Fugitive. The availability of the water varies over time. Water is essentially a flux. There are stocks of water: groundwater aquifers and natural lakes. But these lakes and aquifers only can be used sustainably if they are replenished by the flux. We can store water artificially but then the stock is small compared to the flux. It is the annual recharge rates that determine safe and sustainable yields, not the stocks.

Water is a System. The annual water cycle from rainfall to runoff is a complex system where several processes are interconnected and interdependent with only one direction of flow: downstream. If the flow is interfered with upstream, downstream impacts result, and externalities and third party effects occur.

Water is Bulky. There are not many examples of water being transported over any considerable distance, particularly not against the force of gravity. Where these transfers occur, they concern water destined for high value uses (for the domestic and industrial sectors). We transport the produce instead: grains, textiles, dried fruit, etc.

LALZAD (2007, p9) describes another key characteristic of water; it's Vulnerability. Water can be misused, polluted or its flow pattern and chemical properties can easily be changed by human activities and other factors. Water quality is another important aspect of water supply. Water is rarely pure and it can be polluted by different sources of pollution. These demonstrate the qualitative vulnerability of water.

2.1.1.2 Water Uses

As stated by SELBORNE (2000) any of the entire range of natural water that exists in the earth regardless of their state is of potential use for humans. It is impossible to substitute for most of its employments. Basically, water is one of the most manageable of the natural resources, as it can be diverted, transported and recycled. Water is also of vital importance to all socio-economic sectors. Where water is sparse, conflicts over its usage have become common. Competing human uses of water include drinking water supply, industrial application, transportation, recreation, industry, agriculture and waste disposal. Water is also a source of life.

POVEDA (1998, p 1) highlights the global role of water in a wide variety of Earth's system processes. Water plays a key function in regulating climate and biogeochemical cycles. In addition to its involvement in ocean circulation and precipitation of water and water vapour. Water can also affect the climate through evapo-transpiration in plants ecosystems. Water in its liquid and gaseous forms mediate the movements of the key chemical elements like carbon, nitrogen, phosphorus and oxygen through the earth system. Extreme hydrological events such as droughts or floods can cause substantial ecological changes on regional scales. Also, the long term changes such as variation in sea level may have an overall impact on the life and on the landscape.

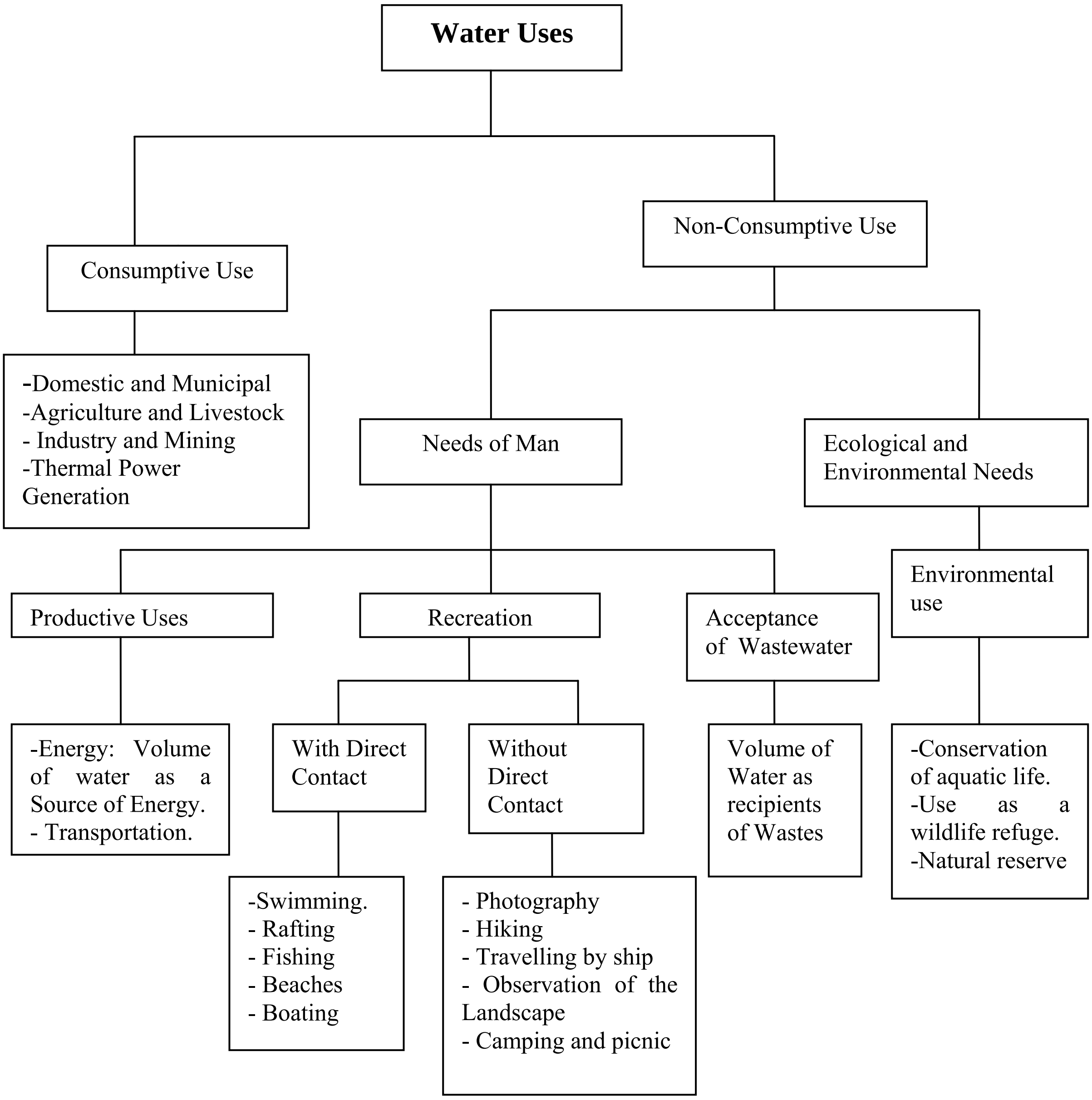
ARROJO (2006, p 3) classifies and defines three important functions of water. The basic functions of life, the public service functions or of general interest and the functions related to production activities and businesses.

Basic Functions of Life. These functions do not only include the necessary uses for drinking and for ensuring basic hygiene, but also the necessary water flows in quantity and quality to ensure a healthy ecological status of rivers, ecosystems and the planet in general.

Social Functions. Social functions of water are its application in public service or for general interest. To have water quality and sewerage in homes 24 hours a day and 365 days a year is a social right tied to our citizen condition.

Business Functions. The function of water and production activities and other businesses is to drive economic development.

MOP (2000, p 3-6) points out that water offers multiple uses that are not always compatible with each other. Some uses extract the water from its natural cycle for long periods of time, others for shorter periods and others do not extract the water at all. Water uses can be classified into two major groups: consumptive and non-consumptive uses, as it is shown in Figure 1. Consumptive uses or extractive uses are those that consume the water or remove it from their place of origin (rivers, lakes and groundwater). Non-consumptive uses, non extractive uses, or in situ, occur in the natural environment of the water. No water is removed.



Source: MOP (2000).
Figure 1: Types of Water Uses

The consumptive uses of water can be measured quantitatively and have economic benefits because of its productive uses in industry, municipalities, agriculture and energy production. Non-consumptive uses are comprised by the generation of hydroelectric energy, transportation, fishery, wild life, recreation and residual acceptance. They also include the recreational and environmental uses which can not be measured quantitatively. Its use generates social welfare and sociological and aesthetic benefits, even when their benefits are not apparent (MOP, 2000, p 9)

2.1.2 Water as an Economic Good

In the past water has been treated as though it were available in unlimited quantities. It has been supplied at zero or low cost to consumers that resent the idea of water as an economic good. To consider water as an economic resource was a process.

2.1.2.1 The Economy of Water

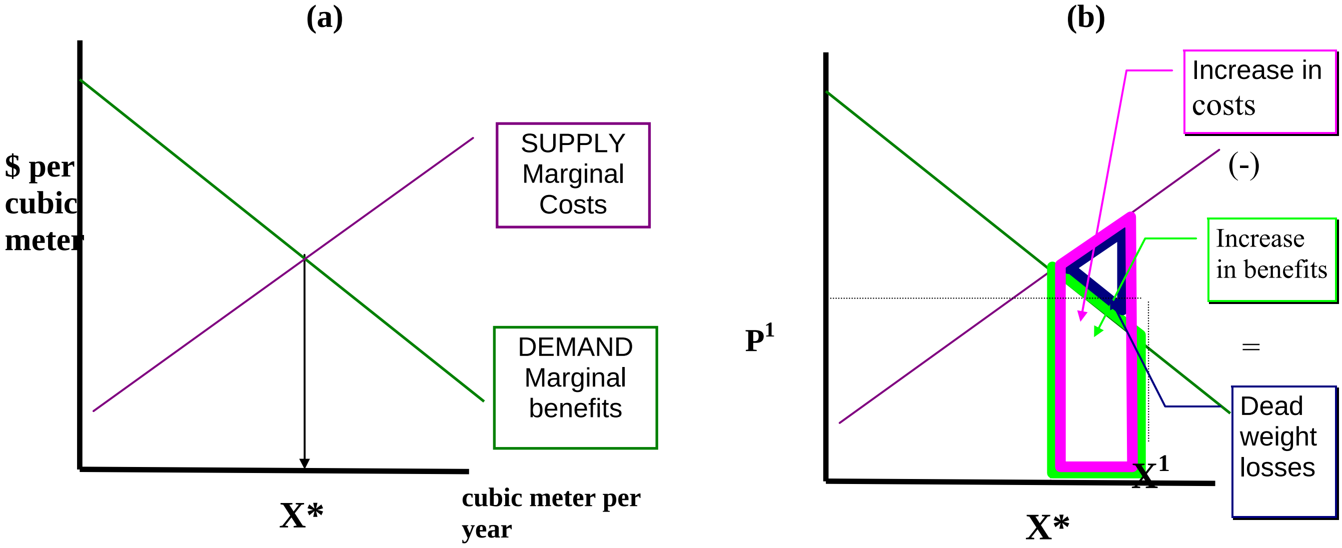
According to ICWE (1992), water has been managed as an economic good, since the International Conference on Water and Environment, held in Dublin-Ireland in 1992. In this conference the four Dublin principles for water were defined as follows:

- Water is a finite, vulnerable and essential resource which should be managed in an integrated manner.
- Water resources development and management should be based on a participatory approach, involving all relevant stakeholders.
- Women play a central role in the provision, management and safe guarding of water.
- Water has an economic value and should be recognised as an economic good, taking into account affordability and equity criteria.

From the four "Dublin principles" can be concluded that water is essential for human life. Treating it only as a commodity governed by the rules of the market will inadvertently lead to those who cannot afford clean water suffering the many ills and problems associated with its absence. But, making it available at subsidized prices can result in inefficient use and short supply. There is a need to rely on water management for getting the most value from the available water, while not depriving people of sufficient clean water to meet their basic needs (ICWE, 1992).

ROBINS (1935) defines economics as "the science which studies human behaviour as a relationship between ends and scarce means which have alternatives uses". According to PERRY et al., (1997, p 3), water meets these requirements. It serves a multiplicity of ends and thus satisfies the condition of "alternative uses".

BRISCOE (1996, p 4) states that the idea of "water as an economic good" is simple. Like any other good, water has a value to users who are willing to pay for it. Consumers will use water so long as the benefits from the use of an additional cubic meter exceed the costs so incurred. Figure 2 (a) shows that the optimal consumption is X*. Figure 2 (b) shows that if a consumer is charged a price P^1, which is different from the marginal cost of supply, then the consumer will not consume X* but X^1. The increase in costs (the area under the cost curve) exceeds the increase in benefits (the area under the benefit curve) and there is a corresponding loss of net benefits (called the "deadweight loss"). The simple logic of Figure 2 is applied in the aggregate for society as a whole, and the social welfare is maximized when water is priced at its marginal cost and when water is used until the marginal cost equals the marginal benefit.



Source: BRISCOE (1996).
Figure 2: Optimal Consumption and Deadweight Losses

The recognition of water as an economic good is the subject of many authors, more literature can be found in PERRY et al., (1997), ROGERS et al., (1998), MCNEILL (1998), BRISCOE (1997), and GARN (1998).

2.1.2.2 The Value of Water

In the past water was not considered scarce. Economists and others ignored its economic value, assuming it was an indefinitely available free good. The water running through the system was generally not considered to have a separate economic value. The economic value of water to a user derives from the specific use to which this resource is applied. Water users reveal the value they put on water by the amount they are willing to pay for it. This information is embodied in their demand curve for water. To satisfy their highest priority needs, users are typically willing to pay a premium price for the first units of water. In most cases the total value of water to a user will increase with the used quantity, but at a decreasing rate. This suggests that the marginal value of each additional unit of water decreases as the use increases, because the additional units are put to less valuable uses. In the absence of market clearing prices, there are a number of alternative means of estimating the value of water resources (SADOFF and GREY, 2002, p 19).

As there can be derived different economic benefits from water, it can be assigned different types of value. In this paper these types are classified into three typologies.

Typology I - YOUNG (2005, p 36) distinguishes between the values of water with economic value and with non-economic value. First, he classifies the values of water into 5 groups:

(a) Commodity benefits

(b) Waste assimilation benefits

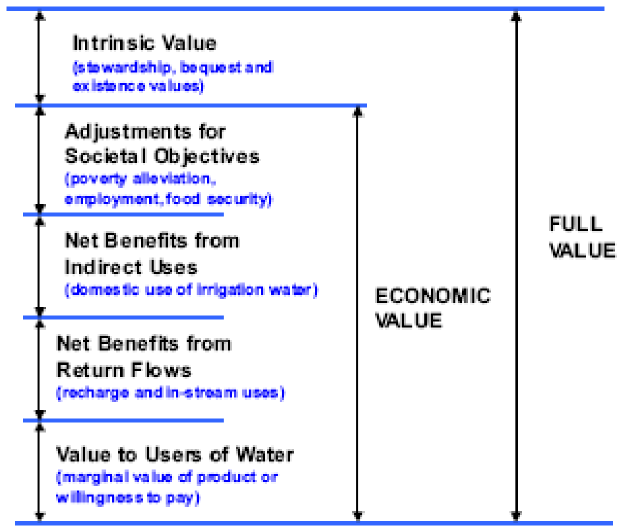
(c) Public and private aesthetic, recreational and fish and wildlife habitat values

(d) Biodiversity and ecosystem preservation

(e) Social and cultural values.

Within this classification, the first three groups are treated with economic considerations, because they are characterized by increasing scarcity and the associated problems of allocating among competing uses to maximize economic value.. The commodity benefits are derived from personal drinking, cooking and sanitation as well as those values that contribute to productive activities on farms and in commercial businesses and industries. The value of waste disposal considers that bodies of water are significant assets because of their assimilative capacity. They can carry away wastes into less undesirable forms. This capacity of water is closer to being a public than a private value, because of the difficulty in including these services. The aesthetic values like recreation and fish and wildlife habitat values represent the third group. Once regarded as luxury goods, this type of benefits are increasingly recognised as important matters of public concern. The last two groups are considered as non-economic values and constitute a potential economic value of water. In addition to valuation of goods and services, people are willing to pay for environmental services that they will neither use nor experience. Non-use values are benefits received from knowing that a good exists, even though the individual may not ever directly experience the good. The benefits reflected by voluntary contributions towards preserving and endangered fish species are an illustrative example. Most resource economics now agree that non-use values should be included with use values so as to more accurately measure total environment values (FREEMAN 2003).

Typology II - ROGERS et al., (1998, p 10) presents another view of valuing water. The value of water depends both upon the user and to the use to which it is put. Figure 3 shows schematically the components of the value in use of water, which is the sum of the economic and intrinsic values. The components of the full value are:



Source: ROGERS et al (1998)
Figure 3: General Principles for the Value of Water

Value to Users of Water - For domestic use, direct use can be estimated in terms of individual willingness to pay (WTP). For economic equilibrium the value of water estimated from the value-in-use is equal to the full cost of water. At that point, social welfare is maximized. In practical cases, the value-in-use is typically expected to be higher than the estimated full cost. This is often because of difficulties in estimating the environmental externalities in the full cost calculations.

Net Benefit from Return Flow - Net benefits should be estimated from irrigation return flows. The effects of these flows must be taken into account while estimating the value and cost of water. The water diverted for irrigation may recharge the groundwater in the watershed.

Net Benefits from Indirect Uses - Irrigation ditches not only provide water for livestock uses but also provide water for recreation. These indirect benefits have to be included while estimating the value-in-use of water that is diverted for agricultural purposes.

Adjustments for Societal Objectives - There may be an adjustment made for societal objectives such as: poverty alleviation, employment and food security (particularly in rural areas).

Intrinsic Value - Is the stewardships, bequest values, and pure existence values. While these are difficult to measure they are valid concepts and do reflect real values associated with water use (or non-use).

Typology III - This Typology was formulated by HOEKSTRA et al., (2003). He explains that the full value of a water particle consists of two components: a direct value of water which is the in situ value and an indirect value of water which results from transferring downstream values back to the source of the water. As opposed to a water flow, which goes from upstream to downstream, attributing a value to the source of water can be seen as the reverse process, in which water values move in upstream direction and backward in time.

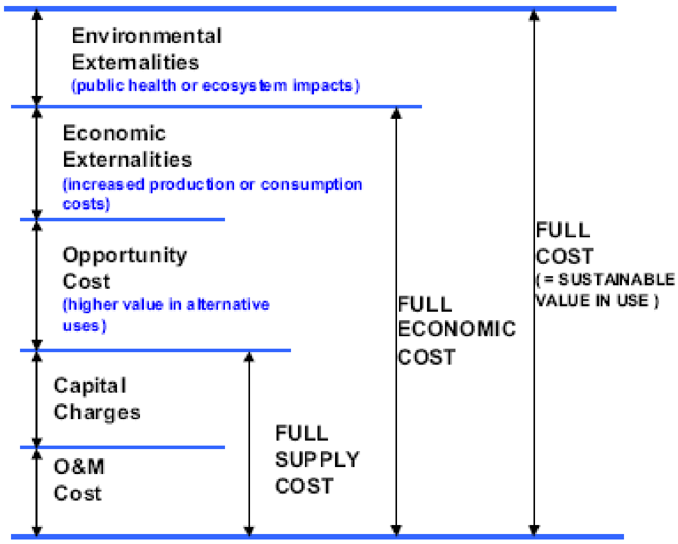
The relationship between these three typologies is the diverse values that the benefits of water receive by different authors. Each author classifies the benefits of water, giving then a value to it. Therefore many different typologies in valuing water can be found. These can be better explain by GIBBONS (1986), he states that the economic value of water to an individual is not equivalent to the economic value of water to another individual or to the society, since an individual's use of water at one time and place may affect the interests or well being of another. Several economic and hydrologic factors affect the value of water, like the sector that use the water, the type of product supplied by the sector, the demand for the water's final product, the productivity of the location where the water is used, the level of complementary resources at the site, and the transport, storage and processing costs for off-stream uses. ABU-ZEID (1998) adds that water valuation remains a very illusive subject, for which a unifying approach is needed. Most efforts have focused on measuring the value of water in certain water-using sectors, so that only the part of the water cycle nearest to the end user is recognised as an economic good Assessing the monetary value of water is challenging, and there are many methods that have been developed. In his publication GIBBONS (1986) provides the theoretical framework for understanding the water values discusses methodologies of estimation and summarises substantial published and unpublished literature on the value of and demand for water in various sectors.

2.1.2.3 The Cost of Water

Water is treated as a free resource. No charge is imposed for withdrawing water from a water source. Users pay for the transport of water from its source to its place of use and perhaps for treatment of the water and disposal of the return flows. But there is rarely any charge to reflect the opportunity cost of putting water to one use at the expense of another. This opportunity cost has generally been ignored in planning and investment decisions, resulting in inefficiencies and conflicts that might arise when water values are ignored and off stream supplies are developed regardless of the cost and prospective values to be derived from the water (GIBBONS 1986, p 3).

In providing water, BRISCOE (1997, p 9) explains two different types of costs. The first cost is that of constructing and operating the infrastructure necessary for storing, treating and distributing the water. He refers to them as the "use cost". The second cost is the "opportunity cost" incurred when one user uses water and therefore affects the use of the resource by another user. SADOFF and GREY (2002, p 21) comment that water scarcity, necessitates recognition of the opportunity cost of using water for particular purposes.

ROGERS et al., (1998, p 6) developed the general principles for the cost of water. In the build-up of the costs, he distinguishes: the *full supply cost*, the *full economic cost*, and the *full cost* as illustrated in Figure 4. The distinction between the latter two is open to discussion. The economic cost includes the full supply cost plus the opportunity cost, considering all other impacts to be externalities.



Source: ROGERS et al (1998)

Figure 4: General Principles for the Cost of Water

The ***Full Supply Cost*** includes the cost associated with the supply of water to a consumer without consideration of the externalities or the alternatives uses of water. The Full supply cost is about the financial costs related to the production of the water, which consist of the operational and maintenance costs (O&M). Typical costs include purchased raw water, electricity for pumping, labour, repair materials, and input cost of managing and operating storage, distribution and treatment plants). Full supply costs also include the costs of investments or capital charges which in turn include capital consumption and interest costs associated with the reservoirs, treatment plants and distribution system.

The ***Full Economic Cost*** of water is the sum of the *Full Supply Cost*, and the opportunity cost associated with other use of the same water resource and the economic externalities imposed on others as a result of the water consumption by a specific factor.

Economic Externalities for water utilities is a cost (or benefit) that relates to providing water service but is external to the utility and is not included in the utility's cost of service (ROGERS et al., 1998). It is an economic externality for example if pollution produces increases in production or consumption costs to downstream users.

SADOFF and GREY (2002, p 19) show that externalities occur when the actions of one water user, affect the interest or well-being of another user. Externalities can be positive or negative. They can also run both upstream and downstream. The most common recognised negative externality occurs when an upstream riparian withdraws water, reducing the supply of water for a downstream user. Negative externalities can be generated by changes in quality as well as quantity. If a river regulation infrastructure is built by an upstream riparian to generate hydropower, downstream riparian's could enjoy the positive externalities. The magnitude of the economic value of positive externalities is estimated by the maximum amount the individuals receiving such externalities, will be willing to pay for them. Negative externalities by contrast result in economic losses to other individuals. The magnitude of such losses can be estimated by the amount of money that other individuals would be willing to pay to avoid them.

