Managing Water Scarcity in Kenya:
Industrial Response to Tariffs and Regulatory Enforcement

Ph.D Dissertation

submitted

By

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Abbreviations

DWR	Department of Water Resources
FKE	Federation of Kenya Employers
GTZ	German Technical Cooperation Agency
JICA	Japan International Corporation Agency
KAM	Kenya Association of Manufacturers
KCO	Kenya Consumers Organization
KEWI	Kenya Water Institute
LA	Local Authorities
LGLA	Local Government Loans Authority
LSK	Law Society of Kenya
MENR	Ministry of Environment and Natural Resources
MOLG	Ministry of Local Government
MOLA	Ministry for Local Authorities
MOWD	Ministry of Water Development
NWCPC	National Water Conservation and Pipeline Corporation
PSC	Public Service Commission
UDD	Urban Development Department
UFW	Unaccounted For Water
UWASAM	Urban Water and Sanitation Management
UWS	Urban Water Service
WAB	Water Apportionment Board
WDD	Water Development Division
WSDs	Water and Sanitation Departments

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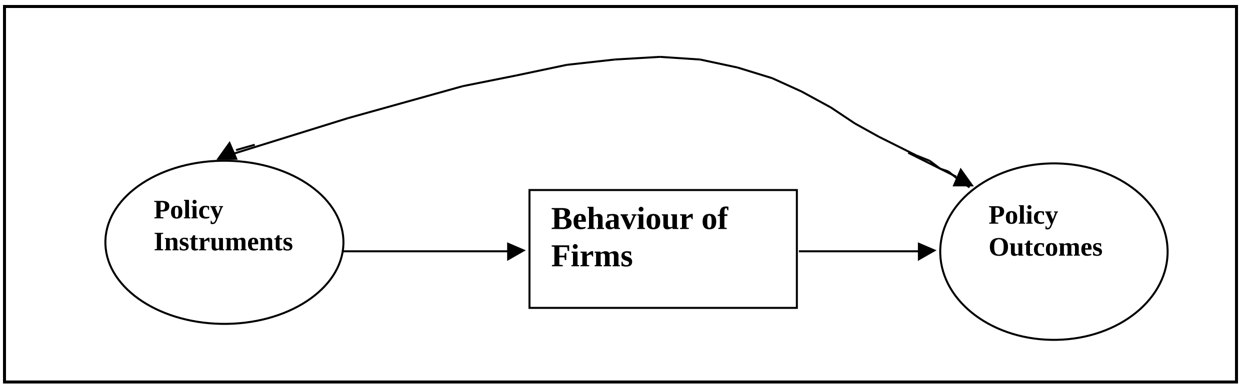
Introduction

The Research Problem and Hypothesis

Public intervention has been perceived as crucial to equitable distribution of water resources. Accordingly, many governments have spent enormous efforts in devising *pricing* and *regulatory* policies to control access in the belief that such efforts will lead to greater restraint in the use of scarce water resources. Nevertheless, all over the world, and especially in developing countries, we find that *pricing* policies devised by governments have failed to induce desired *response* (Frey, 1992). Regulatory policies have been somewhat more successful, but only in developed countries (Glazer and Laze, 1996). Furthermore, in spite of the failure of the policy instruments to induce desired response in developing countries, it is surprising to find that little empirical attention has been paid to investigating how consumers in developing countries behave when faced with externally imposed *pricing* and *regulatory* constraints designed to influence (restrict) the use of water resources. Instead, there has been overemphasis on the direct linkage between policy instruments and the outcomes. This is shown by the illustration in Fig A below.

Fig A: Policy, Firms, Policy Outcomes paths



The behaviour of firms in the face of implementation and enforcement of policy instruments is central to understanding the possible reasons for failure of the policy instruments in developing countries. This is what we attempt to explore here through the analysis of industrial firms' *response* to water prices and wastewater regulation in Kenya.

Literature identifies three main forces that could significantly influence the incidence of industrial water use and wastewater generation and affect the water/environmental balance: the industry characteristics; the institutional setting; and the policy instruments. We distil a line of thesis based on the role of policy instruments and the institutional environment for the enforcement of the instruments to be pursued in our study. We use the price theory to probe interconnections between changes in policy instruments and firm behaviour. There are unifying neoclassical expectations regarding the influence of the *pricing* and *regulatory* policy instruments on firms. *Ceteris paribus*, the water tariffs and regulatory enforcement will influence the water demand negatively and wastewater compliance positively among industrial firms. However, our central research hypothesis is that since industrial firms cannot be considered a homogenous group operating in identical environments, the use of uniform *pricing* and *regulatory* mechanisms may not result in the predicted *response.*

Background and Significance of the Study

Pricing and regulatory strategies, when used as policy instruments to manage water resources, presuppose that all individual firms will follow the same behavioural pattern. However, there can be as much discussion and debate about whether firms *respond* mainly to self-interest, whether incentives are more effective than disincentives, and about the role of norms vis a viz government policies. In many cases none of the industrial firms may fit the image of an omniscient rational producer who attempts to optimize the benefits to costs of using an input. Firms may even be unaware of effluent standards or have no idea of the technological engineering and organizational prospects for upgrading their production system i.e. to use less water, abate wastewater treatment, or of the costs involved in responding to price and regulatory pressure (Braadraart, 1995: 449). In the absence of a general pattern of behaviour, only policy prescriptions unique to each firm would be desirable. On the other hand, in some cases, like the Porter hypothesis (1991), environmental (wastewater) regulation (and by implication – water pricing) has been mis-construed to imply a free lunch (or even “a paid lunch"), that is, regulation (and pricing) induce innovation or practices whose benefits exceed its costs, making regulation (and pricing) socially desirable, even ignoring the environmental (or resource use) problems it was designed to solve. Our aim in this paper is modest in the sense that we do not attempt to test the Porter, or any of these neoclassical hypotheses. Rather, we attempt to discover the broad statistical and qualitative relationships that exist among pricing and wastewater regulatory levels and the behaviour of industrial firms in Kenya .

The way in which the industries choose to exploit resources as well as provide the means of minimizing and managing adverse impacts on the environment will significantly alter the development process in any economy. Any short-term achievements of long-term sustainable goals must therefore be preceded by a critical focus on the activities of the industrial sector. This need arises because the industrial sector can immensely contribute to sustainable development especially since it is well positioned to transfer sound practices and habits to the rest of the economy and in the process play a key role by functioning simultaneously as a major engine of development and as a means to improving the national environment. However, the industrial sector, especially in the developing world is rarely the repository of scarce technical skills for preservation and enhancement of the environmental resources while they continue to conduct their activities in a sector that has known severe impact on the natural resources and environment. This adverse phenomenon is compounded by the fact that little is currently known about the effect of policies on practices of the industries in general with regard to natural resource exploitation issues. In order to determine the current patterns of behaviour as well as the potential of the industrial sector in fostering sustainable water use in Kenya, a policy response study is proposed.

There are two critical aspects of industrial water practices, these are (i) demand, (ii) wastewater discharges.

> *efficient management of industrial water resource has to integrate both, water use and the management of wastewater resources in Kenya.*

While all the conventional (existing) studies focus on only one aspect of these industrial water practices, this study is unique in the sense that we have analysed both issues in the same study in order to capture the synergies that exist between the two practices in the industry. It is hoped that an integrated and broader understanding of industrial practices could foster water resource management by realising the benefits beyond choice of selective policy (regulatory and economic) instruments. It is also hoped that industries not yet as engaged in water conservation will be inspired to incorporate water resource concerns into their decision making process. I have examined the policy response in 60 firms surveyed using semi-structured questionnaires - and in-depth interviews.

Research Objectives

This study presents three main objectives to be fulfilled. They are interrelated to each other; each of them tries to specifically address at least one of our main research theme(s) that revolve around firm response to water tariffs and wastewater regulation, and the institutional environment for the enforcement of the instruments. The goal includes not only an understanding of the processes governing the firm behavior, but also the institutional context for the enforcement of the policy instruments. These objectives are listed below.

1. Examine the current sourcing, water use, and effluent disposal by the industries and how this practice is linked to the water tariffs and wastewater regulation.

2. Investigate how changes in water tariffs and regulatory instruments correspond with behavioural patterns of industrial firms in Kenya.

3. Demonstrate the effectiveness of the policy instruments by analysing the role of the institutional setting in the enforcement of water tariffs and waste-water regulation.

The broad objective of this study is to examine the *effect* of water tariffs and wastewater regulation on industrial water consumption (demand) and effluent disposal behaviour in the urban areas of Kenya. Expressed differently, we seek to examine how firms respond to tariff changes and regulatory enforcement. Implicit in our objective is the need to describe, explain and predict the behaviour firms in relation to the use of the two policy instruments. Superficial description is possible at the level of the firm response, but explanation requires the establishment of purpose and causality between dependent variables. Consequently, by aiming to explain and predict events relating to firm water use against changes in factor/input prices, we need a theory. Our broad objective also necessitates field activities for the above understanding to be realised. First, we require information on the structure of industrial water usage and how water consumption in firms has evolved over time, say, by examining the past and current sourcing of water, levels and type of usage, and effluent disposal patterns within firms. Our second major requirement is the information on the structure and purpose of the changes in water tariffs and how regulatory enforcement has evolved over time. Finally, our methodological challenge is to isolate the above *influence* amidst varying contextual background, a feat that is unattainable without making some assumptions.

Research Questions

Our study has originated from a general question on the response of firms, and the appropriate policy instruments for water resource management in Kenya. There are a number of questions related to this research that will assist us in our attempt to understand the effect of water pricing and regulatory instruments on industrial firms. These questions are listed below.

1. The first question we ask is what is the likely *response* of industries to changes in water tariffs. What is the expected industry response (behaviour), what actually are these response (measures) (whether they entail production process reorganization and/or technological changes) in firms?

2. Under what circumstances do we observe such industry behaviour?

3. How about wastewater regulatory enforcement, to what extent does it influence firm behaviour. What kind of response do we anticipate and what is the underlying factors behind such response?

4. What are the existing institutional deficiencies in the enforcement of pricing and regulation of the supply and demand chain. What do these inefficiencies imply for the effectiveness of the existing pricing and regulatory framework?

5. Finally, can we answer the ultimate question on *how far, given the circumstances, the Kenyan authorities can go with tariffs and regulation as instruments for water resource management in industry*?

Structure of the Dissertation

Chapter 1 discusses water resource endowment, its distribution in urban and industrial sector and the implications for sustainable industrial development in Kenya. The chapter begins with a situational analysis of the water resource availability in space and time. This is followed by a discussion on the regional and sectoral distribution. In order to analyze the implications of sustainable industrial development on water use in Kenya, our discussions begin from a broader platform in which global trends in industrial resource use strategies (resource-use practices) is partially examined. We extend the discussion to locate the role of prices (tariffs) and regulation in Kenya, and how they could motivate proper use of water by industrial firms. Overall, an important goal of the chapter is to uncover the linkage between water resource endowment, proper management and the direct bearing on industrial water and wastewater practices.

Chapter 2 discusses the water sector policy formulation and implementation in Kenya. The chapter provides a formal analysis of the links between the evolution (origin) of water sector policies and the policies for industrial water demand and wastewater regulation. The chapter identifies the range of policy instruments commonly used for industrial water management and their experience in Kenya.

Chapter 3 presents the literature review for industry water use, wastewater disposal and their interaction with pricing and regulatory policy instruments. It also explores and anticipates the influence of these policy instruments, and the institutional setting on the industrial water-use and wastewater practices.

Chapter 4 acts as bridge between theoretical/literature section and the rest of the chapters. The chapter provides an assessment of the empirical context, various competing methodological approaches to social science research and how they are linked to our study on firm water use and wastewater disposal in response to tariffs and wastewater regulation. Our contention is that our research problem flows directly from *positivism*, whereas part of our field research and analysis attempts to *account* for firm behaviour. Based on experiences from our fieldwork, we discuss the research design and the lessons from data collection. The overall goal of the chapter is to provide sufficient background and justification to the design of field methodology for the study. Since our study includes not only an understanding of the firm response to policy instruments, but also the social and institutional context. We use more than one research method to examine the same phenomenon classed by Denzin (1978) as methodological triangulation. The concept of triangulation first introduced in social sciences by Webb et al (1966) and used by Denzin (1978) involves a process of linking, mixing or combining methodologies and data at two levels. One level is the mixing of quantitative with "moments of qualitative methods". The other concerns the mixing of the conflicting paradigms on which quantitative and qualitative methods are based.

Chapter 5 looks at the institutional context for the water management – the use of tariffs and regulation. We look at the functions of water authorities, their mandates/ obligations, their day-to-day business and some of their weaknesses; ii) the actors interested in the water regulation, their activities and limitations, their framework for participation, the linkage between all these institutions and the problems they pose to the water sector management, and implications for industrial water behaviour. Since the institutional arrangements governing water service provision have undergone remarkable changes since the time of Kenya's independence in 1963, we unravel the trends and patterns, and attempt to address the following questions. Which are the key factors that have motivated these institutional changes? What are the nature and direction of these changes? How adequate are these changes for addressing both the existing and emerging industrial water challenges? What do they ultimately mean for overall water sector performance? The answers to these and related questions help in understanding the institutional context for the enforcement of industrial water tariffs and in delineating the role of water tariffs in determining industrial water demand.

In chapter 6, we analyze industrial water consumption behaviour based on the empirical data collected from the Kenyan manufacturing firms in five urban areas. Our broad objective is to analyze firm response and the implications of water tariffs currently employed by the water authorities. We do this by analyzing the short-run response of firms to changes in water tariffs. We also explore specific differences in the price elasticity of industrial water demand by five sectors and urban areas (classifications). Our goal in this chapter is to characterize the effect of existing water pricing policies on industrial firms. The pertinent questions answered in this chapter are: What factors explain differences in water use in the industry? What factors are responsible for the turning points or critical changes/ differences between different firms in the different categories?

In chapter 7, we discuss and analyse the institutional context for the enforcement of industrial wastewater standards in Kenya by primarily looking at the objectives for wastewater standards and their enforcement (monitoring, inspections, warning letters, and court prosecutions) in various towns. Industrial wastewater compliance is linked to the enforcement behaviour of the regulatory agency. The enforcement behaviour is dependent on the institutional context in which wastewater regulation is pursued. The chapter looks at the the following issues: i) institutions in the urban wastewater management, their mandates/ obligations, their day-to-day business and some of their weaknesses; ii) the actors interested in the wastewater regulation, their activities and limitations. How are all these institutions linked? Finally, we ask whether the institutional arrangement was suited to the Kenyan context.

In chapter 8, we extend the analysis applying monitoring, inspections, warning letters and court prosecutions and estimating a model of the enforcement incidence and wastewater compliance in industry. It is obvious that some instruments might have been of relatively greater or lesser importance for wastewater regulation. However, rather than attempt to identify an optimal policy for wastewater regulation, our goal is to measure the effects of existing regulatory instruments available to the wastewater enforcement authorities (monitoring, inspection, warning letters and court actions) on firms. Our model and empirical results would still have implications for the water policy design.

Chapter 9 provides summary, conclusion and policy recommendations. The results of chapter 5-

8 are synthesised to explain the behaviour of industrial and why the pricing and regulatory instruments are insufficient as tools of industrial water and wastewater management in Kenya. In the chapter, Kenya's unique context is highlighted, the main findings of the study are reviewed, and the implications of this for policy. This chapter can be read independent from the rest of the book.

1 The Gloomy Arithmetic of Water Resources in Kenya: The Search for an Appropriate Industrial Water Policy

1.1 Introduction

Resource management has been a major issue for scientists and politicians since Thomas Malthus published his epoch making essay on the principles of population in 1798. The economy and long-term wealth are largely based on the exploitation of non-renewable resources although other factors such as human knowledge and labour are to a certain extent complementary. Long before the green movement of the 1980s, the debate on the relationship between natural resource depletion and long-run economic growth appeared. Formerly, the economy considered environmental services such as water and air as free goods without physical boundaries. Then, some publications (above all: Report to the Club of Rome, Limits to growth, 1972) predicted that raw material would run out very soon. At the time, the emphasis was on the depletion of fossil and mineral resources (it was assumed that various important natural resources such as oil and various metal ores would be exhausted within a few decades and it turned out not to be true). But the failure in the above predictions did not provide reason for complacency. Indeed the prominent discussions of global resources over the last few decades focused on the depletion of non-renewable resources such as minerals, ores and petroleum, much at the expense of environmental and renewable resources. Today, it is increasingly accepted that environmental and renewable resources are at even greater risk[1]. Examples include water scarcity, collapsing fisheries, carbon-induced climate change, stratospheric ozone depletion, species extinction, deforestation, and the loss of groundwater in much of the world. The depletion of these assets is serious since people are a part of nature, and depend on its steady supply of the basic requirements for life: food, water energy, fiber, waste sinks, and other life support services. The depletion is particularly serious since the human demand for these resources is still growing, thereby accelerating the liquidation of natural assets.

Since the publication of the Rome report, two main orientations, have been developed to deal with the emerging natural resource crisis: On the one hand, is the “cornucopian theory” emphasising the creative power of technology and free-market to find substitutes for scarce resources. On the other hand, is the “neo-Malthusian school” paying attention to the scarcity of critical environmental resources and the need to limit economic growth and population (GUA, 2000). While "cornucopian" thesis is more central to our study, one of the most prominent concepts that is synergistic of both the "cornucopian theory" and the "neo-Malthusian thoughts" which has shown the way to the goal of stopping the emerging threat of resource scarcity and the threat of overburden, is the concept of “dematerialization”[2]. This concept states that de-linking should occur between material use and economic growth during economic development (Weizsåcker, 1998). The strategy is to reduce the material needs and consumption of resources without compromising the welfare by progress by enhancing know-how, services, and knowledge (qualitative progress). Economies can grow and prosper while reducing the use of scarce resources; material; and the production of harmful material through greater efficiency in the use of resources, and minimizing the generation of wastes.

The importance of water service as an infrastructural constraint to the process of development can be explained in several ways. The close relationship existing between urban growth, infrastructure facilities and gross domestic product has been established empirically. Experience particularly based on Newly Industrialised Countries (NICs), has shown that before, a country can move into a higher growth path of rapid industrialisation, it has to achieve certain critical masses in human and infrastructural conditions as well as sound institutional capacity and an appropriate policy framework. Towns with higher per capita infrastructure facilities such as water are the ones which can sustain the fastest growth while productivity in such towns are also greatly enhanced. On the contrary, towns that are faced with water service constraints are doomed to decay. Thus poor performance or inefficiency in the water service chain will eventually besiege the growth potential of a whole nation. Yet today, water is regarded as the most serious infrastructural constraint inhibiting industrial expansion in Kenya (Republic of Kenya, 1996b: p.19; p.76)[3]. Deficiencies in the public water supply and sanitation in Kenya threatens to force more and more households, commercial enterprises and industrial units to make their own arrangements. Furthermore, efficiency in delivery of water has serious bearing on productivity and corporate profitability for industrial firms. As a way forward to attaining industrialisation by the year 2020, one of the strategies put forth by the government involves rehabilitation and expansion of water infrastructural constraints (Republic of Kenya, 1996b: p.21). Besides the need for adequate water supplies for domestic, agricultural and industrial uses in Kenya, there is a desperate need for a properly organised and efficient system of sanitation.

In this chapter, we provide an overview of the water resource situation in Kenya and what the scenario portends for the industrial sector. The chapter begins with a situational overview of the spatial and temporal water resource availability (section 1.2) and a discussion on the public (piped) water demand and the delicate balance required to provide water to all consumers - domestic, institutional and industrial. Section 1.3 looks at industrial water demand and the challenge it poses: the extent of water use, the growth in demand and deficit is supply, and the degradation of water resources by industries. Section 1.4 discusses the urban water use and the need for multiple balancing. Section 1.5 covers the challenges posed by industrial water demand in urban areas. Finally section 1.6 revisits "dematerialization" and highlights global trends in dematerialization, cleaner production technologies and their relevance to industrial water management policies in Kenya. We conclude in section 1.7. Overall, an important goal of the chapter is to provide a systematic link between the water resource situation and the need for sound industrial water policies in Kenya.

1.2 The Water Resource Problem in Kenya

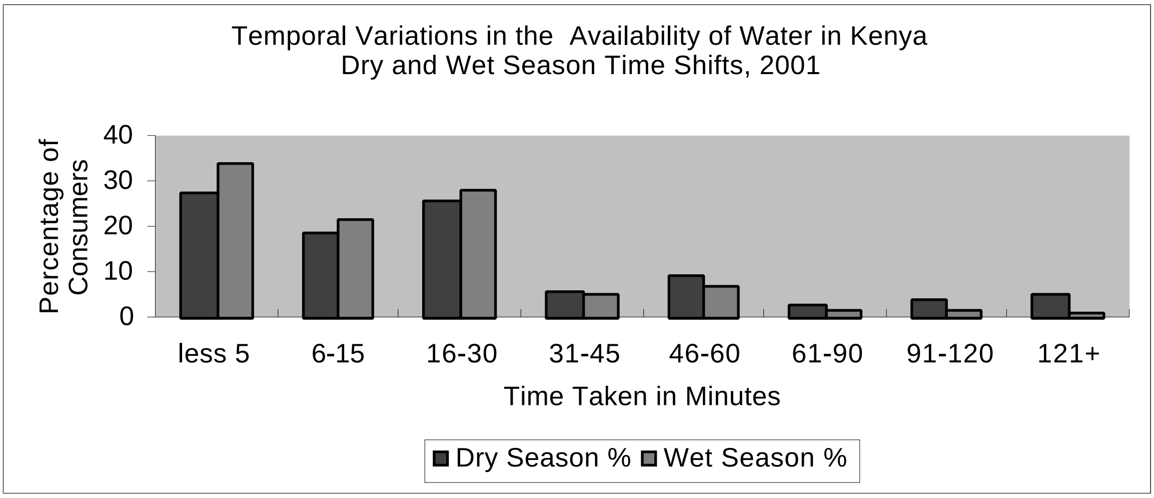
1.2.1 The Physical Constraints imposed by Nature

With a land mass area of approximately 592,000 sq.km, of which 2/3 are permanent pastures, 1/5 wilderness, and comparatively low land proportions occupied by either forests or cropland, Kenya is mainly an agricultural country with an expanding economy whose basic element for development is water. The annual quantity of renewable fresh water resources is estimated at 20.2 billion m^3 comprising 19.59 m^3 of surface water and 0.62 billion m^3 of ground water[4]. The amount of water actually available for utilisation in any one year (among other factors) depends on the rate of run-off, the aridity of the catchment area and the methods of interception at various points in the hydrological cycle. Given the country’s population of about 29 million people, per capita supply is approximately 696 m^3 /person per year, which makes Kenya a water scarce country since the global benchmark is 1,000 m^3 /person per year. The major development challenge that Kenya faces is creating conditions for rapid and sustained economic growth. Prudent management of water resources is an essential component of the whole process. As Kenya hopes to transform into a Newly Industrialised Country by the year 2020, the twin challenges it will face will be to provide water to both agriculture (irrigation) and urban areas and to promote industrialization without undermining its water resource base[5]. The availability and demand for clean water resources in Kenya varies, spatially, temporally and sectorally. In the next section, we examine the main features of water resource endowment.

1.2.2 Temporal Variations in the Availability of Water

Precipitation across parts of Kenya is exceptionally variable and unpredictable, and runoff is exceptionally low (varying from near zero in the north-eastern part of the country to over 1600mm/yr in the western part of the country). The consequence of these two features is endemic drought in large parts of the country. Throughout Kenya, even within the same districts, there is an enormous variance in water amounts[6]. Because of pronounced differences in average annual rainfall, evapo-transpiration, and hydrogeology, there is high variability within the same season, between different seasons i.e. twelve-month period, and over several years. Existing studies have used "water collection time" to characterize rainfall variability across the country (Republic of Kenya, 1996). Figures 1.1, 1.2, and 1.3 illustrate the temporal variations of water nationally, in rural areas and urban areas respectively. The illustration in figure 1.1 shows that for consumers who spend 5-30 minutes to fetch water, their proportion decreases during dry season. On the other hand for consumers who spend more than 30 minutes to fetch water, the proportion increases during dry season. This suggests an upward shift in the proportion of Kenyans who switch from 5-30 minutes time range to over 30 minutes collecting water.

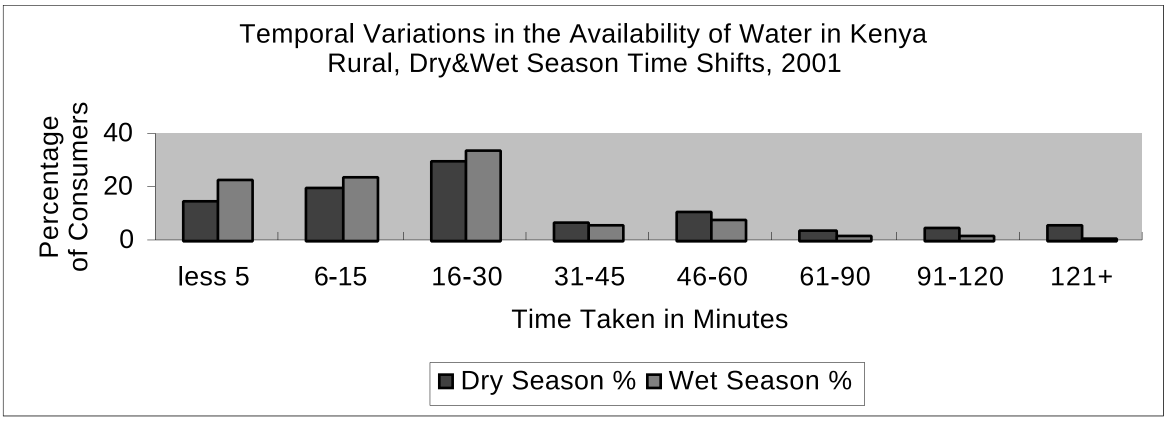
Figure 1.1: Seasonal Time Shifts, Kenya



Note: Graphs derived from the Welfare Monitoring Survey II, 1994, Basic Report. Central Bureau of Statistics, Office of the Vice-President and Ministry of Planning and National Development - Kenya, May 1996.

In the rural areas, a large number of homesteads are still far from water points, especially those in the low - potential areas where rivers are mainly seasonal. On the other hand, groundwater resource are either limited or undeveloped. Although ample water resources may exist, the patterns of use and accessibility may be a serious problem. The level of coverage goes down as low as 20 per cent during the dry seasons when seasonal water sources often dry up, making distances to water long and often exceeding 5 kilometres (Republic of Kenya, 1990).

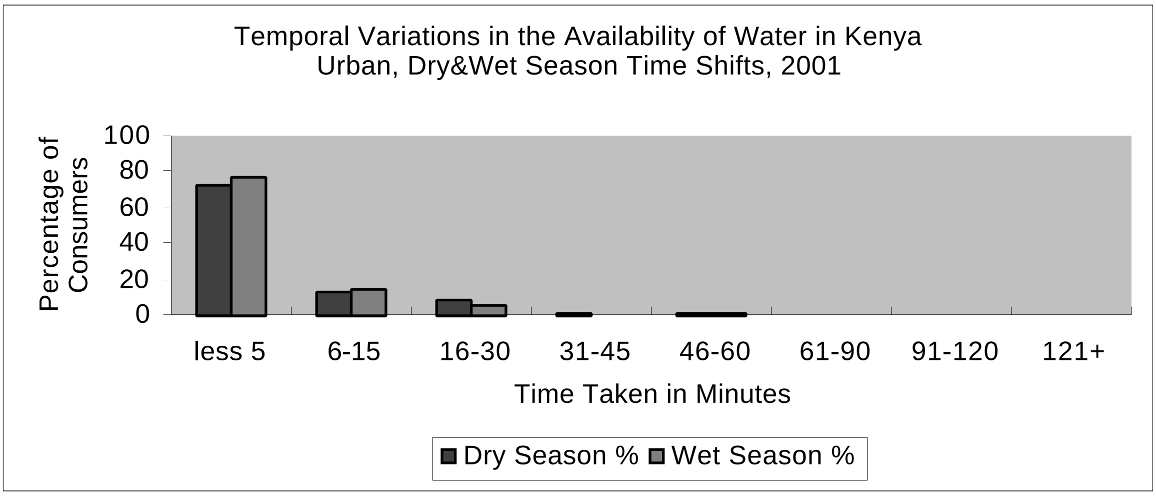
Figure 1.2: Rural, Seasonal Time Shifts



Note: Graphs derived from the Welfare Monitoring Survey II, 1994, Basic Report. Central Bureau of Statistics, Office of the Vice-President and Ministry of Planning and National Development - Kenya, May 1996.

Within the urban areas, the main reasons for shifts in time taken in sourcing water are; (i) the low service coverage and inability of the local water of authorities to sustain supplies of piped water to all segments of the towns where there is reduced supply pressure in dry season (see Table 5.1 in chapter 5). Hence more consumers have to fetch their piped water from alternative sources and often-contaminated locations, and (ii) in some of the towns there is increased concentration of piped water users to inferior alternative sources (such as boreholes, nearby rivers) even during wet seasons, due to unreliability (caused by bursts etc) of piped water supply.

Figure 1.3: Urban Seasonal Time Shifts



Note: Graphs derived from the Welfare Monitoring Survey II, 1994, Basic Report. Central Bureau of Statistics, Office of the Vice-President and Ministry of Planning and National Development - Kenya, May 1996.

1.2.3 Spatial Access to Water Resources

Analysis of access to water sources in Kenya shows that in all regions piped water, rivers and springs have been the main sources of water used by the majority of the households. A survey conducted in 1988 (Kenya Demographic Health Survey, 1989), showed that about 30.7 percent of the population used piped water as their main source of water compared to 32.1 percent in 1994[7]. Another 36.8 percent used rivers in 1988 compared to 24.9 percent in 1994. About 37 and 25 percent of Kenyans obtained their water directly from rivers 1988 and 1994. The 31 and 32 percent who used piped water in 1988 and 1994 obtained it directly from rivers. In total, about 68 and 67 percent of Kenyans obtained their water from rivers either directly or indirectly in 1988 and 1994 respectively. These figures illustrate the importance of surface water as the main source of clean water to Kenyans. There are significant regional variations in access to water resources. In some regions, i.e. only a mere 9% of the population has access to piped water while in Nairobi, more than 90% have access to piped water. The critical nature of surface water suggests the need for sound protective measures in order to safeguard the water resource base in Kenya. Even though comparisons of 1988 and 1994 indicate slight improvements in the use of piped water by about 2%, in real terms this growth could have resulted from loss of water availability in the other sources. In per capita terms, an increasingly large number of Kenyans are having to contend with lack of piped water. Current estimates of water supply in Kenya also indicate that 75 per cent (this could be a serious overestimate) of the country's urban population has access to safe drinking water, while only 50 per cent of the rural population has access to potable water from various schemes, including piped water schemes, bore-holes, protected springs, pans and dams (Republic of Kenya, 1997: p.125). However in both urban and rural areas, water supply is generally inadequate for domestic, industrial and commercial uses.

1.3 Public (Piped) Water Demand: The Delicate Balance in Kenya

Estimates available from Kenya's National Water Master Plan shows that in public demand, the urban daily use is highest (42.9%), followed by rural (27.5%), and livestock (15.7%) (see Table 1.1). This trend in consumption is projected to continue over the next decade with urban consumption constituting an even larger proportion of the total water use. In the table, the proportion of rural demand for public water is expected to decline from 32% in 1990 to 28% in 2010. The projected decline is based on assumption that an increasing number of Kenyans will be urbanised within the next decade. At the same time, urban water consumption is expected to rise from 35% in 1990 to 45% in 2010 of the total public water demand in Kenya. Based on these projections, the proportion industrial water is expected change from 13% in 1990 to only 12% in 2010. The decline in proportion of industrial consumption is projected on the basis of two assumptions: (i) industrial water recovery in Kenya is assumed to reach half of the industrialised countries' level (of over 50%) by 2010, a feat that is unlikely to be attained without sound water policies and regulatory enforcement for water resource conservation. (ii) slow industrialisation in Kenya.

Table 1.1:Potential Water Demand in Kenya

Unit: Thousand m^3/day				
		1990	2000	2010
Rural	Residential	376.2 (22.8)	560.2 (20.6)	932.6 (22.3)
	Non-Residential*	155.9 (9.4)	189.1 (6.9)	229.1 (5.5)
	Sub-total	532.1 (32.2)	749.3 (27.5)	1,161.8 (27.8)
Urban	Residential	491.2 (29.8)	1,004.5 (36.9)	1,642.8 (39.3)
	Non-Residential*	82.2 (4.9)	164.4 (6.0)	263.2 (6.3)
	Sub-total	573.4 (34.7)	1,168.9 (42.9)	1,906.0 (45.6)
Livestock		326.7 (19.8)	426.5 (15.7)	621.4 (14.9)
Industry		218.7 (13.2)	377.5 (13.9)	494.0 (11.8)
Total		1,650.9	2,722.2	4,183.2

Source: Republic of Kenya, 1992. National Water Master Plan. Ministry of Water Development. Shaded regions (rows) in the above table show the areas covered in our study. *The non-residential demand includes institutional and commercial enterprises such as schools, hotels, and shops (it does exclude irrigation in rural areas).

In absolute terms, the demand for water is expected to increase by between 300 - 400% over the period of 20 years from 1990 to 2010. The projections are however questionable on grounds that large numbers of rural consumers are lacking access to safe water while there is continued decay of urban water service delivery in Kenya. Given the current physical constraints in the water resource availability, even when the assumptions are relaxed, it is unlikely that the expected surge in demand can be met. The demand projections also overlooked other important facts: First, the existing water supply master plan in Kenya is typically engineering driven, focussing on technical issues and assuming a working institutional arrangement for water management. The plan was drafted in an institutional vacuum and fails to address pricing, ownership, and incentive issues effective for sustainable water management in Kenya. Even the strategic plans for the different towns do not incorporate adequate analysis of demand and supply, pricing and ownership issues. Instead, they pay attention to the bulk water supply arrangements / needs. Unless the policies and institutions currently in vogue are radically transformed and re-oriented to focus on the hitherto neglected sustainability dimensions of water resource development and utilization in Kenya, an impending water crisis and the attendant water-related disputes are more likely to culminate in still more diabolic economic, social and even, political crises. It is not surprising that Kenya is among the countries listed to run short of water in the next 25 years (*Population Reports*, 1998)[8].

1.4 Urban Water Use: The Need for Multiple Water Balancing

There are two delicate scenarios that necessitate balancing of the urban water provision in Kenya. First, urban water supply entails imports of large volumes of water from the rural areas. Secondly, there is growing competition and a rise in unmet demand for water within the urban areas, hence necessitating a balance in the distribution across competing consumers. We have provided a breakdown of urban water consumption in Table 1.2 below. From the table, residential usage remains the highest in all the urban areas, consuming an average of 59% of the urban total. Industrial use is the second largest use (31%), while non-residential (institutional, commercial enterprises such as shops etc) is also a significant use at 10%.