Further information on externalities is given by BAUMOL and OATES (1975) in their book. They present an extensive review of literature in externalities. They begin with a definition of externalities and then make some important distinctions among various classes of externalities. They explore the basic policy prescriptions for the regulation of externalities turning them into the formal analysis of externalities.

The Full Cost is the *Full Economic Cost* with the addition of the environmental externalities. These costs have to be determined based on the damages caused, where such data is available or as additional costs of treatments to return the water to its original quality.

Environmental externalities are a particular form of externalities. They are identified as part of the environmental assessment. They are quantified where possible and are included in the economic analysis as project costs (e.g., increased illness, or reduced productivity of nearby farmlands) or benefits (such as reduction in pollution of coastal areas). A monetary value is assigned to the costs and benefits and they are entered into the cash flow tables just as any other costs and benefits (WORLD BANK 1998).

According to ROGERS et al., (1998, p 5), there are several general principles involved in assessing the economic value of water and the costs associated with its provision. These costs and values may be determined either individually, or by analysis of the whole system. GLEICK et al., (2002) adds that regardless of the method of estimation, the ideal for the sustainable use of water requires that the values and the costs should balance each other. Full cost must equal the sustainable value in use.

2.1.3 Water as a Social Good

Water is vital for society. To ensure accountability, it is important that water governance includes citizen's participation for social and environmental justice concerns. If social and environmental goals of water use are ignored, the implications can be detrimental particularly for the poorest members of society. The access to clean water is fundamental to survival and critical for reducing the prevalence of many water related diseases. Piped water is typically one of the first community services people search for, before electricity, sanitation, or other basic services. To ensure that the public receives an adequate supply of social goods, a certain level of governmental action is required, because private markets do not find it profitable to provide social goods. For example, water quality affects public health, both in the short-term and the long-term. However, private water sellers have little or no incentive to mitigate long-term water quality issues (UNSD 1997).

In 1992 in the Conference of Rio, the so called Rio principle was stated: "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature". This principle implicates that water is also a social good and humans are entitled to use it, at least at a certain level, especially under responsibility of their respective governments (FOLMER and TIETENBERG 2005, p 1).

After water has been recognized as a social good, the social aspects of water and its use began to be taken into account. Water is important to the process of economic development, essential for life and health, and has cultural or religious significance. It has often been provided at subsidized prices or for free in many situations. This makes water available to even the poorest segments of society. This is politically popular but brings a financial problem because society must pay for the subsidy. It can also encourage wasteful use of water (GLEICK et al., 2002, p 6).

According to the WHO (2003, p 6), water is a social good and all people have the right to water. The human right to water is indispensable for leading a life in dignity. Lack of safe water is a cause of serious illnesses, which kill over 2 million people every year (the vast majority being children, mostly in developing countries). In 2002 water has been recognized as an independent right. The criteria for the full enjoyment of the right to water is: "the human rights to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" (WHO, 2003). The right to water guarantees essential quantity of water for a secure and adequate standard of living, since it is one of the most fundamental conditions for survival: It determines the minimum of water supply necessary for survival (Daily needs requirements and uses).

LALZAD (2007, p 17) states that a person needs 1 or 2 litres of water per day to live, but water is also required for domestic needs, industry and agriculture. Several different amounts have been proposed as minimum standards. According to UNDP (1994), human beings need about 5 litres of water each day for cooking and drinking. In addition, good health and cleanliness require a total daily supply of about 30 lpd[1] per person. GLEICK (1996) proposed an overall basic water requirement of 50 lpd per person as a minimum standard to meet the four basic needs of drinking (5 lpd), cooking (10 lpd), bathing (15 lpd) and sanitation (20 lpd).

[1] Lpd= Litres per day.

INOCENCIO et al., (1999, p 3) contributed broadly on the topic of the determination of the basic or minimum water requirement per person, using econometric tools. The study obtains actual per capita water consumption by the activities based on household water usage. It determines household and per capita water requirement that cuts across income classes, water sources, cost of water, and location. The results provide a valuable input in water-sector planning, like the allocation of available water supply between domestic and other uses (i.e., industrial and agricultural) and the determination of the appropriate water tariff structure for domestic consumption. Inocencio et al., conclude that for personal hygiene and public health it is required for domestic consumption 100 l/c/d[2]. Falkenmark (1991) and Gleick (1996) give estimations of basic water requirement between 50 and 100 l/c/d. These basic water requirements include: *Drinking*- The majority of the available studies that are reviewed in this study estimated about 2 to 2.5 l/c/d. *Food Preparation*- In both developed and developing countries is required about 10 to 20 l/c/d. and 10 to 50 l/c/d for wealthy regions. *Bathing*-In developed countries the estimated requirements are between 27-99 l/c/d and in developing countries are 5-25 l/c/d. *Sanitation*-by technology water used for toilets including leakage can go from 1-7.5 l/c/d to more than 75 l/c/d for inefficient conventional sewerage;. *Laundry*- laundry usage are lower when sourced from private wells 8 to 10 l/c/d than when sourced from piped connection 5-38 l/c/.For the U.S., washing clothes uses about 29 to 71 l/c/d while in Nepal 5 l/c/d.

It is also important to highlight how much should people afford to spend on water consumption. Evidence presented in KOMIVES et al., (2005, p 40-43) point out that in South Asia, Eastern Europe, and Latin America monthly water expenditures of households tend to increase with income. However, the proportion of total income that is spent on water decreases with income. For households in the bottom quintile of the income distribution, the study reports average expenditures between 2% of income in South Asia and around 3.5% of income in Latin America and Eastern Europe. For households in the top quintile of the income distribution, the average expenditures were less, 1%for South Asia, 1.5% for Eastern Europe and 2% for Latin America. A number of countries and organization set burden limits on the proportion of income that they consider a household can afford to spend in water consumption. This burden limit is 5% of the income, and has been widely adopted as a rule of thumb for assessing affordability

2.2 Criteria for Evaluation of Tariffs

The dimension of water as an economic good leads to an economic pricing of water that maybe will damage the interests of the poor population. Therefore pricing water should consider all the dimensions of water. To this end tariffs are applied as an economic instrument to help achieving the social and economic equilibrium for most goods. Water tariffs achieve different stakeholder's objectives and support disadvantaged groups. The

[2] l/c/d= Litres per capita per day.

dimensions of water were translated into objectives. To evaluate if the water tariffs fulfil these different objectives this paper defines a criteria for the evaluation.

BOLAND(1997) describes some important characteristics of the water tariffs. They should be consistent with the needs and objectives of the community. This objectives are not easy to define, may be in conflict with one another. Consumers and suppliers of water have different expectations from water tariffs. Consumers like high quality water at an affordable and stable price. Suppliers like to cover all costs and have a stable revenue base. The level and structure of tariffs for water and wastewater services have consequences far beyond these expectations (POTTER, 1994). A practical tariff therefore embodies a set of compromises among the different objectives. The art of tariff design is to make only those compromises which need to be made, and to seek the best combination of achievements with respect to the various objectives. A tariff can take many different forms, each form or design will address a specific objective. The ‘‘best’’ tariff design for a particular community and situation is one which strikes the most desirable balance among the objectives that are important to that community (BOLAND 1997).

The following is a list of the different objectives that water tariffs can fulfil. No one tariff design can meet all objectives. But the utility or community should identify the objectives most relevant to its situation.

- The tariff must maximize efficient allocation of the resource.
- Water users should perceive the tariff as fair.
- Rates must be equitable across customer classes.
- They must bring sufficient revenue to the suppliers.
- Provide net revenue stability to the suppliers.
- The public must understand the rate-setting process.
- Promote resource conservation.
- Tariff-setting process should avoid rate shocks.
- Be easily implemented.
- Water must be affordable.
- Rates must be forward looking.
- The rate structure must attempt to reduce administrative costs.
- Include environmental costs.
- Not conflict with other government policies.
- Water prices must also reflect supply characteristics like water quality, supply reliability, frequency of supply.
- Tariff structure must vary depending on consumption measurability.

- More sophisticated rate structures may also account for daily peaks and seasonal variations in water demand.

Source: BOLAND (1997), OECD (1987), POTTER (1994), HOWE (1997).

In assessing the use of this economic instrument, a necessary first step is to establish criteria to evaluate the tariff's fulfilment of the objectives. Criteria that will be used in this paper are as follows:

2.2.1 Effectiveness

As a scarce and vulnerable natural resource, water should be used so as to protect the basic ecological functions of natural capital and preserve it for future generations. Water savings are part of this objective, which requires avoiding wasteful uses that put unnecessary pressure on the resource. But a reduction in water use is not an objective *per se* (OECD 2009, p 81). If water conservation is understood to be the beneficial reduction of water use, then marginal cost pricing (where marginal costs exceed current rate levels) is an effective conservation measure. The economic incentives provided by marginal cost-based utility tariffs lead to pattern of use which minimizes the total use of all scarce resources for a given level of social benefit (BOLAND, 1997).

Water tariffs should reflect the ecological, recreational and environmental uses of water. It was observed that the more visible commercial and urban uses of water had traditionally taken precedence over these environmental and aesthetic uses. A pricing system should promote the sensible use of the environment and thus reflect the complete social and environmental cost of providing a water service. This would include consideration of the opportunity costs of use of the water resources base and the long-term aspects of water resources use (OECD 1987, p 23-25). What matters is the capacity of available resources to provide the desired ecological functions over time. It may be possible to do so even with declining water resources, so long as man-made capital (*e.g.* more efficient irrigation technologies, technologies for wastewater re-use) can compensate for a reduction in water availability (OECD 2009, p 81).

2.2.2 Cost Recovery

According to FOLMER and TIETENBERG (2005, p 3), one of the key roles of water pricing is its financial role as a mechanism for recovering the investment and operation and maintenance (O&M) cost of the water system. The costs of water services are usually recovered, at least in part, through water tariffs. A certain proportion of the costs may be recovered directly from Government. An important factor in cost-recovery is the setting of adequate standards of service. Consumers are willing to pay for good quality services and are prepared to pay increased costs for improved services in terms of water quality and supply continuity. However, where water supply services are poor, the collection of revenue is difficult and costs are rarely recovered. In some situations, consumers may be willing to be disconnected from a water supply whose service quality is poor and whose costs are high.

According to the OECD (2009, p 15), full cost recovery from tariffs, in practice remains a distant objective in many countries. However, even very poor countries can reach important cost-recovery targets at the sub-sector level: such as cost recovery for operation and maintenance (O&M) and investments in urban water supply. Where full cost recovery from tariffs cannot be achieved, not only the government but also poorer developing countries ODA's (Official Development Assistance) will need to play an important role in financing sector costs. The water sector should therefore aim to achieve cost recovery from a combination of financial sources, including user charges, public budgets and ODA, rather than from tariffs alone, a concept that has been termed "sustainable cost recovery".

Where cost recovery and sector funding has been ignored, the effect has been a deterioration of infrastructure which eventually leads to the breakdown of systems, absence of an adequate water supply and an increased public health risk. It is also important to recognise that costs for treatment and disposal of return flows of wastewater must also be recovered for the sector to be sustainable (OECD, 2003).

2.2.3 Cost Effectiveness-Efficiency

Efficient prices are those which lead to the highest possible level of welfare, defined as the sum of consumer surplus and producer surplus. Economists often use the sum of consumer surplus and producer surplus as an index of economic efficiency (BROWN and SIBLEY, 1986; p 26). The tariff structure must generate revenues for the water suppliers as well as, welfare to the population. Should be able to attract capital, skills and technology; by adequately compensating suppliers. ROGERS et al., (1998) states that for an economic equilibrium, the marginal value of water that is estimated from the Value in Use should just equal the marginal full cost of water. At that point, the classical economic model indicates that social welfare is maximized.

According to HERRINGTON (2006, p 5), an efficient tariff will create incentives that ensure, for a fixed water supply cost, that users obtain the largest possible aggregate benefits. A different, but equivalent statement of this objective is that for a given level of aggregate benefits from water use, the supply cost should be minimized. Generations of economists have insisted on the importance of this objective, and noted that it can be achieved by setting all prices equal to their relevant marginal costs.

Water should be allocated to the uses that maximise overall benefits to society (*allocation efficiency*). In this context, uses to preserve ecological functions should be given the same status as other uses. There is a clear synergy between the effectiveness criteria and the efficiency criteria, as reducing the wasteful use of water will lead to lower requirements for investment in the expansion of water supply. This objective also supports financial sustainability of service provision. The role of regulation (both of resource allocation and of cost levels) is important in this area (OECD 2009, p 81).

2.2.4 Equity

The OECD (2009, p 81) highlights that water and its services should be accessible and affordable by all people, including lower-income groups. The focus is primarily on how to protect vulnerable groups and ensure that they have access to water services that remain affordable over time. In this context, it is not the average tariff level that matters, but the way in which costs are allocated across different groups through tariff structures.

YEPES (2003 p 2-3) adds that to ensure access first require that the water service reaches home or close to home with acceptable quality and that the excreta have to be removed in a safe sanitary way. Second those consumers, particularly poor families have to be able to pay for these basic services (fairness). In practice equity meaning is often extended to cover equitable pricing that accounts for the living standard of consumers and is thus in line with affordability and fairness targets.

There are a number of concepts of the equity objective. They ranged from broader notions, including social pricing whereby no consumer should be prevented by income considerations from enjoying the benefits of water, to narrower concepts such as that provided by the requirement that each consumer should pay the same per unit of water service regardless of its cost. In some countries, water pricing is structured to foster development in agricultural and industrial sectors, to lighten charges on isolated communities or to help low income households; in others the view is taken that it is preferable to adopt an economically efficient water pricing system in combination with a social security system for those consumers' disadvantaged by the policy. This is known as financial subsidies. Financial subsidies to the water services as a hole, or to one group of water service users from another, should be made explicit and be justified by arguments for especial treatment (OECD 1987, p 26-28)

2.2.5 Political Feasibility

To analyse the feasibility of the water tariff, issues as the implementation, the simplicity, the understandability and the acceptability of the policy have to be considered. The tariff should avoid unneeded complexity and be readily understandable to water users and others who are expected to make decisions based on water prices. In the case of implementation, for example a new tariff may require additional metering or other data, new billing procedures, or other implementation effort, in this case the implementation procedure should provide for a smooth efficient transition from the old to the new procedures. One reason for considering the political feasibility criteria is that is one way of bridging the gap between the desirable and the possible (BOLAND 1997).

3 Water Tariff Structures

This chapter provides information of the most common water tariff structures. First, each tariff structure is described and illustrated by examples mainly from developing countries. Following this a review of theoretical and empirical literature for the evaluation of the different tariffs design is presented. In this paper there are described two main groups of tariff structures used in the municipal water supply sector; single-part tariffs and two-part tariffs. The single part tariffs are the fixed charge tariffs, uniform volumetric tariffs, increasing block tariffs and decreasing block tariffs. Finally the concept of two part tariffs is described. Another single part tariff is the increasing linear tariff, but its usage is not common as a water tariff. Therefore it is not discussed in this paper.

3.1 Fixed Charge Tariff

This tariff structure belongs to the single part tariff group. It is also known as fixed fee, flat rate, and flat fee. The concept of this tariff structure is that the monthly water bill does not independent on the volume of water consumed.

3.1.1 Design and Description of Fixed Charge Tariffs

Historically, fixed charges were the first means used in most countries to calculate monthly water bills for customers on piped distribution systems (WHITTINGTON 2003, p 65). The lack of metered connections are the principal reason for using fixed charge tariffs, and makes it the only possible water tariff structure. With a fixed charge tariff the consumer's monthly water bill is the same regardless of the volume used. In many small and medium size cities in developing countries, they are still the most prevalent way to calculate a household's monthly water bill (WHITTINGTON 2006, p 19).

In developing countries water connection charges often act as the major barrier to connecting poor population. Poor households in many places neither are able to afford the upfront payment of the full connection charge nor to comply with additional administrative requirements. Therefore, the lack of metering present fixed charge tariffs as the only option (FRAUENDORFER 2008, p 2). A handful of cities of developing countries that apply fixed charges based the tariff on the assessed value of the dwelling, the number of taps or on the daily duration of the water supply (RAGHUPATI and FOSTER 2002).

According to OECD (1987, p 39), until the end of the nineteenth century most of the domestic water supplied by private and public utilities in the industrialised countries were charged on flat rates. These flat rate payments have been levied on various bases, including number of residents, number and type of water-using fixtures, the number of taps, number of rooms in the house, the aperture of the inflow pipe, grown area and number of measures of property value. OLIVIER (2006, p 5) adds that fixed charges are still quite widely used in industrialized countries, such as Canada, Norway, and the United Kingdom (and until recently in New York City). The reasons for the use of this tariff structure are different than those for developing countries. In these countries water has historically been abundant and hence metering is not widespread. Fixed charge tariffs also depend on some other factors (volume of water meters and geographic location or customer group).

3.1.2 Examples from Developing Countries

An example from India and Uganda will illustrate the structure and use of fixed charge tariffs.

3.1.2.1 Fixed Charge Tariff in India

According to RAGHUPATI and FOSTER (2002, p 2), in India the state government generally prescribe a minimum tariffs for municipal bodies of various categories, therefore individual cities have the option to set the tariff above this minimum level in order to recover costs. This is the reason why there is a very wide variety of water charging practices across India. All Indian cities operate a mixture of unmeasured tariffs, due to the relatively low coverage of metering. Fixed charge tariffs are by far the most common tariff structure used charging 56% of the water users. It is used in approximately 10 Metropolitan cities in India.

The ferrulated-based charge is commonly used. It is a fixed charge tariff differentiated according to the diameter of the connection, since all houses tend to use half inch connections, this ferrulated-based charges only shows its tariff differential between houses and apartment buildings. Unmetered customers have an average fixed charge tariff of around Rs[3] 45 per month. The official metered coverage figures overstate the true extend of metering. Evidence suggests that meters are often non-functional either due to the low quality of the equipment and intermittent nature of supply, or to the deliberately tamper by the household. For both reasons many metered customers end up paying fixed charge tariffs sometimes based on their last recorded meter reading. In practice water supply is so limited that there is little scope of wasting water. Water can be available for barely one hour per day and people struggle to collect water even when it is available.

Water tariffs are fixed by government bodies whose decisions are largely influenced by political motivation. Current water tariffs in India are well within the WHO affordability criterion of 5% of household income. An average poor household with a metered connection spends on an average 0.3 to 1.2 % of its monthly income, while the family without metered connection spends about 2 % of its income.

[3] Rs = Rupees (India Currency).

3.1.2.2 Fixed Charge Tariff in Uganda

According to DINAR and SUBRAMANIAN (1997, p 134-137), In Uganda, before the National Water and Sewerage Corporation took over water and sewerage services in 1972, water charges were set mainly to satisfy the desires of the urban inhabitants, and consumers were paying no more than a symbolic fee for water. Uganda prices of water have tended to be influenced by social factors. Water charges were incorporated into house rents (house rents were also heavily subsidised) and did not come close to reflecting the cost of supplying water. In 1984 the government changed the tariff system. The water charge system was based on the following principles: prices should be set to encourage customers to conserve the resource; water utilities should be financially self-supporting; prices should ensure social equity; tariff systems should be easy to understand and administer and tariffs should be different for different categories of users.

In 1990 a new charge system with different categories of consumer was introduced (domestic, institutional and government, industrial and commercial consumers). Unmetered residential consumers pay flat rates based on the number of taps per domestic consumer. This is shown in Table 3, the tariff schedule for the period 1989-1995. By 1995 the lower rate per month is 3,696 shilling[4] (US$3.75) for consumers with only one tap, follow by 11,088 shillings for consumers with 2-4 taps, and the highest rate is 27,720 shilling for consumers with more than 8 taps (Minimum charges, connection fees, reconnection fees, penalties and sewerage charges are not included).

	Dec. 1989	June 1990	Sept. 1991	Sept. 1992	Sept. 1993	April 1995
Public standpipes						
Unmetered (per month)	5,520	9,375	10,800	15,700	18,750	30,000
Metered (per cubic meter)	74	125	145	210	250	400
Domestic use						
Unmetered (per month)						
1 tap	736	1,250	1,440	2,100	2,310	3,696
2-4 taps	2,208	3,745	4,310	6,250	6,930	11,088
5-8 taps	3,312	5,620	6,460	6,930	11,550	18,480
over 8 taps	4,968	8,430	9,700	14,070	17,325	27,720
Metered (per cubic meter)	112	190	220	320	385	616
Institutions and government						
Metered[a] (per cubic meter)	133	225	270	395	475	760

Source: DINAR and SUBRAMANIAN (1997).

Table 3: Tariff Schedule in Uganda 1989-1995

The attitude that water is a free gift of God still persists in Uganda, and not all consumers pay their water bill in a timely manner. It is difficult to stop vendors from charging excessive pricing. In some smaller urban centres were the corporation operates, poor inhabitants sometimes prefer to collect water free of charge form the nearest wells , even

[4] Shillings = Uganda currency (US$=1,050 Shillings).

when they can afford to pay form water from taps, because of the low value of labour of the people who collect the water, usually children.

3.1.3 Theoretical Evaluation of Fixed Charge Tariffs

Theoretical information from various sources is going to be use to support the objectives that fixed charge tariffs fulfilled.

3.1.3.1 Effectiveness

OECD (2009, p 102) states that as in the fixed charge tariffs the bills remain the same no matter how much volume is consumed, there are no incentives for water saving nor to other aspects of sustainable water use, such as continuous provision of the population with the necessary amount of potable water of adequate quality, protection of the population and the industrial complex from harmful effects of floods, water erosion, droughts, etc. LAREDO (1991, p 22) adds that the main disadvantage of flat rates is the lack of concern or accountability for waste. This is less of a problem when the majority of the consumers have fairly uniform and limited needs. For this purpose, special fees can be incorporated into flat rate systems to accommodate extra use, e.g., watering gardens.

3.1.3.2 Cost Recovery

OECD (1999, p 44) points out that in a metered environment, fixed charge tariffs should not recover more than "ongoing" customer costs which are not directly linked to the volumes of water used. The fixed charge tariff may include a minimal water allowance, above which a variable rate is applied. In the other hand flat rates provide sure revenues for the utility. RAFTELIS (1993, p 185) explains that several types of costs could logically be recovered through the fixed charge tariffs, as the cost of servicing a customer's account (billing, collection, meter reading, and customer service costs) and those costs related to meter installation, testing and maintenance.