Table 1.2. Water Balance for Urban Centres (Kenya), 1990

Urban Name	Water Demand (1000 m^3/day)						
	Population (000)	Residential Demand	Non-Residential Demand	Industrial Demand	Livestock Demand	Total Demand	Area Served (estimated) (ha)
Nairobi	1,413	175.05 (52.59)	29.29 (8.80)	128.30 (38.55)	0.19 (0.06)	332.83 (58)	10,553
Mombasa	480	59.41 (59.26)	9.94 (9.91)	30.77 (30.69)	0.14 (0.14)	100.26, (17.35)	3,582
Nakuru	172	21.33 (61.61)	3.57 (10.31)	8.92 (25.76)	0.80 (2.32)	34.62 (5.9)	1,286
Meru	79	9.77 (73.99)	1.64 (12.38)	1.58 (11.96)	0.22 (1.67)	13.21 (2.3)	589
Kisumu	176	21.83 (63.85)	3.64 (14.00)	6 (22)	0.51 (1.95)	32.03 (5.5)	1,316
Kitale	56	6.99 (74.40)	1.17 (12.44)	1.06 (11.30)	0.18 (1.86)	9.39 (1.6)	421
Eldoret	113	13.99 (68.64)	2.34 (11.49)	3.47 (17.02)	0.58 (2.85)	20.37 (3.5)	843
Nyeri	97	12.02 (77.23)	2.01 (12.93)	1.37 (8.78)	0.17 (1.07)	15.56 (2.7)	724
Thika	59	7.31 (65.65)	1.22 (10.98)	2.52 (22.65)	0.08 (0.72)	11.13 (1.9)	441
Machakos	91	11.29 (78.87)	1.89 (13.19)	0.98 (6.85)	0.16 (1.09)	14.31 (2.5)	680
Total	2,736	338.972 (58.67)	56.700 (9.81)	179.022 (30.99)	3.019 (.52)	577.713 (100)	

Source: Republic of Kenya, 1992. National Water Master Plan. Ministry of Water Development. Shaded regions (rows) in the above table show the areas covered in our study.

1.4.1 Rural-Urban Balancing

For many years, the need to balance development in both rural and urban areas has been critical in Kenya. The rural sector where the majority of Kenyans live is the agricultural base which is the backbone of Kenyan economy. The need for a balance in the rural-urban water transfers arise due to the following factors:

1. A major problem confronting policy makers is that growth of urban areas has so far occasioned water re-allocation from the rural to urban areas. The existing pattern of development that implies net-resource transfers i.e. in terms of water etc. would appear to undermine the long-term development goals of creating rural-urban balance since the rural areas themselves do not have adequate supplies of clean water. The challenge of balancing water allocation between urban and rural constituencies is thus real for Kenya.

2. Our earlier discussions (on spatial and temporal availability) suggest two features of Kenyan water resources that increase the challenge for effective management in the rural-urban water balance; i) precipitation across much of Kenya is exceptionally variable both in time and in space and unpredictable. ii) runoff which equates to the useable and renewable water resources in Kenya is extraordinarily low. A significant hydrologic feature in many parts of Kenya is the concentration of runoff in limited upland areas (generating long rivers that run through dry downstrean terrain) such as the Abedares and slopes of Mt. Kenya. Kenya is in a region influenced by the inter-tropical convergence zone, and is subject to marked seasonal and annual variation (Sharma et al, 1996). Concentration of runoff in the upstream areas, and the increased urban withdrawals means that, in most cases, the downstream riparians, often with a dry climate, are very dependent upon the actions that *upstream* and *urban* users take to develop their water resources. This is also complicated by the need for rapid growth of agriculture which is the backbone of the economy. So far, 76% of water in Kenya is used for agriculture – although these figures give the impression that irrigation is relatively common in Kenyan agriculture, only 5% of the total cropland is currently irrigated, compared with 29% for Asia. Thus, the dominance of agricultural end-uses in Kenya only indicates that irrigation, domestic and industrial supply systems are relatively undeveloped in Kenya. The above issues suggest that the scope for expanding future water supplies in urban areas would be narrower with increased irrigation and urban demand. While water transfers create positive externalities in the urban areas to which water is being moved, the negative externalities in the source areas include reduced water supplies for other water right holders, diminished economic activity, lower river flows and groundwater tables, and consequent degradation of water quality, wildlife habitat, and recreation opportunities (Colby, 1995).

An illustration of the above point is the Nairobi City, which is frequently affected by the over-dependence on upstream water supply from rural areas. Nairobi has an installed water production capacity from its sources of 519,000 m^3/d, estimated to meet the demand for the city up to the year 2006-2007. The current (year 2000) gross estimated water demand is about 371,000m^3/d. Recent episodes of drought in Kenya (in 1999/2000) which were mild by any standards impacted severely on the level of water supply in the city. The two largest sources of water for the city, the Ngethu and the Sasumwa dams, along with three other smaller dams, experienced a decline in their supply capacity from 346, 600m^3/d during normal conditions to only 274,900 m^3/d. Despite the fact that the drought was mild, it caused a decline of about 20% to the city that has always experienced water problems, the city water services were affected dramatically.

3. While drought and rural agricultural needs begin to compound and constrain the water supply situation to the urban areas, other factors have also contributed to the reduced supply, including the destruction of the catchment forests which has changed weather patterns and led to acute run-offs with resultant siltation problems in water dams and intakes.

4. Another dimension to the rural-urban water problem in Kenya is that the urban areas have already been tapped easily accessible water sources in rural areas, and supplies are approaching their physical limits, and new supplies for growing populations and rising consumption levels are available only at increasing cost. The syndrome of "water stress" is thus a reality in Kenya[9].

5. In spite the massive water transfers from the rural areas, high levels of "unaccounted for water", including leakage, illegal connections and, meter under registration currently estimated at over 50 per cent (leakage alone, however, accounts for only about half this value) continues to be recorded. In the meantime, inefficient and wasteful water use by consumers has continued even during drought when there was a tight rationing schedule. Measures are thus required to reduce the impact of unfavourable weather by making the

supply system more efficient in urban areas rather than continuing with transfers from the rural areas.

1.4.2 The Problem of Urban Water Insufficiency in Kenya

Even though growth of urban areas has occasioned development and water re-allocation from the rural to urban areas of Kenya, problems of urban water insufficiency continue to intensify (as these areas have rapidly grown in size and density and become focal point of industrial activity). Water service coverage for the urban areas are estimated at Nairobi (88%), Eldoret (58%), Kisumu (56%), Nakuru (60%), Thika (80%), and Nyeri (40%) (see table 5.2 chapter 5). There is persistent and growing unreliability and /or non-availability of water supply in all the urban areas. Because of this unreliability, 5-15% of the water service recipients in all the urban areas who obtain their supply from piped water have to change their sources of water between dry and wet seasons, implying the inadequacy or insufficient flow of the piped water supply to those already connected (Republic of Kenya, 1989, Demographic and Health Survey).

Because of the deficit in water service coverage within Kenyan urban areas, competition between domestic and industrial users has also heightened attention to the needs for prioritizing water resource allocation within the urban areas as these urban areas continue to rapidly grow in size and become focal points of economic activity. All the urban areas in Kenya attest to the need to address increasing urban water competition. Take examples of Nakuru and Kisumu, although Nakuru town has a large number of industries, water supply is inadequate while its disposal is also a major problem. According to the current Nakuru district development plan for 1997-2001, shortage of water is a major problem that has affected industrialization. The existing water sources are over-utilized. For example, the current water supply for Nakuru Town is 32,000 m^3, which meets only 50% of the required consumption for Nakuru. Due to shortage of surface water, there has been over dependence on groundwater sources. Unfortunately, groundwater resources are limited because most bore holes have high fluoride contents and hence are unsuitable for domestic use, thus the exploitation of ground water for domestic purposes is getting constrained (Republic of Kenya, Nakuru District Development Plan, 1994-1996:21). On the other hand, Kisumu City, the principal urban centre of western Kenya, stands at the shores of Lake Victoria - one of the largest fresh water lakes in the world. Yet the main constraint to its development is water supply. This is because the water schemes were designed for 50,000 persons; but today the population has increased over six-fold while the size of the supply has remained the same. All the existing water facilities are over-utilized. In order for Kisumu City to fully industrialize, more water facilities need to be initiated and the existing ones be improved to reduce water losses (Republic of Kenya, Kisumu District Development Plan, 1997-2001).

1.5 Industrial Water Demand in Urban Areas: The Challenge in Kenya

In the total use of public water in Kenya, the industry is still a minor user, only consuming 4% of the public water supply. The relatively small industrial water use however masks substantial differences in the industrial water consumption and its impact on the water resources. In all the urban areas the manufacturing industry consumes 13% of the public water and in the large urban centers the industrial consumption is much higher i.e. in Nairobi (39%), Nakuru (26%), Kisumu (22%), Thika (23%), and Eldoret (17%) (National Water Master Plan, 1992). However even these figures underestimate the impact of the industrial water use, first because in addition to the public water, many of the large industries consume large amounts of water from the rivers and private boreholes i.e. about half of the industrial firms use water from rivers and own boreholes. Secondly, many industries send polluted effluents into the rivers and thereby degrading water resources on which the population downstream is dependent. Industrial use of water is a critical aspect of the urban water strategy in all the urban areas.

A summary of Water consumption by industrial type in Kenya is given in table 1.3. From the table, both in terms of value added and total number of manufacturing units, Food Beverages and Tobacco is leading in Kenya. Wood and Wood products constitute the second largest activity followed by Textile Apparel and Leather; Paper and Paper Products. However in terms of unit water consumption, Basic Metal industries, Chemical & Petroleum Products and Paper Products and Printing are leading in Kenya.

Table 1 .3
Water Consumption by Industrial Type (Kenya): 1989

	Value Added in 1988 (Kshs 1000)	Total Units of Manufacturing Establishments (Nos)	Value Added per Establishments (Kshs 1000)	Unit Water Consumption Rate per Value Added (c.m/day/Kshs.billion (at 1989 prices)		Unit Water Replenishment (Raw Water) Rate per Value Added (c.m/day/ Kshs. billion (at 1989 prices)	
Food Beverages & Tobacco	6,423	678	9,474	5,617	6	3,300	5
Textile Apparel & Leather	1,630	398	4,096	8,443	5	6,794	2
Wood & Wood Products	458	442	1,084	732	9	655	8
Paper Products & Printing	1,238	283	4,374	19,471	3	11,394	1
Chemicals & Petroleum Products	2,643	211	12,524	26,521	2	5,295	4
Non-metallic Mineral Products	744	98	7,586	8,561	4	2,327	6
Basic Metal Industries	948	19	49,934	51,738	1	6,211	3
Machinery & Equipment	1,527	304	5,024	3,654	7	698	7
Others	339	94	3,612	1,360	8	568	9
Manufacturing Industry	15,951	2,527	6,312	13,015		3,287	

Source: Republic of Kenya, 1992. National Water Master Plan. Ministry of Water Development. Shaded columns show rankings of industrial sectors for the specific water attributes.

Even though the quality of water in Kenya's rivers is still considered to be generally good (Nyaoro, 2001), it is constantly under threat due to local pollution, particularly where there are intensive industrial, agricultural and human settlement activities. The problem is that most development experts and institutions think that water degradation due to industrial activities in Kenya is insignificant. Many of Kenya's largest and fastest growing water users are, for historical reasons, found at the beginning of small erratic streams rather than at the end of large, reliable rivers in Kenya. Evidence gathered from the field (provided in chapter 4) suggests growing possibility of over-pumping of vital groundwater reservoirs[10]. Furthermore, most of these industries discharge untreated wastewater and sewage on surface water, killing river life and making surface water unfit for downstream re-use. It is possible that much of this discharge is also causing contamination of groundwater. Although the total pollution load on the environment is relatively low due to the low industrialization level, the social impact of water scarcity and industrial pollution is significant due to the direct dependency of Kenyans on open water resources. Furthermore, the proportion of the population without access to adequate water in Kenya is still very high, making it essential to conserve the available river resources. About 68% of Kenyans obtain their drinking water from rivers either directly or indirectly (Republic of Kenya, National Demographic Survey, 1994).

Emissions of organic pollutants from industrial activities are becoming a major cause of degradation of water quality in Kenya. Every year large volumes of water are extracted by industries and in return toxic effluents and hazardous waste are released into the riverine environment. A significant number of chemicals persist in the environment and cause widespread soil and water pollution. The downward migration of pollutants from the soil into the groundwater can especially be problematic in Kenya where groundwater is often directly used for drinking without any prior treatment. Polluting substances include organic matter, metals, minerals, sediment, bacteria, and toxic chemicals. Data on emissions of organic water pollutants show that the load increased in Kenya from 26,834 kilograms per day in 1980 to 49,125 kilograms per day in 1998 (World Development Indicators, 2001). The industry shares of the emissions of organic water pollutants load in 1998 was distributed among several industrial sectors in Kenya as follows: Primary metals (4.1%); Paper and Pulp (12.2%); Chemicals (5.9%); Food and Beverages (68.4%); Stone, Ceramics, and glass (0.1%); Textiles (8.8%); and Wood (1.9%) (World Development Indicators, 2001). As a result of their strategic location, the waste from industrial activity is concentrated where it has the most severe impact. It is not uncommon to see rivers and streams treated as industrial sewers in urban areas of Kenya.

In all the streams and rivers, dissolved oxygen levels are so low as to preclude aquatic life in receiving waters. For example, data (Otieno, 1991a, 1991b; Office of the President 1991) regarding the pollution of Nairobi river shows pollution increases from the point the river enters the city. The pollution levels reach their peak as the river passes through industrial areas. This profile persists in spite of a) the flushing effects of the rains on the rivers; and c) the favorable nature of the tropical climate which allows for significant amount of self-purification of the industrial wastewater in Kenya. The Otieno study indicates that BOD for the Nairobi rivers (tributaries of Athi) have concentrations between 40 and 4400mg/1 (unpolluted waters have Oxygen Demand (BOD) values of 2mg/1 oxygen or less). The study also discovered high concentrations of sodium, calcium, potassium, magnesium, chlorine, and phosphorous. Toxic metals such as lead, chromium, zinc, and copper were also found in the Athi river. Some of the Kenyan Rivers are basically just “slow moving mass” of industrial effluents (The Daily Nation, January 28, 2001). A stream of effluent collected in Nairobi and its environs snakes through the semi-arid Yatta plateau and Tsavo wildlife ecosystem to pour into the vast Indian Ocean. En route, thousands of people, livestock and wildlife, and aquatic life live off it, oblivious of its perils.

1.6 Dematerialization: Implications of Industrial Water Practices in Kenya

Since the late 1960s there has been a "volatile and turbulent transition" in the developed countries towards a new pattern of industrial development with a shift towards relative "dematerialization" of production in which the volume of raw materials and energy needed to generate added value is reduced. For example one of the most notable aspects of these changes has been the relative "dematerialization" of production following the two oil crises in the 1970s where a drive for efficiency and "eco" improvements ensured that while the output of the chemicals industry has more than doubled since 1970, its energy consumption per unit of output has fallen by 57 per cent (Robins and Trisoglio, 1995). As an International Monetary Fund study shows, the improved resource productivity in the developed countries has become a long-term trend in which raw material requirements for a given unit of output have fallen by an average of 1.25% per a year since the start of the century (Robins & Trisoglio, 1995). Such advances are openly notable in the pulp and paper industry (the traditional water intensive and dirty industry) where recent advances in the wastepaper recycling technologies have enabled a reduction of water consumed by over 70 per cent. Ironically, it is alleged that the relative dematerialization in the developed countries, to a significant degree, has been brought about by the net transfer of energy- and resource-intensive industries to the developing world, in effect displacing rather than solving resource-use intensity and environmental problems of production[11]. Not surprisingly, it is estimated that the developing countries' proportion of global industrial production has increased from 9.3 per cent to 13.2 per cent since 1970 due to this industrial displacement (Kirkby, et al, 1995). In particular, there has been a marked redeployment of traditional industries such as textiles, leather, iron and steel, industrial chemicals and petrochemicals from the developed to developing countries. Often, these are the most water intensive and dirty industries.

Industries in the developed world have found that they can deliver the same or a better service with fewer material resources; for example, the average weight of a car has declined by nearly 400 kilograms since 1975, through improved design and the partial substitution of plastics for steel. "Eco-industrial revolution" has now become the global catch-word to help achieve a balance in industrial resource-use activity[12]. A number of scholars have spoken on the need to redefine the goals of industrialization and the tools and technologies used to achieve the goals with a primary aim of maximizing long-run efficiency in the use of environmental resources (such as water, air, minerals) in the production and consumption of useful goods and services. This has evolved into a move to industrial ecosystems that are increasingly "closed" resource or input use terms, with increasing bias to recyclable-conservation of resources (Robins & Trisoglio, 1995). The concept of “dematerialization” has extended to the agricultural sector where recent advances in biotechnology have opened up big potential to save water, principally by reducing the water consumption of plants and treating wastewater i.e. through the possibilities of changing the metabolism of plants for lower water consumption and the potential of biotechnology in treatment of waste-water, specifically, in biodegrading or separating heavy metals and other toxins, and in purification (World Commission on Water, 1999).

Many other examples have been presented to demonstrate the supposed trend towards dematerialization and a per capita industrial water use in industrial societies (Ayres, 2001). On the other hand, there are two countervailing trends that are often forgotten. Of course there have also been skeptics of dematerialization whose pessimism is based on two issues:

1. One is the so-called “rebound effect” – to the extent that dematerialization is accompanied by efficiency - lower costs and real savings to consumers, demand for products tends to increase. The lower cost of a unit of output simply encourage the consumers to buy more of goods or to replace these goods sooner that they would otherwise do. Allowing wasteful production might thus increase cost of production and minimize the demand for the goods.

2. Apart from the rebound phenomenon, there is another trend that may be working in the opposite direction. The ratio of indirect material consumption to material actually embodied in the product may become extremely large.

Our counter-argument to the first point is that if dematerialization is accompanied with upward adjustment of water tariffs then the question of rebound effect does not arise. Moreover, in most developing countries, the question of lowering the cost of products upon dematerialization can only be observed on the breach. In any case, if water resource costs constitute a very small proportion of the production costs they are unlikely to cause lowering of production costs significantly when the quantities consumed is reduced. Only deliberate pricing and regulatory measures could thus result in a meaningful reduction of water consumption.

There is no doubt that technological changes can be central to trigger dematerialization and help improve and reduce stress on water systems around the world. Without major technological development, there is little hope of bringing the water equation into balance (Report of the World Commission on Water, 2000). The technological possibilities are tantalizing, and must be a central part of overcoming the gloomy arithmetic of water (ibid:309).

> *However, much of the current industrial water practices in many developing countries are also deliberately wasteful and can be adjusted without any technological changes. The wasteful consumption is often a result of the perception that water resource costs constitute a very small or negligible proportion of the total production cost, hence the industrial firms have no reason to worry about. Furthermore, none of these firms are currently being compelled to bear the full cost of the negative impacts arising from wastewater discharges.*

The World Commission on Environment and Development the "Brundtland Commission" devoted a special chapter in *Our Common Future* (1987) to the concept of "**sustainable industrial development**"[13]. This concept is of universal significance, relevant to developed and developing nations as well as the so-called countries in transition to a market economy. However, even before a formal birth of "sustainable industrial development" concept to the global economy, among the developed countries, the threat posed by industrial development has been countered very aggressively through, stringent natural resource and environmental policies that ensure efficiency in water conservation. This uncompromising stance has resulted into *water resource use efficiency* and a partial *dematerialisation* of the manufacturing production process in the industrial countries. The need for sound water resource management is only beginning to make sense in the less developed countries where until recently, the negative effects of industrial activities were not drastic enough to warrant immediate attention.

1.6.2 Dematerialization and Industrial Efficiency: The Kenyan Case

While in the last few decades technology has promoted dematerialization and the internalization of production, thus assisting in mitigating water resource scarcity and abating environmental degradation in the developed countries, the extent to which developing countries have had the capacity to absorb such technological advances remains doubtful. Many developing countries have remained at the periphery of these developments. Indeed one of the assumptions of the current water master plan in Kenya is that:

> *"Industrial water recovery rate in Kenya would be half of that of the developed countries by the year 2010" (Republic of Kenya-Water Master Plan, 1992).*

Even though the assumptions of the water master plan are modest, we hasten to add that given the current state of events, the projected water consumption and degradation levels will be surpassed unless appropriate policy measures are put in place. In most cases, lack of political will (due to low priority attention given to water resource management matters) to enforce fundamental policy and *technological* changes, and the absence of local industrial initiative, has led to preference for easy, quick fix to technological (pollution) problems, water scarcities, with unsystematic solutions. For example, one striking feature of the Kenyan industry noted in various surveys is the low levels of reported capacity utilization. Most firms could increase output substantially with existing resources. In a Teitel (2000) study on Regional Enterprise Development Programme, 13.3% of the firms indicated they could increase output by up to 25%, 54% by between 26 and 50%, 21.6% by between 51 and 100%. A substantial share of firms, 11.1%, said that they could increase output by more than 100%. The excess capacity is largest in textile and metal-working, however the excess capacity is often in outdated and uneconomic equipment. The Teitel study shows that up to forty percent of the firms were planning to invest in order to expand activities and improve technology. A number of firms did not have specific plans for the future. Some expressed serious doubts about their prospects; others were planning to retreat from the industries they were in. A large majority of the firms with specific plans for the future were contemplating both expansion of the physical plant and technology improvement. The vast majority of enterprises with firm plans were planning to acquire new machinery. The reasons and motivation for the planned technical changes varied substantially from industry to industry and among firms. They included: improvements in quality, capacity expansion, lowering of costs, and production for exports, among others. None of these industries expressed resource efficiency as their primary pursuit for planned technical changes. With regard to technological development,

> *From the Teitel study, the picture that emerges from the Kenyan industry is that of an industry that lacks dynamism and adaptability since it uses the technology as delivered by the machine suppliers, with hardly any independent attempts at technological development or even improvement.*

What does this imply for water management? On the one hand the general level of training is not that low in Kenya (Teitel, 2000). On the hand there seems to be a general lack of incentives for undertaking production improvements that could enhance resource/input-use efficiency. This is likely to be a major factor in industrial water use. It does point to the fact that unless deliberate policy measures are undertaken by the government to improve water use efficiency industry, the initiative is unlikely to come from the industries themselves.

1.7 Conclusion

This chapter has identified a number of culprits in the impending *water trap* that could warrant urgent policy and institutional measures in Kenya. The primary issues are the rapid urbanization, and industrial development, coupled with the finite nature of the freshwater resources in Kenya. The scale of severity is visible in the lack of water services, with between 12 and 14 million people without access to safe water and over 20 million without adequate sanitation. Secondary explanations linked to the growing water scarcity are; water catchment degradation, droughts, and pollution of waterways by industries, and inefficiency of water use among different users. Because the water resources in Kenya are finite, water use efficiency holds the key to Kenya's long-term water needs. In view of these challenges, water policy and institutional structures must be made appropriate to the emerging social and economic contexts. Efficient management of industrial water resource has to integrate both, water use and the management of wastewater resources for sustainability to be attained in Kenya. In the next chapter, we examine the water sector policies.

Notes

[1] World Resources Institute (WRI), United Nations Development Programme (UNDP), UNEP, World Bank, 2000, *World Resources 200-2001, People and Ecosystems: Fraying Web of Life,* Oxford University Press, New York. United Nations Environment Programme (UNEP), Stockholm Environment Institute, 1999, *Global Environment Outlook 2000*, Oxford University Press, New York.

[2] Reduction of the use of natural resources in production and consumption is often referred to as "dematerialization".

[3] The others are power, telecommunications, roads, rail and port facilities.

[4] These figures are attributed to Dr. Mohammed Isahakia, the permanent secretary in the Ministry of Environment and Natural Resources, during a press release on the water situation in Kenya, September 19, 2001, East African Standard Newspaper.

[5] These hopes are expressed in the National Development Plan 1997-2001 and Sessional Paper No.2 of 1996 on Industrial Transformation to the Year 2020 (Republic of Kenya).

[6] The other countries are Ethiopia, India, Nigeria, and Peru (*Population Reports*, 1998.

[7] Indeed Sahel has experienced a statistically significant decline in rainfall by 30 percent over the last 20 years. Some authors argue that per capita water supplies in Africa have actually declined by as much as 50% since 1950.

[8] See the Kenya Demographic and Health Survey Report 1989 for details of the water situation.

[9] It has been argued that societies suffer water stress when annual renewable supplies fall below approximately 2,000 cubic metres per person at a time when demands for water are increasing in the process of development Winpenny (1994:3).

[10] Since the water supply in most of these towns is less than the demand, we can conclude that some competition must exist in sectoral water allocation /distribution.

[11] A parallel activity to this has been the cross-border trade in toxic waste that began as a general practice in the late 1970s and continued to grow throughout the 1980s and into the 1990s (Clapp, 1994:506).

[12] A group of ecological economists are documenting the prospects for "dematerialization" at the Wuppertal Institute for Climate, Environment, and Energy in Germany. They have calculated the material input per unit of service for numerous consumption goods (Costanza et al, 1997; p.73).

[13] Also emphasized in various chapters of Agenda 21 i.e Chap. 4 "4.5. Special attention should be paid to the demand for natural resources generated by unsustainable consumption and to the efficient use of those resources consistent with the goal of minimizing depletion and reducing pollution.....Changing consumption patterns will require a multi-pronged strategy focusing on demand, meeting the basic needs of the poor, and reducing wastage and the use of finite resources in the production process". Chapter. 30 on Business and Industry etc.

2 The Water Sector Policies in Kenya

2.1 Introduction

The term *policy* denotes a set of ideological arrangements, introduced by government, which could be used to attain some development goals through use of instruments. P*olicy instrument* has been used to denote a set of measures used to attain some target of policy (Perman et al, 1996: 223). Policy instrument is an authoritative choice of means to accomplish a certain purpose (Elmore, 1987: 175). Policy instruments and their embedded assumptions are transferred to institution-building and project implementation. Policy formulation and implementation create interest groups that become constituencies supporting the development paradigm. Many social scientists have labored for decades trying to explain why state governments adopt the policies and programs that they do (Rinquist, 1994). In this chapter, we provide a formal analysis of the links between the development of water sector policies and the policies for industrial water demand and wastewater regulation in Kenya. The chapter is organised as follows: we begin in section 2.2 by discussing the origins, historical foundation, and experience of the water sector policy. Section 2.3 examines the primary factors influencing the choice of water-sector policy paradigm, while section 2.4 looks at water sector policy strategies. In section 2.5 we identify range of policy instruments commonly used for industrial water management. In section 2.6 we turn to the water pricing structure in Urban Areas while section 2.7 provides an evaluation of pricing and regulatory strategies in urban areas. We conclude in section 2.8.

2.2 The Origins and Trends in Water Sector Policies

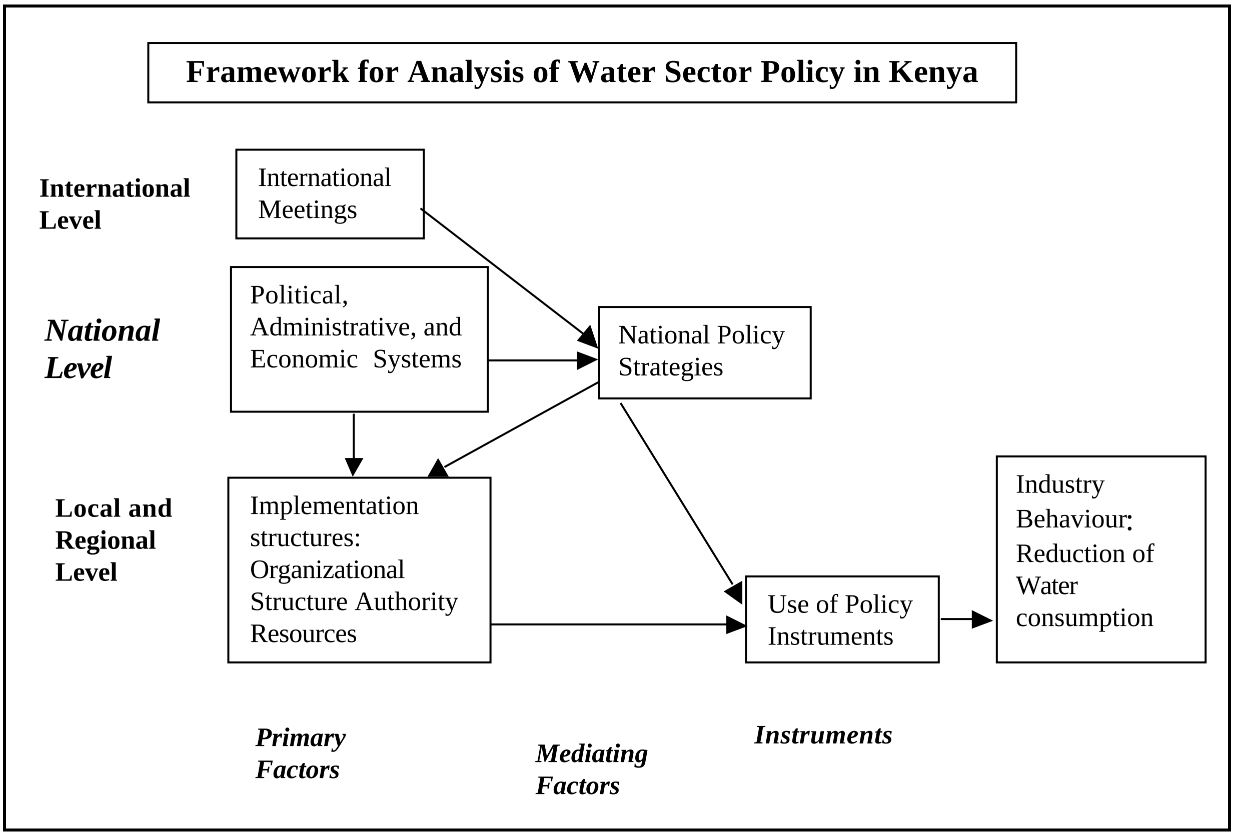
2.2.1 Our Framework for Water Sector Policy Analysis

In many developing countries, the national water and sanitation policies are shaped by two influential forces: (a) national needs for water and sanitation services and (b) pressure exerted by international development agencies and lending institutions. In countries where sector needs are well known, clearly defined and information is readily available, there usually exists a government response to these needs. One of the signs of this responsiveness is the presence of national policies for water and sanitation that spell out national concerns, sector priorities and overall goals. Having formal policies assists governments in formulating long-term plans, mobilizing domestic resources and approaching international development agencies and donors for additional resources. The international organizations, in turn, often encourage countries to establish sector policies as a precondition for financial and technical support. Water sector policies are a product of three steps summarised in Figure 2.1. The first step comprises the existence and influence of *primary factors* that inform the water policy stance. These factors include (i) international events, (ii) the national needs and development goals and (iii) local level implementation structures (the structures are discussed further in chapters 5&7 under "institutions").

The second step comprises of the *mediating factors* - the *national policy strategies*. The national policy strategies reflect an interpretation or translation of the policy goals as stipulated by the primary factors. Often, this step is fraught with political, regional or local (and sometimes, myopic) interests with strategies that serve *vested interests* gaining expediency. The end result of the mediating forces is that policies that appear sound at the primary level get distorted at this level. On the other hand, unintended consequences might also result from the effect of these mediating variables. Finally, in the third step are the *instruments* – the choice of water-management *policy instruments*, i.e. those surrounding the use of water tariffs and wastewater regulation. Each policy objective has a range of policy instruments available to it, although mediating factors and the institutional arrangement will heavily determine the extent of successful implementation. Although all countries have some type of guiding policies for water and sanitation development, not all have legal enactments or formal written statements to back such policies. In fact, most countries identify with formal water and sanitation policy guidance from general development policies, often embedded in national development plans or, in some cases, water acts. Depending on how a country organizes its water sector, formal written policies may not be needed, as long as the country is clear about what it wants to do about water and sanitation services. Another aspect which contributes to *de facto* policy formulation for water and sanitation is the establishment of policies, standards and programmes in areas or sectors such agriculture, manufacturing, that are associated with the water sector needs. The establishment and enforcement of guidelines for or within other sectors provide limits, or boundaries, to unwritten policies dealing with national coverage and access to water and sanitation.

Policies may be formally stated or they may only be implicit in government's actions. For example, until 1990s, the Kenya Government did not have a published comprehensive water sector policy but, instead, relied on the guiding principles formulated for the water sector and contained in National Development Plans for sector specific development; and the Water Master Plan. There was no comprehensive documented framework to guide the development of the water sector. Much of the policy was implicit in government programmes for the other development sectors such as agriculture, energy, urban and rural areas. Various water development programmes and projects were formulated and implemented to meet development requirements of various sectors and sub-sectors of the economy. This reflected, in principle, the policy strategies adopted by the government to meet the water sector needs. Despite the absence of formal policies, water and sanitation were very high in the development agenda and enjoyed a prominent political profile. These were embedded in the general development policy goal of providing potable water within a reasonable walking distance in rural areas and providing piped water within the household in urban areas.

Figure 2.1 A Framework for Water Sector Policy Analysis in Kenya



2.2.2 Historical Steps in water policies

The Kenyan water policy is fundamentally located in the Water Act, Section 3, under which the overall ownership of water resources in Kenya is vested in the Government. At the time of independence, water policy issues were treated as part of general government development policy. The political economy of Kenya's independence in 1963 put a great deal of emphasis on the process of nation building. Immediately after Kenya's attainment of independence in 1963, the Government launched "Sessional Paper No.10 1965 on *African Socialism and its Application to Planning in Kenya*." This paper directed Government Policy towards priority development concerns for Africans, which at that time were identified as poverty, illiteracy and diseases. The policy broadly meant that major *basic services* were going to be expanded and provided free or subsidised by the Government. At the time of independence, the Government and donors saw poverty, ignorance and disease as the critical enemies of development that needed to be tackled expeditiously.

> *The essential component of poverty alleviation was to be through provision of drinking water in 1960s. Expansion rather than conservation took the center-stage for development. The effort towards the development of the water sector was based primarily on a global development paradigm that viewed water as a basic need and an important catalyst necessary to accelerate both economic and social development.*

The major management challenge was the development of water supply systems to store and transport water to the population. The construction and operation of great dams, tunnels and pipelines, the local construction of systems of weirs, pump stations and irrigation canals, symbolized what for many was the business of *water management* to eradicate poverty.

During 1974, the Government of Kenya promulgated the National Master Water Plan with the express aim of ensuring the availability of portable water within 4 kilometres of every household by the year 2000. This was to be achieved through

> *the expansion and establishment of water supply projects, sinking boreholes, construction of catchment dams and provision of the necessary conveyance infrastructure in the form of pipes and furrows.*

On the *management* of water resources, Kenya's third development plan for 1974-1978 articulated the need to manage the resources for ecological, socio-cultural and economic benefits. Eventhough, it recognized the lack of appropriate institutional arrangements and clear policies as limiting the task of water resource management. Commitment to management of water was not viewed from an expansionary perspective entirely. There were "soft" concerns (perhaps expressed in writing only without any action programmes) for the future of water resource base. For example, on water resource degradation (conservation), the 1965 Sessional Paper had recognised that the heritage of future generations depended on the adoption and implementation of policies designed to conserve natural resources and create the physical environment in which progress could be enjoyed. Thus the policy paper articulated the need to integrate water resources management concerns into development planning while the thoughtless destruction of natural resource base i.e. through pollution, water catchment degradation had to be brought under control.

2.3 Primary Factors Influencing the General Water Policy

Kenya's water development policy was reinforced by the prevailing Western development paradigms of development that emphasised "big push" and "unbalanced growth," and by the programs of the foreign-assistance agencies and multilateral banks which built large public institutions to manage substantial portions of the economy. Under the "Basic Needs Approach", the predominant framework to water resources development in Kenya focused on new water supplies and structures to meet *perceived* water needs. Hallmarks of this supply driven – basic needs approach included large dams, water diversions, central water supplies and wastewater treatment works, and such structures in many parts of Kenya. There were other landmark international events and declarations that also influenced the direction of water management in Kenya. We have summarised these in Box 2.1.

Box 2.1: Key International Events in Kenya's Water Sector

1970: The location of the Environment Liason Centre International in Nairobi in the mid-1970.

1972: Environmental awareness in Kenya was given new impetus with the location of the UNEP in Nairobi following the 1972 United Nations Conference on the Human Environment in Stockholm.

1974: The National Environment Secretariat was created by a Presidential Decree in 1974 in response to a perceived need for a single national agency to coordinate environmental activities. The formation of NES in 1974 and the location of the Environment Liason Centre International in Nairobi added to a large extent on effective environmental management.