WHITTINGTON et al., (1996, p 19) highlights that from a cost recovery perspective, a fixed-charge system creates a potentially large problem for the utility. If some households still lack individual connections: customers that have a connection can supply water to other users (e.g., unconnected households, vendors) without incurring an increase in the household water bill (usual in developing countries). A fixed charge tariff that provided sufficient revenues at one point in time will become increasingly inadequate as the economy and incomes grow, and water use increases. Water and sewerage service providers will be reluctant to expand coverage because more customers may mean more financial losses. Fixed-charge tariffs will lead then to low cost recovery, low revenues, and poor service. If the same fixed charge tariff is applied to all customers, then it must be set at the average cost of supplying a customer, in order to recover the utility's costs.

3.1.3.3 Cost-Effectiveness/ Efficiency

In fixed charge tariffs, as consumers can use as much water as they want, the marginal cost is zero. But in an event of a tariff increase; households have no opportunity to alter their consumption in order to reduce their bill, while using less water will not change their water bill (WHITTINGTON 2006, p 19). Fixed charge tariffs are not economically efficient, because they do not give signal to consumers of the cost consequences of their consumption. This is likely to result in an overconsumption of water, relative to efficient levels. By the other hand, with this system the revenues are cheap to collect, being the same for all customers. There is a low risk of revenue volatility, because the recovery of costs does not rely on the level of consumption (O'DEA & COOPER 2008, p 32).

Fixed charge tariffs are also defended on the argument that property values are a satisfactory alternative measure for the water supply capacity, which must be provided for a consumer (capacity costs being a major part of overall costs), this offends the efficiency criterion by placing all capital costs in a fixed charge tariff. Flat rate systems offend also the allocative efficiency thought, because an extra water using appliance doesn't mean an extra charge. An often powerful argument for using a flat rate status is the high cost of switching to an alternative charging system. Such transition and transaction costs appear to frustrate the apparent efficiency and equity benefits of switching away from many existing flat rate systems (OECD 1987, p 40-41).

3.1.3.4 Equity

WHITTINGTON (2006, p 19) suggests that fixed charge tariffs are considered equitable under the concept that all customers pay the same unit price for general water services and in periods of rising costs, because it is increased for all the customers. But equity means to tread in equal conditions, consumers with the same characteristics and in different conditions when they are different. They can be fair following the concept that they can vary across households or consumer classes depending on characteristics of the consumer. For example, set higher fixed charges on more valuable residential properties, on the assumption that people living there use more water and/or have a greater ability to pay for water. Another common approach is to charge different monthly fees depending on the diameter of the pipe used by the customer to connect to the distribution system. Single-family domestic connections generally require a smaller bore than connections for larger concerns (e.g., businesses, hospitals, and apartments), such differentiation within fixed tariffs is positive from the point of view of equity, but make the structure complex.

According to OECD (1987, p 41) fixed charge tariff systems are occasionally defended on the equity arguments that property value is a satisfactory measure for the ability to pay. This argument must be opposed by another equity proposition. Such system frequently discriminates against the low volume consumers, especially one making insignificant demands at peak periods. It will create equity concerns which can reduce the willingness to pay, because poor people don't want to pay the same amount of money that people with more resources pay (OECD 2009, p 102).

3.1.3.5 Political Feasibility

DINAR et al., (1997, p 12) states that fixed charge tariffs are common, easy to manage and easy for users to understand because it does not require meters to be read or maintained, with customers receiving the same bill. OECD (1987, p 40) adds that using fixed charge tariffs political and public opposition might be less than with other tariff structure. Fixed charges require little policy.

3.1.4 Empirical Findings of Fixed Charge Tariffs

Based on various experiential findings and the examples given above, fixed charge tariffs evaluation is presented in this part.

3.1.4.1 Effectiveness

In the example given from India, water supply is so limited in many cities that there is a little scope for wasting water. Customers are rationed in their use of water, rather than control via price. Besides, water tariffs are too low. In order to promote water saving, tariffs must reflect the incremental cost of developing new sources. This tends to be more expensive than the water currently supply. With low tariff and low effective meter coverage there are no real economic incentives on Indian consumers to economize on water use, because they are physical rationing (RAGHUPATI and FOSTER 2002, p 6).

The impact of a change in a pricing method in Abu Dhabi City, where a flat rate was replaced by a volumetric method, increases the price of water in 300 percent. 66 per cent of the sampled consumers reduced their consumption by 5 to 85 per cent, which had an immediate effect on the proceeds of suppliers, with short and long term consequences for consumers (ABU QDAIS and NASSAY 2001).

3.1.4.2 Cost Recovery

In the example of India, RAGHUPATI and FOSTER (2002, p 4) conclude that from the cost recovery perspective unmetered customers using fixed charge tariffs do not come any close to recover the costs for the utility. The low tariffs have put Indian water utilities in a precarious financial position jeopardizing their ability to sustain service levels. With an average fixed charge tariff of only Rs. 45 per month, customers only contribute to pay for the O&M cost of providing 3 m^3 per month, when most unmetered households consume close to 20 m^3 per month. Although industrial customers pay higher tariffs than domestic users, they continue to pay less than the full economic cost of the service.

In the example presented of Uganda, within the fixed charge tariffs used, all operation and maintenance cost, depreciation and capital costs are included in the tariff. Charges also reflect the different levels and costs of providing services. Because of the move to full cost recovery approach, the corporation has been able to sustain its operations and even expand its manpower development programs (DINAR and SUBRAMANIAN 1997, p 136-137).

3.1.4.3 Cost-Effectiveness/ Efficiency

In India utilities currently operate at very low levels of efficiency, suggesting that an efficient company might have operating and maintaining cost significantly below this level. It was already seen that the fixed charge tariffs in India do not even come close to reflecting the average cost of water supply. Only a handful of Metropolitan cities in India have come close to achieving universal meter coverage, there is no revenue for the utilities and they can not invest in infrastructure and maintenance, meters are often non functional and metered customers end up paying fixed charge tariffs based on their last recorded meter reading (RAGHUPATI and FOSTER 2002, p 6).

The new implemented tariff system in Uganda demonstrates its efficiency by the revenues received by the utilities and the service received by the consumers. It is been studied the possibility to privatise some of the utility activities to improve its efficiency (DINAR and SUBRAMANIAN 1997, p 136).

3.1.4.4 Equity

Indian water tariffs are extremely affordable, even for families that live in extreme poverty. This is the only objective they can unquestionably meet in full, but has come at major expense in terms of sacrificing cost recovery, economic efficiency, equity and effectiveness. In India the use of unmetered charges is intrinsically unfair as all customers are charged the same amount irrespective of how much they consume. Large consumers gain at the expense of the small. This can be calculated based on how much water unmeasured customers would be able to buy, if they spend their fixed charge tariff on metered water. In about ¾ of Indian cities this equivalent consumption is less than 20 m^3 per month (a typical level of household water consumption). In other words unmeasured costumers are getting a relatively good deal, since they are probably consuming more water than what they could have bought. This creates a resistance towards metering. Indian water tariffs tend to be unfair to industrial customers, as well as measured residential users, and small consumers without meters (RAGHUPATI and FOSTER; 2002, p 6-7).

In Uganda the fixed tariffs are set to differentiate between different categories of consumers, where poor urban households pay the lowest rate. Commercial users pay three times as much per m^3 than persons obtaining water from public standpipes. The rationale is that water used for commercial and industrial purposes is an input to business activities and generate profits. Water charges for the less privilege are about 1/3 of the charges of more affluent commercial and industrial users. Stand post consumers pay 400 shillings per cubic meter (US$0.38). Commercial consumers must also pay a charge of 100 % for sewerage while stand post consumers do not. This construction of the fixed charge tariff makes the policy equal and fair (DINAR and SUBRAMANIAN 1997, p 136-137)

3.1.4.5 Political Feasibility

The fixed tariff system in Uganda are easy to administer; tariffs are reviewed each year as part of the budgeting process, expected revenue from tariffs is compared with planned expenditures, and both are adjusted so that revenues over costs; increases in tariffs are made only after considering the unit costs of production, affordability and the level of inflation since the last tariff increase. The flat rate charge system are easy to be understand for the residential consumers, so they are much more able and willing to pay than in the past (DINAR and SUBRAMANIAN 1997, p 136-137)

3.2 Uniform Volumetric Tariff

With metering came the potential to charge for water on a per unit basis. The second tariff structure analysed in this paper is the uniform volumetric and belongs to the group of the single part tariff. The concept of this water tariff is based on metering water use charges.

3.2.1 Design and Description of Uniform Volumetric Tariffs

AWWA (2000, p 85) states that this type of water tariff is also known as uniform tariff, and uniform commodity rate. Unlike flat fees, uniform rates require metered service and can be applied to all customer categories, such as residential, commercial, industrial and governmental. This type of tariff might be considered when customer groups or service classes exhibit similarities in usage (demand characteristics), this uniform rates by class provide separate uniform volume rates within a customer or service classification. The term uniform rate sometimes refers to applying a common rate structure to no interconnected as well as interconnected systems operated by the same water utility. It is a constant unit price for all metered volumetric units of water consumed. WHITTINGTON (2006, p 21) adds that with a uniform volumetric charge, the household's water bill is simply the quantity used times the price per unit of water (e.g., US$ per cubic meter). Uniform rates send customers a usage-based price signal. Although the unit price is constant, customer’s bill will increase while the water uses increase. The uniform rate also implies that all increments of water provided are associated with the same unit cost of services.

Uniform volumetric tariffs are the most common type of volumetric charge among water utilities in the United States, Australia, and a number of European countries. Besides they are the most common in metered municipal water supply in developing countries. They are very commonly used by industrial and commercial users throughout the world (SCHIFFLER 1998, p 80).

3.2.2 Examples from Developing Countries

To exemplify the structure and use of uniform volumetric tariffs, two examples are presented. The first example is from Indian cities and the second example is from Ethiopia.

3.2.2.1 Uniform Volumetric Tariff in Kanpur, Indore, Surat and Madurai

According to GUPTA et al., (2004, p6), unifrom volumetric tariffs form an important part of the water pricing structures in several Indian cities and towns. In 12 of the 22 Metropolitan cities sampled by Gupta, uniform volumetric rates are used within the metered connections. Most metropolitan cities charge a rate ranging between Rs. 2.00 and Rs. 3.50 per kL[5] per month. Uniform volumetric tariff are different for each user category. Thus, water charges may be fixed at Rs.2/kL for domestic users and at another rate for non-domestic users. Table 4 shows the uniform volumetric tariff structures from cities such as Kanpur, Indore, Surat and Madurai.

City	**Water Tariff (Rupees per kL) Domestic**	**Water Tariff (Rupees per kL) Non-Domestic**
Kanpur	2.0	10.0
Indore	2.0	22.0
Surat	2.0	8.0
Madurai	2.0	20.0

Source: GUPTA et al., (2004)).

Table 4: Uniform Volumetric Tariff

3.2.2.2 Uniform Volumetric Tariff in Ethiopia

According to ADDIS ABABA (2004, p 235), in Ethiopia Uniform tariffs have been used and remained unchanged for many years; while at the same time the cost of supplying water to consumers has risen steadily. Every regions carry the responsibility of providing and running the water schemes. Individual connections pay according to their metered consumption and consumers using public fountains pay a public vendor for the quantity they take. In almost all towns, irrespective of the amount consumed, uniform rates per unit consumed were applied.

By 1999 the metered tariffs were between 0.50-2.5 Birr[6] per m^3. The tariff has been applied uniformly. Where the water is sold by public vendors, the water is still charged at

[5] kL = kilolitre
[6] Birr = National currency of Ethiopia

the same rate as that for private connections. However, when water from public supplies is scarce or the distance to a public fountain is too great, residents are often forced to buy water from houses with private connections. The private water vendors charge a very high price, making the cost of water 5-10 Birr per cubic meter. Currently the situation is being changed for better. Since1999, water pricing has started to change. The water policy has provided a foundation on which progress for recovering costs could be built. However, the process is still in its early stages, and cost recovery has not been effectively implemented in the whole country yet.

3.2.3 Theoretical Evaluation of Uniform Volumetric Tariffs

Theoretical information from various sources is going to be use to support the objectives that Uniform Volumetric tariffs can fulfilled.

3.2.3.1 Effectiveness

According to AWWA (2000, p 87), uniform volumetric rates facilitates conservation because customers bill vary with the level of water usage. They send customers a usage-based price signal. OECD (2002, p 126) adds that in the last years, there is a clear trend away from flat-fee pricing structures, towards uniform volumetric tariff system which gives a stronger conservation signal. Thus, uniform rates are considered superior to flat fees. Conservation advocates might believe that the conservation orientation of water prices could be enhanced by more complex rate forms.

3.2.3.2 Cost Recovery

FREIRE and STREN (2001, p 186) state that to ensure that the full capital and operation and maintenance cost can be recovered, as any other volumetric tariff, uniform volumetric tariff should be set at an appropriate level. If the tariff equals the marginal cost of service provision, the utility may loose money because the average costs tend to be higher than the marginal cost of production. To solve this problem the monthly bill would consist of a fixed charge apart from the volumetric charge. Uniform volumetric tariffs can be used to send a clear, unambiguous signal about the short-run marginal cost of using water (WHITTINGTON 2006, p 21).

3.2.3.3 Cost-Effectiveness/ Efficiency

AWWA (2000, p 86-87) states that uniform tariff adequately set, addresses efficiency. Metering and volume-based rates are considered vital steps toward efficient water production and consumption. In the 1990's, many utilities reconsidered uniform volumetric structure as a cost effective way to simplify rate design. Uniform rates were accepted, approved and used by many regulated or unregulated water utilities. Uniform rates provide utilities with a degree of revenue stability in comparison to other more complex rate forms. According to DINAR (2000, p 230), uniform volumetric tariffs are efficient if they are set at or near the marginal cost of water. If the marginal cost of supplying water exceeds the average cost, perhaps due to the increasing opportunity cost of raw water, setting prices equal to marginal cost results in excess revenues for the water utility. In this case an important political issue in tariff design is how to achieve economic efficiency without collecting too much revenue.

3.2.3.4 Equity

AWWA (2000, p 87) points out that uniform volumetric tariffs are considered equitable because all customers pay the same unit price for general water services. They might also be perceived as equitable in periods of rising costs. With uniform rates across all customer classes, the appearance of large volume customer subsidising small volume customers, or vice versa is avoided. By the other hand, uniform rates might be not perceived as equitable when variations in the cost of serving different customer groups are substantial (large volume costumers might believe that lower cost associated with more favourable demand patterns, justified the use of uniform rates by customer's class). DINAR (2000, p 233) adds that with uniform volumetric tariffs, the reliable identification of low-income households is problematic, but when the institutional capacity to identify them exists, it may be possible to administer subsidies through existing social agencies.

3.2.3.5 Political Feasibility

WHITTINGTON (2006, p 21) states that unifrom volumetric tariffs are easy for the consumer to understand, due to the unique price per unit consumed. In part also this is how most other commodities are priced so it is easier to implement in the political process. The main merit of uniform tariff lies in its simplicity and its political acceptance. AWWA (2000, p87) adds that utilities might consider uniform rates when simplicity and customer understanding of the rate structure are valued highly and the cost and usage data by customers or service classification are not available or are too costly to develop (i.e. cost overweight potential benefits). Uniform volumetric tariff requires less data for design revenue estimation. Other utility functions such as cost analysis, customer service and regulatory proceeding, also are simplified with this less complex rate form. About implementation, uniform tariffs across all customer classes avoids the expense of detail cost allocation, public education and customer service.

3.2.4 Empirical Findings of Uniform Volumetric tariffs

Based on diverse experiential findings and the examples given above, uniform volumetric tariff evaluation is presented in this part.

3.2.4.1 Effectiveness

According to ADDIS ABABA (2004, p 236), the uniform volumetric tariff used in Ethiopia give an incentive in conserve water, because consumers pay the amount consumed. The tariffs set in some regions of Ethiopia are higher than others, and as it increases with water consumption, some believe that this may discourage customers from using enough water, necessary for their health. The amount of water required for such reasons is low; the discouraging effect on personal consumption is small.

3.2.4.2 Cost Recovery

In many cities in India, the general pattern of cost recovery indicates that only 65% of the cost incurred on providing water supply is recovered. In the case of Kanpur city there is 50% of cost recovery. Most water supply accounts show deficit and the service has to be subsidized by higher levels of government intervention (CPHEEO 2005, p 72).

The uniform tariffs charged to Ethiopian users for water supply are very much lower than the economic cost of supplying water. For a long time tariffs for most urban water supplies have not been increased. And the revenue obtained from consumers does not cover even the operation and maintenance costs in several cases. This means that many systems are operating under subsidies from the government (ADDIS ABABA 2004, p 235).

3.2.4.3 Cost-Effectiveness/ Efficiency

In Indian cities there is inefficiency in managing water services. Charging for water has not been given due attention, while the water tariff itself is very low in many urban centres. Concerning the tariff system, despite the general deficit scenario, urban centres where water supply accounts show a positive balance with revenue receipts exceeding revenue expenditure. For example city has a revenue receipts to revenue expenditure percentage of 118, and O&M expenditure per Kl (Rs) of 0.23 Rupees. Madurai city has also a positive revenue receipts to revenue expenditure percentage of 123%, and O&M expenditure per Kl (Rs) of 0.53 Rupees. These surplus revenues could be due to a number of reasons like an efficient management (positive reason), non-payment of outstanding bills or deferred payments (negative reasons) (CPHEEO 2005, p 72).

According to ADDIS ABABA (2004, p 235), the tariff system used in Ethiopia is inefficient due to the characteristics of the water system. The tariffs that were set are too low and for a long time there are no increases in these water tariffs.

3.2.4.4 Equity

The domestic tariff in Kanpur, Indore, Surat and Madurai are fairly elaborated. The uniform volumetric tariffs are structured by different customers groups. In larger cities where there are individual houses as well as large apartment blocks, tariffs are often higher for apartment blocks than for individual houses. Tariff for domestic connections are often significantly lower than those for non-domestic connections, particularly industrial and commercial connections. There is a cross-subsidy within the water sector whereby domestic consumers are subsidised by industrial and commercial consumers. The extent of the cross-subsidy varies; an average industrial consumer pays between 2 to 10 times higher tariffs than a domestic consumer (CPHEEO 2005, p 57).

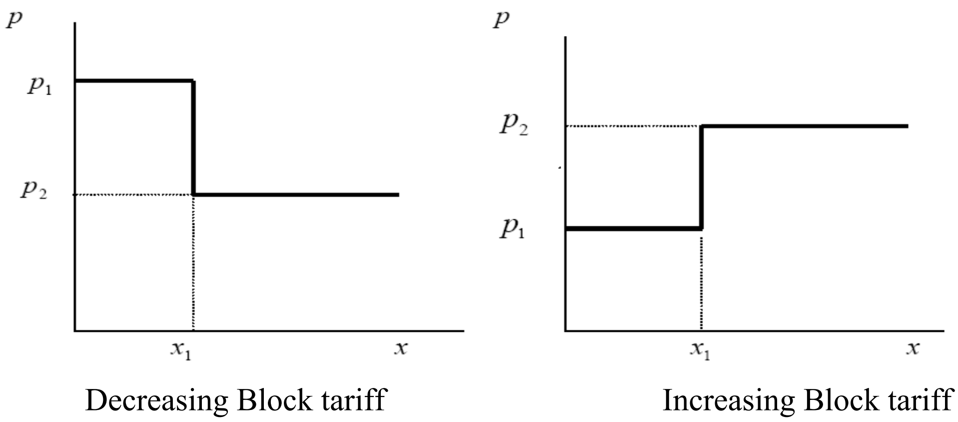
Even thought in Ethiopia uniform volumetric tariffs are applied, the tariff system is not equitable. The subsidies made by the government benefit the higher income group of society who have individual connections and who use relatively large quantities of water. Those who buy from public fountains and who receive a much inferior service, with long queues and frequent shortages pay the same rate per m³ to the public vendor. The public fountain users can afford less to pay the charges than those with individual connections. If the poorest members of a community can not afford to pay for water from public fountain, there is a great danger that these consumers will continue to use water from traditional sources (ADDIS ABABA 2004, p 236).

3.2.4.5 Political Feasibility

The uniform volumetric tariff structure used in Indian cities as Kanpur, Indore, Surat and Madurai are have been politically feasible, the tariffs were easy to implement and easy to understood for the population (PADWAL 2003, p 10).

3.3 Block Tariffs

Block tariffs constitute a sequence of marginal prices for different blocks or ranges of demand. There are two types of block tariffs, increasing block tariffs (IBT) and decreasing block tariffs (DBT). In this type of tariff structure, the price for each additional unit consumed varies when the level of consumption reaches a certain threshold. Figure 5 shows that being X the units of good consumers purchased, and P the marginal price, for increasing block tariffs the marginal price for different blocks will decrease $p\ 1 > p\ 2$, while for decreasing block tariffs the marginal price for the different blocks will increase ,$p\ 1 < p\ 2$ (ALVAREZ et al., 2003, p 4-6).



Source: Alvarez et al., (2003).
Figure 5: Block Tariffs

According to WHITTINGTON (2006, p 21), for block tariffs structures the water bill is calculated in the following manner:

Q^* := Amount of water sold to a specific consumer,

Q_1 := Maximum amount of water that can be sold in the first block at price P_1,

Q_2 := Maximum amount of water than can be sold to a consumer in the second block at P_2,

Q_3 := Maximum amount of water than can be sold to a consumer in the second block at P_3.

If: $Q^* < Q_1$, the consumer's water bill= $(Q^*) P_1$.

If: $Q_1 < Q^* < Q_2$, the consumer's water bill= $P_1Q_1 + (Q^* – Q_1) P_2$.

If: $Q_1 + Q_2 < Q^* < Q_3$, the consumer's water bill= $P_1Q_1 + P_2Q_2 + (Q^*– (Q_1+Q_2)) P_3$.

And so on for however many blocks there are in the tariff structure.

In the following both types of block tariffs are presented and evaluated in detail.

3.3.1 Increasing Block Tariffs (IBT)

Increasing Block tariff structures are single part tariffs. They are one of the most widespread water tariff used and also the most common tariff used in developing countries.

3.3.1.1 Design and Description of Increasing Block tariffs

Increasing block tariffs (IBT) are based on a volumetric component. A water user in a particular category is charged a relatively low per unit price of consumption up to a specific amount. This amount defines the end of the initial or first block. If the user consumes more water, faces a higher per unit price for his additional consumption until he reaches the top block of the IBT. The user can typically extract as much water as desired in this top block, but for each additional unit of water used, the bill increases by an amount equal to the highest price in the rate structure. The utility must set three parameters for each category of user: the number of blocks, the volume of water use in each block, and the per unit prices for each block (DINAR 2000, p 217).