1977: The International Drinking Water Supply and Sanitation Decade launch (Mar del Plata, 1977);

1981: Permanent Presidential Commission on Soil Conservation and Afforestation (formed in 1981). The president has prerogative to deal expeditiously with matters of substantial public concern. This power has been used on several occasions to address environmental issues. In 1981 the President used this power to establish the Permanent Presidential Commission on Soil Conservation and Afforestation. At the National Level, the 1980s was marked with National Conservation Strategies (NCS). This was a Centre-piece of environmental policy in every country. International Union of Conservation of Nature (IUCN) was the prime mover.

1988: District Focus Strategy for Rural Development. In 1988, the Government decided to appoint District Environmental Officers (DEOs) in each district. DEOs lend administrative support at the district level to the evolution of national efforts towards an integrated approach to the environment. The 1980s also saw the re-emergence of serious global issues (such as ozone depletion and climate change). This led to the formation of the World Commission on Environment and Development (WCED) under the leadership of Norwegian Prime Minister Gro Harlem Brundtland. The WCED rekindled the Stockholm spirit and reshaped the environmental agenda to reflect efforts to meet our current needs without undermining the needs of the future generations (sustainable development).

1990: The 1990s National Environmental Action Plans (NEAPs). World Bank has been the prime mover.

1992: The World Conference on Water and the Environment (Dublin, 1992);

1992: The 1992 United Nations Conference on Environment and Development in Rio de Janeiro is the crowning glory of sustainable development.

1994: The Drinking Water and Environmental Sanitation Conference on the Implementation of Agenda 21 (Noordwijk, Meeting of Ministers, 1994);

1996: The Global Water Partnership meeting (Stockholm, 1996); and

1997: The First World Water Forum of the World Water Council (Marrakesh, 1997).

2.4 Water Sector Policy Strategies

2.4.1 Strategy for Rural Water Provision

Experience of the early decades showed that, guided by the goal of seeing that water availability did not become a constraint to the country's development,

> *the deliberate policy of the government was to champion expansion of water supply development.*

While water resources appeared plentiful, the task was simply to harness and deliver them to consumers. In much of the 1970s, dams, pumping stations and pipelines were built to store floodwater for use in periods of drought and to redistribute it to supply the activities and areas where it was most needed. Many communities had joined hands in the spirit of **Harambee** (pulling together) and initiated a large number of self-help water projects in various parts of the country. Many projects had been prepared and implemented in isolation focusing mainly in raising the service coverage levels. Such projects failed to deliver sustainable supply of water due to lack of meaningful improvement of the support of these facilities. The Water Development Department operated from various Government ministries before it became a fully-fledged Ministry in 1974. Upon creation of the new Ministry, there was a systematic effort by the new ministry not only to embark on an intensive water programme in both rural and urban areas but also to inherit most of the self-help water schemes without looking into their socio-economic viability. The outcomes of the dominant role by the ministry in the provision of water supply were that the Ministry's effort overshadowed the self-help (cost sharing) initiative that had characterized the process in rural areas. Although many donor interventions were also encountered at this early period, their assistance to the Ministry was mainly complimentary in the development of new schemes while very little attention was paid to the operation and maintenance issues.

2.4.2 Urban Water Provision Strategy

In line with rural water strategy, there was a systematic trend by the government of taking over Self-Help Water Supplies and County Council Water Supplies i.e. in small urban areas in the belief that there would be a better management and further development of the urban water schemes. The broad policy objectives (among other objectives) in the urban areas was to:

i) provide incentives for efficient water use and penalizing wasteful or environmentally harmful water use practices;

ii) adopt water distribution practices and water pricing policies to ensure that social objectives were not ignored; and iii) develop technologically appropriate wastewater treatment facilities to deal with liquid wastes, and to monitor the possible pollution effects of the disposal of wastewater.

Under the Municipal Water Supply Programme augmentations to the systems of all municipalities were planned. Revenue generated through water rates in these municipalities was projected to constitute only about 40% of the total costs of running the supplies.

2.4.3 Problems with the Water Supply Management Strategy

There were several problems with the approach to water supply development in Kenya in which the water sector policies were embedded in the national development goals and programmes:

(i) the business of *water supply expansion* was perceived as development, even in areas where supply shortfall was not critical or a priority.

(ii) Because of this perception, water issues quickly acquired political expediency. Expanding the water supply without requisite plans thus characterised the process of water provision in the 1970s.

(iii) On the other hand, there was lack of political will to operate within the resource constraints and stated priority areas. Even in urban areas where there were possibilities for full cost-recovery, low recovery rates were maintained i.e. 40%. The above scenario meant that financial and economic viability (sustainability) goals for the water schemes were subverted for purely political ones. Issues of cost-effectiveness, appropriate delivery technology etc completely escaped the policy makers[1]. Instead there was over-emphasis on the political expediency and the socio-cultural importance of the water resource supply itself, even in locations where the supply was compounded with problems of insufficient coverage, poor utilisation and high costs. The water sources had also been neglected with the catchment areas being left unattended resulting in depletion of the water resources.

(iv) Little or no attention was paid to demand management and issues affecting operational efficiency of the water schemes in both urban and rural areas.

(v) Water sector policy of "expansion" and "inheritance" also brought other lessons, as the expansion was not commensurate with the existing institutional situation. Focusing the state's institutional capability on the most important tasks would have been very critical to the process. The Ministry of Water had inherited numerous water schemes without reflecting on its own institutional capacity. The policy of expanding supply had been "institution-intensive" since with so many actors involved in the provision of water, there were need to co-ordinate these activities by the various players. As a result, not only were the various arms of the Government in disagreement or in confusion but also there were no clear policies providing for water resource management and well-established and coherent institutional system to implement the water policies.

(vi) Effective management of water resource degradation in Kenya required that water quality and quantity be dealt with conjunctively, however the wastewater policies have barely changed over the years. For example, construction of urban water supply systems was not harmonized with the construction and extension of sewage disposal systems to avoid problems of wastewater disposal in most of the urban areas. Because in the previous years the construction and extension of sewage disposal facilities proceeded at a much slower rate than water supply augmentations, a substantial backlog of sewerage works in urban centres was planned from 1974-78 period to reach a point where water supply and sewage disposal requirements were in approximate balance in the principal urban centres. But, as history would indicate, these plans proved to be ambitious and were never implemented. Self-disposal of wastewater discharges or sewer disposal became an acceptable alternative in the urban areas.

As activities that use water became more varied, and as the use of water became financially unsustainable, the nature of the water management business had to change in the late 1970s. Attention increasingly turned to the need to protect and sustain the water resources with particular emphasis being given to the sustainable management of water as a limited natural resource. The Government of Kenya with assistance from the Government of Sweden conducted a study for a nation-wide master plan between 1976 and 1981. This study in addition to proposing a framework for the water development also highlighted the fact that there was the lack of a comprehensive policy/institutional/legal framework to guide development in the water sector. The historic development characterized by supply expansion in the water sector policies and strategies had to change. The water management system and the law that underpinned it had to reflect the new realities. To address these shifts it was prudent that a thorough review of both policy and institutional framework be undertaken in the water sector.

2.4.4 The Water Sector Policy Reforms: Shift to Cost Recovery in the 1980s

Policy reforms that characterized the water sector in 1980s were precipitated by a number of factors that mainly arose from lessons of the earlier decades. *First,* it was apparent that the depth of government involvement in the water sector had become both economically and institutionally unbearable even though it remained very attractive politically. This became a serious burden and triggered the need to reduce the dependence of the public sector on the exchequer so as to improve the utilization of scarce resources by enhancing returns on those resources to achieve greater efficiency. *Secondly,* there were secondary factors that precipitated the process including i) very drastic changes that had occurred in the international economic setting since 1973 when oil prices started their dramatic rise; ii) government revenues became harder to raise and iii) foreign aid was becoming more difficult to obtain (Sessional Paper No.4 of 1982). Faced with serious financial crisis that made it impossible to maintain a strong presence in the provision of water services, there was a policy reversal in Kenya in the late 1970s.

Consequently, the new and prominent policy position taken by the Kenya Government was that everybody should pay for water services. The policy statement was nevertheless quick to add that since water was a basic need, its pricing would be such that the water rates would only cover direct operation and maintenance costs for the water supply schemes (Kenya Development Plan, 1979-83). Even within the urban areas, pricing and demand management and other efficiency measures had so far received only lukewarm attention. The shift in policy meant that instead of viewing water as an instrument of *socio-economic* development, a financial sustainability approach was being adopted. The above policy shifts notwithstanding, the provision of water, both in the urban and rural areas, would still be viewed by the Government as a *provision of service* and not as a source of revenue. The new policy direction did not reflect changes in the domestic economic environment alone. Globally, the approach by multinational donors (World Bank etc) to "development funding" in the same period was marked by a shift from Basic Needs Approach to demand driven approach beginning in the mid 1980s (coupled with demand management strategies). This was to culminate into a key aspect of Structural Adjustment Programme implemented in the 1980s. Thus “Commercialization of Water and Sanitation” facilities in Kenya first featured in Sessional Paper Number 1 of 1986 on “*Economic Management for Renewed Growth”*. The paper suggested decentralization of the water provision facilities by the operations to Local authorities, which had the necessary administrative and technical capacity. The Local authorities through the Ministry of Local Authority were urged to revise the pricing of the utilities and services (i.e. health and water services) to ensure that they reflect the real cost of operation, maintenance, and long term capital stock replacement.

In spite of the earlier declarations to focus on cost-recovery and demand management in the water sector, the government appeared to backtrack in the Sixth National Development Plan for 1989-1993 by reiterating a wish to expand the existing water programmes and to start new ones. In the rural areas, there were plans to increase the proportion of people served by organised water points from 26 to 50 percent by 1993. In the urban areas, the proportion was to increase to 95 from 75 percent. At the same time, private sector and harambee initiatives were encouraged to supplement government effort and allocations (Republic of Kenya, 1993). Nevertheless, it remained oblivious how cost-recovery measures and private sector role would be encouraged. Another landmark event came in 1992, when the government, in collaboration with Japan International Cooperation Agency (JICA), published the National Water Master Plan. The master plan (an update of a nation-wide conducted between 1976-1981 with Swedish finance), aimed at identifying the constraints and formulating a framework for the implementation of the all the water development needs towards the year 2000. : The main weakness of the 1992 (current) water master plan in Kenya is that it is

> *typically engineering driven, focussing on technical issues. The plan was drafted in an institutional vacuum and fails to address pricing, ownership, and incentive issues effective for sustainable water management in Kenya. Even the strategic plans for the different towns do not incorporate adequate analysis of demand and supply, pricing and ownership issues. Instead, they pay attention to the bulk water supply arrangements / needs.*

In 1994, the government published the National Environment Action Plan Report in which it was recognised that there were over thirty institutions both public and private that played various roles in the water sector, but that they lacked policy guidelines, thus generating duplication of efforts, conflicts and non-accountability. The report recommended the introduction of incentives for recycling water – recognition of the fact that hitherto, the uses of water were wasteful and inefficient. The report also recommended for the introduction of proper facilities for pollution control and for the usage of cleaner process technologies. In the Seventh National Development Plan (1994-1996), in order to ensure water resource conservation and management, the use of harvesting technologies that are sustainable and environment-friendly would be given priority in both surface and groundwater development.

2.4.5 Water Financing Policies Specific to Urban Areas

From their inception at the time of independence, it was intended that systems for urban supply and sewage disposal (Local Authorities) became self-supporting financially. Some attempts had been made to establish water rates on the basis of full recovery of capital, operating and maintenance costs. However, most of the urban water projects had faired very well in the first decade and the need to recover full costs had been taken lightly partly because of the massive capital support (donor and government) injected into the sector[2]. Per capita water availability improved, there was very little water loss from the supply system (since the infrastucture was new anyway) and UFW remained very low (below 20%), there was surplus revenue above the costs of supplying water in the major urban areas. Local Authorities in Kenya played an important role until 1970. The Local Authorities spent about 20% percent of the total expenditures of central and local government combined received as grants. However, from the very beginning the financial position of the LAs was made weak by this dependence on central and local government for financial resources. While their revenue remained constant until 1970, their recurrent expenditures increased by approximately 25% over the same period. The deficit was financed through overdrafts and drawing down on reserves.

The direct state provision of Urban Water Service (UWS) was the institutional norm throughout most of the world. Until the mid-1980s, UWSs was the public service in which the private sector was least involved. Although the argument in favour of direct public provision has often been defended on the assumption that it is a public good, other considerations, both ideological and practical, weighted heavily. Among these were: past preference among both governments and donor agencies for state-led development, the weakness of the private sector, and the professional culture of water-engineers.

Water pricing policy in the first decade of independent Kenya had intended to make systems for urban supply and sewage disposal *self-supporting financially* as rapidly as possible. The policy statement then, indicated that the water tariffs be structured on the basis of a full recovery of capital, operating and maintenance costs of all schemes taken together in the long run. However since all the water authorities were receiving substantial financial grants from central government and other donors, the water authorities were financially sustainable (or *self-supporting*) at relatively low level of cost recovery. In situations where national development objectives required the installation of water and sewage facilities before local conditions permitted that they be fully self-supporting, the policy stance was to defer recovery of such costs (Kenya Development Plan 1974-1978, p.328). In most cases the policy statements fell short of stipulating the local conditions that could warrant deferring of cost-recovery water rates enforcement in urban. This weak requirement provided a leeway for the local authorities to discard the use of water rates to recover operational costs. Instead, the Local Government Loans Authority (LGLA) and the general taxation for the running of water utilities became the easy sources for Local authority finances.

To compliment government policy formulated in 1974, there were new policy objectives of making urban places of similar size and function have similar tariff rates by establishing charges for water and sewerage services. The achievement of these objectives required that rates be based upon the *average variable cost* of water schemes in the urban centres of the same class. The policy objective faced multiple difficulties which led to radical modifications in the tariffs policy. Among the difficulties were the fact that:

(i) Different urban areas even those of the same size were operating under different institutional settings which implied differences in the costs of operation.

(ii) In many cases, the financial systems were consolidated, with the water revenues covering the expenses of all the other departments.

(iii) Water pricing policy in most cases had to be determined on the basis of local authorities' financial (accounting) requirements to meet part of their general operating expenses and debt service requirements.

(iv) In many cases the urban water authorities could not establish the extent to which they were subsidizing or overcharging their customers.

Most, if not all of the urban authorities in Kenya could not successfully implement the cost recovery-policy on pricing of water services as recommended. Furthermore:

(v) water tariffs (rates) were based on engineering principles and not sound economic management principles; in many instances, ethics, principles and practices differed from one urban area to another, while political and social considerations remained predominant.

(vi) Often the collection of water tariffs concentrated on a segment of the "obedient consumers" who were compliant in paying their water bills. This had the danger of leaving out the stubborn or notorious users who used their connections (political etc) to maintain illegal and probably more profligate consumption (Republic of Kenya 1990; Socio-Economic Profiles, Ministry of Planning and National Development, and UNICEF. p.257). The end result was either inadequate or inequitable rates to the same consumers in different urban areas.

By 1980, it had become clear that the Government's capital investment for urban development had not kept pace with the growth of urban population. The capital funds were usually channeled to the Local Authorities through LGLA. With the exception of City of Nairobi where there was massive investment in the water supply system from 1981 onwards, per capita spending had dwindled steadily in all the other urban areas. Between 1971–84, the capital expenditures to municipalities decreased from Kshs1812 million in 1971/77 to Kshs1758 million in 1978/84, and per capita water allocation had declined from Kshs1640 per additional urban resident to only Kshs1440 over the same period. The number of urban councils sharing the goverment financial support had dramatically increased over time due to the implementation of the *growth centre strategy*. Most of the Local Authorities were losing their capacity to service their accumulating debts against the government (these were mainly loan charges for LGLA and statutory deductions). On the other hand, Government departments owed local authorities arrears in form of contributions in lieu of rates, water and sewerage charges, service charge and house rents. This status of indebtedness could be resolved through a clearinghouse, offsetting of debts and partial write-off but has remained one of the major issues contributing financial apathy and mismanagement in the local authorities.

When Structural Adjustment Programmes (SAPs) were first introduced in Kenya during the 1980/81 fiscal year with the aim of restoring efficiency in all sectors of the economy, one of the sectors that was targeted was water[3]. To enable Local Government Loans Authorities (LGLA) fulfill its crucial role more effectively, attempts were made to restructure it along the lines of municipal development bank (i.e. so that it could offer loans to LAs at commercial interest rates). While this could result in higher interest costs and a greater burden to local authorities, it was also hoped it could encourage prompt repayment of loans and stimulate savings deposits from local authorities themselves. Furthermore, the LGLA was to be authorized to seek funds on the capital market, both in Kenya and abroad, thus increasing the total resources available to local authorities and reducing their dependence on the Central Government (Sessional Paper 1, 1986:51). Over 60% of LGLA disbursements were for water and sewerage projects. The attempts to reform LGLA were completely unsuccessful. LGLA was mostly procuring its monetary sources lending to local authorities through Ministry of Finance and MOLG. The principal donors provided around 80% of the original sources as loan sources. These donors included African Development Bank (AfDB), United States International Development agency (USAID), International Development Assistance (IDA). One of the issues of contention was that most of these loans had been written-off (or forgiven) by the original lenders hence the LAs did not feel obliged to continue repaying them to LGLA. The other main SAPs component of Government budget rationalization which entailed a reduction in government budget further impaired the performance of the water sector institutions as there was systematic staff reduction; lack of equipment; and general poor working environment between 1980s and 2000.

The institutional environment for the LAs operations was also complicated in 1980s by the introduction of a development strategy – District Focus for Rural Development, requiring the local authorities to channel their planned projects through the District Development Committees under the chair of the District Commissioner. Since July 1983, most of the LAs also had to function through District Development Committee (DDC) under the chairmanship of the District Commissioner - Office of the President. For logical institutionalisation of urban development co-ordination the Urban Development Department (UDD) was created in 1991 within the MOLG with the exclusive function of: strengthening local authorities technical capacity for operation and maintenance of infrastructural system, contribute to training of local authority staff; guide LAs on consultancy and contractual matters; prepare policy and legal framework among other functions. Furthermore, In the 1980s some of the major municipalities including Nairobi were put under commissions appointed by the Ministry of Local Authorities due to faltering administration and weak revenue base. In this way, the Ministry got directly involved in the day-to-day executive functions of the LAs.

2.5 Water Sector Policy Instruments

2.5.1 The Range of Policy Instruments

There is a wide range of policy instruments currently available for (industrial) water resources management. However, only a few of these instruments (in shaded regions) have been adopted in Kenya.

> *The main reason for this limited choice in Kenya is that most of the water sector policy instruments remain sophisticated and very demanding to implement.*

Other water sector policy instruments are still at formative stages and countries that have adopted their use (mainly developed) have done so on experimental basis. In Table 2.1 below, we display a comprehensive listing of all the possible policy instruments that are currently used to influence water management (industrial) either in Kenya or elsewhere. In line with this limited choice of instruments in Kenya, our discussion here focuses on the dominant instruments in Kenya (water tariffs and regulation).

Table 2.1. Instruments to Influence Industrial Water Management

Instrument	Focus of Management		Usage Elsewhere	Usage in Kenya
Non-Economic Command and Control Policies				
Water use quotas[1]	Demand		Low	Low
Wastewater generation quotas	Demand		Low	None
Mandated recycling percentage	Demand		Low	None
Effluent Standards	Demand		High	High
Bubbles/Offsets/Banking		Supply	New	None
Industrial Ecology- management within industrial complexes	Demand		New	None[3]
Licensing of water supply/Wastewater disposal	Demand		High	High[4]
Enabling conditions-coordinating institutions, legislation, macroeconomic framework		Supply	High	Low
Technology transfer of efficient equipment/processes		Supply	Low	None
Information availability and exchange-on products, processes, waste exchanges		Supply	Moderate	None
Development of alternative supply options (domestic wastewater, desalination)		Supply	Moderate	None
Publicizing Pollution Culprits		Supply	Moderate	Informal
Encouragement of research, development, production and adoption of conservation, recycling, and wastewater treatment measures		Supply	Low	None
Economic Policies				
Water supply tariffs[2]	Demand	Supply	High	High
Sewer Tariffs/Charges	Demand	Supply	Moderate	Moderate
Effluent charges/taxes (as a function of Quality and Quantity)	Demand		Low	None[5]
Penalties for violation quotas	Demand		Low	None
Tradable permits	Demand		None	None
Subsidies on research, development, production and adoption of conservation/recycling processes (including water saving devices/processes)		Supply	Low	None
Subsidies on research, development, production and adoption of wastewater treatment technologies		Supply	Low	None
Privatization of the water sector (supply, distribution, collection, treatment and disposal)	Demand		Moderate	New

The shaded rows show the policy instruments currently in use in Kenya. [1]Rationing is used in Kenya during periods of extreme water scarcity in both urban and rural areas. [2]Price policy can also be viewed as a supply enhancing option because as the prices rise supply options that were previously too expensive now become economical. [3]The idea of industrial ecology i.e. joint effluent treatment works has been raised by several industries in Nairobi and Thika. [4]Licensing of supply/ Wastewater disposal is pursued together with effluent standards. [5]Authorities in Thika and Eldoret are currently pursuing this instrument selectively.

2.5.2 Water Pricing Strategies

Our discussion in the previous section (2.4) suggests that water-pricing policy has undergone significant evolution in Kenya. The goal of current water pricing in all the urban areas in Kenya is to achieve cost-recovery. This requires that costs incurred in making water available at source include some or all of the following elements: The costs of operation and maintenance; Capital costs, comprising a return on paid-up assets, the repayment of loans; Overheads such as the administration and support required to operate such schemes; An allowance to provide for depreciation, replacement or refurbishment. The major problems arising from the current water pricing policy in Kenya can be broadly classified into (i) those related to financial sustainability of urban water schemes and (ii) those related to water use efficiency and conservation. The focus of the current policy debate in Kenya continues to be on the cost-recovery rather than on making water prices an instrument for water use efficiency. When the goal of water pricing is elevated from mere cost-recovery to deriving the greatest value from scarce water and associated non-water resources, the above rate regime are found to be deficient (Griffin, 2001). Furthermore, there are other important examples of water use for which no charge is currently levied in Kenya but which impose significant costs on other users and on society more generally. Examples of these are the catchment management costs and the disposal of industrial wastewater into rivers or other water bodies to remove wastes and which render these rivers unacceptable.

2.5.3 Wastewater Management

In most countries, controls relating to industrial wastewater are predominantly confined to regulation at the point of production, not discharge. These tend to take the form of mandatory technology standards, required capital equipment, or effluent standards required from plant units of given sizes. Technology standards specify the actual pollution control equipment to be installed by a range of industrial sectors. For many years however, the Kenya government has remained torn between use of sewer charges, standards and technology policy for industrial water management. At the same time, there has been over-emphasis on the end-of-pipe abatement technology (at the point of discharge) without taking into account the incentive requirements that could induce desired industry behaviour or response to this instrument. Often, there have been piecemeal and fragmented efforts by industries to comply with requisite end-of-pipe standards. The standards or regulations at the point of discharge often do not generate financial incentives for the firms to improve the overall production technology i.e. adoption of water saving technology, since they encourage window dressing activities aiming to appease the enforcement officers. The result of this is for the policy makers to gauge the effectiveness of the policy instruments using the compliance status.

2.6 Water Pricing Structure in Urban Areas

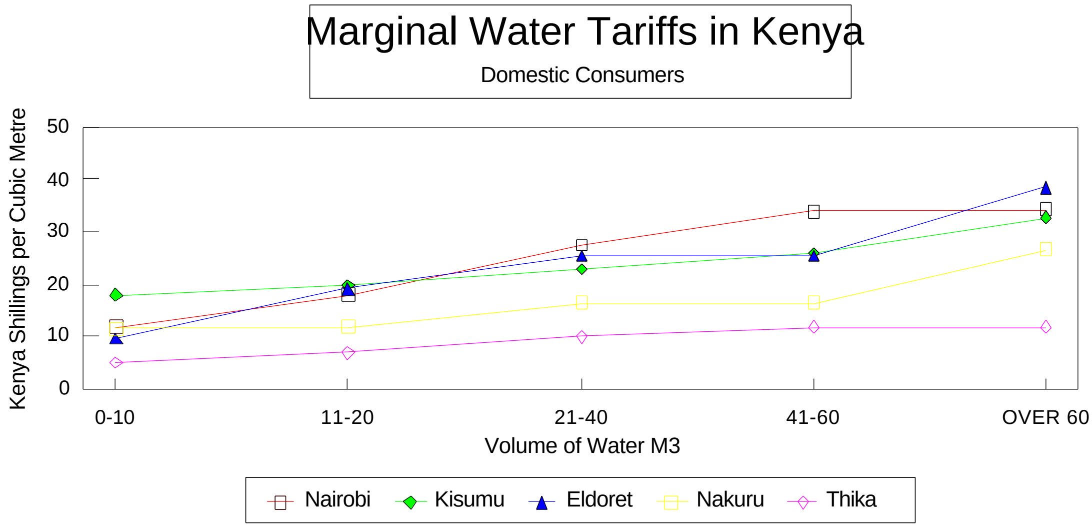
2.6.1 A Comparison of Water Charges across Towns

In Kenya where local authorities are water undertakers, the local authorities with the approval of Ministry of Local Government (MOLG) set tariffs. Our review of the current water pricing practices in the urban areas reveals the following common features: Water rates vary widely across the urban areas. Such variations and disparities have often led to very complicated rate structures whose purpose and goals are not evident; the rates are based on crude revenue projections rather than actual cost considerations; Although the water rates in different urban areas and different users are frequently revised, such revisions only appear marginal and less purposive. The central government policy is to encourage tariffs that are high enough to recover all costs. The reluctance comes from political leaders who believe a tariff increase to be unpopular with the people. Given the choice between a service at reasonable cost and a breakdown in service delivery, the local officials have opted to let service suffer. Rising and declining block tariffs are implemented in the urban areas we have studied. Thika, Nairobi, Kisumu and Eldoret have a rising block structure while Nakuru maintains a declining block tariffs. All the towns have two-part tariffs (fixed monthly fee and variable volumetric tariffs). For Nairobi city, the tariff structure is the same for all the water consumers while for the other towns the rate is differentiated by consumer categories i.e. domestic, institutional, commercial and industrial. Usually, where such differentiation occurs, the industrial tariff rate rises at a much higher rate. The tariff structure is further complicated by the block size that varies from one urban area to another.

2.6.2 Domestic Consumers

Among the domestic consumers, Thika maintains the lowest tariff rates for all blocks of consumers. The highest block rate is lower than the lowest for other towns, moreover, the rates between the blocks appear to change by very small margins, making the structure a near flat rate. While the other towns have four blocks, Nairobi has only three blocks which peak off at $41m^3$.

Figure 2.2:



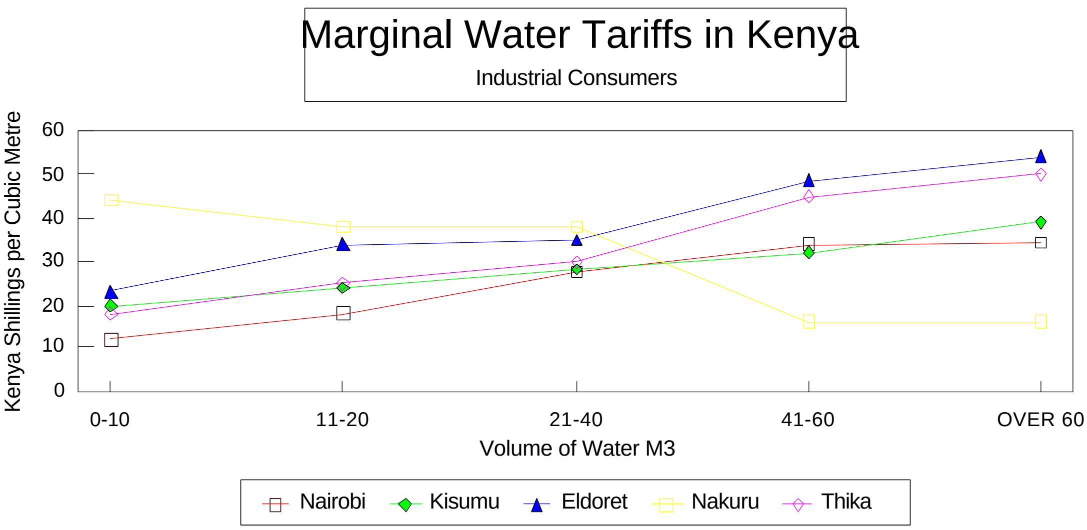
Source: Own Estimates

While Eldoret had a minimum water charge which is equivalent to a consumption of $1m^3$ per month, the minimum charges for Kisumu and Nakuru are equivalent to monthly consumption of $30m^3$ and $25m^3$, respectively. Although generally increasing block rates are thought to be effective in discouraging wasteful consumption, their effectiveness is eroded when the margin between blocks is very small as it is the case above.

2.6.3 Industrial Consumers

In this category, Eldoret has the highest block rate followed by Thika town. Nakuru has a declining rate, with only four block rates. Declining block rates may be ideal for cost-recovery measures but are not suited for demand management since additional water consumption is charged at a lower rate. The primary influence of a declining structure in Nakuru was to attract and to keep large industrial water users and to promote growth of the urban area. A comparison of the water charges for various industrial consumption levels is indicated in figure 2.3 and table 2.2.

Figure 2.3:



Source: Own Estimates

In Nairobi, the marginal tariff levels is the same for all categories of consumers, i.e. domestic, institutional and industrial/ commercial, with a tendency for the tariff levels to be flat since the sewer rates increase at a declining rate. In other urban areas, Thika, Nakuru, Kisumu and Eldoret, the tariffs are differentiated between different consumer categories hence cross-subsidization is possible. For example in Eldoret and Thika, the marginal tariff rates domestic consumers are lower than the other urban areas while the industrial rates are also higher than other urban areas, suggesting a policy of cross-subsidization in the two urban areas.

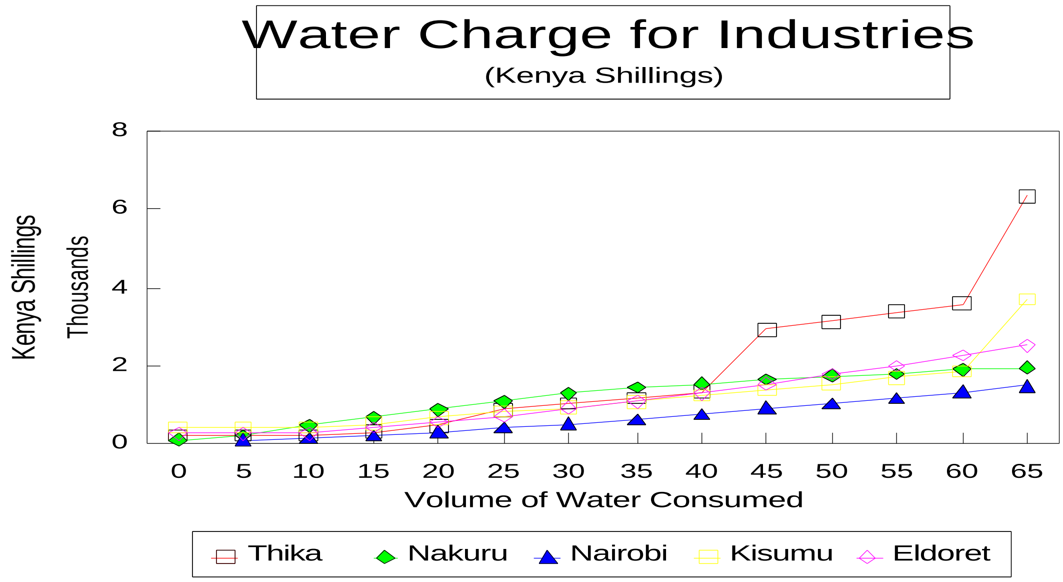
Table 2.2: Comparison of Current Industrial Water Charge

Volume M^3	**Thika**	**Nakuru**	**Nairobi**	**Kisumu**	**Eldoret**
		(Total charge in Kenya Shillings)			
0	180	97.26		400	239
5	180	205.26	60	400	239
10	180	440.86	120	400	239
15	305	667.86	210	520	388.5
20	430	870.36	300	640	538
25	880	1072.86	390	780	717.25
30	1030	1241.36	480	920	896.5
35	1180	1409.86	617.5	1060	1075.75
40	1330	1517.86	755	1200	1255
45	2905	1625.86	892.5	1360	1504
50	3130	1706.86	1030	1520	1753
55	3355	1787.86	1167.5	1680	2002
60	3580	1868.86	1305	1840	2251
65	6330	1949.86	1477.5	3680	2500
Sewer charge as % of water charge	50%	100%	55->30%	55%	50%
	1	**3**	**5**	**2**	**4**

Source: Own Survey data.

Nairobi has the lowest water charge, followed by Eldoret, Nakuru, Kisumu, while Thika town has the highest water charge. Incidentally, Thika town, which has the highest water charge, also has the highest incidence of groundwater and surface water sourcing. Since the public water supply exceeds demand and is much more stable compared to other urban areas with stochastic supply, the prevalence of groundwater sourcing is a possible indication of high water charge in Thika town. Unlike the practice in other urban areas, some individual firms within Thika town have also negotiated for a waiver or reduced sewer charge.

Figure 2.4:



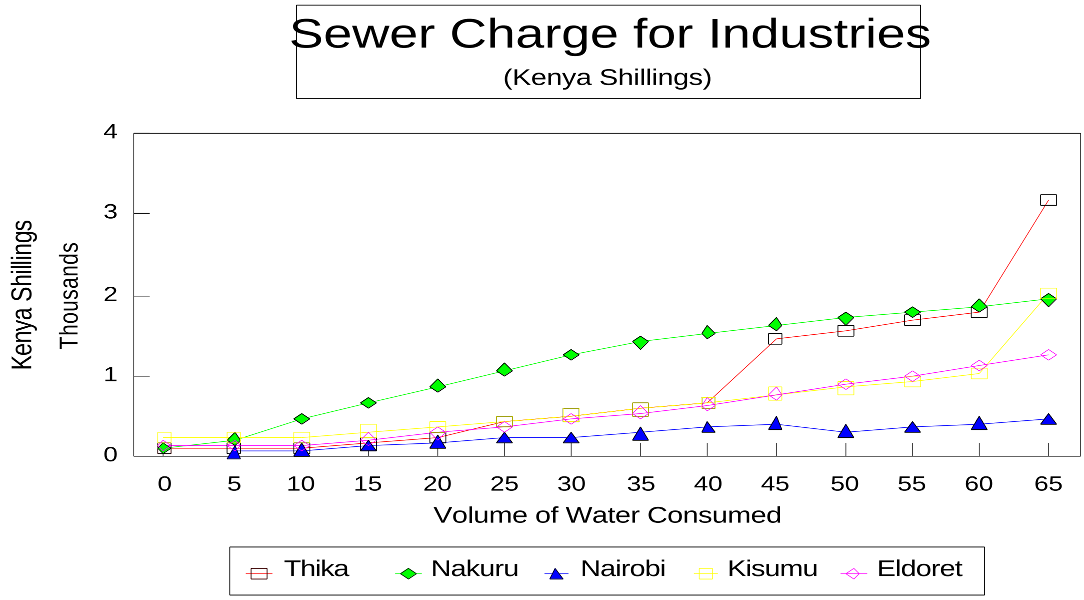
Source: Own Estimates

Figure 2.4 shows the extent of tariff differences when the water charges are computed. These are cumulative amounts of money that an industrial consumer has to pay in different urban areas. The figure suggests that Thika town has charges that are way above all the other towns. Eldoret follows this, while Nairobi has the lowest charges.