IBTs are widespread used in developing countries; they are now the tariff structure of choice. The WORLD BANK (2002, p 3) states that in 1997 the ADB water utilities datebook reports that 20 out of 30 utilities surveyed in Asia use IBTs. A 2001 study of 260 cities by the national institute of urban affairs in India, found that in total, it is estimated that about 38% of the population of urban India live in cities which use IBTs. According to OLIVIER (2006, p 215), multilateral donors, international financial, engineering consultants, and water sector professionals working in developing countries presume that IBT structures are the most appropriate way to determine water user’s monthly bill. Most recent water tariff studies from the ADB over developing countries propose IBT structures. BARKATULLAH (1999, p 97) states IBT is adopted by developing countries for financial and equity reasons. The higher block meet the financial constraint and the lower first block meet the equity constraint. According to DINAR (2000, p 216), although they are so popular in developing countries (playing a minor role in industrialised countries), most poorer household do not have private metered connections to the water distribution system and thus IBT do not help them. WHITTINGTON (2006, p 21).adds that also in developed countries as Japan, United States, Spain, and parts of the Middle East (where water resources have historically been scarce), increasing block tariffs are also widely used

An outstanding feature of IBTs is the cross-subsidies. According to the WORLD BANK (2006, p 85), cross-subsidies occur when one customer pays more than the cost of service so that another customer can pay less. Cross-subsidies can be an effective way of achieving social goals, while ensuring that water and sanitation utilities as a whole are self-financing. One of the most common types of tariff that uses cross-subsidy is the increasing block tariff. IBT attempts to ensure that al customers can afford enough water to meet their basic needs by providing an initial quantity ("block") of water at a low price, with volumes in excess of that block sold at a higher price. Another common approach is to charge industrial customers more than the cost of service so that residential customers are charged less. Cross-subsidies can have disadvantages: if the poorest are not connected to the network, they will not benefit from the subsidies. If connected poor households are large, they may not be benefit from the subsidies as well as if they share a single connection. And the last disadvantage occurs if cross-subsidies reduce the revenue from poor households below the cost of serving them, operators will have an incentive to keep them unconnected.

3.3.1.2 Examples from Developing Countries

To exemplify the structure and use of increasing block tariffs, two examples are presented. The first example is from Ghana and the second example is from Malaysia.

3.3.1.2.1 Increasing Block Tariffs in Ghana

According to WHITTINGTON (1992), the water tariff structure in Ghana in 1989 was designed to assist low-income households and can be used to illustrate the magnitude of the effect of IBTs on the monthly water bill of households that share a single metered connection and live in high-density housing, a fact that is very common in developing countries. Table 5 shows the IBT structure used in Ghana.

Blocks	Tariffs
0 – 3000	184 cedis[7] (US$0.53) per 1,000 gallons
3001 – 10.000	316 cedis (US$0.90) per 1,000 gallons
> 10.000	460 cedis (US$1.31) per 1,000 gallons

Source: Whittington (1992)

Table 5: IBT Structure in Ghana

A description of how IBTs work is shown below. Households share a building and single water connection with another household. Each household has five members (Media) and each person uses 10 gallons of water per day. The total water used by the two households is 3,000 gallons per month plus a minimum charge per month set in 552 cedis per month; this means that each household pays 368 cedis per month. Another household shares a building and a single water connection with 19 other households (each also with five members, who use 10 gallons of water per day). The total water use for the entire building, through the shared single connection, is 28,500 gallons per month. Following the IBT structure outlined above, the water bill for the building will be: 184 cedis per 1,000 gallons for the first 3,000 gallons (552 cedis), plus 316 cedis per 1,000 gallons for the next 7,000 gallons (2,212 cedis), plus 460 cedis per 1,000 gallons for the final 20,000 gallons (9,200 cedis). These sum a total of 11,964 cedis between 19 households, 598 cedis per household.

A study of water and sewerage conditions in Kumasi-Ghana, support the data shown above. In some common situations IBTs do not help the poor. The study was conducted in 1989 as part of a World Bank research project on demand for improved sanitation in Kumasi. Information was collected from a random sample of households throughout the city on the household's assets, weekly expenditures, sources of water, monthly water expenditures, number of households sharing the building or compound, and whether the building's water bill was shared and, if so, how it was shared. The results show that about 89% of Kumasi's 600,000 people are tenants. The housing conditions are very crowded; 90% of the sample households lived in a single room. On average there were more than 11 households (50 people) in a building or compound. 25% of the households in the sample lived in multi-storey buildings; another 70% lived in single storey multifamily compounds. Multi-storey apartment buildings tend to have the largest number of households. 32% percent of the sample households bought water from neighbours who had private connections to the public water system. Another 10% relied on public taps and neighbours' wells. The rest, 58%, had shared access to a connection in their building; in most cases (85%) these were metered connections, and 95% of the meters were working.

[7] Cedis = Uganda Currency.

There were three principal methods of allocating the monthly water bill among families that shared a connection in a building, about 37% used a system of points assigned on the basis of number of persons per household, 35% according to the number of rooms per household, and for 22% the bill was divided equally among households regardless of size. Because of those who share the water bill for the building equally among households, the total water bill for the building can be estimated. If the tariff is known, the total water use for the building can be calculated, and the average household water use can be also estimated. Dividing the household's share of the monthly water bill by the estimate of the average household water use, the average price of water to the household can be calculated.

3.3.1.2.2 Increasing Block Tariff in Malaysia

LEE (2005, p 12) states that in Malaysia, the tariff structure employed is increasing block tariffs for domestic consumers and another structure (two-part tariff) for industrial consumers. Domestic water tariff is cross-subsidized by the industrial tariff. Hence, industry rates are higher than domestic rates. Most of the developed states (such as Selangor and Johor) have relatively higher industry water tariff, which may explain the high per capita water consumption. Water tariffs in Malaysia include a very low ‘lifeline’ rate used to cover the basic needs for domestic purposes. The incentives for an efficient use of water are applied through the use of volumetric charges under IBT. The tariffs structures per category are shown in Table 6. There are also significant differences in the structure of residential water tariffs between the different states

State	Unit Cost	Residential			Industrial	
		1st/2nd Block (m^3)	Rate (RM/m^3)	Subsidy	1st/2nd Block (m^3)	Rate (RM/m^3)
Kedah	0.37	20	0.40	-8.1%	10,000	1.20
Sarawak	0.48	15	0.44	8.3%	25	0.97
Labuan	1.35	Flat	0.90	33.3%	Flat	0.90
Perlis	0.43	15	0.40	7.0%	Flat	1.10
Pahang	0.47	18	0.37	21.3%	227	0.92
N.Sembilan	0.32	20	0.55	-71.9%	35	1.50
Sabah	0.80	Flat	0.90	-12.5%	Flat	0.90
Perak	0.55	10	0.30	45.5%	10	1.20
Melaka	0.62	15	0.45	27.4%	Flat	1.40
Kuching	0.54	15	0.48	11.1%	25	0.97
Sibu	0.76	15	0.48	36.8%	25	0.97
P.Pinang	0.38	20	0.22	42.1%	20	0.52
Terengganu	0.34	20	0.42	-23.5%	Flat	1.15
Selangor	1.07	20	0.57	46.7%	35	1.80
Johor	0.59	15	0.30	49.2%	20	1.68
Kelantan	0.43	20 21-40	0.25 0.40	41.9% 7.0%	Flat	1.25

Source: LEE (2005, p 20).

Table 6: Residential and Industrial Water Tariffs and Subsidies in Malaysia (2003)

There are quite a few states (Melaka, Terengganu, Perlis, Kelantan and Sabah) that use flat rate tariffs for industrial and commercial categories. Overall, in almost all states (with the exception of Sabah), residential water users are subsidized by industrial/commercial water users. For the first 15 m³ of water consumption, the level of industrial/commercial water tariff is 2–5 times the corresponding level for residential water tariff, for example in the city of Kedah for the first block the residential water tariff is 0.4 Rm[8]/m³ while for industrial water tariff is 1.2 Rm/m³. These subsidies usually apply only for the first block of consumption (around 10-20 m³) and range between 7 % (in Perlis) to 49 % (in Johor) as can be see in Table 6. The exception in the use of cross-subsidies is the island of Labuan, where flat rates are applied. It is also important to comment that connection charges are borne entirely by users. Typically, users pay for the connection work that is undertaken by a private contractor (provided by the water supplier). No subsidy is provided for connection charges in Malaysia (LEE 2005, p 14)

3.3.1.3 Theoretical Evaluations of Increasing Block Tariffs

Theoretical information from various sources is going to be use to sustain the objectives that increasing block tariffs can fulfill.

3.3.1.3.1 Effectiveness

Water use increased dramatically when household switched from a source outside the home (e.g., a hand pump or well) to a private connection to a piped distribution system. IBTs present as an advantage, the high water prices (due perhaps to marginal cost or cost-recovery pricing) that would reduce household water use, leading to water saving (HERRINGTON 2006, p 5). These high prices from the higher blocks of consumption of the increasing block tariff structure, can be made punitively high, and thus discourage wasteful water use. Customers who can consume less are rewarded by a lower unit and total cost (DINAR 2000, p 219).

WHITTINGTON (2006), points out that in practice, concerning effectiveness, IBT present unintended effects in developing countries. The justification for using IBTs based on the rationale of water conservation is true in many cities in industrialized countries assuming that each household has its own metered water connection. In developing countries, individuals often have unmetered connections or not water connection at all. They obtain their water from public systems indirectly, purchasing water from neighbours that have connections or from water vendors, who fill their trucks from public systems. IBTs in this case have the opposite effect than the intended conservation objective. Households with connections sell water at minimal cost as a courtesy, or sell water is a significant source of household income and are organized as a business operation. A single household that sells water to neighbours soon faces the same situation as the large apartment building with one

[8] Rm= Ringgit= Malaysian currency.

tap, the more units dispense, the higher marginal price of water from the tap, but this will not discourage the household in consuming or selling water. So IBTs fail to achieve this expected objective.

3.3.1.3.2 Cost Recovery

According to FOSTER and YEPES (2006, p 23), in theory at least, the IBT should still allow utilities to recover the full costs of service provision, by charging above cost on higher blocks of consumption. A well-designed IBT should therefore incorporate a relatively small first block that genuinely relates to subsistence consumption needs. Thereafter, the gradient between marginal tariff and consumption should be steep enough to allow prices to reach cost recovery levels within a normal range of consumption. FAY and MORRISON (2007, p 48-49) add that IBTs are often badly design. The tariff covers the costs only at extremely high rates of consumption. Indeed in more than half of the utilities (in developing countries), tariffs never reach the cost recovery level, so IBTs effectively subsidise all residential water consumers.

3.3.1.3.3 Cost-Effectiveness/ Efficiency

DINAR (2000, p 228) highlight that IBT structure are do not reach the efficiency objective. Designing an IBT to produce a specified revenue stream leads to some significant difficulties; the most important concerning efficiency is that compromises between revenue collection and economic efficiency objectives may further distort other functions of the tariff. It is usually argued that, where marginal cost pricing produces too much or too little revenue, prices can be adjusted in a way that meets the revenue constraint while minimizing the loss of economic efficiency. This adjustment is often called RAMSEY pricing (RAMSEY, 1927). Some authors, like PORTER (1996) have claimed that IBTs can achieve an optimum balance between the two objectives. PORTER provides a mathematical appendix which he represents as proving that, where additional revenue must be raised, an optimal departure from marginal cost pricing can be achieved with a two-block IBT. PORTER'S conclusion seems contradictory in the light of the usual assumption that larger water users have a higher price elasticity of demand. A common characterization of Ramsey pricing is that it assigns the highest prices to the least elastic users, which in the case of residential water use would be the small users (e.g., poor households). This would contradict an IBT. But a closer inspection of PORTER'S derivation shows that his assumed linear demand curves actually make the demands of the poor more elastic than the rich, a highly implausible circumstance. Thus his conclusions as to the optimality of IBTs are unfounded.

According to CRASE et al., (2007, p71), IBTs fail on the economic efficiency for several reasons. Setting multiple prices is inconsistent with the notion that customers should face the incremental costs of their actions, unless the service provided is attended by different costs. In essence, is difficult to see how the cost of supplying a small number of households who use a larger quantity of water is higher than supplying small quantities of water to more numerous households. The economies of scale from tariff collection and the dynamics of water delivery would suggest that larger water users should face lower costs rather than higher costs. In addition, there are potential scale economies that attend consumption; larger households may frequently use less water per capita than smaller households (DWYER, 2006).

According to AWWA (2000, p 100), IBTs structures tend to result in more revenue volatility than other type of rates because an IBT anticipates recovering a proportionately greater percentage of the customer's class revenue requirements, at higher levels of consumptions. These high levels of consumption tend to be more subject to variations in seasonal weather, and coupled with a higher unit pricing, customers reduce their consumption in these higher consumption blocks.

3.3.1.3.4 Equity

CRASE et al., (2007, p 72) state that the equity objective of water tariffs are also not well served by IBTs. Equity in this case means treating customers in similar circumstances equally and those in different circumstances differently. If the circumstances in question are financial, there is no guarantee that water usage will be perfectly correlated with income. A high income apartment dweller could easily face much lower marginal tariffs than a large, low income household. DINAR (2000, p 222-224) point out that the idea that IBTs promote equity by forcing wealthy households to cross-subsidize the water usage of poor households is wrong. The argument is that wealthy households use more water, because water is a normal good and use increases with income as it is stated before there is no guarantee of this. Advocates of the IBT structure also content that charging industrial and commercial customer a higher rate than residential customers also promotes equity. but this arguments must be revisited, considering the argument that cross-subsidies promote equity, a household must use the entire first block of water to receive the full subsidy, as a household reduces its water use, its receive a smaller subsidy and there is not need to employ an IBT to set industrial prices above residential prices. Furthermore, subsidies create conflicts with the objectives of economic efficiency and equity, because it applies the highest prices to those customers who are the most likely to exist in the system, placing residential customers in disadvantage in a long run because as large users elect to exit, the water agency losses economies of scale in water intake, treatment, transmission and distribution and the prices have to increase.

ALVAREZ et al., (2003, p 7) add that in the first block of the IBT a minimum quota should be set. This quota should include a level of consumption that covers the basic needs to achieve the goal of equity. If not, there is a possibility of establishing a first block sufficiently reduced as to force low-income families to be placed in successive blocks.

DINAR (2000, p 225) state another limitation of IBTs, setting the initial block, that affects the equity criteria. The ability of an IBT to deliver on its promise of effectively targeting the poor depends on the tariff designer's success in setting the volume of water in the initial block equal to a household's essential water needs. There are internationally standards for basic water needs, as we discuss before in this paper, that are in the range of 25-30 litres per capita per day (FALKENMARK 1991; GLEICK 1996). The IBT structures used in most cities give households with private connections much more water than this at the lowest price. It is difficult for politicians and senior civil servants to restrict the size of the initial block of an IBT structure because a large initial block directly benefits not just the poor but also the middle and upper income households with private connections. Since in many cities the middle and upper income households have the majority of private, metered connections, it is often the case that such households receive the vast majority of water sold at the subsidized prices.

Furthermore, in developing countries IBT structures have the opposite effect than that intended equity or fair objective. Poor people are more apt to live in high density housing and share a common metered water connection. The more households that share single water connections, the more units of water will be used. IBTs push the water bill of the building as a whole into the higher-priced blocks. The marginal price paid for the water increases and so does the average price paid. Thus, they will pay higher average prices for water (WHITTINGTON 1992).

3.3.1.3.5 Political Feasibility

According to DINAR (2000, p 225) IBTs have achieved some degree of public and political acceptability, perhaps because they have been so routinely applied. But they are certainly neither simple nor transparent. With a typical IBT, it is impossible to deduce the average or marginal price that is actually being paid for water. The kind of price signal that most customers rely on becomes misleading and confusing when the resulting water use moves from one block to another. This is an important point because when customers cannot detect a coherent price signal, they cannot respond as expected.

AWWA (2000, p 99-101) states that IBT are not feasible policies. IBTs are not simply to design (setting the initial block), definitions of rate blocks can be based on more than one rationale and the rate structure can be more difficult to communicate to customers. Utilities should consider IBTs when they are able to distinguish separate customer classes for billing, when they have the analytical capability to design block rate structure (like defining the amount of water sold per block and the potential demand responses to differential rate impacts) and when the utilities are willing to spend additional effort to communicate the nature and rationale of increasing block rates (high administrative efforts are needed).

3.3.1.4 Empirical Findings of Increasing Block Tariffs

Based on diverse experiential findings and the examples given above, increasing block tariff evaluation is presented in this part.

3.3.1.4.1 Effectiveness

According to ASHMORE (1989, p 1), the effectiveness of the IBT structure as water conservation measure will depend on demand price elasticity. The price the consumers pays for water can have a significant effect on the amount of water used. Meeting demands can prove to be a difficult task when dealing with a finite resource like water. There are many opinions concerning the appropriate methodology for estimating water demand. A model of consumer behaviour was first developed by TAYLOR (1975) and NORDIN (1976). TAYLOR and NORDIN had shown that the amount of water purchased by a consumer facing a multipart tariff can be expressed as a function of the marginal price faced by the consumer, and a second quantity defined as the difference between the consumer's bill and the amount of the water purchased. BILLING and AGTHE (1980) reported a study of the demand for water in Tucson, Arizona; they based their analysis on TAYLOR'S and NORDIN'S model. They made a regression analysis, attempting to explain the variation in water consumption by the variation in marginal price. They interpreted the relationship between water consumption, marginal price and the difference indicated by their regression as being the demand function. Showing how water consumption is influenced by changes in the price schedule. They also demonstrated that the demand model developed by TAYLOR and modifies by NORDIN is theoretically correct for IBTs and DBTs. The demand models show that under the existing increasing block rate pricing schedules, higher income households not only use more water, but have lower elasticities of demand. Thus a uniform proportional rate increase will cause a larger percentage drop in water use among low income households than among high income households. Given the assumption of declining marginal utility of water use, this result leads to a policy recommendation for substantially steeper block rates to improve interpersonal equity in water pricing. As additional articles concerning water demand can be cited AGTHE et al., (1986), AGTHE and BILLINGS (1987), RENWICK and ARCHIBALD (1998), GAUDIN et al., (2001).

From the example presented in Malaysia, the high rates form the highest blocks of consumption of the increasing block tariff used, discourage water wastage between the populations (LEE 2005, p 13). From the example of Ghana, WHITTINGTON (1992) states that the promotion of water conservation fails because people life in high density houses and the higher water prices from the higher blocks do not discourage people from using water as they are sharing the water bill.

3.3.1.4.2 Cost Recovery

In Table 7 is shown that the Malaysian water sector experiences a total revenue-cost deficit of about -Rm 245.5 million (or about 9.1 %of cost defined as operating and maintenance cost). Nevertheless, only about half of the cities in Malaysia are currently experiencing a financial deficit in their water operations. For example, the cities with large deficits include Selangor with –Rm 449.1 millions and Sabah with –Rm 125.0 million. Also Table 7 shown that the unit revenue[9] exceeds the unit cost[10] in all the cities that experience financial deficit in water operations. There is only one exception, the city of Labuan (LEE 2005, p 18).

State	Cost	Revenue	Revenue – Cost Gap	% Deficit	Unit Cost	Unit Revenue
Kedah	117,110,842	148,520,086	31,409,244		0.37	0.81
Sarawak	26,209,664	22,001,870	-4,207,794	16.1	0.48	0.51
Labuan	16,555,975	9,640,336	-6,915,639	41.8	1.35	0.98
Perlis	13,748,304	12,849,629	-898,675	6.5	0.43	0.67
Pahang	109,257,244	98,722,938	-10,534,306	9.6	0.47	0.83
N.Sembilan	72,752,318	99,561,120	26,808,802		0.32	0.95
Sabah	200,872,317	75,850,000	-125,022,317	62.2	0.80	1.15
Perak	166,221,930	201,056,555	34,834,625		0.55	0.95
Melaka	77,837,946	105,486,723	27,648,777		0.62	1.20
Kuching	55,743,344	62,795,270	7,051,926		0.54	0.91
Sibu	21,247,969	19,508,893	-1,739,076	8.2	0.76	0.98
P.Pinang	107,501,332	167,950,719	60,449,387		0.38	0.75
Terengganu	45,619,654	80,750,864	35,131,210		0.34	0.89
Selangor	1,310,523,468	861,421,335	-449,102,133	34.3	1.07	1.28
Johor	270,722,202	382,373,342	111,651,140		0.59	1.23
Kelantan	34,183,814	45,704,857	11,521,043		0.43	1.05
LAKU	40,283,687	46,679,330	6,395,643		0.68	0.96
	2,686,392,010	**2,440,873,867**	**-245,518,143**	9.1	0.69	1.05

Source: LEE (2005, p 19)
Table 7: Financial Performance of Water Operation in Malaysia

3.3.1.4.3 Cost-Effectiveness/ Efficiency

RUIJS (2009) addresses a disadvantage of the IBTs, a potential welfare loss. In his paper, he analyzes the distribution and welfare effects of changes in block price systems. The results show that there is a trade off between average welfare and income distribution. An IBT price system may result in lower average welfare than a flat price system, but in a higher individual welfare for the poor. Also there is a trade off between revenues for the water company and income distribution. Even thought IBTs are not as good in average welfare as flat rates, they have very important direct effects on poverty. Besides others in this field of research, HAJISPYROU et al., (2002) estimate the price and income elasticities of residential demand for water in Cyprus and evaluate the welfare effects associated with changes in the water pricing system. They found that IBT system in Cyprus introduces price distortions and uniform marginal cost pricing will reduce distortions and increase the

[9] Unit Revenue= derived by dividing total revenue by total metered water sold.
[10] Unit Cost= derived by dividing total operation and maintenance cost by total production.

efficiency of the water allocation system. On the other hand it will also be biased towards improving the welfare of the better-off households.

According to LEE (2005, p 19) the tariff system apply in Malaysia is not efficient Table 7 shows the revenues that are produced in each city of Malaysia, from 17 cities 7 present deficits. The reason of the inefficiency is the inability of the utilities, to obtain sufficient revenues to cover capital expenditures (investment). This, in turn, is due to water tariffs being currently set at less than full-cost recovery levels. Part of the financial deficit experienced by state water operations are also due to the subsidy on residential water consumption. A major reason for these financial deficits is the loss of revenues from non-revenue waters (NRW). NRW are the water that are produced but not billed to consumers due to leakages, under-meter registration, and pilferage. The average percentage of NRW in Malaysia is very high at 40.6 percent in 2002 the financial deficits in state water operations can be reduced if the level of NRW is lower.

3.3.1.4.4 Equity

In the example from Ghana, IBT penalize low income households instead of helping them. An opposite effect that the intended equity objective. A household living in a building with 19 other households must pay more than twice as much per month for the same amount of water as a household that shares a building with only one other household. It is clear that the existing IBT structure in Ghana can create a dramatic rise in the average price of water for households that live in high-density housing. This does not mean that their total water expenditures would increase, because water use per capita is likely to be lower in more crowded housing situations. Probably they face greater social restrictions on water use, including longer queue times at the tap during periods of peak use, and fewer convenient options for bathing, clothes washing, and disposal of water. Besides, low income households are likely to use less water than high-income households because of a positive income elasticity of demand for water. This situation was further investigated. Results from a regression analysis in which the average price paid for water is regressed on the number of households in the building, show that the number of households in the building has a positive and highly significant impact on the average price of water paid by the household. The IBT structure thus appears to be raising the price of water paid by households living in high-density conditions. IBT structure affects the poor in Kumasi. Three types of data were collected to characterize a household socioeconomic level: Number of assets owned, number of electric points and weekly expenditures. As expected, households located in buildings with fewer households have the highest socioeconomic level as measured by all three indicators. The average water bills and the average socioeconomic level, for households with different means of obtaining water were compared. The data showed that the poorest group of households, those buying from neighbours and paying by the bucket, are paying the most per month for water. The IBT structure does nothing to protect them and, in fact, appears to exacerbate their situation (WHITTINGTON 1992).

LEE (2005, p 22) addresses that in Malaysia, the tariff system imposed tries to follow the equity criteria. Water tariffs as a percentage of average monthly household expenditure in urban areas, exceed those of rural areas. The industrial consumers subsidize the domestic consumers. For example, for the first 15 m3 of water consumption, the level of industrial/commercial water tariff is 2 – 5 times the corresponding level for residential water tariff. And there is very low 'lifeline' rate to meet the 'ability to pay' criterion of the lower-income group to cover basic everyday need for domestic purposes.

According to LIU et al., (2003) IBTs seems to provide an effective tariff structure to achieve the objective of maintain equity for the society. But, this tariff has not been designed well in most developing countries. Liu et al., in his paper intent to critically examine the use of IBT-con (increasing block tariff based on water consumption per connection)and to strongly promote a new tariff structure, IRT-cap (increasing rate tariffs based on water consumption per capita, where users pay the same price for all water use in the same billing period). Liu's case study in Weinan city shows the effectiveness of IRT-cap in achieving the objective of equity. IRT-cap can avoid the shortages of IBT-con, such as the difficulties of setting the first block, cost recovery, simplicity, transparency and implementation. This new design of water based on IBT tariff should be formulated in some pilot projects for verification.

3.3.1.4.5 Political Feasibility

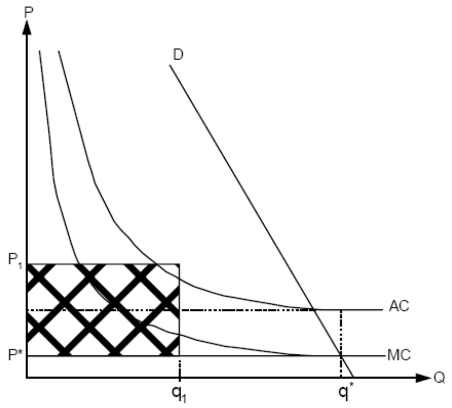
In Malaysia there is a public perception that the quality of water services is very low. Major investments are needed to improve this situation. In response to this problem, the federal government is currently attempting to shift the regulation of water resources. Politicians have emphasized the need to revise current water tariffs to get funds for some projected investments to improve the service. This implies that the past and current levels of water tariffs in the country have been very much below the levels that ensure sustainability of water service provision (LEE, 2005, p 1).

3.3.2 Decreasing Block Tariff

Decreasing block tariffs are single part tariff. It is a less common water tariff structure nowadays.

3.3.2.1 Design and Description of Decreasing Block Tariffs (DBT)

WHITTINGTON (2006 p 21) explains that with a decreasing block tariff (DBT), consumers face a high volumetric charge up to the specified quantity in the first block, pay less per unit for additional water, up to the limit for second block, then less still for the third, and so on. It is possible to keep the price at the margin equal to the marginal cost and recover the revenue needed by the business to stay solvent. The regime of a DBT is presented in Figure 6. The customer pays a price p1 for the quantity of water consumed up to the point q1 and a price of p* for the water consume thereafter, between q1 and q* (MUNASINGHE AND WARDFORD (1982).



Source: MUNASINGHE and WARDFORD (1982)
Figure 6: The Regime of a Decreasing Block Tariff

WATSON & ASSOCIATES ECONOMISTS (2007, p 6-3) state that typically the first, or first and second block cover residential and light commercial uses. Subsequent blocks normally are used for heavier commercial and industrial uses. This rate structure requires the use of meter to record the volume consumed by each type of user .This method requires the collection and analysis of consumptions patterns by user's classification to establish rates at a level which does not over or under collect revenue from consumers.

According to AWWA (2000, p 92), during the 1960's many middle sized and large utilities used decreasing block rate structure, they were often justified on the grounds that large volume customers typically had favourable demand and cost of service characteristic. By the late 70's concerns about conservation in the energy and water sector have arisen. A movement away from decreasing block structures has started. Conservation advocates believe that DBTs do not sent an appropriate pricing signal to encourage water conservation. In the 90's there was a movement towards uniform volumetric prices. The application of this structure nowadays seems to be more selective than in the past, it is used in areas where water supply is available and where a single schedule of rate is applicable to all retail customers. Consumers that are not familiar with the rate design process, consider DBT as to be anti conservative and favourable to only large volume users of water. The size of the rate blocks and the variability of the declining unit rates should reflect the types of customers served and the cost differences between peaks an average use for the different classes of customers. DBT has been shown popularity which in OECD countries because succeeding blocks of units of water are sold at lower and lower prices. This tariff can include a fixed or minimum charge per billing period (two part tariff) related by some criterion such as the size of supply pipe (OECD 1987, p 42).

There is an important issue regarding developing countries and DBTs. The usual rationale behind DBTs is that they encourage the purchase of larger quantities of water thus enhancing economies of scale in production and in delivery. The situation is quite different when infrastructure deficiencies are present as is the case in developing countries. The production of larger quantities of water puts a strain on the delivery of the service by increasing system load and system congestion. This, results in bottlenecks and in failures which reduces the quality of the infrastructure service delivered. The smaller users also have a lower capacity to bear the costs of private provision because their operations do not have the benefit of high scale of economies. Hence, DBTs in a developing countries context favour the larger users, who value the infrastructure service the least and burden the smaller users who value the service the most. In a comparison, IBT results not only in a socially more efficient redistribution of the infrastructure service in a developing country but also in a higher quality service as well (ANAS et al., 1996, p 19-20)

Decreasing block tariffs have been also well examined, more literature over DBTs can found by CHICOINE *et al.* (1986), WILLIAMS and Suh (1986), FOSTER and BEATTIE (1981), SCHEFTER and DAVID (1985), NIESWIADOMY and MOLINA (1989) and TIMMINS (2002).

3.3.2.1.1 Examples of Decreasing Block Tariffs

DBTs are commonly used as a part of a tariff structure. Two examples are shown to illustrate the use of DBTs in the water tariff system. One the examples are from Taiwan and other from Canada.

3.3.2.1.2 Decreasing Block Tariff in Taiwan

In Taiwan form the water supply, 14% go to urban consumers, more than 70% for residential consumers and the reminder is for industrial, commercial and others users. Water demand for domestic use is increasing rapidly; daily per capita consumption has doubled over the past twenty years. Over the same period water prices have nearly tripled from NT$3.3 in 1975 to NT$9.0 in 1994. It appears that prices are too low to significantly dampen consumers demand in all sectors. The public utility “Taiwan water supply corporation” implemented a block pricing system in 1975 and has adjusted the rates four times since then. Table 8 presents the water rates in (NT$ /m^3) [11] (DINAR and SUBRAMANIAN 1997, p 115-118).

[11] NT $ = New Taiwan dollar.

	1975	1979	1982	1991	1994
Average rates	3.30	4.95	6.60	8.25	9.00
First block					
Monthly usage	<20	<10	<10	<10	<10
Rate	2.50	3.50	5.00	7.00	7.00
Second block					
Monthly usage	21–30	11–30	11–30	11–30	11–30
Rate	3.5	4.50	6.50	8.00	9.00
Third block					
Monthly usage	31–50	31–50	31–50	31–50	31–50
Rate	4.50	6.00	8.00	9.00	11.00
Fourth block					
Monthly usage	51–200	51–200	51–200	>51	>51
Rate	5.50	7.50	10.00	10.50	11.50
Fifth block					
Monthly usage	201–2,000	201–2,000	201–2,000	n.a.	n.a.
Rate	4.50	6.50	8.50	n.a.	n.a.
Sixth block					
Monthly usage	>2,001	>2,001	>2,001	n.a.	n.a.
Rate	3.50	5.00	7.00	n.a.	n.a.

Source: DINAR and SUBRAMANIAN (1997)
Table 8: Water Tariff Structure for Taiwan 1975-1994

The utility structured a complex water tariff using a combination of DBTs, IBTs and fixed charge tariffs. The first four blocks are structured as IBTs and the last two blocks as DBTs. For the first block of consumption users pay a flat fee regardless of quantity used as well as users that reach the highest block of consumption.

3.3.2.1.3 Decreasing Block Tariff in Canada

According to DINAR and SUBRAMANIAN (1997, p 115-118), in a market oriented economy such as Canada, the prices of most goods and services are a major determinant of usage. Even in the case of services such as water supply and waste water treatment. By 1996 fewer than 45% of all Canadian municipalities were metered for residential water. Throughout Canada there is a wide variety of rate structures. More than one half of municipal agencies charge flat rates, more than 25% uniform volumetric tariffs, 19% DBTs and only 3% IBTs, the left 1%, represent the users affected by various rate schedule. The DBTs generally includes a basic or fixed service charge per period. The first two initial blocks cover residential and light commercial users, with subsequent blocks covering heavy commercial and industrial users. The fixed charge often varies with the size of the service connection. Minimum charges corresponding to a minimum amount of water consumption in each billing period are common in this system. According to MILLER and VAILLANCOURT (2006, p 150), water prices in Canada are generally based on average cost. Peak load demand is not taken into account and distance from source is not captured. A recent study based on 77 water utilities in Ontario concluded that the marginal cost of water supply and sewerage treatment exceeded the price for water output and sewerage treatment in every municipality. Specifically, the average price of water for residential consumers was [12]Can$ 0.32 per cubic meter while the estimated marginal cost was Can$ 0.87 per cubic meter. In the case of sewerage treatment the average marginal cost was Can $ 0.52 per cubic meter while the average price was Can$ 0.13.

By 2004, in all Canada the use of DBTs fell over the period 1991-2001. In 1991, 24.0% of residential ratepayers were billed by DBT, down to 13.8% in 1996, and to 7.5% in 2001. Between 2001 and 2004, however, the percentage raised a very small amount of 7.9% (ENVIRONMENT CANADA REPORT 2008, p 6).

3.3.2.2 Theoretical Evaluation of Decreasing Block Tariffs

Information from various sources is used to support the objectives that Decreasing Block tariff can fulfil.

3.3.2.2.1 Effectiveness

The AWWA (2000, p 94) describes that a DBT structure appears to conflict with the goals of efficient water use and resource conservation. DBTs may be perceived as promoting consumption rather than conservation, they are often viewed negatively regarding to conservation. During periods of water scarcity or emergency the focus may be shifted away from a DBT structure to a rate structure perceived to be more conservation oriented. AWWA (2000, p 92) adds that utilities might consider to use DBTs when, economic circumstances dictate that price incentives should be provided to encourage specific large volume customer to remain on the system (e.g., a large volume customer that can develop its own source of supply by drilling as well). under DBTs, customers with the least ability to change consumption (inelastic demand) tend to consume water primarily in the highest price initial block, while those customer with greatest ability to change consumption (elastic demand) tend to consume more water in the lower price tail block from the DBT structure.

3.3.2.2.2 Cost Recovery

KERF (1998, p 33) shows that an argument of DBTs is that costs are recovered through the high per unit price paid on the first units of consumption. BROWN and SIBLEY (1986, p 1) state that DBTs have been justified when is used as a part of a tariff structure (two part tariff) helping to recover large fixed costs of operation. A properly design DBT should be able to adequately recover the costs, if the size and height of the blocks are well designed.

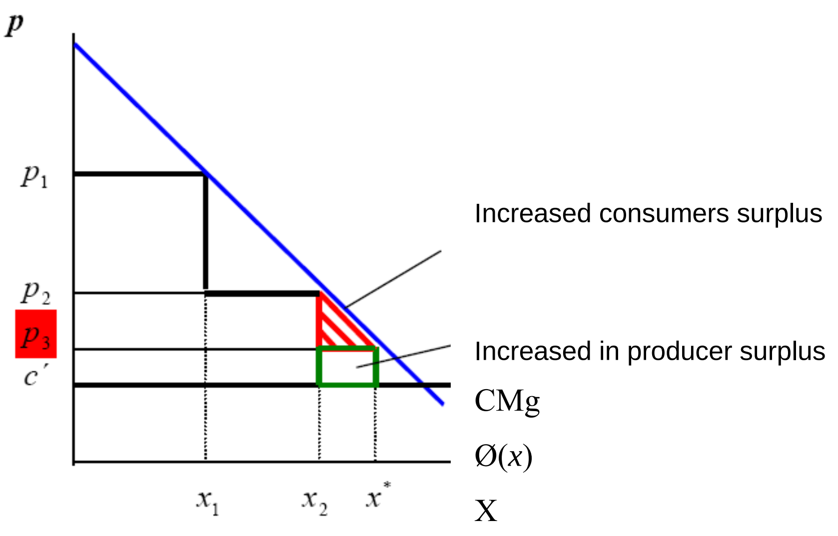
3.3.2.2.3 Cost-Effectiveness/ Efficiency

According to BROWN and SIBLEY (1986, p1-2), DBT are justified, because they encourage greater consumption, causing larger more effective plants to be constructed over time (many regulated firms benefit from economies of scale). This justification has come over

[12] Can$= Canadian dollars= Canadian currency.

attack from those who believe that the regulated firm goal is profit maximization. Thus, DBTs are simply a means of increasing profits through a subtle for of price discrimination. OECD (1987, p 42)adds that also DBTs might be designed if a utility, by charging consumers a marginal cost based priced, were to be likely to fail to meet its financial requirements. The higher priced blocks are the way by which the utility recovers as revenue part, of what would otherwise be consumer's surplus. The prices of the earlier and more expensive blocks should then be determined by residual financing requirements. The idea is to reflect the fact that large consumers often impose lower average costs on the system. ALVAREZ et al., (2003, p 4-7) adds that DBT has gradually fallen out of favour. Its efficiency fails while only little water is sold at marginal price. In part because short-run marginal costs, properly defined, are now relatively high in some parts of the world, and there is thus increased interest in promoting water conservation by the largest customers

For an efficient tariff structure it is necessary to choose the design that will produce a greater surplus. From Pareto's standpoint, a block tariff shall not constitute an optimal tariff, when a change in the size of any block involves improvements in the total welfare (ALVAREZ et al., 2003, p 4-7). In this regard, if the price exceeds the marginal cost, the surplus can be increased by adding an additional block (WILLIG, 1978). If the price of the last block of a DBT of n blocks is higher than the marginal cost, it is preferable a tariff with n+1 blocks, as shown in Figure 7, where is added a third block to a DBT that was initially composed of two blocks.



Source: ALVAREZ et al., (2003).
Figure 7: Block Numbers and Efficiency

HOUSTON (1982) states that, there are numerous pitfalls associated with the use of a DBT structure. In general, the informational requirements to estimate the consumption and revenue effects with block pricing are far more imposing than for a single-priced good. Accurate revenue predictions are quite difficult to make with the block structure. In times of continual upward adjustments in the rate schedules, the DBT may have been responsible for some unexpected adverse revenue effects for utilities like damping or overestimation.

3.3.2.2.4 Equity

Concerning equity DBTs are not advisable. Larger water-users as a class, tend to have lower peak factors with characteristically lower extra capital requirements and related costs than do the smaller users as a class, the DBTs would often be in accordance with the cost of providing service to the respective classes. DBT have paradoxical results, very large domestic users of water may end up facing a significantly lower marginal and average price than the low-volume user who makes very few claims on peak capacity. If the larger consumer has, as is more than likely a much higher income, the resulting cross-subsidisation will be at variance with all conceivable notions of equity as well as reflecting serious distortions in the use of the resource (OECD 1987, p 42)

DBTs can be justified in the two circumstances. First, when users have very different levels of consumption. A consumer several times bigger than the average consumer does not create costs several times higher, because there is only one pipe line, one billing process and, since cost per volume is lower with large consumers, it is justifiable to propose DBTs in case of heterogeneous users. And second, in order to incite users to stay in the utility. DBTs do not have the negative incentive of encouraging users who have access to alternative water sources to quit (partially at least) the network as IBTs do (TIDBALL and TERREAUX 2008, p3).

3.3.2.2.5 Political Feasibility

According to O'DEA and COOPER (2008, p 27), DBTs are not as simple to design. As a block tariff there are problems in determining the number of blocks, the size of the blocks and the price levels of each block. Nevertheless, once implemented, a DBT is likely to be relatively simple to administer. It is politically unattractive for the consumers; it is likely to be a difficult structure for customers to understand, consumers are unlikely to know in which consumption block they are and, consequently, which price they are paying at each point in time.

3.3.2.3 Empirical findings related to Decreasing Block Tariffs

Based on diverse experiential findings and the examples given above, DBTs evaluation is presented in this part.

3.3.2.3.1 Effectiveness

The effectiveness of the DBT structure as water conservation measure will depend on demand price elasticity. The price the consumers pays for water can have a significant effect on the amount of water used. To influence water consumption, economists have attended to show on the consequences of block schemes, paying attention to the demand estimation (ASHMORE 1989, p 1). There are many opinions concerning the appropriate methodology for estimating water demand based on the model of consumer behaviour developed by TAYLOR (1975) and modified by NORDIN (1976) (Both explained in IBT section), as an example SHIN (1985) introduced the price perception variable, in addition to the marginal price. SHIN'S (1985) price perception model showed that consumers respond to average prices rather than marginal prices when faced with DBT structures. NIESWIADOMY and MOLINA (1991) used a price perception model to compare IBTs and DBTs and conclude that customers react to marginal prices when facing IBTs and to average prices when faced with DBTs.

TATE and LACELLE (1995, p 17) the low percentage of municipal water connections in Canada (< 45%) is an impediment for water conservation. LOUDON (1986, p 3-4) cited experiences in several Canadian municipalities; it appears that metering alone could reduce municipal water use by 15% to 20% over pre metering levels. Consumers therefore have a basic incentive to conserve their use of water. In terms of domestic water use per capita, Canada is a relatively high water user, with 360 litres per capita per day. MILLER and VAILLANCOURT (2006, p 151) add that for the residential consumers, the deviation between marginal cost and average price generate deadweight loss estimates per unit of output. Under pricing water and sewerage generates a higher level of consumption than its allocative efficiency. The effect of the prices and the predominant Canadian restructuring practices are significant in their water use effects, consumer receive wrong signals about the value of water.

In Taiwan the tariff used is not effective; it appears that water charges are too low to significantly dampen consumers demand in all sectors. There are no incentives to conserve water. (DINAR and SUBRAMANIAN 1997, p 118)

3.3.2.3.2 Cost Recovery

In Canada there is a high demand of water. A high demands means that operating and maintenance cost are inflated, the under pricing fail to reflect the total cost of the system. the deteriorating conditions of the water infrastructure is proof of these, DBTs fail to recognise large water users as the ones who are primarily responsible for overall system capacity design and costs (DINAR and SUBRAMANIAN 1997, p 41)

In Taiwan water charges are too low to fully recover the costs. This can be observed in Table 9 presenting data on unit costs of supplying water (Total cost) and water charges (price). (DINAR and SUBRAMANIAN 1997, p 118)

	Production cost	Sales cost	Administrative cost	Financial cost	**Total cost**	Price	Revenue
1988	4.43	1.16	0.25	0.57	**6.41**	6.28	(0.13)
1989	4.46	1.09	0.28	0.57	**6.40**	6.31	(0.09)
1990	4.83	0.89	0.29	0.59	**6.60**	6.33	(0.27)
1991	4.84	0.96	0.31	0.53	**6.64**	6.35	(0.29)

Source: DINAR and SUBRAMANIAN (1997).
Table 9: Unit Costs of Supplying Water and Charges in Taiwan (NT$ per m³)

3.3.2.3.3 Cost-Effectiveness/ Efficiency

In Canada the tariff system is inefficient. Efficiency is achieved when the price is set to the cover marginal cost, but the average price of water for residential consumers Can$ 0.32 per cubic meter is under the estimated marginal cost of Can$ 0.87 per cubic meter. In the case of sewerage treatment also the average marginal cost was Can $ 0.52 per cubic meter is higher than the average price of Can$ 0.13. The high percentage of unmetered connections also increases the inefficiency of the tariff system (MILLER an VAILLANCOURT 2006, p 150).

In Taiwan the tariff used is not efficient, as is shown in Table 9, there are no revenues obtained by the utility during the period 1989-1991 (DINAR and SUBRAMANIAN 1997, p 118)

There are empirical evidence from Indonesia and Thailand, which switched their tariffs from a DBT structure to an IBT, maximising the welfare gain from the switch and being beneficiated with savings in total operating costs. It is not justified to implement DBTs structures in developing countries (ANAS et al., 1996, p 19-20)

3.3.2.3.4 Equity

The situation of the water sector in Canada: prices are generally based on average cost, peak load demand is not taken into consideration and the distance from the source of supply is not captured; not only lead to an inefficient allocation of the resource, but also is unfair on the basis of benefits received. Customers whose price exceeds marginal costs subsidize those whose price is below marginal cost. Considering utilities, when smaller versus large utilities were compared the discrepancy between price and marginal cost was higher for the small utilities (MILLER an VAILLANCOURT 2006, p 151).