2.6.4 Water Charges Versus Sewer Charges

In most of the urban areas, sewerage charges are applied as a surcharge on water, rather than as separate charges for sewer service. Those with separate septic tanks which require exhauster service face a different charge. Even though these charges are based on a number of parameters such as the type of waste, they have no similarity across the urban areas and do not reflect the cost of wastewater treatment. Another obvious problem noted in the tariffs structure is that when they are revised, say, between 1993 and 1996, both the tariffs and the water consumption blocks are shifted upwards. This reduces the marginal tariff changes for the upper block and may indeed favour higher water consumers against lower users. The sewer charges are illustrated in figure 2.5. There is no justification for the sewerage charges differentials across the urban areas except for the cost of sewer treatment. Nairobi City that has the lowest water charge (tariffs), imposes a declining block sewerage charge. Ironically, if the sewer charge is a declining rate while the water tariff is an increasing block rate, then the net result is a near *flat rate* tariff structure.

Fig. 2.5:



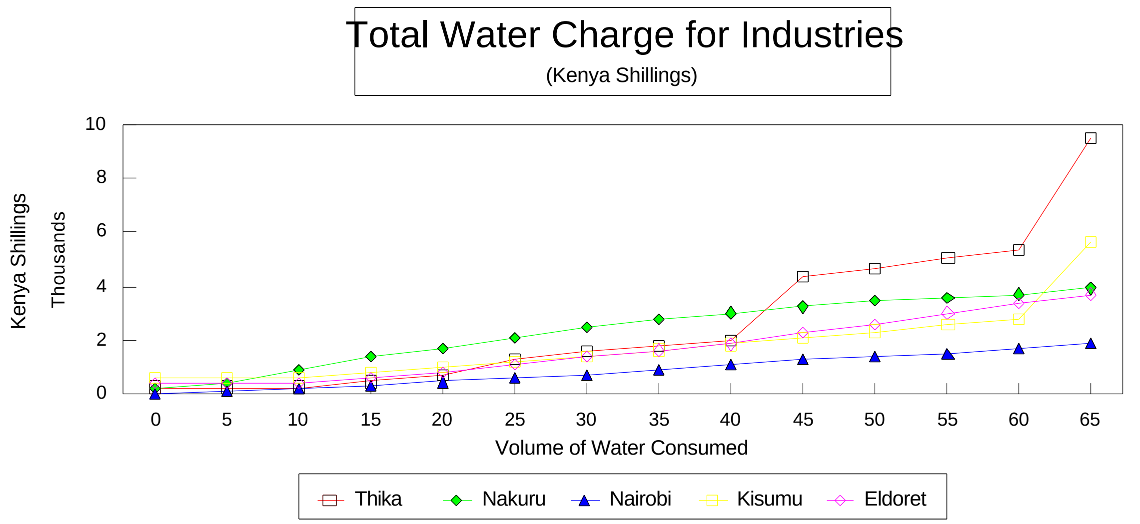
Source: Own Estimates

The sewer charges range between 53 percent for the lowest bracket the water tariff charge and declines to 29.7 percent for the largest bracket water tariff. The net effect is that the marginal tariff rates for the different block of consumers in Nairobi is smaller. Another problem with sewer charge in Nairobi is that it does not distinguish between different categories of consumers such as domestic and industrial users. This is not realistic for cost recovery objectives as it creates a false impression that wastewater from all the consumers costs the same to treat. In Kisumu, the sewer charge is uniform at 75 percent of the water tariff, which in essence makes the charge a rising block rate. In Nakuru, the sewer charge is fixed at 100 percent of the water tariffs rate – thus it is declining sewer charge since the water charge is a declining block rate. In Thika and Eldoret, the sewer charge is 50 percent of the water tariff, making the structure a rising block rate also.

2.6.4 Final Disparities in Levels of Industrial

The total industrial water service charges (combining the sewer and water) for the five urban areas are shown in figure 2.6. Thika town has a rapidly inclining tariff structure followed by Kisumu, Nakuru, Eldoret and Nairobi city respectively.

Figure 2.6



Source: Own Estimates

2.6.5 Water Service Charge and Economic Efficiency of Water Authorities

The economic efficiency of the entire urban water schemes of over 158 systems have been examined using Net Present Value (NPV), Benefit-Cost Ratio (B/C), and Internal Rate of Return (IRR) (Republic of Kenya, 1992). Of 158 schemes, only 4 schemes exceeded 10%, the opportunity cost of capital. They are Embu, Thika, Mariakani and Nairobi in order of economic efficiency. In addition to these four schemes, only 36 schemes had positive IRR. The other 118 schemes (about 75% of the urban schemes), resulted in negative efficiency, hence, they would not be expected to return the capital investment through their accruing economic benefits, from economic point of view. Among the five towns we have examined, Thika had the highest IRR of 14.4, followed by Nairobi (11.5), Kisumu (3.7), Nakuru (-4.7) and Eldoret (-11.7). In spite of lowest tariffs, Nairobi has a high IRR probably because its water scheme is based on gravity with a large size of consumers. The IRR for the other towns seem to be highly correlated with the tariff levels.

2.7 Evaluating Water Sector Policies in Kenya

The major problems arising from the current water policy in Kenya can be broadly classified into (i) those related to water use efficiency and conservation; and (ii) those related to financial sustainability of urban water schemes. Our review so far indicates that the water sector policies have evolved over the years from a weak to strong emphasis on cost-recovery; from direct to indirect provider institutional roles by the government. However, it remains misleading for anyone think that policy declarations as expressed in government documents was translated into action. Many of the policies purporting to shift responsibility either through cost-recovery or self-provision did not translate into action. For example a policy declaring in 1994 that industries should become self-reliant in water provision was not translated beyond public documents nor was there a clear indication on how this policy could be achieved. High sounding policy statements were diluted by mediating variables as they were translated and implemented at local levels. There are several controversies inherent in the existing policy framework:

(i) The implementation of these policies, particularly on cost recovery, does not conform to the declarations made at the national level.

(ii) The focus of the current policy debate in Kenya continues to be on the cost-recovery rather than on making water prices an instrument for water use efficiency.

(iii) Wastewater policies have been considered being primary to sustainability of water resource base in Kenya.

Implementation of Pricing Policies

The main source of controversy in pricing implementation in all the urban areas arises from differentials in tariff structure among different local authorities. There are three main issues with the disparities in the pricing. The issues are related to a) the levels of tariffs, b) objectives for differential charges for different categories consumers and c) how the sewer charge as a proportion of the water charge is determined. In most of the water authorities, the final tariffs have very little correlation with the national goals of cost-recovery.

From Financial to Ecological Sustainability

Ecological sustainability is important because Kenya faces a likelihood of acute water scarcity in future. An economic charge reflecting the scarcity value of water could be introduced in water stressed areas, applicable to the "economic uses" of water, and therefore will not apply to the basic needs and ecological reserve. As water resources have become scarce (greater competing use), sustainability issues must be a central aspect of pricing. National policy with respect to pricing of first tier water (that is, raw water extracted from the fresh water resource) should be spelt out.

Wastewater Policies

The focus of industrial wastewater management in Kenya has been on "end-of-pipe" control policies with no attention paid to avoiding the generation of the wastes in the first place. Attention has concentrated on command and control regulatory "end-of-pipe" retrofit technology at existing industrial facilities. Unsuccessful programs to upgrade existing and install new industrial wastewater treatment facilities have accompanied this. Kenya needs to move towards "Eco-Efficiency and Cleaner Production", concepts championed by the United Nations Environmental Programme and the World Business Council for Sustainable Development. "Eco-efficiency and cleaner production" policies could provide crucial elements in both water quality and quantity issues. Water policy positions remain isolated due to lack of synergy with the other sectors. For example relocating the culprit factories to new industrial locations and increased collaboration between firms could eliminate some of the existing wastewater quality problems. Over the last decade, there has been a strong movement in Europe and, more recently, in North America, away from "end-of-pipe" approaches to industrial waste management towards waste minimization strategies (Huisingh et al. 1986).

> *end-of-pipe technologies, which focus on wastewater treatment, tend to transform wastes from one form to another rather than achieving genuine waste reduction and reduction of water consumption. The*

policy strategies do not improve efficiency in water use. In contrast, wastewater minimization strategies could avoid the generation of wastewater in the first place and reuse or recycle as much remaining waste as possible.

Source reduction is generally perceived as being the highest rung on the waste minimization ladder with the greatest potential for avoiding energy and raw material consumption as well as waste production. With respect to pollution regulation currently enforced in Kenya, source reduction refers to only the volume or weight of wastewater but also to a reduction of toxicity. Many countries have also established award programs that give public recognition to outstanding waste minimization efforts by individual companies. Government may sponsor the award programs, by business associations or by non-government organizations and they may or may not have monetary rewards associated with them. These are instruments that need to be explored with urgency because of the impending water crisis.

2.8 Conclusion

In this chapter, we have examined the strength of government intervention in the water management in Kenya by initially looking at the general trends of policy statements. Our view is that the water sector policies have evolved over the years from a weak to strong emphasis on cost-recovery; from direct to indirect provider role by the government. However, it remains misleading for anyone think all of the pricing policy declarations as expressed in government documents was translated into action. Many of the policies purporting to discourage profligate use of water and shift of responsibility either through cost-recovery or self-provision did not translate into action. For example a policy declaring in 1994 that industries should become self-reliant through self-provision was not translated beyond public documents nor was there any indication on how this policy could be achieved. High sounding policy statements are diluted by mediating variables as they are translated and implemented at local levels. While conceptually, cost recovery policy is sound, the policy is insufficient for a country that is faced with growing water scarcity. Efforts to price water in a way that reflects scarcity and other incentives to water conservation would be much more conducive. Though at formative stages, there are global policy developments that appear to be displacing the centrality of pricing and regulatory mechanisms as the sole instruments for enforcing efficiency in water resource use in industry. Such policies tend to exploit the existing synergies between water sector and other sectors i.e. location policies and industrial metabolism.

Notes

[1] Much of the delivery was perceived in terms of treated piped water, completely ignoring delivery of untreated water, and other cheaper technologies for harvesting surface water.

[2] This policy statement in the National Development Plan only referred to financial performance (revenues and expenditures) rather than performance in general.

[3] They did not, however become an important part of the economic management until after the publication of the Sessional Paper No. 1 of 1986.

3 A Survey of Theories of the Firm and Response to Policy Instruments

3.1. Introduction

Our goal in this chapter is to provide some critical insight into the behaviour and dynamics of large firms in response to pricing and wastewater regulation. The chapter is divided into three parts: The first part looks at theories of the firm as originally formulated and applied in empirical work. The second part deals with industrial demand for water and the firm response to tariffs changes. The third part concentrates on wastewater regulation. Each part is organised to deal with both theoretical discussions and empirical work.

Part I: Theories of the Firm

Much of the current debate on firm behaviour relates to the question of how production is organised and the process of response in the face of changing economic contexts such factor prices, market conditions, and government policies. At the moment, it seems there are no theories available, solely focussed on analysing firm response to water tariffs changes. We are therefore going to be selective on the theories we are going to review. At the moment, there seems to be three theories available solely focussing on analysing the behaviour of firms to changes in costs of factor inputs and regulation. Theoretical perspectives differ on the economic behaviour of firms when faced with these (pricing) perturbations. We organise our discussions into the following broad theoretical categories: Section 3.2 Neoclassical Framework; section 3.3 the New institutional Economics (NIE) versions; section 3.4 Evolutionary Economics approaches to the firm; and in section 3.5 we draw conclusion on the theories of the firm.

3.2 Neoclassical models of Firm Behaviour

Beginning from a neoclassical framework, rationality and the need to maximize profits characteristic of firms will propel them towards cost minimization. Wherever some perturbations occur within the firm, it is assumed that equilibrium is instantaneously restored with zero adjustment costs. Firms are expected to be having all the necessary information pertaining to the characteristics of all the products to be exchanged. Therefore, no effort will be required to effect any exchange in transactions. According to Gill (1972), in the neoclassical decision framework of a firm, the entrepreneur is seen as

> *"a lightning calculator of gains and losses, who oscillates like a homogenous globule of desire of profits under the impulse of stimuli that shift him about the area, but leave him intact"*

The essence of the neoclassical framework is that it is possible for firms to respond instantaneously to small changes in factor prices in order to maximize profits. Traditionally, this framework posits the existence in each firm of an entrepreneur who exercises continuous monitoring and control over the firm's profit function by *fiddling around with factor inputs.* Even though the neoclassical concept of the organization of the firm is not unrealistic in the profit motive, it seems oversimplified and strained in several ways. In reality, most of firm production entails division of labour, making it impossible to optimise on all the decisions.

As long as the price is right, allocative efficiency will to some extent be automatically guaranteed. The theoretic importance of the neoclassical framework is that these are unifying expectations regarding the influence of the pricing and regulatory policy instruments on behaviour of all firms. For example when prices of one of the inputs to production change, price theory anticipates that several things might happen to account for the increased cost of production. For example, an increase in water tariffs will compel firms to undertake the following measures: (i) substitute the costly input with i.e. other sources of water or other products if it is technologically feasible; (ii) reduce the amount of waste i.e. through recycling and improved housekeeping or (iii) firms may transfer (distribute) some of their production costs to the consumers of their output, thus leading to a decline in output demand and output production.

Neoclassical theory has been criticised extensively for the weakness inherent in the model. Such a version of firm behaviour is not only bad psychology but hopelessly uninformative, according to Gill (1972:67). According to Salais and Storper (1992: 170), production organisation is the result of much more than the traditional dyad of the exogenous forces such as prices, technologies and markets. Even in much theoretical work in industrial economics, fundamentally unrealistic assumptions are made about the optimality of production organisation at any one time etc. Each world of production corresponds to a unique form of flexibility of resource use which enables its firms to coordinate their actions in most cases in a manner that affects profoundly resource use (such as water, labour, capital etc) differently. Thus, prices can not produce similar behavioural reactions to even identical firms operating in the same market due to styles of production inherent in each firm.

Furthermore, firms never engage in profit optimisation as suggested by the neoclassical framework. In Veblen's words, firm managers are

> *"ignorant of industrial processes and wholly engage in pecuniary manipulations and "capitalistic sabotage".*
>
> *The firm makes profits not by manipulating the factors of production (to minimize costs) but by deranging them – holding back production to keep prices high, engaging in credit transactions that bring on crises, constantly interfering with the "**output**" of his technology." (Gill, 1972: 68)*

Theoretical assertions of the neoclassical model are much more untenable given the pressing realities of developing countries' transaction environments within which industrial firms operate. These are the same realities that confronted Marshall a century ago. He pointed out that resource allocation might take place in a world where knowledge required for decision-making is incomplete and dispersed both within markets and within firms. To overcome the informational problems and related imperfections, he emphasised the role of institutions in aiding coordination, and desired behaviour. The emphasis by Marshall was on the significance of the institution as a coordinating device. Thus a firm-theoretic approach that endogenizes institutions into its analytical framework for governing or coordinating production would be more useful in explaining how response to policies works.

3.3 The New Institutional Economics (NIE)

The new institutional economics approach, which includes the economics of information and organisation, has made progress in the direction of the role of institutions. The approach recognises that a mixture of institutional arrangements such as mutual collaboration, observance of customs and rules, and sometimes force, and the enforcement of such rules etc. must compensate for the incompleteness of contracts i.e. pricing, regulatory. The new Institutional Economics suggests that important roles may be played by dispute resolution mechanisms or *institutional arrangements* (Williamson 1985, North 1990, Stone 1994, Holden 1996). italic added). Specifically, in the case of water pricing and regulation, expectations created upon industrial firms during enforcement of prices and regulation are critical in determining the outcomes of the policy instruments. The purpose of institutional arrangement is basically to increase efficiency through the minimization of both production and transaction costs as well as spreading the risks among transacting firms involved in the exchange process. The resultant set of compensatory institutional arrangements also influences economic organisation and behaviour of firms to comply with the norms. In addition to the neoclassical economics' preoccupation with getting the *price, levels of monitoring, fines etc. right* our central objective,

> here is also concerned with getting the *institutions (rules of the game, enforcement structure) right* if the desired behaviour on the part of firms is to be attained. For example, it is only when firms' attitudes, preferences, values etc are changed, that prices may also become right.

The right prices for water must exist within appropriate institutional setting, they must be enforceable, there should exist a liability mechanism to guarantee that prices are effective. These prices must apply within a given institutional framework. In fact, most economic relations are governed not just by prices but also by such institutions like contracts and reputations (Stiglitz 1992:64). Therefore, it may be insufficient to study the process of exchange and corresponding firm behaviour without specifying or taking into account the institutional setting in which pricing and regulation takes place. This institutional context affects the incentives to produce and both the costs of production and transacting (Coase, 1992:718).

New Institutional Economics embraces four school of thought, namely the property rights school, transactions cost economics, the principal agent framework, and the imperfect information paradigms. Whilst all theories that fall under the generic label of New Institutional Economics see organisational or institutional forms (such as particular types of contractual relations between and their regulatory relationships) to be decisive in influencing firm behaviour, the evolutionary Economics view put forward the firm's routines and capabilities as the main determinants of its behaviour.

As a discipline, the New Institutional Economics puts much emphasis on the role of risk, transaction and production costs as well as various incentive constraints on influencing the firm's choice set. In our case, the characterisation of New Institutional Economics will serve to provide us with a richer view of the relationship between firm response to policies and the distribution of property rights in water resources. Of particular importance is the fact that whilst, in neoclassical economics, it is often suggested that the key to efficient resource allocation is the near perfect formal law and pricing, the New Institutional Economics suggests that important roles may be played by styles of enforcement that include informal dispute resolution mechanisms or institutional arrangements. The costliness of delineating and policing property rights and enforcing water prices i.e. where multiple sourcing of water apply (ground, surface, public), could generate opportunities for some firms to capture other agencies' wealth. A whole array of institutional arrangements may often be needed to constrain such opportunist behaviour among firms.

3.4 Evolutionary Economics approaches to the Firm

Evolutionary economics has its theoretical roots in the work of Alchian (1950) who questioned the logic of the neoclassical equilibrium and the profit maximization thesis. He refuted the equilibrium approach and adopted an evolutionary approach to economic analysis. Recent developments in evolutionary economics (Nelson & Winter 1980) have focussed on a view of heterogeneity of firms as the analogies behind the evolutionary process. Within the evolutionary economics perspective, firms are conceptualised as bundles of hierarchically arranged production routines. Routines are repositories of knowledge concerning how a firm can do different things. From an evolutionary perspective, therefore, a firm will be able to continue doing what it has always been doing without problems, but it will encounter great problems if it tries to do something completely new. It will be *locked in* to a particular production style. Therefore, firms are assumed to follow rigid, but reliable, self-sustaining routines and cannot adapt their routines rapidly to changed or changing circumstances (Vromen, 1995). By describing the firm as a collection of routines, which need to be continuously reproduced, the evolutionary theory deviates on several counts from neoclassical theory. When a firm is characterised as a production function only, such a characterization is *ahistorical*. Yet in spite of this evolutionary theory attaches great significance to viewing the firm as *historical* entity. Past institutions play a crucial role in latter processes since they determine the extent to which firms will learn, experiment or deviate from existing patterns of behaviour *when policy changes or regulatory enforcement occur* (Aoki, forthcoming; italics, own).

> *Seen in this way, it would be of decisive importance that the specific history of the firm be re-constructed, if we are to understand its present behaviour patters in relation to water tariffs changes and regulatory enforcement.*

Rule-following behaviour makes firms to be relatively unresponsive to variations in particular situational circumstances, say changes in water tariffs. The very point by a firm in following rules is in not "calculating" each case of response individually. The tendency for firms to adopt rules, to behave in a pre-programmed way rather than on the basis of case by case adjustments, is inherent in human nature as it is, for that matter, to the nature of living organisms in general (Vanberg, 1994: 17). There are basically three ways by which the fact that following certain rules is advantageous (compared to case by case adaptation) may be translated into effective behavioural dispositions by firms, these are through: (i) habitual learning on the part of the individuals in firms, (ii) deliberate and conscious choice to adopt a rule, and (iii) efforts to avoid costs of learning (or acquiring) new techniques. Rule-following may not allow for the best pattern of action due to *pre-commitment problem*. However, rule-following reduces decision-making costs as compared to case by case choices.

Simon (1963) work on the *Behavioural Theory of the Firm* and similar works also support organisational arguments for rule governed behaviour depicting: *the firm as an adaptive, imperfectly rational coalition of different interest groups whose bargaining processes lead to rules which may be considered as a kind of truce in inter-organisational conflict.* Such a firm may have considerable organisational slack which absorbs a substantial share of the environmental shocks while the given rules are upheld.

> *"Only when performance does not live up to the acceptable-level goals, is a 'problemastic' search for alternative rules then performed."*

The proponents of *bounded rationality* have argued that the *rule-focused* version, does not imply that there exists a determinable and finite set of alternative rules from which "the best" can be chosen in a firm. At the level of rules of action we cannot meaningfully speak of a "given" set, known to the firm. There is, instead, an "open universe" of potential rules, a universe that allows for discovery and genuine creativity by firms. Not all behavioural rules can be directly observed in firms. Only particular acts or choices, that is, particular "applications" of a rule, can be observed, from which inferences may be drawn regarding the underlying rules. What is asserted is that firms can and do evaluate the results of their actions in terms of their desirability, that they can learn from experience, and that they tend to adopt behavioural strategies that they find to be successful overall, while replacing those that they experience to work less well (Vanberg, 1994:30).

As a critic of the unbounded rationality framework, Simon (1955, 1959), has argued that "satisficing" rather than optimizing behaviour better characterizes much of firm behaviour and proposed that the concept of an optimizing firm be replaced by that of administered firm. He argues that Firms have limited knowledge, data is costly to collect and to store, and much economic behavior of firms involves search and trial and error processes, with firms being prepared to settle for satisfactory outcomes rather than requiring an optimal one. Furthermore, corporate firm managers face human cognitive constraints faced, such as limited computational ability and selective memory and perception. Assertions by Institutional Economists also view "firm" behaviour as not only goal oriented and purposive but also heavily influenced by "stupidity, ignorance, and passion" that is characteristic of human behaviour. Passion alone can impart numerous biases and irrationalities into firm decision making, hence bounded rationality.

The production technology in industry are the sum of individual routines, behavioural patterns or rule-guided decisions, and a behavioural setting on which a theory based on unbounded rationality and rules can be built (Kamien, 1988). A theory of rational, maximizing choice, as commonly understood in neoclassical framework, cannot account for a firms decisions (Vanberg, 1994). Many of the rules affecting water use in production will be "customs" of the industry in which firms have grown up and only some will be individual "habits" which firms have accidentally or deliberately acquired. The rules presumably evolve through confrontation with similar situations over time and some experimentation (Kamien, 1988: 112). But they all serve to abbreviate the list of circumstances which should be taken into account in the particular instances, singling out certain facts as alone determining the general kind of policy action which should be taken (Hayek 1964 in Vanberg, 1994) i.e. to change water use.

The evolutionary thesis has been strengthened by empirical work which shows that in the case of industrial units, the influence of water prices on the prices of other goods remain small, in general. Water costs as a percentage of inputs costs are typically small (less than 5%) in the vast majority of industrial manufacturing processes including power generation (Eberhard, 2001d). In view of these small costs, changes in water prices cannot be sufficiently high to pose a problem to rule following firms. If the water tariffs rise gradually without shocks to the firms, they are unlikely to trigger any reaction among industrial firms. Several studies show that firms explore alternatives (captive, practices) more purposefully only if the price or water constraints hold. The response options include multiple sourcing of water i.e. groundwater, public source, and technological possibilities (and others already mentioned). Renzetti (1993) study of factors affecting the firms' choice of supply source shows that increases in annual fees by public utilities reduce the probability that firms will choose to use publicly supplied water. This finding dismisses the neo-classical thoughts that firms may alter their water consumption levels in response to changes in prices. Secondly it shows that reduction of water consumption when tariffs increase is only one of the many options and may not be an important choice for firms. Thus

> *"a significant implication of this is that it may be futile to capture a firm's response to tariff changes by estimating price elasticity of water demand since many other choices exist".*

Another fundamental finding by Renzetti (1992) is that firms that have experienced relatively high water expenditures are also the firms whose water demands are predicted to be the most sensitive to changes in water prices. He interprets this to mean, "low industrial water prices may discourage firms from adopting water-conserving technologies or undertaking research and development into water conservation." Thus

> *"the most significant implication of under-pricing water for industrial use may not be that it encourages excess consumption in the short-run but that it allows these profligate water using practices to become embedded (or routinised) in the firm's production technology and capital stock in the long-run" (Renzetti, 1992: 40).*

Firms may respond to water price changes (increases) rather slowly than the shocks to water input demand could warrant (Hamermesh & Pfann, 1996). The explanation for this slow adjustment is that, because the firm must incur *adjustment costs* to an input with no substitutes, the inherent act of changing the amount of the water used will not be instantaneous because of periods of learning and doing (i.e. time to shop for and acquire the skills of water saving technology i.e. for recycling etc). According to Lawson (1997) firms, like human beings, chronically engage in the *performance of routines* using water. At no time do firms stop to calculate whether the amount of water applied to a particular activity is worth it. An obvious point to observe is that firm behaviour in relation to water use will be intent on producing goods and not profit maximization. Furthermore, the widespread routinized behaviour in firms is not merely efficient, but usually, the best "technologically" known way of meeting day to day fundamental goals and objectives of producing the goods. Much of the production life/ activities in firms is so closely structured by relatively enduring procedures and rules, that all workers necessarily draw upon them repeatedly, and in so doing act in a routine fashion, in order to produce the desired goods. In spite of its robustness in explaining firm behaviour, the biological anatomy of the evolutionary economics constitutes the main source of the weakness of evolutionary economics. It ignores the interrelation between economic agents and their external environment. Furthermore, the theory does not provide a systematic way of analysing firm behaviour, similar to neoclassical analysis.

3.5 Conclusion of the theories of the Firm

Neoclassical framework has incurred the heaviest criticism for its pioneering treatment of the theory of firm behaviour. The fact that the neoclassical economic framework characterises a firm as “production function” remains widely unacceptable. However, it is one thing to criticise and another to build a positive and systematic theory to replace what has been abandoned. Both the institutional and evolutionary theories have been sceptics rather than builders of new theories of firm behaviour. Thus, in spite of all of the above weaknesses of the neoclassical framework, it persists as an ideal framework in which to base the analysis of firm response to water tariffs. Indeed as the review of empirical literature shows in the next sections, all studies in industrial water demand (response to prices) and wastewater regulation trace their analytical framework from the neoclassical school. Despite their inability to build new theories, there is need to search beyond the production function framework of neoclassical economics in order to understand the dynamics of firm behaviour. This could be done by: (i) endogenizing institutions charged with the enforcement of policy instruments, and (ii) examining the past patterns of behaviour in firms while at the same time grounding the analysis on neoclassical theory.

Part II: Industrial Demand for Water

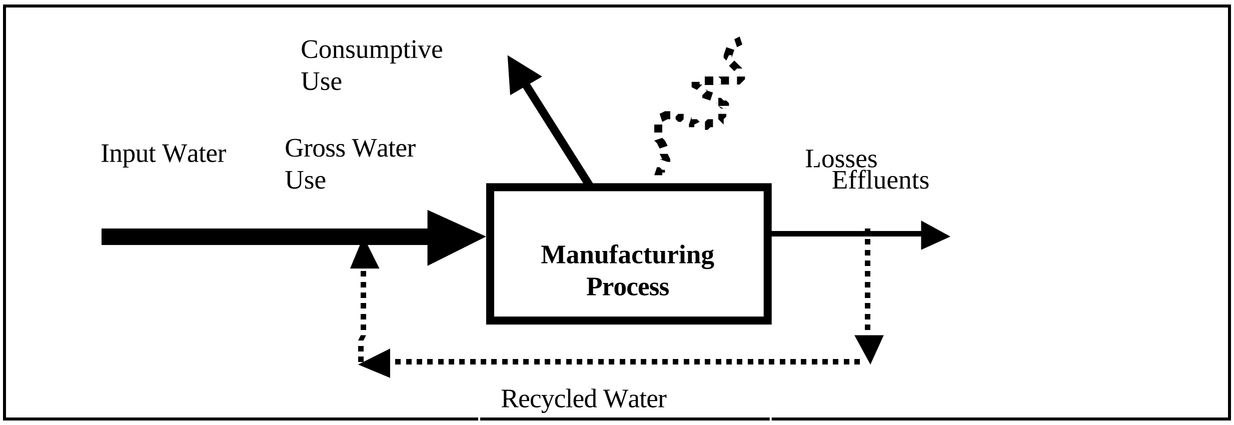
This part is concerned with reviewing of the existing studies of firm response to water tariffs. The goal of the chapter is to provide some empirical insight into the behaviour and dynamics of water using firms in relation to water tariff changes. Section 3.6 covers the nature of industrial water demand and the goal of water pricing; section 3.7 discusses empirical evidence of firm response to water prices. Section 3.8 covers pessimism in the efficacy of prices, while section 3.9 discusses methodological controversies in measuring firm response.

3.6 The nature of industrial water demand and the goal of pricing

Most firms require a wide variety of inputs, for example water, energy, skilled labour and other capital equipment. The amount of most inputs can be varied to some extent, no matter how brief the time interval. The firm' production function is the relationship between the various inputs used per period of time and the maximum quantity of the commodity that can be produced per period of time. The production function summarises the characteristics of existing technology at given point in time, it shows the technological constraints that the firm must reckon with. There is a variety of ways to produce a given output and a variety of efficient input combinations; thus it may be possible for the firm to substitute one input for another in producing a specified amount of output.

The uses of water by industry inevitably generate industrial wastewater, that is, aqueous waste[1]. The generation and disposal of aqueous waste is illustrated in Fig.3.1. Abstracted water is supplied to industry for the multifarious uses and this leads to the production of raw wastewater. In some cases, the wastewater is collected and discharged directly to rivers, lakes, estuaries, and to underground locations. In other cases, it is discharged to sewer for treatment in sewage treatment works. The third possibility is that the effluent receives pre-treatment on the premises and then disposed into watercourse or sewer or is cycled for internal use within the firm.

Figure 3.1: Schematic of generation and disposal of aqueous waste



Source: Adapted from Rogers and Harshadeep, 1996

Industrial water use may either be consumptive or non-consumptive. In most cases, industrial water use has a large non-consumptive component. This means that a significant portion of water that is used is eventually discharged back to the environment. In many cases, the quality of the industrial wastewater may be significantly affected. The nature of water demand in industrial activities varies widely. Water may be used as an input in the classic sense in which it is incorporated into the final product (for example, the beverages industry), or it may be used for heating, cooling, conveyance, product washing, waste removal, personal hygiene and landscaping, to name a few of the more important of a wide variety of uses. Industrial water demand is therefore a multidimensional phenomenon. The factors that may influence water demand include: production technology, product mix, quality and price of raw materials, price of water, costs of water pre-treatment, treatment and circulation, wastewater and other pollutant discharge regulations and fees, the cost and availability of capital and the climate (Stone and Whittington, 1984: 52).

Even though the focus on pricing as a necessary instrument is not in dispute (at least theoretically), in almost all the studies, the need to operationalize the concept of efficient water use among industries has been assumed away (Eberhard, 2001). Pricing is an obvious tool to promote greater water use efficiency. However, for the reasons already outlined (i.e. firm diversity), there is not necessarily one "efficient" water use or price. Given our initial discussion and focus on dematerialisation, the exclusive focus on Pareto-allocative efficiency is inappropriate for our analysis. Other definitions of efficiency, such as technical efficiency, x-efficiency[2] and optimal beneficial use[3] provide a richer “tool set” with which to evaluate the efficiency impacts of pricing policy[4]. Typically, however, an improvement in efficiency requires a substitution of resources. For example, in order to use less water per unit of product produced, it may be necessary to invest in water saving technology. The decision as to whether or not to go ahead with such a resource substitution (in this case, capital investment for water saving) is usually taken on the basis of an explicit or implicit cost-benefit analysis. This requires the costs and benefits of the alternatives to be valued. In this sense, technical efficiency is not very different from allocative efficiency because both require the valuation of resources. Pricing therefore is seen as a desired tool to catalyse processes that will encourage industrial water efficiency.

3.7 Empirical Evidence of Firm Response to Water Prices

The literature concerning industrial water use is significantly less developed than that which addresses residential water use. Relatively few studies have been undertaken on industrial water demand. DeRooy (1974) represents one of the earliest attempts at estimating industrial water demands using firm level data from the New Jersey chemical industry. DeRooy estimates single-equation demand models for each of cooling, processing, and steam generation. Each equation is estimated using ordinary least squares techniques and the explanatory variables are the price (measured by average cost of water), and index of labour input, and index of the firm's technology. The estimation results demonstrate a significant but inelastic price elasticity for industrial water use. A related study is by Ziegler and Bell (1984) who confront the problem of defining the price of water for self-supplied firms. They use a data set of observations on the annual expenditures on water use and water consumption by a cross section of 23 "high volume water using firms" in the Paper and Chemicals industries. They first regress total intake expenditures against the quantity of intake water and the square of this term. From this regression, estimates of the marginal and average costs of intake are derived and used in the estimation of water-intake demand equations. The estimated demands demonstrate a degree of price responsiveness but presumably suffer from a simultaneity bias associated with the definition of the price variable.

Sims (1979) used the duality theory approach for the analysis of industrial water and wastewater demand. Babin *et al* (1982) used a *translog* cost function for the analysis of industrial water demand in the United States. Williams and Suh (1986) have also examined the effect of price on industrial water demand by using three alternative price measures (the average price, price based on typical bill, and the marginal price). The price elasticities are typically higher than the price elasticity estimates obtained for residential and commercial demand. Industrial demand is more responsive than residential and commercial (business enterprises such as shops) demand. The relatively high price elasticity of industrial water demand reveals that industrial customers are more likely to find alternative sources of supply or recycle water in the production process in adjusting to price changes.

Rogers and Harshadeep (1996) constructed a simple non-linear simulation model whose basis are numerous simplifying assumptions about the operations in firms. The core argument of the approach is not to model the exact processes within a plant, but to demonstrate in a simulation how rationally acting plant managers would react to various water and wastewater policy regulations using a "cradle-to-grave" comprehensive analysis of the water from a plant's point of view. The industries chosen are typical industries in Pulp & Paper and a Tannery. The activities of firms are modeled to include a wide variety of water sources that can be chosen including surface water, groundwater, brackish water and municipal water at different qualities. In addition, the industries can purchase treated wastewater and can also internally recycle treated or untreated wastewater. Although the model glitters in its depth of scoping the possible scenarios that the industries can go through, it is deficient in accepting that the reality in most LDCs is more constraining. Most firms do not face the many options that are given away in the model. In view of this, the model only captures a glimpse of the possible outcomes under price and regulatory changes.

A study by *Schneider et al* (1991) for the City of Columbus, Ohio, found the marginal price of water to be a significant parameter in all user categories (residential, commercial, government, and schools) except industrial. The long-term price elasticity of demand for water was not significantly less than zero. The results from the industrial models were, in general, inconclusive relative to the effects of the real marginal price of water on water usage. Average values for the estimated own-price elasticity for water intake range from -0.1534 to -0.5885. Water recirculation is found to be a substitute for both water intake and water discharge confirming that expanding the use of economic incentives (e.g. effluent fees) may be effective in encouraging firms to reduce their water use while increasing in-plant recirculation.

Substitution Effects of Water Price Changes: Renzetti (1992) used a *translog* to estimate water demands based on detailed cross-sectional survey of establishment-level observations on water prices, quantities, and expenditures. Industrial water use is modelled as having four components: intake, treatment prior to use, recirculation, and discharge. He shows that industrial water use is sensitive to economic factors. The calculated own-price elasticities were negative for almost all of the industry groups while the cross-price elasticity between intake and recirculation shows them to be substitutes.

Effect of Tariff Structure on Price Response: Nieswiadomy and Cobb (1993) undertook to analyse the impact of rate structure on price-elasticity. Whilst acknowledging that their analysis suffered from incompletely corrected selectivity bias, they noted that price elasticities under increasing blocks were higher than those under decreasing blocks suggesting that increasing block structures were conservation orientated. However, they also concluded that consumers are more likely to respond to average prices than marginal prices. A more obvious point is made by Saleth and Dinar (1997), namely, the steeper the blocks and the higher the marginal prices, the more likely it is that consumers will respond to marginal price rather than average price and the greater the price-elasticity of demand (with respect to marginal price).

Technological Response to Water Tariffs: Renwick (1996) modelled the adoption of water saving technologies. She found that price policy, non-price policy and technology change may all reduce water demand; analogy from the work suggests that firms with higher turnover are more likely to adopt water efficient technologies compared to firms with lower turnover; and if lower turnover (profit) firms adopt water efficient technologies, they are more likely to be particularly labour intensive technologies such as grey-water use.[5] The point concerning household discount rates made by Pearce *et al* (1990) is important in this regard: poor (and elderly) households are likely to apply very much higher implicit discount rates in their decisions to purchase water saving devices because they are more risk averse and the opportunity cost of the money used to purchase the goods is much higher than for higher income households. This further supports the findings of Renwick (1996) and may have important policy implications. For example, Woodwell asserts that *supply side investments in water saving technology (even at the consumer level) may be much more efficient than using marginal cost pricing* and relying on households and industries to invest in water saving technologies. Often collective investments are needed (or preferable).[6]

Using plant-level data on more than 1,000 Chinese industrial plants, Wang and Lall (1999) estimate a production function treating capital, labour, water, and raw material as inputs to industrial production. They then estimate the marginal productivity of water based on the estimated production function. Using the marginal productivity approach to valuing water for industrial use, they also derive a model and estimates for the price elasticity of water use by Chinese industries. Previous studies used water demand functions and total cost functions to estimate firms' willingness to pay for water use. They find that the marginal productivity of water varies among sectors in China, with an industry average of 2.5 yuan per cubic meter of water. The average price elasticity of industrial water demand is about -1.0, suggesting a great potential for the Chinese government to use pricing policies to encourage water conservation in the industrial sector. Increasing water prices would reduce water use substantially.

3.8 Pessimism in the Efficacy of Prices in Firm Response

A number of empirical studies have cautioned against the efficacy or ability of the price to trigger response in firms as a possible oversimplification of reality. Gustafson, (1998) has indicated that the outcome of various empirical studies discloses possible oversimplifications in analysing the influence of economic (prices) factors in resource (water)-use. The reality points to complex causality behind resource-use practices and environmental degradation; a complexity of behavioural functions. The main contention by Gustafson (1998) is that due to the complexity of resource and environmental functions as well as limitations of policy (the market) instruments in determining such functions, the neo-classical framework is rendered irrelevant in many settings. It is, prima facie, difficult to believe that "prices, tariffs, charges" should be the most prominent policy instruments in resource and environmental management, *particularly where production inputs are concerned* (Gustafson 1998, italic own). The issue of the superior efficiency properties of price instruments in factor-utilisation (demand for intermediate factors of production) is not yet settled empirically. Thus the expectations concerning what price could perform in industrial behaviour could be highly exaggerated therefore.

According to *Frey* (1992), even though the use of pricing to fight profligate use of resources is one of the primary policy interest in economics and amenable to a large array of resource problems, be it air, water or noise pollution, land disposal etc., the neoclassical economic theory has failed in many countries. Indeed, it is argued that under identifiable conditions pricing *destroys environmental ethics* which often leads to counterproductive effects on consumption. It is argued that the use of prices may crowd out people's morals or obligations since they can afford it, hence the importance of maintaining ethical or *institutional* basis of human action against purely rationalist pricing of resources (italics, own). One of the problems arising from use of *pricing* arise from the damage it causes to ethics. Individuals or firms may feel that their moral stance is unnecessary when they are induced by the price system to reduce water consumption. Prices, charges, and standards are therefore generally considered to be a "licence to use" as much as possible even during scarcity. The perspective of the industrial water users offer insight into a possible cause of non-response unless prices are sufficiently large. This perspective goes beyond the neo-classical economic theory. The relationship between industrial water-use and pricing instruments will therefore not be deterministic as often portrayed by conventional economics.

The validity of the neoclassical price theory has also been questioned by what is seen as *threshold consumption* in industrial production. For example, the water demand study by Cairncross and Kinnear (1992), one of the few undertaken in developing countries, confirms the fact that there is minimum threshold consumption which consumers value very highly. They found an effective zero price-elasticity of demand even in the context where households pay an average of 55% of their income for between 25 and 30 lcd of water from vendors. This result is confirmed by studies that have examined the relationship between consumption and water carrying distance in rural areas (see, for example, White *et al*, 1972). The concept of threshold consumption is very critical in industrial production where technology dictates that factor inputs be consumed in given (i.e fixed) proportions for production to materialise.

A weak optimism regarding the use of price has also been expressed by Dandy et al (1997) who recommend that water pricing policies should be considered simultaneously with "other efforts" such as regulatory enforcement for providing additional water supplies so as to maximize the benefits to the nation. Given the above results, it would also appear that changes in the price of water *per se* will have little effect on the usage of other inputs, unless the prices are backed by institutional measures. Nevertheless, empirical evidence shows the estimated relationship between capital and water to be complementary in some sectors and substitutes in other sectors.

The idea that prices exhibit non-classical behaviour even under equilibrium allocations has also been indicated by *Olson and Knapp* (1997). They show that competitive or market allocations of resources are not necessarily linked to prices in a neo-classical (deterministic) fashion. Because of these mixed signals, there are suggestions that the analysis of market-based approaches to industrial water use and wastewater disposal should be based on **experience rather than theory** (Brandon and Ramankutty, 1993).

> *The results confirm the expectations that the characteristics of water demand differ significantly between industrial sectors and that sectoral studies might be more useful than studies of aggregate industrial demand.*

In all the above empirical studies of price elasticity of water demand, results vary widely within and between studies; the results vary widely between and within industrial sectors; the results are not comparable between studies and the results are not translatable to new policy contexts. In general, the parameter estimates show considerable variation among the individual industry groups and the pooled data set (Babin et al, 1982).

3.9 Methodological Controversies in Measuring Firm Response

3.9.1 Modelling of Industrial Water Demand

Although the neoclassical exposition of the theory of industrial water demand is relatively straightforward, it is no easy matter to *apply* this theory in a general and consistent matter to the empirical analysis of water demand. This is borne out by the fact that almost all empirical modelling of water demand that has been recorded in the peer review literature to date is formally inconsistent with the neo-classical theory of preferences and demand (Hanemann, 1997). Deaton and Muellbauer (1980:80) make the equally damning point that demand theory is very often used in a "highly cavalier" fashion with little attention being paid to formal consistency between theory and application. Two broad approaches have been used to model industrial water demand, these are the water requirements approach (including the engineering/mathematical programming) and the econometric approaches.

Water requirements Approach

Until recently, the prevailing method of studying and forecasting industrial water needs has relied on the fixed coefficient "water requirements" (engineering) approach. This is the simplest approach to modelling the water "demand" of firms using it in a production process is to assume that water demand is a function of output, that is: $q = f(x_{out})$ where q is the quantity of water "demanded" and x_{out} is the quantity of output. A typical functional form used is: $q = \alpha\ x_{out}{}^{\gamma}$. This is really a "water requirements" approach because output is given as an exogenous parameter and neither output nor inputs are modelled as functions of prices. This approach is typically applied using statistical estimates at an aggregate level (country or region, manufacturing sector or manufacturing aggregate). Despite its obvious limitations, the use of this functional form can fit historical manufacturing data well (Dziegielewski, 1988). This method assumes a fixed relationship between water intake and either output or the quantity of some other input. The difficulty with this approach is that it assumes that industrial water use is insensitive to the price of water.

Another kind of "requirements" approach to water demand modelling is the engineering approach. This approach requires a detailed understanding of the particular production process and is therefore usually undertaken at the firm level (for example, a specific paper mill), although it may also be used at the level of a whole industry (for example, paper milling). Both engineering design and mathematical programming may be used in seeking optimal technical or systems solutions to a change in one or more variables (for example, a change in energy). The disadvantage of this approach is the amount of data required and its accessibility. On the other hand, the act of obtaining the data may significantly enhance the understanding of the particular process and hence this approach may be valuable in its own right. A significant advantage of this approach is the ability to introduce new technologies into the modelling and hence the greater potential validity of scenario analysis in which parameters are varied beyond their historically observed ranges. (The results of the alternative statistical approach that seeks to determine relationships between variables from observation of historical values cannot be relied upon for forecasts in contexts where the parameters used are outside the range of observations.)

Model building and the use of mathematical programming techniques (for example, linear programming) in the engineering or systems approach to industrial water demand modelling are described and discussed by Stone and Whittington (1984) in Kindler and Russell (1984) with respect to a particular application: the modelling of resource use for a hypothetical coal fired power plant. It is worthwhile quoting their conclusions:

> *The development of a sufficiently realistic mathematical programming model requires specialised expertise and a great deal of cost and technological data. These necessary data are … not easily collected. In addition, the development and operation of a model typically requires considerable outlays in terms of both human and computer time. Finally, the communication of model workings and results to relevant planners and decision makers may be the most difficult of all.*

The above obstacles notwithstanding, the advantages of a mathematical programming model are significant. First, it is future-orientated and *permits an integrated analysis of new or hypothetical situations about which there may be no information on the statistical record*. Secondly, its construction is step-by-step and verifiable. … [Thirdly,] the "optimal" decisions are obtained as a result of a model solution in accordance with user-specified objectives, constraints and resource prices. … Finally, in the context of planning and social decision-making, the fact that the mathematical programming model cannot adequately address all of the objectives of social policy is no argument against its use in the decision process. … In short, to the extent that social decisions are not made in an informational vacuum, mathematical programming models of industrial operations (and water demands in particular) have a valuable role to play in providing quantitative input into the decision making process. (Stone and Whittington, 1984: 100)

The Econometric Approach

In contrast to the water requirements (and engineering) approaches described above, the traditional economic approach postulates a water demand relationship of the general form: $q = f(p_{inputs}, p_{output}, x)$; where the quantity of water demand (q) is a function of p_{inputs}, a vector representing the price of the inputs (including water), the price of the output and a vector of other independent variables (x). Once the exact form of the relationship has been hypothesised (using economic theory as a guide), the general aim is to try to verify the relationship empirically (using statistical estimates of historic observations).

One comprehensive approach to estimating industrial water demand relationships is to estimate a production function for the industry under consideration and to derive the demand for water (one of the inputs) from this (Stone and Whittington, 1984). However, in practice, little attention has been given to the estimation of general production relationships or to the simultaneous estimation of factor input demand functions (ibid, 1984:55). The reasons for this are both theoretical and practical. From a theoretical perspective, there is little justification for selecting any particular forms of the production functions commonly postulated (for example, Cobb-Douglas). Practically, the data required for such an analysis simply is not available to water planning agencies, or if available, the small sample sizes may limit the kinds of analyses that are feasible (ibid: 55). Thus, in practice, the most common approach is still the single equation model in one of the following two forms: $q = f(p_{out}, p_{inputs})$ and $q = f(x_{out}, p_{inputs})$.

Equation form and Economic Theory

For the purposes of context, both Hanemann (1997) and Espey *et al* (1996) undertook (selective) surveys of the water demand literature and reported on the forms of the demand equations used in empirical studies. The surveys show that the linear (equation), log-log (equation) and semilog (equations and) forms of the demand equation are all popular and dominate the empirical literature almost to the total exclusion of other forms. Neither study reported on the use of more sophisticated functional forms, such as the translog, which are more consistent with neo-classical consumer theory. Many studies applied both linear and log-log or semilog functional forms, reporting the differences in elasticity estimates obtained. Espey *et al* (1996) undertook a meta-analysis of the impact of the choice of functional form on the magnitude of the estimates of price-elasticity and found this influence not to be statistically significant.

The choice of the functional form depends on the purpose of the empirical modelling. Strict conformity with neo-classical demand theory may not be important. If the estimated price-elasticities are to be used to forecast future water demand based on known future price increments, the validity and accuracy of the prediction will depend on the extent to which future prices remain close to the range used in calculating the price-elasticity estimates. The linear, semi-log and log-log estimates are likely to give different future water demand estimates because they make different assumptions about how price elasticities vary with price and quantity. The choices of linear, semi-log and log-log demand equation forms may yield statistically significantly different results. Because there is no *a priori* reason for choosing any particular equation form, the uncertainty attached to any particular price-elasticity estimate is increased.

3.9.2 The Controversies of Methods

There is considerable methodological controversy and little agreement on three key methodological considerations: the choice of the appropriate equation form, the specification of the price variable and the choice of estimation technique. Yet, all the existing approaches impact significantly on the empirical results. Furthermore, even the empirical results within the same sector and methodological approach are not comparable due to differences among industries. That methodology matters and profoundly impacts on the results of the analysis of water demand is illustrated by several water demand studies. Experience on the impact of methodology on industrial water demand studies is disturbing.

Nieswiadomy and Molina (1989), and Hewitt and Hanemann (1995) studies use the same micro data set yet report significantly different results, even for similar estimation techniques.

> *There is considerable methodologically induced "noise" in all water demand estimates.*

For example, the slightly altered instrumental variable and two-stage least square specifications used by Hewitt and Hanemann (1995) yield positive but insignificant price parameters whereas Nieswiadomy and Molina report significant negative price parameters for essentially the same data set. Hewitt and Hanemann (1995) conclude that specification matters, particularly for the instrumental variables (IV) and two-stage least-squares (2SLS) techniques. However, they are unable to shed light on which specification is more correct.
Even more significantly, an alternative discrete-continuous choice model developed by Hewitt and Hanemann (1995) calculated elastic price-elasticity estimates (-1.6) compared to inelastic estimates (-0.55 to -0.86) calculated by Nieswiadomy and Molina (1989) using IV and 2SLS estimations for essentially the same data set. [7]. Hanemann (1997: 61) has also acknowledged the fact that different demand equation forms "can produce empirical results that are very different".

In light of the nature of industrial water, a cautionary note has been sounded with respect to the modelling of industrial water demand. Because there are different uses of water within specific industrial plants and because of the many factors that affect those uses, the development of specific and accurate relationships explaining water use patterns is not feasible (Stone and Whittington, 1984: 52). In practice, significant theoretical and practical constraints should influence the selection and choice of independent variables for empirical analysis. Stone and Whittington (1984: 55) assert that

> *"since there is little a priori reason for selecting one production function over another, there is no preferred functional form of the single equation water demand model"*

and go on to state:

> *" the choice of functional form is usually determined on the basis of two (sometimes conflicting) criteria: (1) best fit, and (2) ease of estimation. A search for the functional form that yields the best fit can quickly become an exercise with little theoretical content"*

they conclude. Furthermore,

> *"Results from different demand studies are generally not comparable with one another. Similarly, the results of demand studies are generally not transferable from one context to another." (Eberhard, 2001a)*

Results of different demand studies are seldom strictly comparable because of differences in methodology and the estimation context. For the above reason, the results of a demand analysis in one study can infrequently be transferred to another area with any confidence. In particular, the results from demand studies in developed countries generally are not translatable to developing country contexts. This means that an understanding of water demand in a particular developing country context cannot rely on the empirical findings of other studies. Even though no similar studies have been conducted in developing countries, the type of response exhibited by firms to the price of a resource forms a basis of understanding the role of pricing in explaining the behaviour of firms.

3.9.3 The Insufficiency of Elasticity of Demand Estimates

Lucas (1976) made the important points about the parameters estimated from an econometric model. These points raise questions on the usefulness of price elasticity measurements: (i) the econometric results are dependent on the policy prevailing at the time and will change if there is a policy change, thus they are rigid indicators. (ii) significant changes in the price structure and/or price level will render the price-elasticity estimates obtained under different conditions invalid. Therefore, significant changes in the price structure or price level outside the historical range will render the application of price-elasticity estimates obtained under different conditions invalid. (iii) Lack of homogeneity amongst consumers as a whole means that *aggregate estimates* of price elasticities gloss over very real differences between consumers. Furthermore, (iv) when there is a general change in the price level within the economy tariff changes will not induce industrial responses to water-use unless it becomes relatively cheaper to adopt other measures.

3.9.4 Other Important Considerations

While understanding *price responsiveness* is important in balancing supply and demand for water in the industrial sector, a large variety of issues are important in considering the dynamics of the price response in the demand for water as an intermediate input. For example, what is the time period over which the change in price operator is defined? How can we be sure that the adjustment that we observe later stems from influences associated with adjusting prices for water? All these questions suggest the need to investigate factors/ reasons that motivate firm behaviour.

Countervailing Measures: Whether in fact firms' response or dynamic behaviour stems from prices and adjustment costs at all, their structure, and their size remains a subject of theoretical debate. The nature of these functions-their sources, structures, sizes, and the extent of their heterogeneity across firms-underlies the debate about adjustments costs and determines those costs' importance. These costs include disruptions to production occurring when changing water availability causes production to be rearranged. All these costs might arise naturally out of the environments the firm faces in its factor markets and in the nature of technology it uses. Adjustment costs might also be the result, however, of the direct or indirect effects of government policies. To be able to predict the likely response to price changes; we need to know the source of adjustment cost facing the firm. At the most basic level, it might be costs associated with changing a mix of factors or stickiness arising from other aspects of a firm's behaviour or market environment in which the firm operates. The structures of these costs, that is, how their adjustment costs move with variations in the components of water inputs is important. According to Hamermesh and Pfann (1995: 1289), it is unclear which of a large variety of sensible alternative descriptions of adjustment costs best characterizes firm's behaviour. "Most likely no single analytical framework is uniformly applicable, any more than the standard model is", they conclude.

The Role of Institutional Arrangement: Water tariffs must be enforceable for the firm response to be visible. There should be mechanisms for ensuring liability for water service delivery among firms. However in many contexts, the non-economic (non-price) constraints such as political and security interests may indeed override economic factors (such as water costs); For example many urban water utilities in Kenya are small companies, organised on the local level and influenced by local politics. Socio-political influence on water institutions and water allocation by the water authority can be very distinct. Too often, water supply is also seen as a social service that dominates over the pricing as an integrated part of local government policy. This suggests that in exploring water sourcing options, firms may attempt to de-link their dependence on a water source which is less prone to their control. They may opt for a captive source irrespective of the costs involved since in any case, water constitutes a small proportion of the total production costs. Pricing variables for water may not pose a constraint to industrial production. Instead, water use in industry can be influenced by the physical availability of water resource. In most cases, the overall position taken by the firm will have evolved from some form of historical experience.

The Scope of Substitution: Price elasticity will also be dependant on the degree to which existing water use is "substitutable". In some cases, it may be relatively easy to reduce water consumption, whereas in other cases major capital investment may be required. For example, in the case of electricity generation, once an investment in cooling technology (dry versus wet) has been made for a particular power station, the scope for further reduction in water use per unit of electricity generated is limited. In this case, the price signal at the time of the initial investment is crucial. On the other hand, improved operating procedures may save significant amounts of water in some cases. This partly explains why there is such a large range in empirical estimates of the price elasticity of industrial water demand.

3.9.5 Summing Industrial Response to Tariffs

Existing studies are not conclusive in making predictions about how industrial water demand will respond to changes in prices in the future. In view of the sensitivity of price elasticity of demand for industrial water to methodological approaches, analytical approaches designed to deviate from conventional practice of relying entirely on elasticity as a measure of firm response have been proposed. Rather than depend on price elasticity studies to determine firm behaviour (based on the historical record), *third best* methodological approaches that extend beyond econometric analysis i.e. institutional factors have been suggested. In view of these developments, our framework in chapter 6 will seek to trace prices (based on cost considerations) and evaluate the response of the industries over time, both econometrically and by case studies of first hand experience by firms.

Part III: Wastewater Regulation

Regulation is seen as one way to induce industrial plants to improve their wastewater and water performance in many countries (developed and developing), hence it is of interest to understand the factors that influence the firms wastewater performance. In almost three decades since the initial wave of regulation, the academic literature has documented very few, if any, instances of wastewater regulation being an unqualified success. Indeed, in most cases, the problem is even more fundamental, with the typical analysis of government regulation finding that regulation did not even fulfil its primary mission, much less pass a more demanding benefit-cost test (Magat and Viscussi, 1990). These frustrations have developed into empirical studies oscillating between two broad components of regulatory enforcement: (i) on the motivations of firm behaviour, and (ii) the behaviour of the regulatory/enforcement agencies or institutions. In this part of our review, we focus on each of these components. In section 3.10, we define regulation. Section 3.11 deals with motivations of firm behaviour while section 3.12 looks at the behaviour of the regulatory enforcement agency/institutions.

3.10 Defining Regulation

The definition and boundaries of the term regulation has also generated much academic discussion (Blamey and Sutton, 1999). Dubnick and Gitelson (1982, p423), for example, referred to the diversity of definitions of regulation as a 'conceptual quagmire'. One way of thinking about regulation is that it is what regulators do. The problem with such 'agency definitions' is that a government body can become known as a regulator whether or not it undertakes regulatory functions, and whether or not it employs a more comprehensive mix of regulatory instruments. According to Dubnick and Gitelson (1982), if regulation is to be distinguished from other types of policy instruments, it is best defined in action terms. For example, Balch (1980) differentiates regulation from information, facilitative and incentive (price like) strategies on the basis that regulation requires people (firms) to act under *threat of punishment.* A more simplified definition of regulation, taking in some other academic subtleties is also offered by Reagan (1987, p.15). He defines regulation as "a process or activity in which government proscribes certain activities on behaviour of individuals, firms and institutions (private or public) through a continuing administrative process, generally through specially designated regulatory agencies".

The past decade has witnessed a trend toward the use of concepts of regulation that are pluralistic in terms of both action and agency. According to such definition, regulation need not be backed by law, and may be ascribed by any authority, not necessarily government. This opens the way for less formalized rules and norms to be viewed as regulatory in nature.

A broad interpretation of this is inclusive of such authorities as peer groups, industry associations and pressure groups. Not only do social norms perform a regulatory function, but also so do personal norms. Coping mechanisms and "routine practices and habits that help maintain decision stability" can be seen to be regulatory in nature. Whilst such broad interpretations are useful from a practical perspective, where the drawing of lines often results in unnecessary problem compartmentalization and potential inefficiencies, the disadvantage is that the distinction between regulation and other fields is blurred. In the words of Dubnick and Gitelson (1982, p425): "If regulation is everything then effectively it may be nothing".

For the purposes of our analysis, *regulation* is defined a la' Blamey and Sutton (1999) somewhat narrowly and traditionally as a government proscription. It is the deliberate action by the government authorities to enforce compliance by industrial firms to i.e. wastewater standards. The institutional arrangement for wastewater regulation comprises the organisations (enforcement agencies), their mandates, enforcement styles, and regulatory instruments employed to achieve their objectives. We use the term regulatory compliance to refer to behaviour that yields or complies with regulatory objectives (not necessarily in terms of attaining wastewater standards). Regulatory compliance (examined in chapter 8) looks at how firms respond to regulation, and how compliance change levels with enforcement levels. A *regulatory agency or authority* is an organisation with the legal regulatory responsibilities.

In the 250 years since the Industrial Revolution, industrial wastewater has been disposed of predominantly by dumping it untreated into rivers, lakes, public sewers, and the sea and even underground. In the quest for water resource management and sustainable development, efforts to augment water supply through regulation of wastewater quality have been on the increase (Merret, 2000, pp.202). However Braadraat (1995), Catherine (1998), Deily and Gray (1996) suggest that the use of regulation has been effective only in the developed countries even though they are also certainly widely applied in developing countries where they remain less effective. In most countries, industrial wastewater regulations have been passed to address the problem of wastewater quality and promote water conservation. Although most developing countries have strong laws and regulations on industrial discharges, they are seldom effectively enforced (Rogers and Harshadeep, 1996, p.25). These shortcomings often point to the appropriateness of institutional structures to combat the threat of unsustainable wastewater practices within the industries.

3.11 Firm Behavior in Response to Wastewater Regulation

The regulatory enforcement penalty literature begins with Becker's (1968) economic analysis of crime. The basic insight of that seminal article is that potential criminals respond to both the probability of detection and the severity of punishment if detected and convicted. Thus, deterrence may be enhanced either by raising the penalty, by increasing monitoring activities to raise the likelihood that the offender will be caught or by changing legal rules to increase the probability of conviction. Becker's model ultimately leads to an "efficient" level of crime, whereby the marginal cost of enforcement is equated to the marginal social benefit of the crime reduced per unit of enforcement. Thus, given individual preferences and enforcement technologies, both the crime rate and the level of monitoring and enforcement activities are determined by this model. If effective, regulatory enforcement should reduce water intake and the wastewater infractions. The main weakness of this theoretical framework is that profit maximization is the underlying motive in a firm’s decision framework and firms’ continually engaged in trying to weight the costs against the benefits for compliance. However, most economic relations are governed not just by costs but also by such institutions like reputations and the behaviour of enforcement agencies (Stiglitz 1992:64). Even though a lot has been learnt about the effect of monitoring and enforcement on firm behaviour over the past 25 years, there is only a loose consensus that increased monitoring and inspections can increase compliance. The studies diverge on the levels of scepticism: on the strong and weak followers of sanction variables, and sceptics.

3.11.1 Deterrent Hypothesis: Regulatory Enforcement Induces Compliance

Level of Penalties

The earliest variants of the Becker model that appeared in the environmental arena are Downing and Watson (1974), Harford (1978), and Storey and McCabe (1980), all of who investigate firm behaviour in response to penalties. The majority of these researchers conclude that their results support the deterrence hypothesis: that individual firms rationally respond to incentives for participating in illegal activities (see, Furlong & Mehay 1981; Wolpin 1978). According to this group of studies, firms may invest in abatement capital, for example, or reduce output, in response to changes in the stringency of the regulatory enforcement they face. Magat and Viscussi (1990) model pollution as being a function of firm-specific and location-specific variables. They include a measure of government inspections and also a variable for the prior period's pollution level to account for the firm's abatement technology and history of compliance. Like their predecessors, Magat and Viscussi (1990) document the fact that higher levels of enforcement activity result in lower levels of pollution. To explain the phenomenon of high compliance in the absence of strict enforcement, Harrington (1988), Harford and Harrington (1991), and Harford (1991) adapted existing models of income tax enforcement. These models have been referred to as "state-dependent" enforcement, since government policy depends on the firm's previous compliance status. The basic idea is that firms are assigned to groups based upon their known compliance history. Extra incentives for compliance are created by the threat of being faced with a tougher regulatory regime if found to be out of compliance. Harrington (1988) calls this added incentive "enforcement leverage." Such a scheme tends to make the level of compliance appear high relative to the fines actually imposed and the average fine threatened.

Some proponents of new and more stringent environmental regulations have argued that increasing the stringency of wastewater regulations provides an incentive for firms to develop new technologies and less costly ways of reducing pollution or, potentially, entirely new methods of production that eliminate particular types of effluents and reduce costs of production - thus improving economic performance of firms. This view of the relationship between environmental regulation and economic performance has come to be known as the "**Porter hypothesis"** (Jaffe and Palmer, 1997). More systematic economic analysis of the Porter hypothesis is hindered by ambiguity as to exactly what the hypothesis is in explaining firm response. First, a narrow version of the hypothesis is that certain types of regulation stimulate innovation a fact which lacks empirical basis. A second version is that regulation places constraints on the profit opportunities of firms that were not there before, and thus firms maximizing profits subject to those constraints will do a variety of things differently than they would have without the constraints, with a likely area of new activity being investment in ways to meet the regulatory constraints at lower cost.

The "strong" version of the Porter hypothesis rejects the narrow profit-maximizing paradigm and posits that firms under normal operating circumstances do not necessarily find or pursue all profitable opportunities or processes. The shock of wastewater regulation may therefore induce them to broaden their thinking and to find new products or processes that both comply with the regulation and increase profits (Porter, 1991). In this last form, the Porter hypothesis has been construed to imply that environmental regulation is a free lunch (or even a paid lunch"), that is, regulation induces innovation whose benefits exceed its costs, making regulation socially desirable, even ignoring the environmental problems it was designed to solve. According to Granderson (1999), regulation can also impact on a firm’s selection of innovations among inputs. Smith (1974) and Okuguchi (1975) also examined the impact of regulation on a firm’s choice of innovations. They showed theoretically that regulation could alter a firm’s choice of innovations and thus induce compliance.

Monitoring of pollution at pulp and paper mills has been studied in Canada (Laplante and Rilstone, 1996). Their empirical model of pollution is nearly identical to the model estimated in Magat and Viscussi (1990). However, instead of using past inspections directly in their empirical model, Laplante and Rilstone (1996) note that government inspections are not exogenous. For example, smaller plants are less likely to be inspected, firms that are inspected once are less likely to be inspected again soon, and those that make changes to their productive capacity are more likely to be inspected. Thus, Laplante and Rilstone (1996) estimate a probit equation where the dependent variable is the probability of being inspected.

The predicted value of this equation for each firm thus becomes the "expected inspection" rate for that firm. Consistent with previous studies using actual inspection rates, Laplante and Rilstone find that the threat of inspections (or "expected inspection rate") also induces compliance.

Consistent with most of the other published empirical papers, Gray and Deily (1996) find that increased monitoring and enforcement leads to higher compliance in subsequent periods. They also find that firms who were found to be in compliance in prior periods were less likely to be inspected in subsequent periods. Plants that had higher emissions had higher inspection rates - even controlling for compliance in prior periods. At the firm level, larger companies had lower enforcement rates, which they note is consistent with "regulatory sensitivity to firms' political power". One interesting finding is that there appears to be a pattern of compliance or non-compliance across plants owned by the same firm, and multi-plant firms are more likely to be in compliance than single-plant firms. This suggests that corporate policies on environmental compliance might be important, and that enforcement authorities might target plants whose owners have been known to be out of compliance elsewhere. Note that financial status of the firm did not affect compliance, which rules out a purely financial explanation for the last result.

Among the empirical studies in support of the deterrent hypothesis are those that have identified defects in regulatory enforcement. Harrison (1995) is one of the few cross-national studies of enforcement. She compares the different approaches to enforcement policy existing in the U.S. and Canada, once again focusing on the pulp and paper industry. Harrison characterizes the strategy in Canada to be "cooperative" relative to the more stringent approach adopted in the U.S. Canadian enforcement officials are more willing to negotiate and revise compliance programs instead of forcing compliance or imposing a sanction. Empirically, Harrison finds that Canadian pulp and paper mills are not in compliance as much as in the U.S. Moreover, she shows that U.S. enforcement is more even handed across plants - suggesting that Canadian officials are more likely to give in to plants that face higher control costs.

Pargal, Mani and Huq (1997) conduct a two stage least squared regression of enforcement and compliance. They find that although increased emissions prompts government inspections, those inspections have no effect on subsequent emissions. Among possible reasons cited is the low probability of inspections, low penalties for non-compliance, and low pay for inspectors, which might encourage bribery. Fenn and Veljanovski (1988) employ an economic approach to study enforcement in the U.K. They model government enforcement authorities as having discretion over whether or not to prosecute offenders who have violated the law. In that case, bargaining, selective enforcement and negotiated agreements without penalties become important enforcement tools. They conclude that only credible threats of punishment and credible promises of compliance will make an informal system like this work. If firms know that they are always able to negotiate a compliance agreement without further penalty, they will take a `wait and see' approach to compliance. Fenn and Veljanovski (1988) argue that in reality there is uncertainty about the enforcement agency's strategy. Although they might agree to a negotiated settlement involving no penalties, there is no guarantee they will do so.

3.11.2 Compliance Attributed to Other Factors

The validity of the deterrence conclusion has been questioned on several grounds. Much of the criticism can be attributed to the uneasy relationship between theory that is constructed at the individual level of observation and the empirical analysis conducted at some level of aggregation. Specifically, there have been three central lines of criticism levelled at the conclusions drawn in the deterrence studies (Furlong, 1991): spurious correlation, the incapacitation effect, and the identification. Each criticism concedes that there is indeed a negative correlation between violation rates and enforcement measures but is attributes it to some feature of the aggregate data rather than deterrence effect of regulation. Although it is possible that firms comply with environmental laws because of the threat of being placed on the enforcement agency's target list, this is unlikely to be the main reason for compliance. Indeed as Russell, Harrington and Vaughn (1986), and Harrington (1988) note, government-monitoring activities are often quite limited. Moreover, even if discovered to be in non-compliance, fines are low. Hence compliance cannot be attributed entirely to regulatory enforcement.

Risk Aversion, Corporate Image

Downing and Kimball (1982) documented the low penalties for non-compliance and the relatively high compliance rates. First, they argue that industry might want stringent regulation as an entry barrier to new firms. Although this is plausible, it is not clear how this explains compliance (as opposed to regulation). Second, they note that risk aversion might help explain compliance. The fact that subsequent violations are dealt with more harshly provides an impetus for a risk averse decision maker to comply now instead of risking future monitoring. Finally, Downing and Kimball (1982) raise the possibility that managers care about their corporate image, a hypothesis that they claim is supported by survey evidence. Recent surveys that provide some evidence consistent with this claim can be found in Cahill and Kane (1994), Zerbe (1996), and Doonan, Lanoie and Laplante (1998).

Information Constraints

There are other reasons why firms might comply with wastewater standards. It is possible, for example, that due to information constraints, firms do not realize how low the expected penalty is for violating the law. Hammit and Reuter (1988), for example, cite survey evidence that some firms significantly overestimate the chance the government will monitor them. Alternatively, it is possible that the expected penalty for non-compliance is not as low as it appears on the surface. For example, there is growing evidence that the relatively low administratively imposed fines noted by previous authors are not the only penalties imposed on firms that fail to comply with environmental laws. It is also possible, for example, that managers who make the decisions about compliance simply believe that compliance is the right thing to do. In other words, social norms might operate to yield significant compliance rates - even without the threat of penalties. It is also possible that the marketplace rewards firms that comply with environmental regulations if a segment of consumers are more likely to buy their products (Arora and Gangopadhyay, 1995).

Several recent experiments with information disclosure as an enforcement tool have yielded promising results. Most of these efforts are being promoted by the "New Ideas in Pollution Regulation" (NIPR) program of the World Bank, and are reported on at their Internet site, http://www.worldbank.org/nipr. Although some of these experiments are designed to fill a void where no regulations are in place, others have explicitly used the power of information disclosure as a method of pressuring firms to comply with government regulations. This is particularly useful in countries where government enforcement resources are limited. For example, a program in Indonesia rated firms by their level of compliance with existing regulations and gave the firms six months advance notice of the rating that would be made public unless they changed their compliance behavior. Afsah, Laplante, and Wheeler (1997) report considerable improvements in compliance status both before the initial public announcement (which allowed firms to change their status before the announcement) and following the public announcement. Information that a firm has been sanctioned for violating environmental laws (fines, cleanup costs, damage compensation, etc.) may be of interest to shareholders or lenders of that firm.

Consumers and Share-Holders' Pressure

Harford (1997) offers an interesting new theory suggesting that large publicly traded firms might be more inclined to comply with environmental standards than other firms. The theoretical argument follows other recent papers in the economics and finance literatures on corporate governance that suggest shareholders of diversified portfolios will want to maximize their portfolio's value - not the share price of any one firm. Thus, if one firm within a diversified shareholder's portfolio creates an externality against another firm, it will be in the interest of that shareholder to internalise the externality and maximize joint share value. To the extent that shareholders own a diversified portfolio of all publicly traded firms that collectively make up a large portion of the nation's environmental risks, shareholders will not seek share value maximization, but some modified version that includes their own preference for environmental compliance. The effect of consumer pressure and public image has also been illustrated to exert important influence. Alexander and Cohen (1998) argue that incentives within the firm that align top management with shareholders interests can help explain firm compliance behavior. If it were in the best interest of shareholders to comply with environmental laws, we would expect compliance to be more prevalent in firms where top management incentives are more closely aligned with shareholders. Alexander and Cohen provide empirical evidence that publicly traded firms whose top management incentives are closely aligned with shareholders are less likely to commit corporate crimes. The role of community pressure and other forms of informal sanctions are also explored in Pargal and Wheeler (1996), Hettige et al. (1996), Arora and Cason (1996), Brooks and Sethi (1997), and Konar and Cohen (1998). These papers generally find support for informal community pressure and social norms as playing an important role in emissions and/or compliance.