3.3.2.3.5 Political Feasibility

The implementation of DBTs in Canada is supported under the assumption that is a part of the multipart pricing policy used. It is appropriate for the local utilities services that have significant fixed production costs and declining average and marginal costs. But it is not popular between the residential consumers (MILLER an VAILLANCOURT 2006, p 151).

3.4 Two Part Tariffs

This tariff has two charges or parts. The tariffs review above can be used as one of the charges of the two part tariff.

3.4.1 Design and Description of Two Part Tariffs

This type of tariff was first suggested as a model in the later years of the nineteenth century by Dr. John Hopkinson in the electricity industry. Then it was adapted to the telephone system where it is the principal method of pricing nowadays. Finally it was adopted as a water price system. The essence of the two part tariff is that the consumer is called on to pay two charges, one which varies directly with the amount of the commodity that he consumes, and another which does not (LEWIS 1941).

LE BLANC (2008, p 6) points out those two-part tariffs are composed of:

• A variable charge reflecting the marginal costs of providing an additional cubic meter of water for the utility.

• A fixed charge intended to cover the no attributable portion of the costs that is independent of the quantity consumed (fixed costs of production and distribution), as well as ensuring that the utility can break even.

WHITTINGTON (2006 p 24) states that there are many variations in the way these two components of the two part tariffs, can be put together. The fixed charge can be either positive (a flat fee) or negative (a rebate) and the water use charge can be based on any volumetric tariff. ARBUES et al., (2003, p 82) adds that in Two part tariffs, the fixed charge entitles to consume the good, while subsequently consumers pay an additional smaller amount per unit. The variable charge can be non-linear itself, if the cost per additional unit varies when consumption reaches certain thresholds, the tariff consists of a sequence of marginal prices for different consumption blocks (IBTs or DBTs). According to ROGERS et al., (2002, p 6), several OECD countries, for example Australia, Austria, Denmark, Finland and the United Kingdom, with successful water pricing schemes use a two-part tariff structure. In these countries the fixed charge varies according to some characteristic of the user, and the variable part often uses average cost pricing (OECD, 1999). Four issues are the balance between the fixed and variable charges in a two part tariff: the short run and long run marginal cost pricing for the variable charge, the possibility to peak-load or seasonal pricing, and the possibility of non linear structures (BISHOP et al., 1994, p 131).

3.4.2 Examples from Developing Countries

To exemplify the structure and use of two part tariffs, two examples are presented. The first example is from Argentina and the second example is from El Salvador.

3.4.2.1 Two Part Tariff in Argentina

In Argentina, in the 90s metered tariff system was incorporated based on a two part tariff. The fixed charge includes a minimum consumption charge calculated by a formula and the variable charge is a function of m³ consumed in excess. The process of privatisation of services adopted this two par tariff system, but with a target goal of convert the fixed charges into volumetric charges. The actual average tariff of potable water is \$ 0.48 / m³, and the sewerage tariff is \$ 0.31 / m³ (including the value added tax, maintenance fees and taxes and provincial or municipal regulatory fees). Pricing structure offered by the utilities of potable water and sewerage in Argentina, are based in the scheme of "free-faucet". The tariff structure is also characterized by cross-subsidisation. (CALCAGNO et al., 2000, p15).

Charges / Utilities	Fixed charge Water	Fixed charge Water & Sewerage	Volumetric charge Water	Volumetric charge Water & Sewerage
Aguas Argentinas S.A	\$4,07	\$8,15	\$4,07	\$8,15
Aguas Cordovesas S.A	\$9,81	Without sewerage	\$5,08	Without sewerage
Aguas de Corrientes S.A	\$11,18	\$16,77	\$5,94	\$10,26
Aguas de Formosa	\$14,97	\$26,94	\$13,89	\$25,00
Aguas de Salta	\$8,76	\$12,18	--	--
Aguas de Santiago	\$10,08	\$18,17	\$8,71	\$15,69
Aguas Provincia Santa Fe	\$6,51	\$13,02	\$4,68	\$9,34

Source: CALCAGNO et al., (2000).

Table 10: Water Tariff Structure in Argentina (1999)

The water tariffs structure presented in Table 10 shows the minimum tariff per month for the services. All the utilities adopted the two part tariff structure. Water tariffs are assigned by the political power of every jurisdiction not by the utilities; they do not have the autonomy of determine tariffs.

3.4.2.2 Two Part Tariff in San Julian- El Salvador

According to LINARES (2001, p 62), In San Julian the tariff structure used by residential consumers is a two part tariff. San Julian's Municipal Council Decree published in 1998 the legal framework for water tariffs for the utility. This decree defines the consumption tariffs, and the fixed charges of the two part tariff used. All of these charges and fees are currently in use in San Julian (the rate increases require approval of the board and the Municipal Council).

The consumption charge is based on meter readings and includes a progressive tariff (IBT) structure as follows:

- From 1 to 20 m^3 \$0.08/m^3
- From 20.01 to 30 m^3 \$0.14/m^3
- From 30.01 to 40 m^3 \$0.23/m^3
- 40.01 m^3 and above \$0.28/m^3

Public water fountains, schools, and health clinics pay \$0.11/m^3. Tariffs for the municipality have not changed since 1998.

The fixed charge of the tariff is the base amount and includes depreciation, maintenance, and sewerage services. It is calculated as follows:

- System depreciation \$1.10
- Maintenance \$1.44
- Sewerage system \$0.57
- Total Fixed Charge \$3.11

3.4.3 Theoretical Evaluation of Two Part Tariffs

Information from different literature is used to support the objectives that two part tariff can fulfil.

3.4.3.1 Effectiveness

According to ROGERS et al., (2002, p 6), the volumetric charge component of the two part tariff, give a price signal to consumers. They pay according their consumption level, this encourages water conservation. Generally the move from single part tariffs towards two-part tariffs resulted in a decrease in overall water consumption.

3.4.3.2 Cost Recovery

According to LE BLANC (2008), if tariffs were to reflect costs due to the structure of costs of utilities, the prevalent type of tariffs structure could take the form of a two-part tariff. ASHOKA (1996, p 133-134) adds that in some cases a two part tariff are better designed, based on efficient prices and yet recover total cost. The simple version of this tariff structure involves charging the users a constant price per unit to buy any positive amount of the service (FELDSTEIN 1972). The total cost of the enterprise is thus recovered by a non-distortion lump sum access charge on the users, who are then induced to consume in efficient quantities. But a two part tariff mechanism that is based on efficiency prices and that covers total cost is likely to conflict with social objectives. Thereafter a financing plan based on efficiency that adjusts for equitable coverage will require subsidies to cover total costs. In many cases, the fixed charge of the two part tariff is kept uniform across customers, and is used simply as a device for recovering the fixed administrative costs associated with meter reading and billing that are unrelated to the level of water consumption (WHITTINGTON, 2006, p 24).

3.4.3.3 Cost-Effectiveness/ Efficiency

The two part tariff structure has therefore been considered as capable of achieving long run efficiency. A two-part tariff has often been advocated and practiced in situations where a public authority or regulated enterprise must cover total costs but produces with marginal cost below average cost. If the marginal price is set equal to the marginal cost, and the resulting annual charge does not cause any potential consumers to prefer no purchase at all, the allocation of resources is Pareto efficient. If distributional considerations were irrelevant, the pricing problem would be solved. However, marginal cost pricing in a two-part tariff has been criticized because the fixed price part is essentially a regressive head tax. What is needed is a pricing rule that balances efficiency and distributional equity subject to the constraint that every consumer must pay the same marginal price and fixed charge (FELDSTEIN 1972).

Two-part and multipart tariff structures have been justified on efficiency grounds for two reasons (1) there is a cost associated with connecting a customer to the distribution network and a fee for access to the network is an efficient way to recover that cost. This justification needs to be modified if there are external effects; for example, connecting more consumers to the distribution network raises the value of the network, and so fixed fees for connections might reasonably be subsidized. The other reason is (2) production in water industry is subject to increasing return to scale. Uniform prices set at marginal costs would not cover costs, while higher prices would distort welfare. Two part and Multipart tariffs are used to meet the budgetary constraint and still allow marginal prices equal to marginal costs. This justification has not been found empirically (SHERMANN and VISSCHER 1982).

ROGERS et al., (2002, p 6) add that the fixed charge of the two part tariff protects the supplier from demand fluctuations and reduces financial risks. The fixed charge is set to make up the shortfall between the revenue from a marginal cost price and the revenue needed to cover total costs. For the fixed charge to be efficient it's allocation across consumers should be in such a way that each consumer's share of the fixed charge is less than his total benefit from water provision (low fix charge must be levied on those with low surplus from water provision). In most realistic allocations each consumer's fixed charge is much less than his total surplus, but to identify the consumer's total surplus to determine the efficiency of the fixed charge, is an important practical problem.

3.4.3.4 Equity

LE BLANC (2008, p6) shows that the simplest two-part tariff structure consists of dividing the fixed costs equally among the consumers, and charging the marginal cost on all units consumed. If all consumers were identical, it would make sense to provide the service as soon as the net surplus of consumers is positive. However, in practice consumers differ in income and tastes. LEWIS (1941) points out that two part tariff are a form of price discrimination. The effect of making the same fixed charge to all consumers is to discriminate against the small ones. To avoid discriminating against small consumers, sometimes, the volume charge has the effect that larger consumers are made to pay higher average price per unit than the smaller. So every consumer is getting every unit for which he is prepared to pay marginal cost.

SIBLY (2006, p 232) states that, there is no requirement for the fixed charge of the two part tariff be equal across consumers. Indeed, efficiency may require that the charge vary across consumers, if it turned out the fixed charge could be relatively large. This means that for reaching the efficiency criteria, low fixed charge must be levied on those customers with a low surplus from water provision. It is concepts of equity, rather than efficiency that have often dominated the allocation of the fixed charge. ASHOKA (1996, p 133) adds that not only is the fixed charge of the tariff insensitive to the needs of the poor, but social concerns also make it necessary to apply a lifeline charge for services as water, this allows a subsidised charge up to a threshold amount with charges at marginal costs.

3.4.3.5 Political Feasibility

Two part tariffs are widely promoted by the World Bank; they are recognized as feasible in services markets. The two part tariff is characterized by being simple the design is better structure than other tariffs. Since the simplicity of tariffs constitutes a relevant aspect, letting users being familiar with them, helping to improve the effectiveness of price as an instrument of demand management. According to LEWIS (1941) two part tariff can be of great benefit to public, all is needed is an adequate control to prevent abuse of the power it confers to those who use it. They have the advantage of transparency compared to volume-based subsidies (GARCIA-VALIÑAS 2005, p 135).

3.4.4 Empirical Findings of Two Part Tariffs

Based on experiential findings and the examples given, the evaluation of two part Tariff is presented in this part.

3.4.4.1 Effectiveness

CALCAGNO et al., (2000) points out that used of cross-subsidies in Argentina in the water tariff system don't give a price signal to residential consumers. This discourages rational use of water. There is also the idea of abundance between the consumers.

LINARES (2001, p 66) states that the abundance of water resources in San Julian, allows more flexibility in managing the system and takes away the urgency of managing the resource. The idea of abundance discourages the rational use of water. The tariff system is tries to make people conscious about the benefits of water conservation. Given widely publicized water shortages in many places, national level entities and policymakers are just beginning to become aware of the need to introduce more measures at the national level for preserve the resource. Watershed management and aquifer protection are still lacking, even though statutes require that revenues be set aside to that end. The obstacle has been the lack of negotiation skills and creativity to implement incentives, that would motivate landowners (in critical watershed areas) to work with the municipality in reforestation and soil conservation activities to protect aquifers that are the source of potable water for San Julian.

3.4.4.2 Cost Recovery

According to CALCAGNO et al., (2000, p 113), in general, tariffs are barely sufficient to cover the operation and maintenance costs of systems. The average annual cost per user for drinking water and sewerage is $ 203.19 per year per, this means $ 16.9 per month, this is higher than the minimum tariff per month for water and sanitation is approximately $16.3 per month.

LINARES (2001, p 53) states that in San Julian, the overall financial health of the Water Utility is excellent. It began operations in April 1998, and the results shown below demonstrate that the utility could recover their costs. The fixed fee recovers also the investment in a 25-year period. The fixed charge represents 2.3% of minimum wage ($137 per month) in San Julian.

Financial Data for April to December 1998 (9 months):

- Revenues were on the order of US$ 33,257, averaging US$ 3,700 per month.
- Operational expenses were US$ 23,200, with an average of US$ 2,571 per month.
- Excess revenue for the period was US$ 10,000; the Water Company invested it in operational improvements and expansion of services.
- Revenues US$ 33,257
- Expenses (O&M) US$ 23,200
- Excess revenues US$ 10,000

Financial Data for January to December 1999 (12 months):

- Revenues were US$ 50,424, an average of US$ 4,200 per month.
- Operational expenses were US$ 38,574, or US$ 3,215 per month.
- Excess revenue for the year was US$ 11,850. The Water Company invested all excess revenues in operational improvements, resource conservation, and expansion of services.

- Revenues US$ 50,424
- Expenses US$ 38,574
- Excess revenues US$ 11,850

3.4.4.3 Cost-Effectiveness/ Efficiency

According to CALCAGNO et al., (2000, p 63), in Argentina the tariff system do not produce enough revenues. The total costs are less than the minimum tariff that should be used by utilities. But utilities have no autonomy to increase the tariffs per se. The fixed part of the tariff is not enough to get revenues for reinvestment in the utilities. Furthermore, the system generates cross-subsidisation that leads to inefficient and often inequitable investment decisions. The deficient operative situation also has lead to a decapitalisation. The transition process to a private sector improved substantially the situation in terms of tariffs adjusted to the real costs of services.

According to LINARES (2001, p 44), In San Julian, the tariff system used is efficient. Since beginning full operation in 1998, the company has been very successful. Most of the population (96%) has access to the municipal water supply system and every household connection is metered. Service is provided 24 hours per day. As it is shown above, user fees cover all recurrent costs and depreciation, and generate excess revenues to finance modest system expansion.

3.4.4.4 Equity

According to CALCAGNO et al., (2000), the tariff system in Argentina is fair. To apply this tariff, consumers are divided in two groups the residential consumers and non-residential consumers (industrial, commercial and governmental). To each group, a different tariff is applied according to their consumption and their sub category.

LINARES (2001, p 54) states in for San Julian, the tariff structure are fair, an equal. They is a high level of acceptance between the consumers.

3.4.4.5 Political Feasibility

According to CALCAGNO et al., (2000, p 66), the applied regulating tariff systems are complex and require a great quantity of information in the process, so they are expensive , complex and difficult to administer to small and medium size services. For the regulation of the system there are some serious institutional and operational weaknesses, the tariff system require measures that enable the tariff being sustainable in the long term and achieving the objectives of improving their levels of efficiency.

LINARES (2001, p 54) shows that for San Julian, the popular support that was generated in favour of the creation of the Water Company, through a participatory and transparent consultation process helped the company to succeed. This created the support to pay higher tariffs for better service. The Water Company’s autonomy over operational and financial matters and separation from the municipality are the primary reasons for its success. The freedom to operate has allowed the company to flourish.

4 Case Study: Lima

4.1 Introduction

This case study is a collection of data from various sources such as utilities, regulatory entities, ministries and related institutions. Lima has been chosen as a subject for this study because of its exemplary situation in the water sector. It ranks as the second driest city in the world (after Cairo), it is built in a very arid zone and thus water scarcity in many regions is severe and innovative approaches to tackle these problems are urgently needed. Furthermore, the author of this paper was born in Lima and has person experience about the water conditions.

4.2 Background

According to KENDALL (2005, p 92), the population of Lima is difficult to account, but is somewhat more than 8 millions. A large proportion of the total Peruvian population that is approximately 28 millions. The urbanized area of the city is constrained by the Andes mountain chain, which runs parallel to the coast. The future growth is likely to be along this strip of desert and in the three adjacent river valleys: Chillon, Rimac and Lurin. One consequence of this is that Lima is very spread out, covering 2,800. km ^{2}.

Lima is a water-scarce area, with an extremely low average rate of precipitation: less than 15 mm of rainfall a year. Lima is extended into the desert, occupying almost completely the valleys mentioned before (Rímac, Chillón, and Lurín). The river flow through this region is strongly seasonal; the average availability of surface water was estimated as 2,885 m^3 per capita in 1996, compared with an estimated world average of 8500 m^3. Furthermore, water problems will increase in the future due to climate change. Water flows of coastal rivers will become more irregular, because of two main reasons: the glaciers of the Andes are melting fast and deforestation and erosion of the Andean soil is increasing (ALCÁZAR et al., 1999).

The sources of Lima's water supply are the rivers of Rímac, Chillon and Lurin. The Rimac River is the main source of water for the city. Since 1970, the water supply became a problem for Lima, due to falling groundwater tables. The districts of central Lima are settled in former agricultural land, while most peripheral districts have settled in lands that never had natural water. Since the 1980s, the utility that supplies water to the city of lima SEDAPAL (Servicio de Agua Potable y Alcantarillado de Lima - Lima's Drinking Water and Sewerage Service) became increasingly unable to meet the growing water demand. Under-financing led to under-maintenance and to under-expansion of the system. In 1990, the water system was in a state of near collapse. There was severe rationing and frequent interruptions of the service, while water became unsafe to drink (ALCAZAR et al., 1999)

In 1994, the sector was opened to private capital and the government created a regulatory body called SUNASS (Superintendencia Nacional de Servicios Sanitarios – National Superintendence of Sanitary Services). The privatization did not work out well. Lima's geographic location (which demands high production costs) and the mismanagement of the utilities obstructed the process. After heavy debates and street demonstrations against privatization, it was decided to conduct a process of reform and regulation. As a result, SEDAPAL became the responsibility of the national government. The cholera epidemic that affected Peru at the end of the 80's raised the awareness of the importance of water. Extending the water networks to the peripheral areas of Lima became one of the missions for SEDAPAL. Low tariffs for water services; lack of metering connections and low rates of bill collection had left SEDAPAL with neither the incentive nor the resources to expand or maintain the system. The situation of the water sector, do not give the incentives to consumers to control their water consumption except during rationing (FERNANDEZ-MALDONADO 2008, p 1889).

4.3 Challenges in the Lima Water Sector

Considering the background of the water sector in Lima, there are problems to be solved and areas to be develop by the government and utilities in Lima. There are various challenges in the Metropolitan Lima water sector; many of these are influenced by each other. This paper presents a hierarchy of problems and grouping them for the analysis respectively. These problems are the low availability of water, the poor infrastructure of the system, the high demand of water and an ill-designed tariff system.

4.3.1 Water Availability

The low availability of water in Metropolitan Lima is one of the characteristic of the water sector. The water resource is limited because the city is located in an arid zone and is mainly supplied by rivers originated in the highlands. There are two main sources of water in Lima surface water and Ground water.

4.3.1.1 Surface Water Availability

The surface water resources of Metropolitan Lima come from the Rímac, Chillon and Lurín Rivers. By 2007, nearly 75% of the water supply in Lima came from the discharge of the Rio Rimac (32 m^3/s), which is nearly in its entirely diverted and treated for its distribution at the "Atarjea" water treatment plant. Nowadays, the total supply of water in Lima averages 42.5m^3/s (LEAVELL, 2007, p 2). The major part of the water available in the city is used for human consumption (75%), followed by agriculture (22%) and industrial and mining activities (3%). During flooding of the Rimac River in high flow periods10 m^3/s are lost to the sea. In the Chillón River, such losses amount to about 2 m^3/s.The average gradient of the Rio Rimac is more than 3 % and flows from the wetlands, lakes and melt glacier water of the Mountain ranges (INRENA 2005, cited by FERNANDEZ MALDONADO 2008, p 1895).

There are some factors that affect the availability of the surface water in Lima. The first important factor is the melting Glaciers of the Andean mountains. In Peru almost every river systems spring comes from the high Andean ecosystems. Precipitation in the highlands where the river has its origin is significant and during the wet season more than 12m³/s bypasses water treatment plants and flows to the sea. Irrigation, potable water and hydropower systems depend on the water regulation capacity of the ecosystem. Glaciers and high meadows of the 17 mountain ranges of the Andes are the starting points of many water sources. Peru has more glaciers in its mountains than any other tropical country, but the area covered by ice is rapidly decreasing (RECHARTE et al., 2002, p 17). In the1960s the area covered by ice was 2041 km², but a second estimate in 1997 showed coverage of only 1596 km², a reduction of nearly 22% in less than 30 years (AMES et al., 1989). The earth is entering in a period of progressive glacial melting process that began approximately 150 years ago. All the glaciers examined are in negative balance. This will gradually affect the availability of water for the lower river basin ecosystems. Approximately 98% of the available water in Peru comes from the eastern slope. The remaining 2% comes from the western slope, where approximately 67% of the Peruvian population inhabits. Only 68.9% of the coastal population has potable water. Conservation in the upper river basins is therefore a vital issue for the country's major cities such as Lima (RECHARTE et al., 2002, p 17).

The important factor is the deforestation and erosion of the soil in the upper river basins. Forests give services to the ecosystem, which directly affect the availability of water. These services are the storage capacity for dry seasons and the decrease of peak discharges. Deforestation in the upper river basins breaks the flow of services, diminishing the availability of water and causing erosion. The high Andean soil erosion aggravates the problem of availability of water that is normally produced by these ecosystems. Transportation and deposition of sediments is a natural process that can be modified (accelerated or decelerated) by human intervention. Its impact varies, including the destruction of irrigation infrastructure, the rising cost of potable water treatment, the damage in agricultural production and flooding (RAMIREZ and CISNEROS 2007, p 46).

In the last years the Lima water utility (SEDAPAL), has begun the importation of water from reservoirs in the mountainous basins to the east, with the expectation that glacial melt waters will recharge the lakes and reservoirs of these regions. Reservoirs have been constructed in the upper sub-basins of Rio Santa Eulalia and Rio Blanco. These two rivers contribute to the bulk of Rio Rimac. In the mid 90s a series of projects were conceived to increase the supply of water to each of these two sub-basins by constructing aqueducts to bring water from across the continental divide from the headwaters of the Rio Mantaro

(Junín-Andean Mountains). These staged projects (Marcapomacocha I-V) are planned to modify existing lakes into storage reservoirs and gather the resources of the headwaters of the Mantaro River. Water would then be transferred by tunnels across the divide, into the basin of the Rimac River (LEAVELL 2007, p 4).