3.11.3 Non-Compliance Attributed to Other Factors

Firm' Ignorance

An interesting question to ponder is whether non-compliance may be partly explained by ignorance, and not wilful behaviour. Brehm and Hamilton (1996) consider this possibility in the case of new rules requiring certain emitters of toxic chemicals to report their emissions to the U.S. EPA. They develop a model in which violations may occur due to ignorance or evasion. For example, "ignorance" was operationalised by measuring the extent to which a facility had other environmental permits or requirements. It is assumed that firms with other environmental permits were more likely to know about the new reporting requirement. Alternatively, if a firm that failed to report its emissions had a previous violation under other environmental laws that would suggest evasive activity. Brehm and Hamilton (1996) found considerable support for an "ignorance" explanation for non-compliance, although there was also evidence of evasive activity. Their paper highlights the importance of considering the information set of firms subject to regulations.

Stochastic Events

As noted in the environmental economics review article by Cropper and Oates (1992), there are generally two sources of violations. First, a firm might intentionally violate the law by not complying with a regulatory standard or by not paying the appropriate emission fee. That is the type of violation envisioned by Harford (1978), where the firm explicitly chooses an output-emission combination. Second, pollution may be of a stochastic nature, in which case it may not be obvious a priori whether the existence of pollution is due to a wilful violation of the law, some form of negligent behavior, or a random act of nature. Closely related to the first case is the notion of defiance. According to the theory of defiance is defined as "the net increase in the prevalence, incidence, or seriousness of future offending against a sanctioning community caused by a proud, shameless reaction to the administration of a criminal sanction." Defiance is most likely to occur when an individual i) defines a sanction as unfair; ii) is poorly bonded to the sanctioning agent; iii) defines the sanction as stigmatising. Those who refuse to acknowledge shame will often substitute "pride in their bold disrespect for the would-be shaming agent, for the rule the agent enforces, and for the society making those rules. In the context of developing countries, defiance could occur where firms are enjoying patronage from powerful individuals. It might also herald rent-seeking behaviour among the enforcement agencies, leading to selective enforcement of the regulation.

Beavis and Walker (1983), Beavis and Dobbs (1987) and Cohen (1987) examine stochastic pollution. As Cohen (1987) notes, the Becker (1968) model can be written as a special case of a more general model of firm behavior that takes into account the random nature of pollution. In Becker's model, crime is unambiguously "caused" by the criminal, whereas in stochastic pollution, the extent to which a polluter took adequate care in preventing the externality is often an important issue to be resolved.

One of the arguments commonly advanced for non-compliance is that regulation creates additional costs to both regulators and firms and in addition erodes the competitiveness of manufacturing firms when complied with. It is argued that the non-compliant behaviour in LDCs is because compliance poses a threat to the survival of a firm since it might have to invest so heavily in the installation of a treatment plant and that compliance would land a firm in financial difficulties, or the operational costs for waste-water treatment might increase the price of its products to such a degree that the firm would no longer be able to compete with "free-riding" non-compliant competitors. However, according to *Braadraat* (1995), the experience of Indonesia suggests that a) initial investment in waste-water treatment equipment imposed a substantial but not excessive financial burden on industries; b) post-construction operational costs of waste-water treatment did not cause a significant increase in cost prices. Hence these findings do not support the hypothesis that excessive costs force firms into non-compliance. Furthermore *Brandon and Ramankutty* (1993) have conceded that although widely used, standards (concentration-based) are less effective as regulatory mechanisms as industries can simply dilute their waste streams to meet the standard! In India for example, it has been shown that industries were using four times the amount of water as used in water-rich Canada, partly to dilute their waste concentrations in order to meet the stipulated standards. These experiences suggest that water tariffs should be maintained at a sufficiently high level to make it less viable for such dilution.

Firm Characteristics

Khanna and Damon (1999) have explained a firm's motivation to participate in the pollution control program as being dependent on its size, financial characteristics, and desire for public recognition. They refer to the findings by Arora and Cason which show firm size to be significant but financial variables to be insignificant in explaining environmental participation. They show that in addition to size, public recognition and volume of releases motivated participation. They extend these findings by hypothesizing that the incentives for participation arise from program features, mandatory environmental regulations and firm-specific characteristics. In their view, the prescriptive nature of regulations has typically been held responsible for inhibiting innovative and cost-effective strategies for effluent control. On the other hand, threat of the imposition of penalties under mandatory regulations may, however, motivate firms to participate in voluntary programs. The greater the potential liabilities for environmental damages, the greater the deterrent effect on effluent levels.

According to *Knutsen* (1994), large firms, and foreign firms are likely to contribute to environmentally sound technology in developing countries through a) allocation of large amounts of money to research and development; b) employment of highly educated and skilled personnel; c) technological flexibility since costs associated with the environmental demands in a host country can be dispersed. But foreign firms can also perpetuate environmental degradation since

i) they possess substantial bargaining strength. They can threaten to close down factories if their terms are not accepted; and ii) they have limited accountability and social responsibility in their relation to national governments. These arguments have counteracted by suggestions that LDC firms use old technology that may lead to low compliance, hence age of plants have been seen as important parameters. Still on firm size, Demsetz (1997) has argued that if a firm can be small, its assets can be owned by a single person or very few people. The firm's operations will therefore impinge directly on the reputation of the owner(s). The ownership structure of a large firm, however, is more diffuse, hence they are not likely to take ethical responsibility over environmental matters.

3.12 The Behavior of the Enforcement Agency

Wastewater regulatory compliance literature includes a variety of assumptions about motivations for enforcement agency behaviour. Empirical studies of regulatory enforcement generally ask one important question: How does the regulatory agency enforce its regulations? This question is "institutional", and relates to the behaviour of the enforcement agency and the institutional arrangement for wastewater regulation. We have dealt with it in this section and extended our analysis to chapter 7 by looking at the Kenyan setting.

Several theories of enforcement behaviour have been explored including (Cohen, 1998): (1) net political support maximization, (2) bureaucratic behaviour theory, (3) the law enforcement goal of maximizing compliance, (4) maximizing the benefits of compliance without regard to compliance costs, and (5) a median voter model with asymmetric information about enforcement effort and compliance costs. Although the different theories might be used to explain regulatory enforcement behaviour by the government, the empirical implications of those theories are not always distinguishable (see chapter 7). Some of these theories of enforcement agency behaviour are based on the general propositions of the political economy or public choice literature, others are based on more detailed interactions between industrial firms and the regulatory agencies. The enforcement arm of a regulatory agencies (i.e. in Kenya) often have more in common with police or other law enforcement agencies in government than with the regulatory agency itself. The

(Kenyan) enforcement officials work with the courts, thus, an alternative view of enforcement is that it is a pure law enforcement function designed to achieve the highest possible level of compliance.

Previous studies have advanced explanations to the apparent failure by regulatory institutions to maximize compliance (Bartel and Glenn, 1985). The low level of enforcement can be explained by (i) the division of responsibilities among many agencies, with little coordination, making it procedurally difficult and leading to lack of interest among some departments. (ii) the number of laws involved make it difficult to understand and correlate the tasks required. (iii) there is an absence of what can best be described as the "philosophy of enforcement", particularly at senior levels. This is to some extent reflected by the comparatively junior grade responsible for enforcement. (iv) there are staff shortages. Most problems encountered arise from a low level of implementation and enforcement of the law, rather than any serious deficiencies in the legal provisions. The specific theoretical explanations fall under the following broad categories: (i) The principal agency problem; (ii) Non-compliance and inefficiency hypothesis (iii) the regulatory capture hypothesis; (iv) the regulatory styles; (v) the multi-level/agency contexts.

3.12.1 *The Principal Agency Problem*

A theory of regulation based simply on welfare economics and market failure has too narrow a base. It necessarily assumes that the sole objective of regulation is the maximization of welfare through the optimal allocation of resources, regardless of equity , the aspirations of the regulators themselves, or the political debts that have to be paid (Utton, M.A., 1986; 19). Recently a large volume of literature has grown upon around agency theory applied to legislators, with the voter as principal and legislator as agent. Empirical work suggests that legislators frequently vote their own conviction rather than principals' interest (North, 1989: 1323). The same analogy can be applied to the regulators charged with the task of enforcing environmental standard. More important is the recognition that regulators themselves cannot be presumed to be without self-interest. They have an interest in maintaining their jobs etc. There is also an incentive for regulators to overstate the importance of their work and to ensure that they do not remove the need for regulation. If the problem of wastewater control worsens, there is a call for greater resource allocation to their course. If the problem diminishes, it is claimed as a success of the regulation, and further support is justified to their course. Governments and regulatory authorities may thus become overprotective by placing less responsibility on firms for the consequences for their own actions. Mistakes made by regulators will thus not be learning experiences, as they would be for firms, but causes of recrimination and resentment.

The typical textbook on regulation treats regulatory authorities/ institutions as bodies of automatons, selflessly devoting themselves to an effort to implement policy in an effort to simulate compliance by firms. Economists have come to realize that this is not an accurate description of the regulatory process in either of its major respects. Regulators are not automatons,

> "but men and women who go to baseball games, advocate their political philosophies, have their gallbladders removed, take their cats to the veterinarian, and otherwise behave like the rest of us." (Hilton, 1972)

It is important to analyse the factors that explain the regulator's decision to monitor a plant's wastewater performance. Previous work in this area has assumed that the regulator's primary wish is to allocate its resources to maximise the rate of compliance with regulation. Regulators have utility functions like all persons, in which they seek to optimize with calculations concerning the present versus the future in light of the costs and rewards presented to them.

3.12.2 Non-Compliance and In-efficiency Hypothesis

Because of limited statutory and budgetary authority from the Government, a regulatory agency may be unable to compel industrial compliance with its own standards. Advocates of this position point to the pitifully small level of fines and to the small number of firms that are actually inspected in practice. From the perspective of low penalties and small number of inspections, non-compliance by firms will be the root of regulatory authority's failure. This issue has been discussed as a "non-compliance hypothesis" (Bartel and Glenn, 1985). A second argument is that, because the statutory standards emphasised are in fact "superimposed" standards applied without due considerations to local ecological factors, the standards address only part of the problem, and will have at best minimal effect ("inefficacy hypothesis").

3.12.3 The notion of Regulatory and Enforcement Styles

Consistent with the broader definitions of regulation considered earlier is the notion that different regulators may have different styles, and that different styles are suited to different circumstances. Styles relying on an inflexible, legalistic, adversarial, and deterrence-based approaches are commonly distinguished from those employing a more flexible, conciliatory, accommodating and cooperative approach. Regulatory styles vary not only between agencies and programs, but also within them. For example, different inspectors working for the same agency may exhibit different styles. Braithwaite et al (1987) used hierarchical cluster analysis in developing enforcement taxonomy of ninety-six Australian government agencies involved in regulation. Two major dimensions were found to underlie the typology; the first pertaining to the degree of emphasis on enforcement or punitiveness, and the second pertaining to the extent to which a detached command and control approach was emphasized rather than the cooperative fostering of self-regulatory practices.

Differences in enforcement style reflect a range of factors, and in particular, the visibility of violations, the capacity and willingness of regulatees to comply, the technical, economic and legal problems encountered in implementing regulations, and the political acceptability of different styles. Related to these are the frequency of interactions between the regulatee and regulator, the costs of compliance, and the number and size of regulatees (Kagan, 1989). It appears that different regulatory styles provide different opportunities for the utilization of less coercive tools and strategies such as those employed by marketers. Ayres and Braithwaite (1992, p21) observe that "Increasingly within both the scholarly and regulatory communities there is a feeling that the regulatory agencies that do best at achieving their goals are those that strike some sort of sophisticated balance between the two models (of regulation). The crucial question has become: “When to punish; when to persuade?". From a simple economic standpoint, the optimal policy mix will be that which equates the marginal benefits from increments in expenditure for each type of instrument. The benefits and costs associated with an intervention clearly vary with the scale of implementation and are complicated by interactions with other elements of the policy mix.

> *According to the theory of responsive regulation outlined by Ayres and Braithwaite (1992), agencies that consistently rely on either punishment or persuasion are unlikely to be as effective as those that seek to balance the two. Those based mainly on persuasion are open to exploitation by narrowly self-interested parties and those based mainly on punishment tend to undermine the goodwill of those who would normally comply for moral reasons. Punitive strategies tend to result in resistance and defiance, and are costly to monitor and enforce.*

The trick is “to establish a synergy between punishment and persuasion" (Ayres and Braithwaite, 1992). The responsive regulation model provides a framework for balancing punitive and persuasive strategies. Drawing on Scholz's (1984) adoption of Axelrod's (1984) game theoretical work on the prisoner's dilemma, Ayres and Braithwaite (1992) advocate use of a tit-for-tat basis for regulatory responses. Regulators begin by assuming goodwill on the part of the regulatee and accordingly adopt a cooperative and non-punitive approach. However, if the regulatee decides to "exploit the cooperative posture of the regulator and cheats on compliance, then the regulator shifts from a cooperative to a deterrent response" (Ayres and Braithwaite, 1992). The regulator responds to progressively punitive strategies until the regulatee conforms. When compliance occurs, regulators respond with thanks, understanding and even forgiveness, potentially backed up with a retreat to the next level down in the pyramid.

The notion that regulatees should be treated "as if their socially responsible self was always the 'real' self' has parallels with the notion that 'the consumer is always right' which lies at the heart of the marketing concept. In order to avoid the resistance associated with punitive responses, it is important that regulators use appropriate language when communicating with regulatees. "Sophisticated regulators are practitioners of achieving their goals by manipulating vocabularies of motive" (Ayres and Braithwaite, 1992, p32). The enforcement agencies must tread a fine line between making regulatees (firms) aware of the enforcement pyramid whilst constructing an "image of invincibility" and coming across in a forceful manner that regulates (firms) perceive as violating their freedoms.

3.12.4 The Regulatory Capture Hypothesis

The "capture" hypothesis is simply that although regulatory agencies may start out as guardians of the public interest, they may soon succumb to the power and influence of the industry they are supposed to regulate and finish up protecting it rather than the public. It is not usually suggested that regulatory officials are corrupted but simply that they come more and more to identify with the problems of the industry which also controls the information on which the regulators have to rely for assessing performance. In mature regulated industry, therefore, regulation will be seen to work in favour of the members rather than correct a market failure and improve resource allocation (Utton, M.A., 1986; 22). While regulation is intended to protect the public from damage by industrial firms, it can also be used to protect or enhance the interests of the regulated. For example, professional quantification is a form of public regulation designed to impose minimum standards for treatment, but is also a form of private regulation because it enhances the economic rents (incomes) of the regulated. This can lead to what is known as regulatory "capture" where the regulated may eventually or "capture" the regulators. In practice, the efficacy of regulation is likely to be compromised for several additional reasons (Posner 1974). Regulators may fail to use their power over the regulated, or may use it in unnecessary or harmful ways. Regulators, if beneficiaries of political patronage, may not be the most appropriate people to appoint.

3.12.5 Institutional Structure – Multi-Level, Multi-Agency Institutions

An interesting question that has only seldom been discussed in the literature is the extent to which regulatory enforcement and compliance differs with the diverse levels of government. Should monitoring and enforcement be delegated to a state or local jurisdiction, or remain with the national enforcement agency? The scarcity of literature on this topic reflects both the difficulty in obtaining sound data that would allow for such a study, and the lack of definitive theoretical models of government levels that yield strong predictions of enforcement behavior. Thus, the little empirical literature devoted to this topic tends to be focused on policy implementation issues. A good example of this type of research is Burby and Paterson (1993), who study compliance under two different enforcement agencies, a state-level enforcer, and a local enforcement authority. Burby and Paterson are interested in whether delegating enforcement authority to the local level will result in more or less compliance. The theory is ambiguous on this issue. On the one hand, a decentralized enforcement agency might be overly concerned with local issues at the expense of transboundary issues. Thus, we would expect less stringent enforcement and compliance with local government monitoring. On the other hand, a local enforcement agency has the advantage of being familiar with the facilities and individuals within the firm, and is more likely to gain the cooperation of local managers. Burby and Paterson develop a unique data set of inspections in North Carolina, where some local jurisdictions voluntarily enforce state law, with the remaining jurisdictions allowing the state to enforce. They find some evidence of increased compliance by firms subject to local (vis a viz a centralised) enforcement. Given the fact that, local jurisdictions self-selected into the enforcement program and the fact that this is only one program in one state, one should be reluctant to generalize from these findings.

3.12.6 Appropriate Institutional Arrangement for Regulation

We summarise the above theoretical perspectives on agency behaviour in Table 3.1. These tenets form the basis for our discussion in chapter 7 where we examine the appropriateness of the arrangement for wastewater regulation in Kenya.

Table 3.1: The Tenets of an Appropriate Institutional Arrangement for Wastewater Regulation

Characteristic	Types	Features	Comments
Institutional Structure	Single-level	Single layer	Be able to exploit synergies
		Multiple layers	Literature not conclusive
	Multi-agencies	Single layer	
		Multiple layers	
Non-Compliance/ Inefficiency Hypothesis	Budgetary constraints	Financial limitations	These should be limited
	Statutory powers	Defective standards, rules	
Regulatory and Enforcement Styles	Persuasion		A Balance of Options i.e. persuasion, carrot and stick
	Punishment		
	Incentives		
Regulatory Capture		Firms influence enforcement. Firm's interest dominate	There should be no undue influence from the regulatee.
Principal Agency Problem	Enforcement:		There should be autonomy: independence of other government departments, or political patronage. No pursuit of self -interest.
	Policy		
	Philosophy upheld		
	No subjectivity		

3.13 Conclusion

In this chapter, we have made a systematic, but extensive review of theories of the firm and firm response of water tariffs and wastewater regulation. Whilst the neoclassical based theories are still of vital importance in helping us to perceptively deal with issues pertaining to firm behaviour, we have shown that there is a need to go beyond them by explicitly endogenizing institutions (agency behaviour) in studying firm response to water tariffs. These conclusions emanate from the discussion of various theoretical variants on firm reactions to water changes and the empirical evidence that suggest existing methodological approaches to be inconclusive. The major findings of these neoclassical based theories and empirical work point to the need to bring together the institutional and historical variables in order to better understand the processes of firm response to water tariffs. According to Cohen (1998), we probably know the least about the most important and fundamental topic in regulatory enforcement - why firms comply with the law. Two promising areas of research on this topic appear to be developing: (1) incorporating social norms, community pressure and firm reputation into the analysis, and (2) opening up the "black box" of the firm and incorporating incentives within the organization. Although recent attempts to empirically estimate the factors that cause firms to voluntarily reduce emissions have been promising, they have often been unable to substantiate the theoretical models that others have proposed. In spite of the inconclusive evidence on the motivations of firm behaviour in compliance, institutional parameters remain central to the enforcement of wastewater regulation. These findings are critical to our discussions in the subsequent chapters. In particular, the infusion of historical and institutional factors into our analysis has implications for our research methodology, which is pursued in Chapter 4.

Notes

[1] The term “wastewater” means water that has been used for domestic, commercial, agricultural, trading or industrial purposes and as a result of such uses may cause water pollution when discharged into the aquatic environment.

[2] Technical or x-efficiency may be defined as the achievement of a specific objective with the use of the minimum possible resources. This definition is most easily understood in the context of the physical production of a good. A production process is x-efficient if a given output is achieved with minimum resources, that is, if it is not possible to use less resources to achieve the same output or to achieve more output with the same set of input resources. For example, there would be an unambiguous improvement in x-efficiency if the same output was achieved with the use of less water and no additional resources were required to achieve this.

[3] Water use may be described as being of *beneficial use* if it is used for an economically or socially useful purpose. *Optimal beneficial use* achieves the desirable combination of social, economic and environmental objectives, in other words, it is beneficial use in the public interest. The definition of efficiency in terms of optimal beneficial use thus recognises the *social* value of water and the fact that it is inappropriate to value water solely in terms of value placed on the resource by the “highest bidder”. Social choice is implicit within this definition of efficiency.

[4] Another definition of technical efficiency may be useful in certain circumstances. A World Bank paper on technical efficiency in water use defines efficiency as the ratio of consumptive use to gross use (Xie *et a*l, 1993).

[5] "The adoption of water efficient technologies reduces demand most among higher income households because wealthier households tend to have more bathrooms and other water using capital within the home and maintain larger lots with more landscaping" (Renwick, 1996: 82).

[6]"Data specific to Denver show that the potential gains in aggregate consumer surplus attributable to supplier-financed investments in improved water-use efficiency are many times larger that potential gains from reformed [marginal cost] pricing. An expanded efficient pricing rule which incorporates these supplier-financed investments, promises substantial improvements in economic efficiency" (Woodwell, 1992).

[7] Notwithstanding the fact that Nieswiadomy and Molina (1989) have shown OLS estimates to be biased in this context.

4 Methodological Issues and Data Description

"A man must be very sagacious who could discover by reasoning
that crystal is the effect of heat, and ice of cold,
without being previously acquainted with the operation of these qualities"
David Hume (1772)

4.1 Introduction

This chapter acts as bridge between our earlier chapters (1, 2 and 3) and the rest of the chapters. The chapter provides a discussion of the empirical context, various competing methodological approaches to social science research and how they are linked to our study. Our research problem being investigated flows directly from positivism, however, given our earlier critic in chapter 3 of the insufficiencies of the neoclassical framework, part of our research and analysis is based on an interpretative approach to accommodate concerns for institutional factors. We have therefore adopted methodological triangulation in our study. The overall goal of the chapter is to provide background and justification to the design of field and overall methodology for the study. The chapter is organized as follows: In section 4.2 discuss the objectives, context and assumptions of the study, section 4.3 examines the conceptual issues in research methodology, In section 4.4 we discuss methodological triangulation which is our choice of methodology while section 4.5 discusses the research design. Section 4.6 contains a reflection on the lessons from data collection. We conclude in section 4.7.

4.2 The Objectives, and Context of the Study

As stated in the introductory chapter, the main objective of this study is to examine the *effect* of water tariffs and wastewater regulation on industrial water consumption (demand) and effluent disposal behaviour in the urban areas of Kenya. Expressed differently, we seek to examine how firms respond to tariff changes and regulatory enforcement on wastewater. Implicit in our objective is the need to describe and explain the behaviour of firms in relation to the two policy instruments. Superficial description is possible at the level of the event, the dependent variable, itself, but explanation requires the establishment of purpose and causality between dependent variables. Consequently, by aiming to explain events relating to firm input use against changes in

factor/input prices or sanction variables, we need a theoretical framework, which is implicit in our discussions in chapter 3.
In research involving investigations of industrial water demand (if not all) studies, many approaches adopt the conventional neoclassical economics view of the firm as a black box of technological and managerial relationships. Inputs are turned into outputs that are often technically identical and the boundaries of the firm are given. The result is often a given standardized process in which water price changes are expected to inversely affect consumption of water. Likewise, levels of regulatory enforcement are expected to influence firm compliance positively. While we do not refute these theoretical positions, we shall extend our analysis to examine the institutional circumstances surrounding the behaviour of firms.

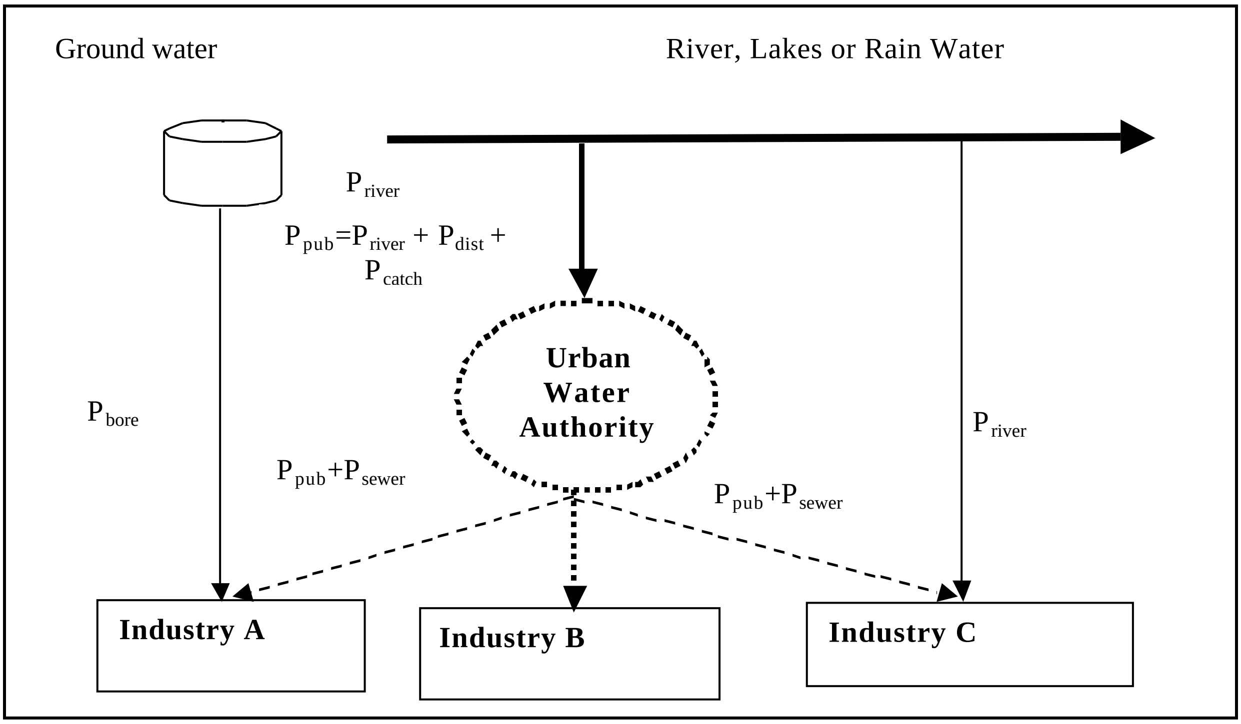
Critics discussed in chapter 3 (and the next section) argue that the positive theories can be useful for predicting aggregate behaviour, but they cannot be helpful in explaining or accounting for individual (firm) behaviour (Tillema, 2001:1). We are sympathetic to the later argument because of the spurious and false relationships that might exist between industrial water practices to water tariffs and regulatory enforcement in Kenya. This is supported by the studies already sighted in chapter 3 (i.e. Hanemann, 1997; Espey et al, 1996; Deaton and Muellbauer, 1980; Stone and Whittington, 1984; Lucas, 1976). For example our discussion in chapter 3, section 3.3 exposed the following issues, that:

i) There is considerable methodologically induced “noise” in all water demand studies.
ii) Given the large noise, there is little a priori reason for selecting one function over another.
iii) While results are not contestable, comparison of results is often unacceptable due to a multiplicity of contexts, giving different results.

There are several contextual issues that we need to address ourselves to in this study. First, firms are located in five different urban areas and are of varying sizes, in a diverse number of sectors. Their operational contexts are completely different, implying that contextual factors could exert significant influence on the attitude and behaviour of firms towards the patterns and levels of water consumption and wastewater disposal. Secondly, water tariffs and wastewater regulation are enforced by the respective urban locations, a fact that influences enforcement, levels of tariffs and regulation, and the perception of firms in relation to enforcement institutions and instruments. The different institutional settings, may in themselves, play a significant role in isolating the final behaviour of firms in dealing with variations in the level of policy instruments. These factors make it essential to analyse not only the quantitative but also qualitative (institutional) relationships between policy instruments and firm behaviour. Third, choices available to firms are not all the same, some firms have multiple water sourcing options because of their location close to a river/lake, or an area endowed with groundwater resources. Likewise, location has a bearing on the options available for discharging wastewater. There are three options for sourcing industrial water in Kenya (see Figure 4.1). For option A, a firm has a choice between ground and publicly supplied water. For option B, the firm has no alternative choice but to rely on public water. For option C, a firm has the choice of sourcing water from a river and the publicly provided supply.

There are several assumptions that are implicit in our study and we need to argue in their defense beforehand. To ask whether the assumptions we have made are realistic is either to make a category mistake (because assumptions do not refer to anything that has real existence) or to miss the point (because, although assumptions refer to real things, the truth or falsity of those references have no bearing on the value of the theoretical framework). According to one version of instrumentalism, the "assumptions" of a theory properly understood, are no more than a compact notation for summarizing the theory's predictions; thus, the question of whether assumptions are realistic or unrealistic does not arise (Sugden, 2000:11). An alternative form of instrumentalism, perhaps more appropriate, accepts that the assumptions *refer* to things in the real world, but maintains that it does not matter whether those assumptions are true or false. On either account, the assumptions of a theory *function* only as a representation of theoretical framework (Friedman, 1953). Since we do not deny the assumptions as unrealistic, but argue that the realism of these assumptions are irrelevant; what is important is the ability of our study to account for behaviour of firms. For example, one general position appealing to our analysis of water demand and price causation is the separability assumption that we shall invoke in our analysis in chapter seven. Mill defines separability as mechanical if the overall effect of all causal factors can be represented as an addition of those separate factors, on the analogy of the vector addition of forces in Newtonian physics (Mill, 1843, Book 3, Ch.6, pp.242-247), (Sugden, 2000:20). Even though separability remains an assumption, it is linked to a lot of practical issues and is reasonable in the real world.

Figure 4.1. Alternative water supply routes for Industries in Kenya



Where P_{bore}= price of groundwater; P_{river}=price of river water; P_{pub}=price of publicly supplied water; P_{catch}=cost of catchment conservation; P_{sewer}=sewer charge; and P_{dist}=cost of distribution.

Another assumption that we make relates to the rationality of behaviour among firms. It is commonplace that all "scientific disciplines" have unexamined postulates -- core beliefs of one kind or another, which establish the standards for judging their knowledge claims (Heap, 2000:96). In contemporary economics (also applying to environmental and natural resource economics), the principle postulates are the rational choice (that is, an instrumental model of rational agency), which also allow mathematical and other logical principles to be used in drawing deductions, and the expectations that define "good" practice in empirical testing (which are primarily those found in "state-of-the-art" econometrics). Counter examples to more fundamental gaps such as the evidence of intransitive behaviour have not raised much interest among economists. Yet the fact that in dynamic choices sometimes agents are not committed to the original set of preferences and a phenomenon of preference reversals have been observed - thus violating the principle of transitivity assumption implicit in rationality.

4.3 Some Conceptual issues in Research Methodology

4.3.1 Discourses on Methodological Paradigms

"Methodology is about what methods should be applied in order to produce new knowledge" (Chakraborty, 1998), hence the discussion of methodology can be very broad. There are competing approaches to social science research based on different philosophical assumptions about the purpose of science and the nature of social reality. These are the ideal-type approaches that attempt to answer the basic questions about research differently (Neuman, 1997:82). There is no single, absolutely correct approach to social science research (ibid, p.84). Most researchers operate primarily within one approach but combine elements from the other to support their answers, a style which is also adopted for our study.

In the previous chapter (3), we saw that processes of change in firms are diverse and usually involve several causal mechanisms that may only be contingently related to one another. Not surprisingly then, the operation of the same condition can produce different results and, alternatively, different mechanisms may produce the same empirical result (Sayer, 1992: 108). For example, the effects of water tariffs increment in forcing firms to reduce water use will vary according to such contingent conditions as technologies of production, management characteristics, etc. Firms may respond in a variety of ways,..., and inevitably, the exercise of causal mechanisms is often unclear from patterns of empirical events. We may capture a shift in the behaviour of firms when investigating the response to water tariffs, yet that particular shift may have originated from “some other” event within or outside the firm. This may lead to spurious correlations. There are also institutional aspects of firm behaviour such as the pricing and regulatory enforcement that determine whether response to policy instruments will be incurred at all. Yet the positivist approach and estimates may thus insist that certain observations point to particular causes. Counteracting forces can also override and conceal the effects of the operation of a perfectly designed and enforced policy mechanism such as the use of pricing and regulations, thus leading to false conclusion that the instruments are ineffective in inducing desired behaviour among firms. According to Sayer (1992), *"if we fail to move a heavy weight it does not mean we weren't pushing (hard enough); when a plane flies it does not mean the law of gravity is no longer working."* Accommodating for the institutional factors may be critical to learning about the response of firms to policy instruments. Scientific research methodology has to attempt to disentangle all the above forces (the response or non-response) from counteracting issues within the firm.

The classical theorists made a major contribution to modern civilization when they argued that the social world could be studied using science. In modern times, science has become the accepted way to gain knowledge. Research methodology is what makes social science scientific (Neuman, 1997 p.60). However, the acceptance of research methods from natural sciences by social sciences as being scientific poses several problems. There is still debate over what science means, even in the natural sciences. Part of the inherent limitations of contemporary mainstream economics and the discipline's state of disarray, does not lie at the level of substantive theory but at the level of methodology (Lawson, 1997:36). It turns on the way that progress in economic policy formation is bound up with methodological discussion. For instance, economists need to know *why firms did or did not respond to upward shifts in water tariffs or to regulatory enforcement* before they can give advice, and this turns in part on methodological discussion of what constitutes "causality" for this purpose (Heap, 2001:96)[1].

So far most economists seem to have dealt with methodological issues implicitly and quite inadvertently, much as the practitioners of language deal in grammatical argument only by the way. Specifically, the most fundamental feature has been a generalized insistence on deductivist mode of explanation, including an unsustainable commitment to the "whenever this then" structure of "theories, laws" which can be derived from a study as it is the case for our hypothesis concerning the role of prices and regulatory enforcement. A few examples pertinent to our study would include the law of demand, which suggests an inverse relationship between price (water tariffs) movements and quantities of resources (water) consumed; regulatory efforts and levels of compliance i.e. taxes, charges, sanctions such as fines, warning letters etc which should be inversely related to violation status by firms. For, while the generalized usefulness of deductivism is dependent upon a ubiquity of closed systems, the social world, the object of social study, is fundamentally open and seemingly insusceptible to scientifically interesting social closures, or at least to closures of the degree of strictness that contemporary methods of economics require (ibid, p.282).

A lot of the economic theories and possibly stereotypes about science come from a period where science was dominated by a particular philosophy -- positivism. Science has today moved on its thinking into an era of post-positivism where many of those stereotypes of the scientist no longer hold up. For example, as we saw earlier in chapter 3, different methodologies (equation form and estimation technique) yield significantly different results for the same data, particularly in the context of non-linear pricing schedules. There is considerable methodologically induced "noise" in all water demand estimates. This experience seems to question the extent to which quantitative and "econometric techniques" could be sufficient in capturing information relating to behaviour of firms. Furthermore, the uncertainty attached to results is further exacerbated because of data unreliability. This is particularly prevalent and important in developing countries (Kenya included). All these factors make it compelling to adopt methodological pluralism in our study of this kind.

4.3.2 Positivism

Let's begin by considering what positivism is. In its broadest sense, positivism is a rejection of metaphysics[2]. It is a position that holds that the goal of knowledge is simply to describe the phenomena that we experience. The purpose of science is simply to stick to what we can observe and measure.

> *"The positivist conception of science has its roots in a definition of knowledge which holds that only things which we are absolutely certain can be counted as knowledge. If a knowledge claim fails the test of certain truth, then it cannot be included within the body of scientifically approved statements" (Polkinghorne, 1983:1).*

Positivists believed that **objectivity** was a characteristic that resided in the individual scientist. Scientists are responsible for putting aside their biases and beliefs and seeing the world as it 'really' is. Knowledge of anything beyond that, a positivist would hold, is impossible i.e. in order to predict how people will behave -- everything else in between (like institutional context) is irrelevant because it can't be measured. In a positivist view of the world, science was seen as the way to get at truth, to understand the world well enough so that we might predict and control it. The world and the universe were deterministic -- they operated by laws of **cause** and **effect** that we could discern if we applied the unique approach of the scientific method. Science was largely a mechanistic or mechanical affair, using deductive reasoning to postulate theories that we can test. Based on the results of our studies, we may learn that our *hypothesis* doesn't fit the facts well and so we need to revise our theory to better predict reality. Thus Burrell and Morgan (1979) characterize positivism as an epistemology that seeks to explain and predict what happens in the social world by searching for regularities and causal relationships between the constituent elements. The positivist belief is grounded in *empiricism* -- the idea that observation and measurement was paramount and the core of the scientific endeavor.