4.3.1.2 Ground Water Availability

The underground water in Metropolitan Lima comes from the filtration of the Rivers Rimac, Chillon and Lurin. The aquifers have been overexploited, resulting in rapidly falling water levels. The estimated average abstraction from the aquifer increased from 1 m^3/s in 1955 to 12.4 m^3/s in 1997. From this 9 $m^3/$ abstracted were from wells operated by SEDAPAL, and the remainder from private owned wells. Local contamination issues result both from land usage, wastewater infiltration and salt water intrusion in many areas, and have forced to abandon several wells. In addition to SEDAPAL's wells (458), nearly 2270 large private wells are used to supply industry and several municipalities. These result in an unsustainable exploitation of the aquifer where water levels were reduced by 15-30 m^3. In the last years some specific actions, such as reduction in the exploitation volume, were applied. The extraction of the aquifer were reduced from 9 m^3/s in 2001 to 8.3 m^3/s by 2002 (QUINTANA and TOVAR, 2002).

4.3.1.3 Water Supplied by SEDAPAL

From the water that is supplied by SEDAPAL, 77 % come from surface water sources. SEDAPAL have two potable water treatment plants "La Atarjea" and "Chillon Plant", "La Atarjea is the most important treatment plant. They capture water from the rivers Rimac and Chillon respectively. The Atarjea plant has a treatment capacity of 20 m^3 / s. During drought seasons; there is a lack of resource availability, as a consequence the production decreased. The Chillón river treatment plant has a treatment capacity of 2.5 m^3 / s. It operates only in flood seasons (April to December) when the source is available, reaching an average production of 1 m^3 / s (SUNASS 2007, p 27-29).

SEDAPAL uses 23% of ground water sources for water purification. Groundwater sources come from a total of 458 wells, located in different areas under SEDAPAL influence. Only 203 wells are in service. These wells supplement the surface water supply of the Rimac River with nearly 8.5 m^3/s of water. Because of the over exploitation of the aquifer, SEDAPAL has considered taking specific actions such as a reduction in the volume extracted, a restriction on new wells drilling and the implementation of induced infiltration projects. In 1997, a hydro-geological evaluation of the Rimac and Chillon aquifers revealed that the extracted volume limit should be 8 m^3 / s. nowadays it is extracted from the Rimac and Chillon aquifers 7.1 m^3 / s, among SEDAPAL and other users (SUNASS 2007 p, 29-30).

The quantity of potable water produced by SEDAPAL in the last years is shown in Table 11. By the first months of 2008 the quantity of potable water produced decreased compared with the first months of 2007. In February 2008 the production decreased in 0.5% compared to January 2008. In January 2009 the production has reached increased in 3.8% compared with January 2008. The volume produced by SEDAPAL is consistent with the projection of the water demand that will be explained afterwards in this paper.

Month	2006	2007	2008	2009
January	60.120.7	59.290.4	57.453.0	59,658.9
February	55.841.1	55.464.3	55.212.6	-
March	61.385.4	60.932.4	58.962.8	-
April	56.327.3	57.574.1	56.744.8	-
May	56.272.5	56.639.6	54.695.1	-
June	52.552.1	52.020.0	50.875.9	-
July	52.920.4	51.433.5	54.068.9	-
August	52.760.6	49.886.0	52.698.2	-
September	51.570.5	49.111.4	52.167.2	-
October	54.167.8	52.334.0	54.402.3	-
November	53.760.9	51.642.6	53.909.6	-
December	57.125.6	54.433.8	57.558.4	-

Source: INEI (2009)

Table 11: Monthly Potable Water Production from SEDAPAL in Thousand m^3 (2006-2009)

4.3.2 Infrastructure

The poor infrastructure of the water system is another important characteristic of the Metropolitan Lima water sector. The infrastructure of the water system is composed of the potable water coverage, sewerage coverage, micro metering, and continuity of supply, water losses and waste water treatment. On the request of SUNASS, in 2005 SEDAPAL submitted a proposal including all necessary investment to be covered by rate increases during the period 2006-2011. By July 2006 SUNASS and SEDAPAL achieve an agreement on this master plan and was put into action. This master plan contains the performance indicators of the water system infrastructure. These performance indicators measure the fulfilment of the targets that should be reached by the infrastructure components within this period.

4.3.2.1 Potable Water Coverage

The coverage of potable water refers to the proportion of the total population of the area managed by the utility that are connected to the network. In 2006, there were approximately 1 million inhabitants in Lima without water service. The percentages from the two national censuses of population and housing in1993 and 2005 give an idea of the improvements in water coverage in Metropolitan Lima, see Table 12. During this period water connection coverage (which includes 1+2+3) improved from 81.78% to 89.03% (FERNANDEZ-MALDONADO 2008, p 1891).

Types of water provision		1993	2005
1	Connection to public network within the home	66.65%	78.03%
2	Connection to public network out of the home, but inside the premises	8.01%	6.19%
3	Public standpipes	7.12%	4.81%
4	Water trucks	12.93%	8.50%
5	Water wells (ground water sources)	3.34%	1.43%
6	Superficial water sources	0.64%	0.18%
7	Other source	1.3%	1.85%

Source: INEI (1993); INEI (2005).

Table 12: Evolution of the Water Provision in Lima

One of the challenges facing the Lima water sector is to increase the coverage of potable water service. Based on the master plan for the years 2006-2011, Table 13 shows the estimated water coverage for the period 2007-2009, based on the annual increment in numbers of potable water connections, compared with the executed water coverage per year. Also it is shown the drinking water coverage reached per year.

Annual Increase in Potable Water Connections (#)[13]	**Year 1[14] 2007**	**Year 2 2008**	**1st Quarter of 2009**	**Year 3 2009 (total)**
Estimated	38.439	40.886	5500	43.520
Executed	17.519	66.251	5600	-
Coverage (%)	89.9 %	91 %	92%	-

Source: (SUNASS-2008; SEDAPAL 2008; FONAFE 2009; SUNASS 2006, SEDAPAL 2007)

Table 13: Potable Water Connections in Metropolitan Lima 2007-2009

From this table can be observed that the first year (2007) the target was not reached. The second year (2008), the target could be reached and the drinking water coverage increase to 91%. For the first trimester of 2009 the target was reached and the water coverage until

[13] The SEDAPAL estimations are calculated in numbers of new connections per year.
[14] Each year begins in July and ends in July next year. (year 1= July 2006- July 2007)

this time of the year increase to 92%. The goal is to reach 100% of potable water coverage for the year 2011 (SEDAPAL 2008).

4.3.2.2 Sewerage Connections

Another challenge that faces the Lima water sector is to increase the number of sewerage connections. Table 14 shows the comparison between the estimation and the execution of the increments in sewerage connection. Also, the sewerage coverage per year is presented.

Annual increase in sewerage connections (#)	**Year 1 2007**	**Year 2 2008**	**1st Quarter of 2009**	**Year 3 2009 (total)**
Estimated	39.999	42.567	4100	45.213
Executed	10.957	58.295	5500	-
Coverage (%)	86%	86%	90%	

Source: (SUNASS-2008; SEDAPAL 2008; FONAFE 2009; SUNASS 2006, SEDAPAL 2007)

Table 14: Sewerage Connections in Metropolitan Lima 2007-2009

From this table can be observed that the first year (2007) the target was not reached. The second year (2008), the target could be reached and the sewerage coverage increase to 86%. For the first trimester of 2009 the target was reached and the sewerage coverage until this time of the year reached 92%. The goal by the year 2011 is to reach 100% of sewerage coverage (SEDAPAL 2008).

4.3.2.3 Micro Metering

Water metering is desirable in order to establish a positive marginal consumption price. It is economically rational to establish metering wherever the economic opportunity cost of water released by metering is greater (WALKER et al., 1999, p 5). To increase the percentage of metering is another challenge faced by the Lima water sector. Based on the master plan for the years 2006-2011, Table 15 shows the comparison between the projected and the executed percentages of micro metering in the period 2007-2009.

Micro metering (%)	**Year 1 2007**	**Year 2 2008**	**1st Quarter of 2009**	**Year 3 2009 (total)**
Estimated	72.3%	74.8%	69.4%	77.6%
Executed	72.7%	76%	70.0%	-

Source: (SUNASS-2008; SEDAPAL 2008; FONAFE 2009; SUNASS 2006, SEDAPAL 2007).

Table 15: Micro Metering in Metropolitan Lima 2007-2009

The target for the first year (2007) was reached as it is shown in Table 15. The second year (2008) and the first trimester of 2009 the targets were reached. The goal by the year 2011 is to reach 100% of sewerage micro metering (SEDAPAL 2008).

4.3.2.4 Continuity of Supply

According to SEDAPAL (2008), Lima's population is affected by problems water quality services. Continuity is an indicator of quality of water service supply. The continuity of service is weak and better infrastructure maintenance is needed in urban areas. There are high rates of breakage and stoppage in the distribution system. Another challenge faced by the Lima water sector is to increase the hours of water supply.

Continuity (Hours/day)	**Year 1 2007**	**Year 2 2008**	**1st Quarter of 2009**	**Year 3 2009 (total)**
Estimated	21.5	21.6	21.4	21.7
Executed	21.3	21.68	21.6	-

Source: (SUNASS-2008; SEDAPAL 2008; FONAFE 2009; SUNASS 2006, SEDAPAL 2007).

Table 16: Continuity of Water Supply in Lima 2007-2009

The estimated continuity for the period 2006-2011 is compared with the executed continuity of water supply. Table 16 shows that the target for the first year was almost reached. For 2008 and the first semester of 2009 the targets were reached. By the year 2011 the expectations are to reach a continuity of 23 hr/day (SEDAPAL 2008).

4.3.2.5 Water Losses

There are many definitions of how to get the percentage of water losses. One approach states that the quantity of water losses can be obtained from the difference between the measured production delivered to the distribution system and the measured consumption. Another approach expresses water losses as a percentage of the water produced. SEDAPAL uses the first approach. It is important to mention that a high micro metering level allows to a more reliable analysis of water losses (YEPES and RINGSKOG 2001, p 15).

A better control on water losses is another challenge faced by the water sector in Lima. Table 17 shows the estimated percentages compared with the executed percentages of water losses in the period 2007-2009.

Water losses (%)	**Year 1 2007**	**Year 2 2008**	**1st Quarter of 2009**	**Year 3 2009 (total)**
Estimated	38.8%	36.5%	35.8%	34%
Executed	38.2%	36.3%	36.3%	-

Source: (SUNASS-2008; SEDAPAL 2008; FONAFE 2009; SUNASS 2006, SEDAPAL 2007).

Table 17: Water Losses in Metropolitan Lima 2007-2009

From this table can be observed that in each period the targets were reached. Despite of the results, around 36% of water losses is an indicator of deficiency in the infrastructure. The goal of SEDAPAL is to reach only 30% of water losses by the year 2011 (SEDAPAL 2008).

4.3.2.6 Waste Water Treatment

SEDAPAL has 18 sewerage treatment plants distributed on the periphery of Lima. By 2005 SEDAPAL treated a total of 49.24 million m³ of wastewater, which constitute only 9.2% of the total water obtained from the potable water system (SUNASS 2006, p 22). Lima's water supply management situation is characterized by a typical linear concept: water is taken from the reservoirs far from the city and is then discharged into the ocean after use. Although some reuse of water already takes place, motivated by the scarcity of water resources, yet untreated or insufficiently treated wastewater is used for irrigation of agricultural land and for watering parks, posing significant health risks for the population. The amount of adequate treated wastewater is low. Significant investments in wastewater management have been made recently in Lima. Nevertheless, most wastewaters collected are discharge into the Pacific Ocean without adequate treatment (YAYA-BEAS et al., 2007).

FURUKAWA (2005, p 24) adds that SEDAPAL should be proactively committed to the construction of water treatment facilities for the sake of sustainable water circulation and improvement of sanitary conditions. To increase the volume of wastewater treatment became another challenge faced by the Lima water sector. Table 18 shows the estimated of the wastewater treated volume (based on the master plan 2006-2011), and the executed for the period 2007-2009.

Wastewater Treatment (m³/s)	**Year 1 2007**	**Year 2 2008**	**Year 3 2009**
Estimated	1.64	1.64	1.64
Executed	1.65	1.77	-

Source: (SUNASS-2008; SEDAPAL 2008; FONAFE 2009; SUNASS 2006, SEDAPAL 2007).

Table 18: Wastewater Treatment in Metropolitan Lima 2007-2009

By 2007 and 2008 the targets were reached, but this volume represents the treatment of only 15% of the total wastewater. The main reason of the low volume of wastewater treated is the lack on infrastructure. It is expected to reach 100% treatment of the wastewater volume produced by the year 2011. To this end the national government is working in the construction of new wastewater treatment plants (SEDAPAL 2008).

4.3.3 Demand

The high demand of potable water is another characteristic of the water sector in Metropolitan Lima. Population growth and urban expansion poses great challenges to the supply of safe drinking water to all inhabitants in Lima. To cover the high demand of potable water is another challenge faced by the Lima water sector. In the next part of this paper the different elements that are important in the estimation of the potable water demand in Lima will be explained.

4.3.3.1 Overall Development of the Demand

According to SUNASS (2006, p 38), the potable water demand is the volume of water that must be produced so that the user receives the appropriate amount of water to meet their needs. The demand is defined by the volume of water that different consumer groups or categories, are willing to consume

The Estimation of Population Projection is the most important part in determining the demand for potable water and therefore the flow of sewerage. This data is essential for the elaboration of approaches that define the characteristics, design and development of the potable water systems and sewerage disposal. There are many studies of the estimation and projection of the Metropolitan Lima population, such as YEPES and RINGSKOG (2002), INEI (2000) and AOM (2002). Table 19 shows a model of projection based in 3 scenarios; the second scenario with a higher degree of occurrence. Each scenario belongs to a different study mentioned above. These model were used by SEDAPAL in 2005 to project the potable water and sewerage services demand until 2030 (SEDAPAL 2005, p 12-15).

Scenarios	2005	2010	2015	2020	2025	2030
I	8.75	9.66	10.62	11.61	12.63	13.67
II	8.08	8.77	9.45	10.13	10.82	11.50
III	8.04	8.5	8.92	9.37	9.83	10.32

Source: SEDAPAL (2005)

Table 19: Population Projection for Metropolitan Lima 2005-2030 (Million Inhabitants)

The Population Served is another important issue that must be taken into account for the estimation of the water demand. The population served is obtained by the formula:

Population served = Coverage x Population projection

Table 20 is an illustration of how to obtain the population served. It was elaborated by SUNASS (2007). The data used as the population of Lima comes from the national census of 2005. It is not taken from the projection of the population presented above.

	Potable Water	Sewerage
Population of Lima	8.037.191	8.037.191
Coverage %	87.3%	82.9%
Population Served	7.013.261	6.662.983

Source: SUNASS (2007)

Table 20: Population served by SEDAPAL (2005)

The estimation of the population served is used to estimate the number of connections per user category. Given the volume required by each consumer group, the utility can define the demand of water services for the coming years (SUNASS 200, p 38)

The Coverage of the water and sewerage services for Metropolitan Lima was already reviewed (Chapter: 4.3.2.1.). The results of coverage vary depending on the method of calculation.

Population not served reported by SEDAPAL is less reliable. However, given the small population of these not served districts (about 0.2 million that represents less than 3% of the total population). Their effect on the total population served in Lima is not significant (YEPES and RINGSKOG, 2001, p 17).

The Network Losses or water losses have two principal components: physical losses and commercial losses. Both can be disaggregated in various subcomponents (YEPES and RINGSKOG, 2001, p 17):

- Physical losses include: Water leaks in pipes and accessories (visible, detectable and non-detectable). Overflow spillages and leaks by infiltration into the storage tanks and lost in the network operations.
- Commercial losses include: sub report of metering connections, unrecorded consumption from connections that are not billed (illegal connections or not regulated etc).

The percentages of water losses were previously presented (Chapter: 4.3.2.5.). It should be noted that the production of the utility will equal the demand for water service, plus the volume of water that is lost in the system.

4.3.3.2 Structure of the Demand

There are two important elements in the structure of the demand that are explained in this paper. The category of users and the average measured water consumption per category of user.

4.3.3.2.1 Category of Users

SEDAPAL distinguishes between five categories of users within the potable water system: domestic, social, commercial, industrial and governmental. Table 21 shows the shares of potable water connection per category.

Category of users	**Share in Connections (%)**	**Number of Active Connections**
Domestic	93%	955.365
Social	1.0%	13.017
Commercial	4.0%	41.202
Industrial	1.0%	6.136
Governmental	1.0%	7.111
Total	100%	1.022.831

Source: SUNASS (2006, p 26-29).

Table 21: Potable Water Connection by Consumer's Categories (2005)

Table 21 shows that the consumer category with the highest share is the domestic category. And the categories with the lowest shares are the industrial and governmental. From the total connections, it is consider 8% of inactive connections. The total shown in the table represents only 92% of the total connections (active connections). SEDAPAL reported a number of sewerage active connections of 1.058.025 (92% of the total connections). The categories and shares for sewerage services are considered as from the potable water services because both services are bring together (SUNASS, 2007, p 11).

4.3.3.2.2 Water Consumption per Category

YEPES and RINGSKOG (2001, p 8) distinguish between two types of water consumption, from the domestic consumption, and from other user categories:

Domestic Consumption:

With household connections: By 2001 the average consumption was **140** lhd. The measured consumption in the lower socioeconomic levels was significantly lower. Water Consumption has been decreased gradually, due to effective increase of micro metering. Since 1996 SEDAPAL has been making a major effort to increase the percentage of micro metering. The impact of the micro metering over the average consumption and total production has been important over the last years. In the period 1998-2001, the production was reduced slightly in 7%, form 705 MMC[15] in 1998 to 660 MMC in 2001, and the total average consumption declined by 22% even when the water connections increase in 14%. This is a natural reaction of consumers, to conserve water before the clear indication of the amount charged on the basis of actual consumption (YEPES and RINGSKOG, 2002, p 2).

The consumption of non metering connections can not be accepted as reliable. However, experiences in many cities show that the metered unit consumption is less than the not metered consumption

Without household connections: is essentially subsistence consumption. It is also closely related to income level. These population are approximately 1.1 million and includes predominantly the population in extreme poverty (0.9 million). By 1996 a study over the water consumption in Peruvian settlements (SERVIYACU), found that the consumption of this group is about 30 lhd. Over the volume delivered by SEDAPAL to the public pylons in 2000, it was estimated a consumption of this group between 8 to 10 lhd.

Other Types of Consumption:

The measured consumption of the commercial and industrial users served by SEDAPAL in 2001 was equivalent to **24 lhd**. The governmental consumption is composed of the consumption in governmental buildings, the water use for watering some parks and the supply of communities without water service connection. This measure consumption is

[15] MMCy is millions cubic meters per year.

equivalent to **16 lhd**. Social consumption includes charitable institutions, colleges and water sold in cistern trucks to serve the population without house connections. This consumption is equivalent to **4 lhd**. The total area of parks in Lima is approximately 1300 hectares. The demand for parks is served by governmental connections. The quantity used of water from wells for parks operated by municipalities is not known. The limited number of wells from the government suggests that this demand is not significant (YEPES and RINGSKOG 2001, P 14).

Category	**Consumption MMCy**	**Unitary Consumption lhd**[16]
Domestic	211.4	140
Social	6.5	4
Commercial	29.5	19
Industrial	7.8	5
Governmental	23.3	16
Total	**278.5**	**184 lhd= (28.5 m^3/UU**[17]**)**

Source: SEDAPAL (2001).

Table 22: Average Measured Water Consumption per Category of Consumer (2001)

Table 22 shows the data (described above) used by YEPES and RINGSKOG in 2001, to elaborate a projection of the demand for the period 2000-2030. The unitary measured demand of 28.5 m3/UU equivalent to 184 lhd of Lima is comparable with that of capital cities in Latin America with similar population such as Bogota (2000) 165 lhd and Santiago (2000) 202 lhd.

4.3.3.3 Elasticity of the Demand

It will be taken into account the analysis of the price elasticity of the domestic demand for lower socioeconomic levels and the analysis of income elasticity.

Price Elasticity of the Domestic Demand

According to YEPES and RINGSKOG (2001, p 10), the reduction of water consumption observed as a micro metering effect, is consistent to the explanation that without metering the consumer has no incentive to limit their consumption because their payment does not vary according to volume consumed. Similarly it is expected that an increase in tariffs result in further reductions in consumption only if the consumption is measured. Based on a sample of 1126 families from Peruvian settlements in 1996, SERVIYACU found through a statistical regression, that the elasticity of domestic demand with respect to price (EP) was -0.28. This value is similar to experiences from other similar studies (CESTI et al., 1997). In 2001 the analysis of the price elasticity of the domestic demand for the lowest socioeconomic level was -0.3. The SEDAPAL tariff structure makes difficult to

[16] Lhd = litre per habitant per day.
[17] UU = housing. 5.1 persons per UU habilitated.

calculate the price elasticity for the residential category, because the tariff increases with the level of consumption (IBT structure). The income per household associated with a given consumption is unknown because there is no historical record. Therefore it is not possible to calculate the price and income elasticity using a regression analysis with two variables

Income Elasticity of the Domestic Demand

The socioeconomic characteristics of the population in 2001 are shown in Table 23.

Socio economic level	**Population percentage**	**Personas per household**
A. High	3.5%	4.3
B. Medium	15.6%	4.7
C. Low	32.3%	6.0
D. Very low	36.3%	6.1
E. Extreme poverty	12.3%	5.1
Total	**100.0%**	**5.7**

Source: Apoyo Opinion y Mercado (AOM) 2001.

Table 23: Socioeconomic stratification in Metropolitan Lima (2001)

The income effect on the consumption is measured by the income elasticity. The analysis made by SERVIYACU found through a statistical regression that the value of the income elasticity varies from +0.3 for low-income population with no connection to +0.6 for the population served by water connections. Furthermore, given the fact that the income elasticity of demand is positive, the consumption per capita or per household increases with income. At the same time, the tariff per cubic meter increases with the range of consumption (IBT structure). When calculating the price elasticity, related to the relative change in the consumption per household, with the relative change of the average tariff per m^3 consumed, the price elasticity is positive. This absurd result is the consequence of the income elasticity effect that states that consumers with higher income, consume more water even if they pay more per cubic meter (YEPES and RINGSKOG, 2001, p 12)

Price Elasticity of the Non-Domestic Demand

Statistically, it is not possible to estimate the price elasticity of demand for commercial, industrial and governmental users through a cross sectional analysis, because the tariff is constant for them. Neither it is possible to perform this calculation by a historical analysis (time-series), since there is no a homogeneous historical record of any of these consumers. Since 1997, when records started, the consumers from each category have changed, mainly due to the inclusion of low-consumption users and to the economic recession of the years 1998 and 1999. Furthermore, industrial and commercial users have their own alternative sources that allow them to reduce their consumption served by SEDAPAL.