The requirement that arguments ought to follow a certain methodological principles in any "scientific method" is rather misconstrued (Chakraborty, 1998:5). One major consequence of this positivist approach is that economic analysis is confined to falsification. A statement is in principle falsifiable if it is logically inconsistent with some finite set of true or false observation report. In other words, our hypothesis is falsifiable if it is not guaranteed that it will pass all tests i.e. if all firms do not respond to water prices and regulation.

> *"Mainstream economists refuse to take any economic theory and analysis seriously if it does not venture to make definite predictions about economic events, and they ultimately judge economic theories in terms of their success in making accurate predictions" Blaug (1992).*

According to Lawson (1992), a fundamental inconsistency of mainstream economics is that although it puts individual choice at the center stage, it ultimately denies it by modeling individual agency in a way that allows for only one (rational) action. If human choice is real, it has to be treated as a potential, as a capacity, of which we cannot know in advance whether and how it is going to be actualized. On the other hand, while individual agency is important, it cannot be understood independently to the social (institutional) structures in which it is embedded. Individuals do not choose or act in a vacuum. It is the social setting that enables certain choices (and prevents others), and it is only in the light of this connection that individual choices make sense.

> *A further important limitation of positivist empirical analysis arises from the Lucas critique. This states that the parameters estimated from an econometric model are dependent on the policy prevailing at the time and will change if there is a policy change. Therefore, significant changes in the price structure or price level outside the historical range will render the application of price-elasticity estimates obtained under different conditions invalid.*

The result of the above practices is that little attention is paid to negative results. Falsification cannot be a recommendable methodology since its structures are extremely demanding. The complexity of many economic problems requires that conceptual and analytical issues be explored very substantially to understand what types of relationships might be involved. The analyses at this stage are not meant for immediate testing and verification, they can greatly help cognitive assessment of the problems and the relations under examination. A great deal of economic theory involving causal relationship is, in fact, of this kind (Sen, 1991:7). Lawson (1992) also presents a rather radical argument against the tying economics to a positivist philosophy, he calls for methodological discussions that will free economics to potentially more fruitful realist philosophy. Things have changed in our views of science since the middle part of the 20th century. Probably the most important has been the shift away from *positivism* into what we term *post-positivism*.

4.3.3 Shift of Interest in Economic Methodology and Post-Positivism

The Popperian philosophy of science, with its emphasis on deductivism and falsificationism, stands squarely in the positivist tradition. Currently, there are shifts of interest in debates about economic methodology. "Rhetoric or realism?" tends to replace – at least implicitly – the controversies over the advantages and disadvantages of variants of the Popperian philosophy of science, that have tended to dominate economic methodology from the 1970s to the late 1980s (Peter, 2001). Rhetoric and Realism are understood as alternatives to positivism. The Rhetoric approach highlights the role of argumentative persuasion in scientific discourse and criticizes the legacy of what McCloskey (1983, 1985) calls alternatively "modernity" or "positivism" in economics. It distinguishes between the official methodology – based on epistemological standards of what constitutes scientific knowledge – and the unofficial methodology – what economists actually practice. It is only recently, partly in reaction to relativist movements, that realism is being proposed as a distinct philosophy in economics. The realist approach emphasizes that, to make sense of the endeavour of economic science, it has to be understood as an attempt to explain economic reality, to discover truth about entities that exist objectively – independently of scientific theories. Lawson advocates the realist position most prominently in a series of articles (Peter, 2001:572). Like critical realism, the position also stresses the importance of ontological considerations, primarily, however, in relation to the role and interpretation of truth in economic explanation. Perhaps the most interesting set of issues that the rhetoric vs realism debate raises crystallizes around the question of what should guide the process of knowledge evaluation and legitimization in economics.

> *All parties to the debate agree that the Popperian preoccupation with epistemological standards is too narrow and that there is a need for an alternative framework.*

But, there is little agreement on how to break free from this heritage and how to re-think the nature of scientific discourse in economics. Lawson and McCloskey's arguments against positivist epistemology translate immediately into a critique of the emphasis on prediction that has prevailed in economic methodology since Milton Friedman's influential piece "The Methodology of Positive Economics" (Friedman, 1953). McCloskey (1983, 1985) summarizes her critique with what she calls the American question, "if you are so smart, why ain't you rich?" To McCloskey's delight, economics defeats itself. Furthermore, the emphasis on prediction is simply a relic of the hope that Science could produce a superior form of knowledge.

> *The rhetoric approach shows that economists should be more modest and understand their discipline as historical and interpretive.*

Post-Positivism is a wholesale rejection of the central tenets of positivism. Post-positivists reject the idea that any individual can see the world perfectly as it really is as we are all biased and all of our observations are affected (theory-laden). Our best hope for achieving objectivity is to triangulate across multiple fallible perspectives! Thus, objectivity is not the characteristic of an individual - it is inherently a social phenomenon. A post-positivist might begin by recognizing that the way scientists think and work and the way we think in our everyday life are not distinctly different. Scientific reasoning and common sense reasoning are essentially the same process. There is no difference in kind between the two, only a difference in degree. Scientists, for example, follow specific procedures to assure that observations are verifiable, accurate and consistent.

> *"Unlike positivism, post-positivist science does not propose a unified view of science and holds that we do not have access to indubitable truths. Knowledge is understood to be the best understanding that we have been able to produce thus far, not a statement of what is ultimately real" (Polkinghorne, 1983:2).*

One of the most common forms of post-positivism is a philosophy called ***critical realism***. A critical realist believes that there is a reality independent of our thinking about it that science can study. (This is in contrast with a ***subjectivist*** who would hold that there is no external reality -- we're each making this all up!). Positivists were also realists. The difference is that the post-positivist critical realist recognizes that all observation is fallible and has error and that all theory is revisable. In other words, the critical realist is *critical* of our ability to know reality with certainty. Where the positivist believed that the goal of science was to uncover the truth, the post-positivist critical realist believes that *the goal of science is to hold steadfastly to the goal of getting it right about reality, even though we can never achieve that goal*!

Most post-positivists are ***constructivists*** who believe that we each construct our view of the world based on our perceptions of it. Because perception and observation is fallible, our constructions must be imperfect. The social phenomena are fundamentally different from natural phenomena, hence, the social world cannot be understood in terms of simple causal relationship (Hammersley and Atkinson, 1995:7). This is because human actions are based upon social meanings. People create their own meanings and attach these meanings to the world around them and to their behavior that they manifest in that world (Lee, 1991:347). Because all measurement is fallible, the post-positivist emphasizes the importance of *multiple measures and observations*, each of which may possess different types of error, and the need to use ***triangulation*** across these multiple errorful sources to try to get a better bead on what's happening in reality. Thus within post-positivism, knowledge is relative and shaped by the cognition of the subject, and by social and institutional (cultural) conditions, symbols and interpretations which make objectivity difficult due to our knowledge being filtered through such processes in our consciousness - we all live in the same world yet we perceive different worlds.

4.3.4 Resolving Methodological Disputes

All parties to the debate on methodology agree that the Popperian framework dominating mainstream economics is an inadequate account of science – not just of economics, but of natural sciences as well. The unifying theme in the rhetoric vs realism debate is to leave behind Popperian notions of what economics should look like and what constitutes “good” economic argumentation. The rhetoric debate has led to a shift in thinking about what would be the appropriate meta-theoretical framework for economics. Even though the attempts to overcome positivist epistemology have been vigorous and encompassing the evolutionary and institutional economics thinking (see chapter 3), the debate so far has not yet led to a more critical and progressive re-thinking of epistemological issues.

Given the need to integrate both firm behaviour and institutional issues into our analysis, we find methodological triangulation more appealing to our study. The concept of triangulation was introduced in social sciences by Webb et al (1966) and used by Denzin (1978). This included not only an understanding of the processes governing behaviour, but also the social and institutional context. Denzin (1978) has classed the use of more than one research method to examine the same phenomenon as methodological triangulation. The method involves a process of linking, mixing or combining methodologies and data and can occur at two levels. One level is the mixing of quantitative with "moments of qualitative methods". The other concerns the mixing of the conflicting paradigms on which quantitative and qualitative methods are based. For example, traditional economic approaches would assume that firms behave within a given (i.e. legal, institutional) which the firm cannot influence, but just respond to. But in our case, firms can influence the institutional structure, e.g. by corruption or other means. Our approach is to estimate the links between quantitative parameters econometrically, then attempt to endogenous institutional factors qualitatively (rhetorically).

4.4 The main Components of Triangulation

The main components of triangulation in our study are a survey method that combines (i) firm histories (and evolutionism), and (ii) case studies. We then analyze these together with panel data on water consumption, tariff changes and regulatory instruments.

4.4.1 Firm Histories and Evolutionism

There are increasing complexity in processing decisions and strategies as well as interactions between instruments on each specific firm. The main question that can be poised is if responses of firms are linked with radical changes or slow adaptive processes (with threshold effects); other correlated questions are how the frequency of tariff changes or regulatory enforcement affect firm behaviour over time, how to specify their qualitative or cumulative content and also how to capture the idea of trajectory? Evolutionism has tried to answer these questions with the help of the Darwinian paradigm (and later, with the Lamarckian paradigm). Nobody ignores that Evolutionism was a first qualitative step to move from static towards non-linear and self-organizational dynamic approaches in Economics. Evolutionism insists on the fact that firm's responsive behavior to policy can heavily be dependent on previous experience i.e. their interaction with enforcement agency. We find a close affinity between this approach and firm response to regulatory enforcement. Turbulent environment also gives some advantages to firms able to deal with novelty and to undertake requisite structural changes without having to depend on policy instruments. This appears to be the main limitation of evolutionism which does not account for the role of turbulence. However water using histories are expected to shed light on the path firms have followed over time and the historical conditions that have influenced firms towards (or away from) compliance and changes in water demand[3].

4.4.2 The case study Approach

In his classic book on case study research, Yin (1994) argues that case research and survey methods are better suited than other techniques for analysing contemporary events. Case research is superior to survey methods at answering the "whys" and "hows" because the case analysis can delve more deeply into motivations and actions than structured surveys. Econometric analysis of archived data better answers the question "what happened?" than either "what is happening" or "why is it happening?" The case study approach can be applied to at least three different situations in our research. *First,* to explain the causal links in real-life interventions that are too complex for other research strategies. *Second*, to describe the real-life context in which an intervention has occurred or for illustrative purposes. *Third,* to explore those situations where a single set of outcomes is not clear (Yin, 1984). The case study approach is particularly important in our new line of research on industrial water use in Kenya since in the process, new perspectives can be generated (Reid, 1987). Furthermore, we believe that case studies are a useful approach wherever 'how' and 'why' questions are being posed and when we have very little control over events. The case study method can serve several roles that include describing existing practices, developing theories and testing theories. Unlike the overall survey research, which relies on statistical generalization, the case study approach relies on specific analytical generalization, in which we strive to generalize from a particular set of results to our broader theory. The case study approach has some limitations when it comes to making generalizations. Usually, case studies are generalizable to theoretical propositions rather than to populations or universes.

There are disagreements mainly concentrating on the roles of case studies in explanatory research. Some researchers take the view that case studies themselves can explain events, while others claim that a single case or few cases cannot provide explanations (Tillema, 2001:1). At the same time, case studies can be used to illustrate findings from the quantitative research and to elucidate results that might be difficult to interpret on the basis of quantitative data alone. Case studies are particularly suited to exploratory aspects, because they allow us to account for many aspects of the phenomena we are examining. The interpretative elements and the case study method become closely linked.

Because in our study, an important objective was also to account for the existing behaviour of firms, it was necessary to decide between an exploratory and explanatory role for our case studies. In the case of our study, the poor response by firms to water tariffs and regulation may suggest that success in reducing water consumption and a high compliance by firms is more of an outlier result than an average or typical situation. Even if these firms may be outliers, the approach taken in this study is that it is also important to remember that outliers can be particularly informative. In some of the firms studied, we have endeavoured to unearth factors that influenced their response paths through case studies.

> *For example in some of the firms where there has been dramatic decline in water consumption over the study period, our quantitative analysis showed that water tariffs policy was effective in catalysing response. Yet, the bottom-line in some of these firms was the restructuring necessitated by the need for efficiency improvements to lower production costs"*

Consequently, we think that the use of case study method has been appropriate. One major precaution has been taken to reduce the risks entailed in the case study approach. Taking advantage of the unique ability of the case study approach to handle a variety of evidence, the information obtained in interviews has been complimented by information from official and unofficial documents and by follow-up interviews to obtain the necessary clarifications.

A single case or multiple cases?

Can the phenomenon being studied be captured within the context of a single case? There are many classic single case studies that have been used for theory-testing and theory-building. In our study, eight firms were selected for closer study based on each of the theoretical responses to water tariffs and wastewater regulation. The aim of the cases as presented in chapter 6 and 8 was to illustrate, deepen, and complement, rather than validate or confirm the theoretical model developed in this study. In analysing the case material special attention has been paid to the scale of water use, scope of the problem they address and how revealing they are. These were analysed and discussed within the empirical findings of this study. From a pragmatic point of view, quantitative analysis embedded in the case study will enhance its value to the audience of economists, particularly when theory-testing is the objective. The point of departure for this discussion is making the distinction between the *phenomenon* and the *context* of the study. The *phenomenon* is the concept or theoretical construct being studied. In econometric studies of demand systems, we are concerned with the phenomena of price and elasticity. One seeks to quantitatively measure these phenomena. The *context* is a temporal, spatial, or structural boundary around the phenomenon. In the demand study example, one bounds the analysis by the commodity (or commodity aggregation), the time period of the analysis, or perhaps by the consumer population (e.g. high users, low users, sectors, etc.). Just as a researcher must draw inferences and conclusions about the phenomena of demand elasticities within the context of the data and models used in the analysis, one must do the same when discussing a phenomenon such as incentive alignment. The extent to which an analysis of the phenomenon can be generalized is a function of the restrictiveness of the context. An estimate of demand elasticity can be generalized for policy analysis only to the extent that it is not an artifact of the restrictive context of the underlying data series.

4.5 Research Design: Sample Design and Selection Procedures

From a methodological point of view the ideal process of primary data collection from firms should entail obtaining a completely random sample. However, water use and wastewater disposal (and pollution) are sensitive to the type (characteristics) and location of firms hence the need to be systematic to avoid information bias. Partly because our methodology is grounded in positivism, it is important that our research is based on systematic protocol and technique. This clarity is requisite for scientific research in order to be able to understand relationship between cause and effect.

4.5.1 The Sample

When sampling, we make a distinction between the theoretical population of interest to our study and the final sample that we actually measure in our study. Our primary criteria for selection of firms was on the basis the dominant water consuming industrial sub-sectors in Kenya (i.e. falling into 5 broad classes as in Table 4.3). These were identified as (1) Food Processing (2) Beverages (3) Textiles (4) Leather Products (5) Pulp and Paper (6) Wood Products (7) Chemical Products and Others. The justification was to capture water-using firms with different intensities and characteristics. Our second sampling frame entailed identifying the towns from where the firms would be surveyed. The selection of urban areas was based on the considerations of water tariffs and regulatory implementation. In principle we chose urban areas whose water departments were active in billing of firms and who had departments for the enforcement of wastewater quality. All these urban areas were programmed for commercialization under the Urban Water and Sanitation Management programme (UWASAM) project in Ministry of Local Authorities, and had received some technical support from the German Technical Assistance (GTZ) to facilitate the transition to commercialization. On the basis of the above criteria we covered the firms as summarized in Table 4.1. In order to permit statistically significant data analysis, we targeted 60 firms because we thought the number would fall within what our resource limitations could accommodate, given the depth of the interviews and the timeframe within which the study was to be undertaken. Primarily, we thought this coverage would be narrow enough to allow meaningful analysis.

Table 4.1: Industry Sampling by Sub-Sector

3 DIGIT ISIC CODE[5]	SECTOR	THIKA	NAIROBI	NAKURU	KISUMU	ELDORET	TOTAL NUMBER
311	Food Processing	4 (1)	1 (1)		2 (0)	3 (0)	10 (2)
313	Beverage Industries	1 (0)	2 (2)	1 (1)	2 (2)	1 (0)	7 (5)
321	Textiles	5 (4)	4 (3)	3 (2)		4 (0)	16 (9)
323	Leather Products	2 (2)	3 (2)				5 (4)
331	Wood Products					1 (1)	1 (1)
341	Pulp and Paper	1 (1)	3 (1)			1 (0)	5 (2)
352/351	Chemical Products/Others	2 (2)	1 (1)	4 (1)			7 (4)
TOTAL		15 (13)	14 (8)	8 (4)	4 (2)	10 (1)	51 (27)
Surface and Groundwater usage (%)		87	57	50	50	10	53
Captive source rankings		**1**	**2**	**3**	**3**	**5**	

Source: Survey data. Figures in parenthesis show the number industries using boreholes/river. Other figures show the total number of firms using public sources covered in our study.

4.5.2 Research Procedure: Data Collection Methods

The primary respondents included local authority and ministry officials with major responsibility for water processes; and firm executives, technical managers with relevant knowledge on firm operations. Primary data covered information on total cost and quantities for water intake, water treatment prior to use, re-circulation, and treatment prior to discharge etc. Information regarding the type of water sourcing and sanitation; i.e. whether public or self-provided and factors governing these decisions/choices i.e. toxicity, abatement practices, regulations, water supply sources, tariffs, volume of water use, capital costs, operation costs, maintenance costs for water services within the urban schemes, institutional structure, rules and regulations in water use, standards and policy statements, local authority by-laws etc. Secondary information covering industrial output and expenditures on water resources were also obtained from the firms, and Local Authorities. Registrar of Industries and Central Bureau of Statistics were an important source of financial data. Information relating to water use and effluent charges was available from various Municipality Water Authorities. Data on effluent standards, compliance, non-compliance, is available from Ministry of Water Resources. Other sources of data were drawn from documentary materials (government legal notices, regulations, city ordinances, municipal and corporate records). In Table 4.2, we summarize our main sources of information and the nature of information sought.

Table 4.2: Source and Type of Information Collected

	Interviews	Observation	Other Sources/Records
Firms	Firm characteristics; developments in sourcing,	Water consumption, disposal practices; routine activities.	Government Offices; Local Authorities Financial information i.e. output, values
Local Authorities	Metering, Billing of firms for water consumption; water payments; tariffs for a number of years; Enforcement activities for regulation; water by-laws		In-house Library Various Consultancy reports
Ministry of Local Government	Local authority restructuring, commercialization;		Policy documents; financial reports for various local authorities; consultancy repots
Ministry of Water Development	Activities on wastewater regulation		Policy documents
Others			Policy documents

4.5.3 Interview of Respondents

In structured and semi-structured questionnaires, questions are formulated in the same way and presented in the same order to all the respondents. Generally speaking, such systematic interviews should be used to collect information where statistical representativity is of concern. Even though the structure of the questionnaires remained the same, experience learnt through pre-testing suggested that there cannot be a unified approach to collecting information from firms. Each firm provided a unique lesson with regard to the procedure of gaining entry, and acquiring information. In some firms, the management was not readily available and one had to gain authority from the highest authority to access the technical departments. In others, the administrative staff were more accessible and were willing to facilitate interviews with relevant technical departments. One issue that emerged is that there are clear limits to the breadth of information one could get from a single respondent in a firm. If the technical managers were uncomfortable with the questions they would consult the general manager and other technical officers for responses. In yet another group, the general manager agreed to respond to the questions and invited the relevant technical persons to contribute. In a few cases the limitation of one respondent to provide all information became a major source of frustration with promises that the information would be availed at a later time. This resulted in several visitations before the information could be availed. Collecting information from government offices and local authorities was also very challenging. One important lesson learn from the process is that most of the officers can provide very rich information once you have struck a cordial relationship.

There were separate questionnaires adopted for Firms, Ministry Enforcement Officers, Ministry of Water Officers, Ministry of Local Government, and the Local Authorities. When interviewing firms, special attention was paid to the question of how they perceived the water price variable. As it turned out, most firms paid attention to the average tariff structure or the total water bill rather than the marginal tariff rate indicated in the block rate structures by the local authorities. Firm executives knew the approximate amount of money they were spending on water per month but were not aware of the rate at each consumption block. Obtaining formal (official) responses is generally inadequate and often not acceptable. It was interesting to provoke firms to give their side of the story by referring to the information collected from or the views of Ministry of Water or other local authorities particularly regarding their behavior to the regulation and enforcement wastewater standards. The additional information was acquired through in-depth interviews without structured questionnaires.

It is generally recognized that most economic or social events are the outcome of what Mill called a "plurality of causes", and it is usually hoped that any irregularities can be shown to be merely the combined effect of separable regular processes. During our interviews we were curious to know from firms why they were sourcing water from a particular sources, why they had changed or not changed their water souring practices. In some cases it became necessary for the interview manual to be sent out in advance when seeking authority to visit the industrial firms. In a few cases, some preliminary response to the manual had been received before a field visit was scheduled. Not all firms that had been sampled accepted to participate in the study, about 16 per cent declined and were replaced accordingly. When interviewing the Local Authorities, our interest was on the implementation and enforcement structure for water pricing, billing and wastewater regulation. We also paid attention to the intergovernmental setting by examining the interaction pattern among multiple organizations at various stages of implementation.

4.5.4 Observations in Factories, In-depth Interviews, and Case Studies

My intention of using the observation technique was to learn about the production process, to be able to identify differences in technological operations that require water and how wastewater disposal by firms is carried out. It was also meant to confirm the status of the water consumption practices and wastewater abatement measures within the firms. The observation occurred during or immediately after the interview with the management. It is not easy for a non-technical person like myself to adopt the operational view on how the production is organized, what the various equipment are for, and how technically advanced the equipment are. However, before my field visit, not only did it become useful for me to familiarize myself with information in the literature regarding state of the art technique in each production process within each industrial sub-sector, but discussions with experienced researchers was also instructive for understanding of what I expected to see in the industries. The entire data collection exercise lasted for about 11 months, from November 1999 to September 2000 with another 3 weeks of revisit in April 2001. Three assistants were involved in the collection of data.

4.5.5 Data Presentation and Analysis: The Empirical Sample

Even though our research design focused on data collection through sectors and urban location, we also experimented the results on the basis of volumes or quantities of water consumed by the various firms. The objective of such analysis was to make a comparison of responses between firms in the various levels (categories) of consumption. The essence of this is to integrate the cost element in the response function since higher consumers spend high absolute amounts of money on water and are likely to benefit more by responding appropriately to changes in water tariffs. The *disaggregation* of consumers into more homogeneous stratified groups will enhance the efficacy of (industrial) water demand analysis. Housing type or census tract (that is, enumerator area) may be appropriate means of grouping residential households (Saleth and Dinar, 1997). Initially, while planning for the fieldwork we had hoped to organise the information and our analysis along similar consumption classes as Saleth and Dinar (1997) suggest. Our results proved less useful and we had to experiment with other classifications such as: (i) industrial sub-sectors; (ii) Consumptive versus Non-Consumptive users; (iii) Firms with captive versus those with public source only.

A summary of consumptive levels is provided in Table 4.3. The size class distribution of the total number (data) of firms (Table 4.3) remained stable over the period 1995-1999. On average, each of the five size classes represents approximately 10-30% the sample. The industry distribution within urban areas remained unstable, with textile firms and food processing dominating. As Table 4.4 shows, two slight but consistent change patterns were found among the panel firms over the period of observation. First, the number of firms in size class 3 (1001-1500 M^3) increased from 26% (1995) to 30% (1999). Second, the number of firms in size class 4 (15001-20000 M^3) decreased from 24% (1995) to 22% (1999). These figures do not necessarily indicate, however, that firms of size class 4 frequently moved to size class 3, since textile firms generally showed remarkable variation from one year to next, which is also reflected in the water consumption data[4]. Except for change of ownership, the number of firms is the same in all years.

Table 4.3. Size class distribution (%) in the total number (data) of Firms.

Panel firms	1995(%)	1996(%)	1997(%)	1998(%)	1999(%)
Size class 1: 100-500 M^3	17	15	18	16	16
Size class 2: 501-1000 M^3	21	24	23	22	20
Size class 3: 1001-1500 M^3	26	24	23	27	30
Size class 4: 15001-20000 M^3	24	25	26	23	22
Size class 5: over 20000 M^3	12	12	10	14	12

Despite the precautions taken to ensure the representativeness of the panel data, it cannot be claimed that the firms of the selected panel are typical of the Kenyan industries. With reference to the focus of this study, i.e., response to water tariffs, it can thus be claimed that the firms selected to the panel appropriately represent shifts in water consumption levels exhibiting a variety of trends, levels, and changes over the period of observation.

Some comment is in order on the decision to limit the focus to data from 1995 to 1999. The main reason for excluding the data for 1990-1994 from detailed analysis was that, given the objectives of the study, the inclusion of this information would not have improved the quality of the longitudinal data and thus the analysis, while adding considerable complexity to the examination and discussion of the quantitative material[6]. Unfortunately, this would also have significantly increased the number of incomplete or incorrect information, thus causing considerable difficulty in the analysis, since a great number of variables covered in the questionnaire are needed for analysis. As a result, limiting the panel to firms with a complete return history seemed the correct solution in terms of the research focus of the study.

Panel attrition is a typical problem encountered in longitudinal research, and in firm research this problem is even more pronounced. Observations may disappear from the panel for a variety of reasons varying from incomplete or to the disappearance of individual firms due to closure, bankruptcy, merger, etc. To some degree, this problem reflects the economic situation in the country, with the severity of competition from imports i.e. the textile sector, political and economic recession in Kenya during the period of observation. It is important to note that attrition *may* introduce bias into the panel. Therefore, some ways of assessing the nature of the possible bias, and thus controlling it, have to be introduced into the research design. This problem was encountered to a very small extent in the textile sub-sector.

In order to permit analysis of the data in Regression Analysis Time Series (RATS) computer software, the panel monthly data set was organised as follows (see Table 4.4):

Table 4.4: Data Organization

Firm	Time	Water X_{it}	Price P_{it}	Price P_{it-1}	D_{conj}	D_{s1}	..	D_{sn}	D_{u1}	..	D_{uk}
1	1996:1	..	..	..	..	..	..	..	..	..	..
1	1996:2	..	..	..	..	..	..	..	..	..	..
1	1996:3	..	..	..	..	..	..	..	..	..	..
1	1996:4	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
1	2000:12	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
2	1996:1	..	..	..	..	..	..	..	..	..	..
2	1996:2	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
53	1996:1	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
53	2000:12	..	..	..	..	..	..	..	..	..	..

Notes: D_{conj} = Access to Conjunctive sources (i.e. bore hole or rivers i.e. 1=ownership, otherwise 0): D_{si} = Sector specific dummies i.e for six sectors; D_{ui} = Location specific dummies i.e. for the five urban areas covered.

4.6 Experience with the Field Research

4.6.1 Problems and Constraints/Limitations

During our fieldwork around firms, we had to contend with a number of problems. There were data inconsistencies that we often had to deal with during fieldwork. In some cases the water billing records at the Local Authorities did not tally with those obtained from firms. Records of meter readings were not in line with quantity of water consumed and billed (particularly for Nairobi city). Moreover, a number of firms had multiple water accounts at the Local Authorities. This made it very difficult to track down and collate water consumption trends among firms. The most common problem encountered was missing data for water consumption in some months. This however did not pose a serious problem for analysis since we had enough observation to generate large degrees of freedom. There were also problems with information provided by firms on output (quantities and values), employment and other financial information. Much of the information obtained from Central Bureau of Statistics (CBS) were highly aggregated and were sometimes rounded off to i.e. nearest thousand when the figures were every high. Furthermore, the measurement units for output were not uniform across firms i.e.

they were in tonnes, kilograms, metres, dozens, litres, crates, pieces etc making output comparisons very difficult. Even within the same sector, each firm had their multiple products measured in different units (for example in textile). The consequence of these data inconsistencies is that some of the information collected has not been included into the analysis.

Field research often requires that researchers spend many hours in direct personal contact with those being studied particularly where case study approach is also used. In many of the firms visited we had to make repeated visits to obtain the necessary interviews. In a number of firms the interviews were rescheduled unexpectedly. Given this kind of experience time and financial constraints provided a limit to the number of firms that could be covered.

Experiences made during our fieldwork as well as strengths and weaknesses in our data may serve as useful guidelines for future research activities in firms. Specifically, even though questionnaires and structured interview techniques were used to good effect in exploring firm behavior, much of our empirical knowledge came about not as a result of investigating the hypothesis-testing variables, but rather a lot of interesting evidence "popped up" as a consequence of the interactions made in the field.

4.6.2 Data Validity and Reliability

Potential sources of error in quantitative studies stem from the process of data collection (measurement instrument) and the analysis performed on the data. The content *validity* of the measurement instrument is the extent to which the data provides accurate and adequate coverage of the topic under study. Validity is closely linked to the quality of research information and the *interpretive* approach taken to support our work. *Reliability* implies that two or more scholars conducting the same study on *industrial response to water tariffs and wastewater regulation in Kenya* should reach approximately the same result. Reliability is more central to the *positivist* analytical approach that is the benchmark of our study.

Validity

Content validity can be determined in three ways. First, the measurement instrument (i.e., the research framework) must be examined. As the research questions of this study were based on suggestions made by scholars in earlier resource-based and industry/manufacturing research, pre-tested, they should therefore be valid questions for empirical research. Second, the content validity of the questionnaire and variables investigated in the study need to be assessed. As indicated in earlier chapters, the approach to the problem of industrial water demand and wastewater regulation is extensively cited in our chapters 1, 2, 3, 7 and 8. Given that previous studies are central to ours (i.e. on demand theories), there should be no doubt about the suitability of the parameters pursued in our questionnaires. In a quasi-longitudinal setting such as ours, the properties of the process under study must be measured and evaluated. Since the evaluation of content validity is subjective, the focus must be on assessing whether the research framework and the research questions adequately cover the topic under examination. The variables used in the analyses were based on earlier industrial water research (Renzetti, DeRooy etc)[7], although some were adapted to the specific aspects of this study. Finally, given that the questionnaires on which the constructed variables were based on numerous discussions with the academic supervisors and devised after pre-testing, it would seem fair to assume that the measurement instrument meets the standards required for content validity. We have also used multiple sources of data for as many of the variables/constructs as is feasible. The degree to which archival data, direct observation, interviews, and document analysis converge makes the conclusions about the phenomenon we are studying more convincing. This level of triangulation is tantamount to validation, thus, it can be concluded that the measurement instrument of this study has adequate content validity.

Reliability

By definition, reliability is the extent to which measurements are repeatable. Any random influence that tends to make the measurement different from occasion to occasion is a source of measurement error (Cortina 1993). Since a measure is reliable only to the degree that it supplies consistent results at different times and under different conditions, assessment of reliability in a longitudinal setting may present a problem. The question of reliability was touched on earlier, with regard to the conceptualisation of industry response and measures for this response. Since the constructed models and processes studied are context-bound to the degree that each group of firms operate in specific contexts of their own – which changes every time the firm initiates new activities within its decision framework – the reliability cannot be assessed on a purely statistical basis. In line with Bourdieu (1984), who rejected the idea of "universal causality" between variables, the measures and results in this study are not viewed as the *ultimate explanatory factors* but rather as *indicators* of the nature of links between firms and government policies. We have nevertheless taken great caution to establish a high degree of reliability by consulting multiple information sources during our fieldwork. During the fieldwork, our sampling design tried to ensure that the choices of firms would not affect our hypothesis in an undesired or specific way. Furthermore, our econometric analysis has deployed the most rigorous analytical techniques available in the latest computer soft wares of econometric analysis such as Regression Analysis for Time Series -(RATS) Version 5.0.

4.7 Conclusion

This chapter has discussed conceptual issues surrounding methods for conducting scientific research. Given our primary goal of determining firm response to water tariffs and wastewater regulation in Kenya, we have discussed methodological developments within this context. The debate on scientific methodology is largely inconclusive even though important questions remain on the overall usefulness of the positivist approach for our study. In view of the questions raised and the broad nature of our study, we have adopted methodological triangulation as our approach. Due to the high degree of firm-specific contextual dependence of the response to water tariffs and regulation, we have been able to shift our analysis from pooled data, to individual cases, thus providing a latitude for us to account for some of the unexpected results circumscribed in aggregate analysis. The results were not expected to be directly generalisable in the positivist sense. In fact, generalisation was not among the purpose of this study. Nevertheless, methodological triangulation has allowed us to look beyond the policy variables to the institutional arrangement for policy implementation.

Notes

[1] The statement in italics are my own and not attributed to Heap (2000).

[2] See Krugman Paul (1996) for a very exciting treatment on evolutionary theory.

[3]Hermaneutics is the science of interpretation and maintains an interesting the content as well as the form of what is being interpreted. The term itself originated with the practice of interpreting sacred texts. It works on the principle that we can only understand the meaning of a statement in relation to a whole discourse or world-view of which it forms a part: for example, we can only understand (say) the statements of monetarist economics, in the context of all the other contemporary cultural phenomena to which they are related. We have to refer to the whole to understand the parts and the parts to understand the whole – the so called hermaneutic cycle (Marshall, 1994:256). Hermaneutic thought points to the situatedness of all activity within a particular interpretative framework. As much as it draws our attention to the presuppositions, and limitations, of all forms of thought and social practice (Outhwaite and Bottomore. Eds,1993: 259).

[4] It is not entirely correct for us to claim that these classifications are related to the size of the firm because some "large" firms were consuming less water than the "small" firms.

[5] The Products Classified by International Standard Industrial Classification (ISIC) is Standard code for manufacturer system used by international standardization. Standard Industrial Classification (SIC) codes are four digit numerical codes assigned by the U.S. government to business establishments to identify the primary business of the establishment. The classification was developed to facilitate the collection, presentation, and analysis of data; and to promote uniformity and comparability in the presentation of statistical data collected by various agencies of the federal government, state agencies, and private organizations. The classification covers all economic activities: agriculture, forestry, fishing, hunting, and trapping; mining; construction; manufacturing; transportation; communications, electric, gas, and sanitary services; wholesale trade; retail trade; finance, insurance, and real estate; personal, business, professional, repair, recreation, and other services; and public administration. The first two digits of the code identify the major industry group, the third digit identifies the industry group, and the fourth digit identifies the industry. For example: 20 Food and Kindred Products; 209 Miscellaneous Food Preparations and Kindred Products; 2096 Potato Chips, Corn Chips, and Similar Snacks. To make it easier to identify specific industries or even particular products, some sources, expand the code to as many as seven digits. For example: 36 Electronic and Other Electrical Equipment and Components, Except Computer Equipment; 367 Electronic Components and Accessories; 3674 Semiconductors and Related Devices; 3674125 Random Access Memory Circuits.

[6] This is because data gaps increased as we moved backwards.

[7] Full reference is cited in other chapters.

5 Industrial Water Management Institutions in Kenya

5.1 Introduction

In this chapter, we discuss the appropriateness of institutional arrangement for water management in Kenya. The scope of the discussion covers the existing institutional framework for water management within the urban areas and the extent to which the arrangement supports pricing and regulatory structures for industrial water management. The chapter is organized as follows: in section 5.2, we discuss the basic concepts and introduce their conceptual application to the analysis of industrial water resource management in Kenya. In section 5.3 we discuss the existing organizational arrangement for water resource management. Section 5.4 covers the institutional structure for management of surface and Ground water resources. In section 5.5 we examine the management of public (piped) water consumption in urban areas. Section 5.6 looks at the appropriateness of the institutional arrangement for water management. We conclude in section 5.8 with a brief summary of the chapter.