4.3.4 Challenges for Tariff Design

The proposal submitted by SEDAPAL in 2005, included all necessary investment to be covered by tariff increases during the period of 2006-2011. SEDAPAL proposed a 137% hike, which eventually led to an impasse situation. The agreement that was finally achieved between SUNASS an SEDAPAL in July 2006 included a 16% tariff increase, which at large will be sufficient to prevent the infrastructure from crumbling further and ensuring increased access to clean drinking water and safe sewerage at affordable tariff rates.

4.4 Existing Tariff System in Lima

The water tariff structure presented as follows is the current tariff being used by Metropolitan Lima. It was published in the Peruvian Official Newspaper "El Peruano" (November 2008) and it is based o the Master Plan of the period 2006-2011.

4.4.1 Tariff Structure

1. Fixed Charge: S/. / 4.44 per month.

2. Volumetric Charge:

Category	**Ranges**	**Current Tariff**
Residential	m^3/month	S/. /m^3
Social	≥ 0	1.311
Domestic	0-20	1.311
	20-30	1.735
	30-50	2.675
	50-80	2.675
	> 80	4.005
Non Residential		
Commercial	≥ 0	5.291
Industrial	≥ 0	5.291
Govermental	≥ 0	2.675

Source: SEDAPAL (2009)

Table 24: SEDAPAL water tariff structure S/. /m^3

Exclusive Use of the Sewerage	**Current Tariff**
Only for users with own water source	3.082

Source: SEDAPAL (2009).

Table 25: SEDAPAL sewerage tariff structure S/. /m^3

SEDAPAL uses the following tariff formula to get the increment in tariffs over the years, during the period 2006-2011 (S /. / M^3):

T_0 := Average tariff of the current tariff structure.
T_1 := Average tariff for Year 1.
T_2 := Average tariff for year 2
T_3 := Average tariff for year 3.
T_4 := Average tariff for year 4.
T_5 := Average tariff for year 5.
Φ := Growth rate of the wholesale price index.

$T_1 = T_0 (1 + 0.1642) (1 + \Phi)$
$T_2 = T_1 (1 + 0.0000) (1 + \Phi)$
$T_3 = T_2 (1 + 0.0700) (1 + \Phi)$
$T_4 = T_3 (1 + 0.0000) (1 + \Phi)$
$T_5 = T_4 (1 + 0.0000) (1 + \Phi)$

The Lima's tariff structure presented in Table 24 is used in metered consumers. It is structured as a Two-part Tariff, with a fixed charge part of S /. 4.44 Per month, independent of the user category. This fixed charge part of the tariff is adjusted because of the inflation effect, according to the established Master Plan 2006-2011. The volumetric charge of the tariff has two user classes: the residential and non-residential users; and five user categories: domestic, social, commercial, industrial and governmental. The volumetric part of the tariff is structured as an increasing block tariff (IBT) with 5 blocks of consumption. The first block of the tariff is equal the social tariff. From the non-residential class, the governmental category has the lowest tariff of the class. It is comparable to the tariff applied in the 3 rd and 4 th block of consumption. This was structured according to the principle of hierarchy that should exist. According to the Resolution of SUNASS (2005, p 14) the principle of hierarchy refers to the tariff sequence assigned to each category, it should be as follows: $Ts \leq Td1 \leq Td2 \leq Td3 \leq Tg \leq Tc \leq Ti$.

The tariff structure use cross-subsidies in which the higher consumers subsidize the lower. There is a social tariff created for the underprivileged population. Besides, the first block of residential consumption is equal to the social tariff. It can be considered as another social tariff. The social tariff is for users with a connection outside the home and for users of public standpipes (informal neighbourhoods). By 2006 the average tariff per m^3 was S/. 1.738, in addition to the social users, all domestic users who consume below $80m^3$ were subsidized, as their actual payment is lower than the average tariff. This means that 89% of users receive subsidies from the state (LEON, 2006).

An economic and financial model was used to determine the formula and the tariff structure for the period 2006-2011. To define the cash flow and future financial statements, the model included: demand projections, revenues, operation and maintenance costs, and investments, as well as the initial situation of the company. Economic evaluation of cash flow allows determining the necessary tariff increases that should be apply by the utilities to be sustainable over time (SUNASS 2007, p 9).

To finance the expansion of the infrastructure and networks in Metropolitan Lima water sector within the period 2006-2011. The Master Plan approved tariff increments of 16.42% in the first year (2006) and 7% in the third year (2009). The increment will be performed if SEDAPAL reaches the proposed performance indicators stated in the Master Plan 2006-2011. SUNASS also determined conditional tariff increases at the start of operation of the projects: (i) Mark II potable water treatment plant (10.37% of increment), and (ii) the wastewater treatment plant of Taboada (12.31% of increment) (SUNASS 2007, p 8). In the reality the first increment (16.42%) was held on 2006 (PERU 21 21.08.09) and the second increment was approved (6.8%) and it was put into practice in November 2008 (ANDINA 13.10.08).

The water tariffs for non-metered consumers that receive the service from SEDAPAL are structured on the basis of an assigned consumption volume. These volumes vary by type of consumer, type of neighbourhoods and by continuity of service. Table 26 shows the structure of the assigned consumption volume applied to these non-metered consumers (SUNASS 2007, p 113).

User Category	**Until 3 hours m³/month**	**4-6 hours m³/month**	**7-24 hours m³/month**
Social	4	7	12
Domestic	Until 3 hours m³/month	4-6 hours m³/month	7-24 hours m³/month
District group I	17	30	30
District group II	15	21	21
User Category	Until 3 hours m³/month	4-6 hours m³/month	7-24 hours m³/month
Commercial	15	18	18
Industrial	27	27	27
Governmental	34	34	34

Source: SUNASS (2007, p 113)

Table 26: Assigned Consumption Volume for non-metered Consumers

For example, a domestic user that belongs to the district group I, with a designated supply time up to 3 hours, will be charged equivalent to 17m³ per month. This 17m³ within the tariff structure used by SEDAPAL is located in the first block (0 - 20 m3) of consumption in the domestic category, the user will pay the tariff that correspond to this block.

4.4.2 Institutional Framework

The current institutional framework of the Lima water sector has evolved over more than half a century of continuous reorganization and structural changes towards focusing alternately on centralization and decentralization within the sector. In the 70's the sector was headed by the DGOS (Direccion General de Obras Sanitarias-General Sanitation Works Service). In 1981, a governmental entity SENAPA (Servicio Nacional de Agua potable y Alcantarillado-National Service for the Supply of Potable Water and Sewerage

Services), replacing the DGOS. In 1992 the sector was placed under the ministry of presidency. Then it was placed in 2002 under VMCS (Vice Ministerio de Construccion y Saneamiento-Vice Ministry of Construction and Sanitation). Since 1994 SUNASS (Superintendencia Nacional de Servicios de Saneamiento-National Superintendence of sanitation services) has been the governmental regulatory entity of the water service providers. The main urban water service providers are the EPS (Empresas Prestadoras de Servicios de Sanemaiento-Sanitation service providers) also known as utilities (GIUGALE et al., 2006, p 324).

The main EPS in Lima is SEDAPAL (Servicio de agua Potable y alcantarillado de Lima-Lima's Drinking Water and Sewerage Service). SEDAPAL was created in 1981, is under central government control and is currently operating under a concession contract. SEDAPAL provide services in 46 districts of Lima and the remainder of the population (6 districts) is supplied directly by municipality departments, with less favourable conditions to those offered by SEDAPAL, or by mobile water vendors. SEDAPAL served approximately 7 975 000 people in Lima, from a total population of about 8 millions. Its activities are regulated by FONAFE (Fondo Nacional de Financiameinto de la Actividad Empresarial del Estado-National Financial Fund of Governmental Business Activities) and SUNASS (YEPES and RINGSKOG 2001, p 2).

SUNASS is responsible of the EPS economic regulation, and nowadays is also focus into improve the current pricing system. In this sense, the tariffs determination follow the criteria stated in Article 29 of the General Law of sanitation Services-Law 26338, which states that the determination of tariffs of water and sewerage is guided by the principles of economic efficiency, financial sustainability, social equity, simplicity and transparency. SUNASS approved the tariffs for SEDAPAL and for the rest of the EPS (2002-2003, p 28-30).

The objectives of the SUNASS are:

- Development of pricing methodologies and supervision programs according to the specific characteristics of the higher and lower size utilities.
- Development and implementation of consultant procedures on tariff plans and changes in the regulatory framework.
- Development of a decentralized system to attend users and regulated utilities.
- Development of permanent mechanisms for communication and coordination with users, companies and stakeholders.
- Incorporation of technologies and information systems to the institutional work.
- Attracting new resources and diversification of the international technical cooperation.

The sector's institutional framework is well established, clearly differentiating between policy setting, regulatory and service provision functions. However, there is a weak coordination between the various entities at the central government level and with other levels of the government. This lack of coordination was observed in the areas of planning and financing and in mechanisms for improving and controlling the management of the EPS. Certain gaps exist that hold back sustained development and interfere with good service provision (GIUGALE et al., 2006, p 321-323).

4.5 Evaluation of the Tariff System

After describing the existing tariff in Metropolitan Lima, an evaluation of the tariff system is prepared. This evaluation will regard the criteria of effectiveness, cost recovery, efficiency, equity and political feasibility as it was done before. The subsequent evaluation is a combination of theoretical and empirical findings form diverse sources.

4.5.1 Effectiveness

Lima's pricing regime does not provide incentives to conserve water to consumers that are not connected to the network. Poor population gets their water from public systems indirectly, purchasing water from neighbours that have connections or from cistern trucks, which fill their trucks from public systems. This situation has the opposite effect than the intended conservation objective. For consumers that are connected to the network, the two part structure used in volumetric charge should encourage conversation of water, by sending price signals to the consumers. But the reality shows that the low tariffs applied in Metropolitan Lima threaten water conservation. There is no incentive to conserve water, while cross-subsidies are not focalised in the poor sector. The increasing demand of water in Lima and the low availability of water threaten also water conservation. Currently SEDAPAL estimates that average demand in Lima has increased to the equivalent of 460 litres per capita per day, above that of cities with abundant water sources (ALCAZAR 1999, p 8).

Another important aspect that remains problematic is the level of non-metered water. In 1991 from the total water produced 43% were non-billed water. In December 2006 it was 38.31% (SUNASS 2007). This situation is a consequence of the low levels of metered connections, clandestine connections in peripheral areas; and water losses (DEFENSORÍA Del PUEBLO 2005). Metered connections are necessary to encourage water conservation, it is being increased remarkably but is still not enough, the goal is to reach 100 of metering by 2011(SEDAPAL 2008).

4.5.2 Cost Recovery

GIUGALE et al., (2006, p 332) states that in Metropolitan Lima, a cost has yet to be assigned to water. The tariffs charged include only the cost of providing the service, and is out of touch with the reality in terms of the investment and financing of SEDAPAL. A tariff must guarantee the cost recovery at least from the maintaining and operation costs. There is only one EPS in PERU, which is not SEDAPAL that appears to be complying with the established rate policy.

According to BID (2006, p 8), in the 90s government had kept prices well below cost recovery for years, this was one of the main reason why the intent to privatise the system failed, a concession would have required a sharp and sudden price increase to cover marginal costs, the analysis of the historic information is based on the financial statements of the period 2003-2006 shows that the financial situation of SEDAPAL was solid. During 2006, operating revenues have been sufficient to cover operation and maintenance costs, to finance the investment program and to meet the financial obligations taken by the company. But, in December 2006, the average water tariff was \$0.50 per m^3 while the average cost was \$0.60 per m^3. Only 11% of households paid more than the real water costs, the rest were subsidized by the state (León, 2006) According to FONAFE (2009) the statement of retained earnings of SEDAPAL show that the operation costs were recovered by the year 1st trimester of 2008 and in the 1st trimester of 2009.

4.5.3 Cost-Efficiency/ Effectiveness

According to ALCAZAR et al., (1999) the tariff structure is not efficient due to the scarcity of water. Scarcity sources meant that marginal costs were high, requiring pumping water from deep wells and building adequate storage for dry periods. High extraction costs were compounded by years of neglect, so that much of the system needed to be replaced. YEPES (2003) adds that also the subsidization of almost all users generates economic inefficiency and jeopardizes the financial viability of SEDAPAL. In this regard, RINGSKOG and YEPES (2002) estimated that the amount of subsidies with respect to the marginal cost is S /. 10.360 millions per year. The inefficiency of increasing block tariffs is demonstrated in this case study, the tariffs in Lima do not equalize the cost of water across customers. In the last years the situation improve, BID (2006, p 8) based in the data collected between 2003 and 2006, states that the reforms of the water sector as the creation of non traditional projects for water provision have produced important improvements. The quality of the service has increased as well as the efficiency of SEDAPAL. FERNANDEZ MALDONADO (2008, p 1894) adds that the intended reform of the water sector, in which tariff convergence and cross-subsidies had an important role, has been only partially implemented. SEDAPAL is more efficient but tariffs still do not reflect the real costs and the indiscriminate cross-subsidies are working against the poor instead of helping them. The low tariffs threaten the sustainability of the water system. In January 2006, SEDAPAL proposed a tariff increase of 136% in the period 2006-2011, for the expansion and maintenance of the networks. The announcement create such heavy criticism in the media that the President Toledo declared that that increase will not be approved SUNASS reject the proposal (GUERRA 13.01.06).

4.5.4 Equity

The million people who get water from informal vendors constitute the most disadvantaged group of the city. They consume much less water, pay the higher prices for it, get the most risky drinking water and spend the highest proportion of their income on water. They are also the ones who live in the most physically vulnerable situations (FERNANDEZ MALDONADO 2008, p 1895). Connection charges would make water unaffordable to many unconnected poor consumers, even compared to water from vendors. Poorer and middle-income consumers who were already connected have to face high bills, because of the introduction of metering (ALCAZAR et al., 1999, p 38). For the metered consumers the tariff system in Metropolitan Lima presents a complex situation of cross-subsidisation system which does not manage properly the resources generated in excess. The sectors with higher consumption are subsidised, under the assumption that consumption and wealth have a direct relationship. In this regard, subsidies should only be concentrated in the population with lower consumption (BID 2006, p 9). The actual payment compared to the average tariff of SEDAPAL SA per m3 (S /. 1,738) shows that not only the social users, but also all domestic users that consume below 80m3 are subsidized. Their actual payment is lower than the average rate. This means that 92% of users are subsidized. Furthermore, the sources of subsidisation come only from the users of the last block of consumption and from the non-residential categories, especially commercial and industrial users (SUNASS 2006, p 112). A study of the national ombudsman, recommended SUNASS to revise its tariff regulation, focusing the subsidies exclusively on the poorest groups (DEFENSORÍA DEl PUEBLO, 2005). The Master Plan for the period 2006-2011, considers reforms for the cross-subsidisation system. The proposal allows consumers from the first block to receive an increment in subsidies from 38.4% to 45.6%. Consumers from the second block of consumption will also be beneficiated with a bigger subsidy from 31.8% to 35.6%. Finally, the block of 30 to 50 m3/month of consumption receives fewer subsidies from 23.1% to 14.0%. And the block between 50 to 80 m3 of consumption will not receive any subsidy (SUNASSS 2006, p 121). The intended reform of the water sector, in which cross-subsidies had an important role, has been only partially implemented (FERNANDEZ MALDONADO 2008, p 1894)

The case of Metropolitan Lima reflects the situation of inequity that is induced by using IBTs. Poor households with water connections sell water to their neighbours or share connections with them. Their consumption reach the higher blocks and they pay the higher prices (higher marginal price of water (WHITTINGTON 1992)

4.5.5 Political Feasibility

The implementation of the tariff structure in Lima is simple because the structure did not change in many years, only adjustments are being done. The population in Lima perceives the tariffs as high and not fair. Public opinion is unhappy with SEDAPAL's operation. Users with home connections are discontented with the low quality of tap water, the frequent water cuts, and the low water pressure. Those without connection are understandably tired of fetching water and buying expensive water from truckers. In 2005, residents from poor settlements organized a movement (''People without Water") and demonstrated in favour of the privatization of SEDAPAL (LAMA, 2005). These unusual protests, however, were short-lived and did not prosper, despite the wide media coverage. Further investigation revealed that the protests were co-organized by institutions in Lima, what suggests that they had been ''inspired" by interested parties.

SEDAPAL do not have enough sources for expansion and maintenance. These sources should come from increments in tariffs and public-private partnerships. But the political pressure to maintain low tariffs is becoming a bottleneck for SEDAPAL. The low tariffs are explained as result of 'governmental opportunism', in which governments "which have relatively short time horizons, prefer poor services and low prices over taking politically costly actions, such as increasing rates, whose benefits are only seen in the mid and long-term"(GIUGALE et al., 2006, p 334).

4.6 Conclusions of the Case Study

The evaluation of the tariff structure in Metropolitan Lima shows that the low tariffs applied plus the percentage of unmetered users threaten water conservation. The cross-subsidy systems that benefit a very high percentage of the population also don't give incentives to conserve water, while the people do not know the real cost of water. In the 90s the government kept prices well below cost recovery for years, but this situation improves in the last years. Revenues have been sufficient to cover operation and maintenance costs and to meet the financial obligations taken by the company. The tariff system is not efficient, the scarcity of water sources mean that marginal costs were high, high extraction costs were compounded by years of neglect, so much of the system needed to be replaced. The high costs of water provision in combination with the troubles of Lima's geographic position and the widespread poverty make the organisation of its equitable distribution a very difficult task. The high proportion of subsidised consumers generates economic inefficiency and jeopardizes the financial viability of SEDAPAL. There is a complex situation of cross-subsidisation that does not manage properly the resources generated in excess. Low income population does not have access to the service and do not enjoy of the cross-subsidisation and pay higher costs for a poor service. The population in Lima perceives the tariffs as high and not fair. The reforms of the water sector as the creation of non traditional projects for water provision have produced important improvements compared to the situation of the last decades. The quality of the service has increased as well as the efficiency of SEDAPAL. But the economic resources generated by the tariffs are not enough for the expansion and maintenance of the networks. Finally the political pressure to maintain low tariffs is becoming a bottleneck for SEDAPAL. The low tariffs are explained as result of 'governmental opportunism, in which governments which have relatively short time horizons, prefer poor services and low prices over taking politically costly actions.

4.7 Recommendations of the Case Study

In Lima the local population is often lacking awareness of the fact that they live in a city located in the middle of an arid zone where water is a scarce resource. The main problem that has to be addressed is the low tariffs that are not enough for the expansion and maintenance of the network. There is an immediate need to raise funds in order to improve the infrastructure of the service. The current status of the infrastructure makes it impossible to fully reach the performance ratios. By increasing the tariffs two important effects could be accomplished. One is the increased of monetary assets for the creation of new wastewater treatment plants, repairing and controlling instalments, extending the network service. Besides, measures have to be taken by the government in order to change people's understanding of the water pricing system. It is also a means of education for making people more sensible in handling water.

5 Conclusions

The availability of water resources plays a critical role in human society. While water seemingly exist in abundant amounts in places like Europe, the tough realities of competition for scarce water resources especially in developing countries have led us to the fact that there is a need for certain policies to ensure an effective protection of this crucial resource. To this end water policies are used to encourage water conservation. Water tariffs are economic instruments used to price water. Water tariffs should be consistent with the needs and objectives of the community. These objectives are not easy to define and may be in conflict between each other. A practical tariff therefore embodies a set of compromises among the different objectives. Properly designed water tariffs are powerful management tools. The "art" of tariff design is to make only those compromises which need to be made and to seek the best combination of achievements. A tariff can assume many different forms, each form addressing a specific objective.

For evaluating the performance of water tariffs, it is necessary to use a common analytical framework. The key criteria of the framework presented in this paper are effectiveness, cost recovery, efficiency, equity and political feasibility. From the empirical and theoretical evaluation of the different water tariffs certain conclusions can be drawn.

Fixed charge tariffs are the only possible tariff structures in the absence of metering. However, it is a problematic tariff structure. It does not give incentives to conserve water. While its cost recovery is adequate because it provides a stable cash flow if set to appropriate levels, the utility is vulnerable to the reselling of water by third parties. Its efficiency is rather poor as it does not give signals about the cost of use of additional water. It does not fulfil the equity objective as people who use larger quantities of water pay the same as those who use less. However, this tariff is feasible, because it is simple, easy to implement and administrate and easy to understand by the consumer.

Uniform volumetric tariffs are effective, giving a clear signal of the quantity of water use. Its cost recovery is good. Moreover, if the tariff is set to appropriate levels, revenues adjust automatically to changing consumption. Its efficiency is good if set to or near the marginal cost of water. Its equity objective is fulfilled, because people pay according to how much they actually use. This structure is feasible, as it is simple, easy to implement and easy to understand because this is how most other commodities are priced.

Increasing block tariffs (IBTs), widely used in the developing world, are claimed to produce desirable income transfers, discourage wasteful use, promote economic efficiency and assure access to sufficient water for basic sanitation. In fact, these claims are either excessive or incorrect. In practice, IBTs are likely to promote inefficiency, inequity, unfairness, net revenue instability, and other negative consequences.

Decreasing Block tariffs (DBTs) were commonly used in the past in developed countries. They are not effective, as the price decreases when consumption increases. There is no incentive to conserve water. Its cost recovery is good but only if the size and height of the blocks are well designed. Its efficiency is poor, because only little water is sold at marginal cost. The equity objective is not fulfilled, as people do not pay according to the cost their water use imposes o the utility, and penalises poor families with low levels of consumption. It is not very feasible, because it is not simple due to the difficulty to define the blocks and because it is not easy to be understood by the consumers.

Two part tariffs demonstrate in real world examples to be a good tariff option. Their success relies on their role in enabling water utilities to simultaneously achieve economic efficiency and cost recovery objectives. Economic efficiency requires water being priced at short run marginal cost. If this leads to a very low water price, it is likely that a single part tariff will not recover the total cost of supply. If a two part tariff is used, the necessary revenues can be raised with the fixed charge without distorting the price signal contained in the volumetric charge.

The evaluation of the different experiences from diverse countries, in using different water tariffs leads to the conclusion that in most developing countries, water tariffs do not fail because of the model that is being used, but because of the inadequately low pricing and the precarious situation of the water sector.

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