5.2 Water Sector Institutions

5.2.1 Institutions Defined

Institutions are generally conceived to be the "rules of the game in society" that provide constraints on action (Ostrom, 1990). North (1991) sees "institutions" as formal rules and conventions, including informal codes of behaviour or norms, emerging to regulate human behaviour and interaction. Within the field of resource economics, there is increasing acceptance of the importance of institutional factors for management of natural resources in general. According to *Fernie and Pitkekethly* (Omara-Ojungu, 1992:35) institutional arrangements are very important in resource use because

"all resource problems - water scarcity, famine, energy shortages - are

fundamentally institutional problems which warrant institutional solutions. The success or failure of resource management is intrinsically tied with institutional structures - the pattern of agencies, laws and policies which pertain to resource issues."

Institutions reflect conventions regarding the behaviour of individuals and groups that have evolved over time. In many contexts, an "institution" is also seen as an entity such as a state, a government agency or a legislative body (Hurwicz, 1998: 43). This latter interpretation has created an unacceptable tendency among policy makers to view the term "institution" colloquially as "organization", with the resulting challenge of mis-specifying implementation of organizational reforms as constituting institutional changes. In the context of this paper, we interpret institutions as systems of incentives and restraints (either a set formal or informal rules), and the enforcement process that govern agents', and agencies' behaviour. The term *institutional framework* encompasses both meanings of "institution" i.e. both institutional arrangements (game forms) and artificial players (institutional entities) (Hurwicz, 1998).

Functions

Institutions facilitate coordination among individuals by helping them form reasonable expectations of each other. In economic transactions, institutions play a crucial role in establishing *expectations* about *rights* to use resources in economic activities (Ruttan, 1998:148). Since institutions are the rules or practices within and between different organizations (in our case that facilitate coordination among individual firms, Local Authorities and Government ministries), they shape the way consumers respond to policy instruments (i.e. water tariffs and regulations). In water resource management, institutional arrangements have a profound effect on pricing decisions and outcomes. In particular, the institutional arrangements affect who makes the decisions and what the distributional impact of these on consumption and water allocation decisions.

Water Resource Institutions

Institutional arrangements for water management establish the basis for market and administrative control over water resources. When not operating properly, water institutions establish impediments to efficient water resource allocation and use. Significant resources can be expended (i.e. higher transaction costs) by the individual water consumers to compensate for their poor design. Our discussions of industrial demand and wastewater regulation in chapter 3 showed that water resource management issues pose very special problems for institutional analysis. Externalities (pollution), common pool resources, infinite horizons, and exhaustibility (or sustainability) are among the labels that have been applied to some of these special issues. If one is forced to identify the single most important reason for all major problems facing our water economy ranging from water depletion to water logging, it would certainly be the undeniable fact that our water utilization institutions are virtually incapable of providing the much-needed economic incentive for both individual and collective action so essential for promoting use efficiency and conservation of water resources (Saleth, 1996). Common phenomena are inefficiency of water resource allocation, poor pricing and enforcement strategies, political meddling and rent seeking. Such situations are often called “market failures” (Hurwicz, 1998:29). The most significant implication of institutional arrangement for (industrial) water use is that water resource allocation i.e. through pricing and regulation should discourage profligate consumption while efficient water using practices should become embedded in the (industrial firm’s) consumption technology (Renzetti, 1992). There should be an effective way of ensuring excludability in the use of surface and ground water sources (as opposed public water) and a means for checking the open access character of the water so that water exploitation does not become a victim of the “tragedy of the commons” (Narain, 1998).

Design of Appropriate Water Institutions

Water resource management can be rational only if the institutions responsible for such management are efficient. The theoretical literature elaborating the possible gains from institutional arrangement—both in the general and in the water sector contexts – are vast and growing (see Olson (1971), Bromley (1989), Ostrom (1990), and North (1991). In the water sector, the literature extends to a game theoretic framework used to analyze the incentive aspects of alternative water institutions, for example, the "tragedy of the commons" has been modeled as a game. However, the design of incentive compatible institutions - institutions capable of achieving compatibility among individual, organizational, and social objectives-remains an art rather than a science. The incentive compatibility problem has not been solved at even the most abstract level. Some theorists have argued that design of incentive compatible institutions is, in principle, not feasible (partly due to political problems posed). *Our* deficiency in capacity for institutional design is evident in our failure to design institutions capable of achieving contemporary distributional equity, either within countries, or among rich and poor countries. It impinges with even greater force on our capacity to design institutions capable of achieving intergenerational equity (Ruttan, 1998:156).

There is no consensus among economists on either remedies, or even whether there really is a problem. While it may be accepted that any failures in water resource allocation that do exist reflect the absence of *appropriate institutions*, there is no agreement on which institutions would be appropriate, nor on whether conscious social intervention is required to bring preferred institutions into being. Some abhor "social engineering" and favor a laissez-faire approach, perhaps counting on the spontaneous ("endogenous") development of needed institutions. Others see the need for intervention, but only for the purpose of clarifying individual property rights assuming that market mechanisms would take care of the rest. This view has been particularly widespread among many of those seeking to understand and remedy the over-utilization of common property or common pool resources (Hurwicz, 1998).

In order to perform the essential role of forming reasonable expectations in dealings among actors, water resource institutions must fulfill the following set of conditions: (i) institutions must be stable for an extended time period (Ruttan, 1998:148). (ii) like technology, institutions must also be adaptable to changes if development is to occur. Institutions that have been efficient in generating smooth transactions in the past may change over time, directing their efforts primarily to protection of vested interests by maintaining the status quo and thus becoming obstacles to changing circumstances (Olson, 1982:74). (iii) the costs of institutional arrangements (i.e. regulation and enforcement) are often ignored in comparing alternative institutional arrangements. Institutional arrangement that seem efficient when these costs are ignored may fail the test of efficiency when they are taken in account (Hurwicz, 1998:30). These facts imply that institutions must operate above financial constraints with autonomy for them to be effective. Several internal factors have been identified that influence the capacity of water sector institutions to perform: organizational and administrative capacity, the skills and professionalism of personnel, and capital. Organization autonomy provides efficiency and effectiveness. The capacity of the water utilities to perform well is often related to the quality of its staff, which is partly a function of the pay and conditions on offer (Nickson, 1999). Five extra-organisational conditions in the surrounding institutional context have been identified that impact on the mobilization of internal capacity, either releasing or constraining it (Batley, 1997: 37-41). They are: financial and economic conditions; public sector interaction with civil society; public sector interaction with the private sector; political practices; and legal and administrative framework. We use these conditions to discuss the appropriateness of the institutional arrangement for urban water delivery in Kenya.

5.3 The Water Sector Organizational Arrangement in Kenya

Customary law governed the management and control over water resources in much of Africa’s traditional societies before the colonial period (Ayibotele, 1990: p.361). This institutional framework had its roots in the pattern of land ownership unique to different countries. Traces of these include the community resource management strategies that are still found in many African countries (including Kenya) where a sense of common property ownership has not dissipated. In parts of Kenya where these management institutions are functioning well, water resource protection has been effective even in times of extreme water scarcity. The basis for the modern day institutional framework can be traced to the Water Act first introduced in Kenya in 1951. The Act vests ownership and management of water resources in the government (rather than the community) and in particular in the responsible minister on behalf of the government.

Under the present water statutes, the Government is the owner and custodian of all water resources in Kenya (Water Acts Cap 372 Laws of Kenya). The Government regulates the utilisation and development of water resources and maintains overall (advisory) responsibility on all aspects of water development. The Water Act is explicit on the need to conserve, control and apportion water resources in Kenya. The right to water is based on English (British) common law derived from land ownership in two ways. The first one is by ownership of the land under or over which water flows. The second one is by ownership of land adjoining surface waters, called riparian rights. The English common law provides the conceptual foundation for water rights in Kenya. Land may even be acquired by the Government to protect this goal either through purchase or decree. The present Water Act Cap. 372 talks of compensation being paid for land compulsorily acquired for water development (for example the construction of water works), when this is in the public interest. Apart from small-scale domestic usage, it is illegal to abstract, impound, obstruct or divert a watercourse by works without authorisation.

Mainly two public organs currently administer water sector management in Kenya. These are the Ministry of Water (Ministry of Environment and Natural Resources) and the Water and Sanitation Departments in the Local Authorities. The management of water resources is undertaken at two levels, the national and local level. The management of water resources at the national level is organized around two government Ministries; Ministry of Environment and Natural Resources (MENR-Water Development Department) and Ministry of Local Government/Authorities (MOLG). The central role is played by MENR while MOLG plays only an indirect role in water issues by virtue of its responsibility over Local Authorities. At the local level, the Local Authorities, National Water Conservation and Pipeline and Corporation, and MENR undertake water management.

5.3.1 Ministry of Environment and Natural Resources

The Ministry of Environment and Natural Resources (MENR) was created at the beginning of 1999 by amalgamating two ministries (Ministry of Environment; and Ministry of Water development). It is currently responsible for granting status of "water undertaker" to all the water agencies including the local authorities. The administration of water resources under the Water Act provides for water undertakers to be designated at the local level. The Ministry administers the Water Act (Cap 372) through the Water Apportionment Board (WAB) of which the Director of Water Development is the Technical Advisor. The Director of Water Development controls six departments, the Kenya Water Institute (KEWI), the eight Provincial Water Engineers and 44 District Water Engineers. The KEWI is responsible for training of employees in the Ministry and local authorities. The Registrar of Water Rights is the Secretary to the Water Apportionment Board (WAB) but s/he also chairs the arbitration between water conflicts among parties.

Since the water undertaker status has so far not been granted to smaller local authorities on the grounds that from a technical and administrative point of view, they are not in a position to run water supply on their own, the MENR is also a water undertaker for most of the authorities in smaller urban areas. The MENR is thus responsible for both regulatory and implementation tasks. The MENR was running 579 water projects in rural areas and another 89 projects in urban areas by 1999. In addition, MENR also claims the right to approve the water tariffs for water undertakers not covered by MOLG. The Water Act of 1962 (amended in 1972) leaves open the question of which ministry (MENR or MOLG) has the ultimate authority over water tariffs in Kenya. For the administration of water resources by the MENR, the country is divided into five catchment regions (drainage areas), namely, the Lake Victoria Basin, Rift Valley Basin, Athi River Basin, Tana River Basin and Ewaso Ngiro River Basin. The MENR has put in place, qualified officers such as, Water Protection Officers, Water Bailiffs and Water Guards in various Catchment areas with the view to ensuring that Water Resources is protected in terms of quality and quantity. For the administration of the Local Authority water undertakers, the Ministry of Environment and Natural Resources works in liaison with Ministry of Local Government that is responsible for regulating the activities of the Local

Authorities.

The National Water Conservation and Pipeline Corporation (NWCPC) responsible for water supplies is closely linked to MENR. This is a state enterprise supervised by Ministry of Environment and Natural Resources. It was set up in 1989 with personnel from then Ministry of Water Development (MOWD) and it took over 42 water supply systems that had previously been operated directly by MOWD. These systems include Kenya's main long distance water supply lines (National Water Master Plan, 1992). In some cases the NWCPC sells water in bulk to water undertakers who are responsible for distributing it to customers. In other cases the NWCPC also runs some municipal distributions with examples of Mombasa city and Malindi town. In none of these cases does it run sewage disposal networks. The NWCPC has also in recent years taken over the water distribution network that was previously in the hands of the local authorities as water undertakers, because the local authorities had not raised the tariffs and were in arrears with payments to the NWCPC. The NWCPC covers its operating and maintenance costs from revenue from sales of water and receives grants for its capital costs. Its tariffs are standardized throughout the country, this is rather unsuitable to apply where there are marked differences in the costs of providing water to different users across the country.

Altogether, there are 6 categories of public water undertakers in Kenya today. They consist of the Ministry of Environment and Natural Resources, the National Water Conservation and Pipeline Corporation and Local Authorities, which control a total of 931 water projects constituting about 52 per cent of all the water projects in the Kenya. Community Water Supplies and Self-help Schemes and NGOs operate 848 water projects (or 48 per cent) of the total. All County Council water supplies are under the Ministry of Environment and Natural Resources. Ministry of Culture and Social Services is responsible for the self-help schemes in the rural areas. Self-help schemes include schools, dispensaries, markets and other facilities in addition to water supplies. These schemes, if operational and functional well, should be able to cater for an estimated 75% of the population in urban areas and approximately 50% of the rural population. However, most of these schemes, especially the gazetted ones, are currently either non-functional or operating grossly below installed capacities due to expiry of useful life or through maintenance and generation of non-sustaining revenues.

Frequent Organizational Changes at MENR

Prior to 1964, the hydraulic branch of the then Ministry of Public Works was responsible for urban water and sewerage development. In the rural areas, water development was vested in the African Land Development Organisation, which was itself under the Ministry of Agriculture. In 1964, the functions of these two organisations were consolidated under a newly created Water Development Department of the Ministry of Natural Resources. The Department was transferred to the Ministry of Agriculture in January 1968. Ten months later, the Department was demoted and became the Water Development Division (WDD) of Agriculture Ministry. The responsibility was later conferred to the provincial organizations of the Division at the Ministry Headquarters and the Provincial Directors of Agriculture. The distribution of authority and responsibility was only vaguely defined and caused considerable unease among the water players at the provincial level.

In 1972, the status of the Division was restored to that of Department and the Director again became directly responsible for the provincial water organizations. This responsibility covered both technical and administrative matters although, because of staff shortages within the Water Department, the Provincial Directors of Agriculture continued to provide some non-controlling administrative assistance to the provincial water organizations. In 1974 the Water Development Department was upgraded to become the Ministry of Water Development. In essence the new Ministry took over the responsibility of the Water Resource Authority in addition to other functions carried out by the Water Department. The beginning of the new ministry also marked Kenya's 1st National Water Master Plan launched 1974 with the express aim of ensuring that portable water made available, at reasonable distance, to all households by the year 2000. The new Ministry ambitiously took off taking over the operation of Government constructed water schemes but also all County Council (Ministry of Local Government) and Settlement (Ministry of Lands and Settlement) water schemes as well as several self/help water supplies. The Urban Water Supply Programme launched with the 1st Master Plan was initiated as an instrument in the Government' growth center strategy which aimed at setting up localized and geographically spread out nuclei of economic, commercial, industrial, and social development around the large cities and their environs. Provision of water was seen as an important input in catalyzing the emergence of the growth nuclei. By the Fourth Development Plan (1979-83) when the Ministry of Water, for the first time, became a separate ministry with its own development allocations, the water development exercise had been broken up into numerous programmes and segments including rural and livestock water supplies, county council supplies, self-help supplies, Mombasa and Coastal Water, Mombasa Pipeline Board, water resources and pollution control, minor urban and service centre water supplies, sewerage and sewerage research, water conservation, rehabilitation of water supplies, and water supplies for integrated rural development programme, among others[1]. With so many actors involved in the provision of water, there was great need to co-ordinate these activities by the various players. We have provided a summary of the major organizational changes in Box 5.1.

Box 5.1: Structural Changes at Ministry of Water Resources Development/MENR

1951:The Water Act was established in 1951 to make better provision for the conservation, control, apportionment and use of water resources.
1964: Hydraulic branch of Ministry of Public Works (handle urban water sewerage development).
1964: African Land Development Organization - Ministry of Agriculture (Rural Water schemes).
1964: Water Development Department consolidating above 2 departments in Ministry of Natural Resources.
1968: January Water Development Department moved to Ministry of Agriculture.
1968: Ministry demoted in November to Water Development Division, Ministry of Agriculture.
1972: Water Development Department restored in Ministry of Agriculture.
1974: Water Development Department upgraded to become the Ministry of Water Development.:
1974: Kenya's 1st National Water Master Plan was launched with the goal of providing water to all households by the 2000.
1988:The National Water Conservation and Pipeline Corporation, established in June 1988 with most of the staff from Ministry of Water Resources.
1993:The MOLRRWD was formed in January 1993 after a merger of the former Ministries of Water Development Regional Development, Reclamation and Development of Arid, Semi-Arid and Waste Lands.
1999:Ministry of Environment and Natural Resources (MENR) created at the beginning of 1999 by amalgamating two ministries (Ministry of Environment; and Ministry of Water development) is currently responsible for granting status of "water undertaker" to all the water agencies.

For many years, frequent changes at MENR have been a major problem (see Box 5.1). For example, between the period 1963-2000, the Ministry had been changed nearly every 2-3 years, in most cases being demoted through a merger with another ministry i.e. Land, Regional Development, Environment, Natural Resources etc an experience which also impacted on the morale of the staff negatively.

> *The frequent changes have hampered the effectiveness of MENR as an overall government agency responsible for water resource policy and management in Kenya.*

Each time the changes at the ministry were announced, staff realignments occurred with changes in responsibility. The new water departments had to literally fight for office space and support facilities (such as office furniture, computers and vehicles) and it took some time for the MENR to become functional again. The frequent changes also hampered capacity by the MENR to develop clear and long-term goals for the water sector. For example by 1980 it had been recognized that the major problem and constraint hampering the development of the water sector in Kenya included the lack of a comprehensive policy/institutional/legal framework to guide development in the sector. Another weakness of the ministry lies in its participation as a water undertaker. For some of the urban areas,

> *it has also emerged as an obvious disadvantage that responsibilities for water and for sewerage in the same urban area are not under the same authority.*

While the ministry has maintained responsibility over water supply in small urban centre, the task of wastewater/sewer management has been left to the local authorities. This has meant that consumers have to pay for water and sewer separately.

5.3.2 Ministry of Local Government (MOLG) and Local Authorities

The Ministry of Local Government (MOLG) plays a facilitative and regulatory role, arranging necessary technical interventions with the Ministry of Water Resources and financing. The Ministry of Local Government (MOLG) is responsible for supervising and supporting Local Authorities (LAs) in the execution of their tasks. At the central Government level the MOLG coordinates the activity of other donor agencies involved with improvement of water and sanitation services in local authorities. The MOLG is responsible for the transfer of senior staff of LAs, supervising in the project implementation of their task and more importantly in the administration of the Local Government Loan Authority (LGLA), which originally served as a conduit for economic cooperation loans, especially for water and sewerage projects and other investments in LAs. It is the overall duty of the MOLG to ensure that Local Authorities (municipalities) are effectively performing their functions, including the provision of water supply and sanitation services, and to support them to achieve this goal. MOLG also handles matters requiring the involvement of the Ministry of Water at the Local Authorities. Nevertheless, water issues remain the central concern of MENR. Furthermore, MOLG approves tariffs of all local authorities that are water undertakers. The LAs propose water and sewerage tariffs for approval by MOLG's. The LGLA was established in 1953 under the Local Government Loans Authority Act (CAP 27). It was formed basically as the principal conduit for channeling capital resources t o local authorities for the financing of various development projects. As defined in the enabling registration, it is a statutory body directed by an independent board with the legal authority to make loans to any local authority. The loan funds include the amount voted annually for the local authorities capital programmes that are passed over to the Ministry of Local Government by the treasury and thereafter are lent on to the local authorities through the LGLA[2].

Local Authorities

The Local authorities in Kenya have a number of roles in terms of the management or urban water systems and other services. These include infrastructure owner, customer representative, service provider, and regulator. For the Local Authorities to function as Water Undertakers, they act in liaison with the Urban Development Department (UDD) of Ministry of Local Government (MOLG). Traditionally, there have been three main categories of Local Authorities (municipalities) with respect to Water Supply and Sanitation in Kenya. Some local authorities run and maintain their water and sanitation facilities (e.g. Nairobi, Eldoret, Kericho, Nyeri). Others receive water in bulk from National Water Conservation and Pipeline Corporation and run sewerage services. Others are dependent on the National Water Conservation and Pipeline Corporation for provision of water and revenue collection for water and sewerage services. By 1997 there were 147-gazetted urban areas with 30% of them designated Local Authority appointed water undertakers. These urban areas are empowered to issue by-laws (subject to MOLG approval) related to the provision of water and sewerage services in their own jurisdiction. The water services are administered by the Water and Sanitation Departments within the Local Authorities.

Water and Sanitation Departments (WSDs) operate within the Local Authorities under guidance by the Water Act (Cap 372) in so far as the Act delineates the powers and responsibilities of a water undertaker. In addition, the Water and Sanitation Departments are subject to the Local Government Act (Cap 265) especially in areas of procurement of stores, appointments of staff and general organizational functions. The General Manager presents all matters in water as motions to the Water and Sewerage Committee for consideration by the elected councilors. What the councilors decide is then forwarded to the Finance Committee and then is adopted by a full council meeting every month. The Water and Sanitation Departments are also subject to the guidelines and regulations provided by the Water by-laws that have been developed by each Local Authorities. The by-laws stipulate conditions for sourcing of public water and wastewater disposal.

5.4 Management of Surface and Ground Water Resources

Managing ground and river water resources of Kenya is under the responsibility of the Department of Water Resources (DWR), in the Ministry of Environment and Natural Resources (MENR). Managing the resources involves, among other activities, monitoring the resource availability, assessing the resource potential, allocating the resource to those that want/need to use, and ensuring that users adhere to allocation decisions. The main instrument for industrial water management is regulation. The MENR regulates direct abstractions of water from rivers and ground sources. Regulation is done through licensing of the industries that have to apply for a permit. A modest application fee is charged on this permit but the basic consideration for approval by the MENR is the ecological limits of the quantity being applied for by the firms. A secondary requirement is for the Local Authorities (LAs) to issue a letter of no objection for the issuance of a water permit by MENR. The usual (formal) justification for the *letter of no-objection* is the unreliability or insufficiency of the public source. Under the present law, a right to use water can only be acquired under the Water Act, by way of permit issued by the Water Apportionment Board (WAB). The WAB is authorized to issue the permit on behalf of the Minister. There are, however, three exceptional cases that will not require permits:

(a) Use of water for domestic purposes by person having lawful access thereto and application of "works" (Water Act: Section 38).

(b) Development of groundwater not situated within 92m (100yards) of any body of surface water or 805m (half mile) of another existing borehole and not situated within a "Conservation Area" (Water Act: Section 50 and 74), where however the acquisition of any authority for development is still required.

(c) Storage of water in or abstraction from a dam built in a channel depression declared by WAB not to be a "watercourse" (Water Act: Section 38).

Procedure for issue of water permits

An application is made to WAB through local Water Bailiff of the area. The Water Bailiff at first inspects the site of the applied work and verifies all information in the application, and then submits the findings/recommendations to the relevant Catchment Board with a copy to WAB enclosing copies of application to open file. The application is advertised to call for any public inquiries or objections for 30 days. Applications may be inspected by the public at the offices of the Board and objections raised by the public. Where the Board is of the opinion that the permit applied for is likely to be in the public interest, or not adverse to it, it must conditionally approve the application. If any objection is lodged against the application, the Board must hold a public inquiry prior to refusal or approval of the application. If the application is approved, WAB conveys an authorization to commence the construction works. The Water Bailiff inspects the completion of works, and then the water permit becomes effective in force.

Conditionality of water permit issue

Water permits are often issued subject to terms and conditions such that: (Water Act:section 28, 73, 91) so that there is:

(a) Installation of controlling and/or measuring devices at water intake.

(b) Abstraction of 60% of the tested safe yield of groundwater.

(c) Passing over of waste or surplus water.

(d) Clearing of weeds in the canal to allow passage of water.

(e) Anti-pollution measures.

(f) a measure ensuring that used water is not returned to the watercourse (in case of coffee factories).

Water Application by Industries

As a way of protecting the water resource base against abuse (pollution) by firms, all industries using wet process in Kenya are under obligation to apply for "water permit" from Ministry of Environment and Natural Resources regardless of their source of water. Under these requirements, the industries are expected to demonstrate in their plant production plans how they intend to source and dispose of their wastewater. Even though this could be a useful tool for regulating wastewater, there is no physical verification to confirm that the gadgets specified on the plant production are constructed before production is commenced.

Charges by Local Authorities

On the other hand LAs regulate public sourcing of water by the industries through pricing and other sanitary requirements stipulated in the by-laws of the respective local authorities. Some Local Authorities have attempted to impose a sewer charge on the basis of water consumed by firms from captive sources (rivers and groundwater). A universal application of this procedure has not been achieved due to high enforcement costs. Besides, the mandate for enforcement falls within the jurisdiction of two government departments (Local Authorities and Ministry of Environment and Natural Resources), hence, leading to lack of clarity on regulatory functions and motivation on the part of the agencies.

Regulatory Performance of the MENR

Efforts have been made to regulate groundwater withdrawals through licensing restrictions for wells or through spacing norms to maintain ecological sustainability. Processing of water permits is lengthy, involving receipt of applications. This often takes months and in some cases years, thereby frustrating the applicants. Unfortunately also, the borehole completion records currently filed in the Groundwater Section of MENR would be the basic data for future groundwater resources management. Of the nearly 10,000 boreholes in the country, only 11% have some water quality data logged on the MENR database. Most of the data represents those tested at the time of initial drilling, but no testing has been undertaken for most of the boreholes since then. The scarcity of existing data makes it quite difficult to meaningfully assess the groundwater quality in the country. Abstraction point investigations are usually inadequate due to limited equipping of water bailiffs, leading to arbitrary apportionment. No enforcement of compliance with the granted permits by the water bailiffs due to inadequate staff and logistical support. WAB does not sit as often as it should due to lack of funds.

Current measures have sought only to regulate the establishment of groundwater boreholes, rather than the quantum of water extracted. During the last decade the financial budget available to Water Resources Department to manage the river and ground water resources has declined. This has meant that there have been fewer funds to mobilise geologists, hydrologists and water bailiffs to undertake field-monitoring exercises. At the same time, demand for river water resources has increased substantially (for domestic, livestock and irrigation). Additionally, access to the rivers has increased dramatically due to settlement/ subdivision of riparian land, meaning that the number of commercial abstractors has grown dramatically. The resulting absence of tight government control for ground and surface water exploitation has effectively provided an open access condition in which industrial water abstractors have abstracted on “take as much as possible” basis. A significant number of industries in urban areas have captive sources (see Table 4.1, chapter 4). Surface and ground water use by industries in Kenya is much more extensive than ordinarily considered by the Ministry officials. These facts suggest that the existing gaps in the institutional structure are detrimental to sustainability of water use.

5.5 Management of the Public Water Consumption in Urban Areas

5.5.1 Enforcement of Tariffs

Under the existing Acts and by-laws, the Municipal councils have the powers to prosecute consumers who contravene water supply and sewerage regulations. Contravention of the by-laws can be punished by disconnection, financial penalties and imprisonment. Disconnections often encourage illegal water consumption since some consumers are able to reconnect the water. In the case of the financial penalties stipulated in the by-laws, they have not kept-up with inflation, hence they are not applied by the Local authorities. These penalties (as well as water tariffs) have to be approved by the Ministry of Local Government. On the one hand imprisonment are rarely appropriate because the enforcement officers often feel that the effort involved in going to court may not be justified because the fines are so low, thus at the moment the water authorities' main interest is to rectify the situation without recourse to the law. Consequently the authorities resort to punitive measures such as physical harassment; bribery etc and other forms of arbitrary action to encourage compliance. It is desirable that where criminal cases are involved the magistrate be provided with powers not only to impose a fine on those found guilty but also order the paying to the Water Undertaker of the estimated losses in revenue. At present recovery of the latter requires a separate and laborious subsequent civil case. Since administration of liability over water consumption is costly to the water authorities, many small consumers could go without paying for the service. There can also be long delays from the time the water is consumed (and a bill issued) to the time of payments since no penalties are imposed on late payments. Some consumers change their addresses (residential location) without settling their bills. Although the magnitude of this problem is still low, it is one of the difficulties facing water authorities. Nakuru town have tried to circumvent this problem by charging the water bill to the land title rather than a tenant.

Regulation (we have dealt with wastewater regulation elsewhere in chapters 3, 7&8) of water consumption through rationing is another option available for water management within the local authorities. The practice has been invoked only during severe shortages i.e. during drought. Its effectiveness is severely hampered where the captive sources are poorly regulated since industrial consumers have multiple options. Furthermore, selective rationing is not feasible in most of the urban areas i.e. to target specific users due to the system of pipe network.

5.5.2 The Performance of Local Authorities

There are considerable problems in discussing the performance of the existing Water Authorities service arrangements. The most commonly used indicators are coverage, service ratio, number of connections, staffing and productivity, unaccounted for water, metering, and collection efficiency (Nickson, 1996). Based on our field experience and secondary sources of information compiled from the Ministry of Local Government (MOLG), we have summarised the performance by the water utilities in urban areas in Table 5.1.

Table 5.1:
Summary of Performance Indicators by the Water Authorities in Kenya

Indicator	Nairobi	Eldoret	Kisumu	Nakuru	Thika	NWCPC	MENR*
Urban Centres	1	1	1	1	1	32	89
Urban Population (‘000)	2100	300	400	500	149	1170	3400
Urban Population Served (‘000)	1853	175	209	300	120	950	1340
Service Ratio (%)	88	58	52	60	80	81	39
Number of connections (‘000)	158	9	14	17	4	54	12
Staff Employed	1870	202	302	599	146	1617	7600
Staff per 1000 connections	12	23	22	35	34	30	61
Water produced (‘000M^3/day)	347	30	18	28	24	80	1700
Water sold (‘000M^3/day)	170	16	4	2	13	51	436
Unaccounted For Water (%age)	51	48	82	45	47	36	74
Collection Efficiency (%age)	39	51	39	62	76	50	41
Metering (%)	25	90	76	85	84	65.1	28
Economic Efficiency**	11.5	-11.7	3.7	-4.7	14.4	-	-

*Water Development Department. Source: Own Survey; **National Water Master Plan.

Table 5.1 shows that the service coverage in most the urban areas are low. All the water utilities are able to meet only a part of the total water demand within their jurisdiction. The range varies between 39-88% and the rest of the consumers have to go without adequate water or find alternative water sources. The water authorities are also characterized by high unaccounted-for water (UFW). About 40-70 per cent of the water produced is lost either during transmission and distribution as a result of old pipes that are neither properly maintained nor replaced; or due to illegal connections. The extent of water metering is also incomplete in all of the Local Authorities. In Nairobi, it is estimated that only 25% of the consumers are properly metered and these are mainly industrial and large commercial consumers. In Kisumu, out of a total of 11,240 meters, only 32% are thought to be working, 26% are not working and therefore consumption is normally estimated, and almost 40% are "disconnected". On the other hand, our survey revealed that not all of the working meters are read on a regular basis despite a stated meter-reading work force of 61. Such a large number of persons were never observed at the meter reading premises, and indeed they would only be required to read a maximum of 3 meters per day each if all working meters were read once a month. However metering errors account for a substantial part of total losses. These losses are caused by inaccuracy in macro metering and metering equipment that measures flow. This category of loss is an indication of the efficiency of metering systems. It has to do with the errors in the metered quantities of water rather than with actual loss of water. Many households who receive no water get billed for the minimum quantity. This inflates the apparent high consumption and default in payments by households. However the council officers argue that the large number of the so-called “inactive” consumers could be illegal water users hence the justification for a minimum bill.

Collection Efficiency for the water revenue is also very low for most of the Local Authorities. Only about 39-76%% of revenue due on the 25-55% of the water that reaches the consumer on average is actually collected. This implies that only 10-42% of the water supplied and consumed is paid for in the urban areas. In a number of the urban areas surveyed (particularly Nairobi, Kisumu and Eldoret), the frequency of billing to domestic consumers is erratic. Funds generated through water revenue are diverted to other uses such as payment of councilors salaries and allowances other than to support the water system. There is an intolerably high incidence of water revenues being diverted to general expenditure that is unrelated to Water and Sanitation services. For example Kisumu municipality generates revenues of 8 to 9 million shillings per month. The direct production costs are around five million shillings per month and this leaves the council with 3 million per month for transfer to the general account. However, the actual transfer is larger because the council is always reluctant to pay for power, supplies of chemicals etc and they run arrears in settling these debts. The additional funds thus generated are also transferred to the general account and are used to finance other council operations. With a reasonable level of efficiency they could easily double their water income.

The economic efficiency of the entire urban water schemes of over 158 systems have been examined using Net Present Value (NPV), Benefit-Cost Ratio (B/C), and Internal Rate of Return (IRR) (Republic of Kenya, 1992). Of 158 schemes, only 4 schemes exceeded 10%, the opportunity cost of capital. They are Embu, Thika, Mariakani and Nairobi in order of economic efficiency. In addition to these four schemes, only 36 schemes had positive IRR. The other 118 schemes (about 75% of the urban schemes), resulted in negative efficiency, hence, they would not be expected to return the capital investment through their accruing economic benefits, from economic point of view. The low *economic efficiency* in most of the water schemes suggests that the degree of cost-recovery in urban water supply in Kenya is very low. Incidentally, Thika town, which has the highest efficiency rate, also has one of the highest tariff rates for the industries in Kenya.

As a result of the financial interference, budget provisions made by the Councils for preventive maintenance are too low, resulting in the decay of the installations system. Furthermore, the water utilities lack the very basic tools for repairs and maintenance. In all the urban centres, Chief Officers are eternally fighting in the financial arena and dealing with all manner of issues due to the numerous vacancies at senior level, whilst down the scale there is an air of apathy amongst disillusioned junior staff with seemingly little to do due to the financial constraints. Some of the elected Councilors had indeed received their sitting allowances and salary advance covering several years in advance when the municipality workers had not been paid for several months. As a result the councils are in constant crises regarding arrears for salary payments, unpaid bills for power, telephone, and dues for supplies.

Since 1984, the WSDs are part of the Public Service Commission (PSC) Act for purposes of human resources management. The PSC has delegated the powers of selection and recruitment to the Councils for non-skilled, semi-skilled and technician levels. It has also delegated the powers of promotion in these scales; but LAs cannot take disciplinary action against any officer in the same salary grades. Disciplinary action is the preserve of the PSC (Dismissal, withholding of increments etc). The Ministry of Local Government supervises the deployment of the most senior officers of the council by recommending appointment of chief officers or their transfer by the PSC. There is very little consultation between the various departments.

They exist as independent departments i.e. water and public health departments often engage in bitter disagreements over financial allocations.

What has emerged in most of these water utilities is an irregular pattern of employment and poor work ethics. Many essential workers have developed a culture of postponing regular work in preference for overtime work especially on weekends and public holidays. Recruitment of the junior staff takes the form of long protracted effort during which the utilities go without essential services. In Thika, the Water and Sewerage Department had staff strength of 143 officers up from 92 in January 2000. The Water and Sanitation Department had been without enough staff for more than 2 years as the councilors and chief officers were still haggling on how many of their persons they should bring and how far down their qualifications should be stretched. Thus within the period of my fieldwork the staff in the department had nearly doubled. There are problems in recruiting and retaining management and technical personnel. The Water and Sanitation Departments are over-established at lower cadre thus absorbing resources that are critically needed to support optimal operations (JICA, 1998).

Throughout the Councils, there is a preoccupation with day-to-day affairs at the expense of longer-term considerations. The problems associated with keeping the Local Authorities running on a daily basis seem to be sufficiently taxing that little time or energy is left for dealing with the current, let alone the growing and future water crisis. In the departments studied most closely, there were no officers who were officially responsible for planning; the amount of planning engaged in seems to be heavily dependent on the personal inclinations of the senior officers. To some extent, the lack of planning in Council departments is a product of staffing shortages and high turnover. Tangible projects that enhance councilors' prestige when they are built in their wards - especially social centres and, to a lesser extent, health centres and roads - are mostly subject to political pressures.

Often the chief officers are preoccupied with opportunistic behaviour that is detrimental to the central function of the LAs. For example, when the water rationing measures were announced by Nairobi city council during drought in 1999/2000, even the council tankers that were normally meant for exhauster (sewer) services were quickly cleaned (washed) and converted to supply clean water in the emerging illegal trade for water. Indeed when the water rationing had taken root in Nairobi, it was discovered that many illegal structures in Nairobi have been built on top of water lines, and their owners have been siphoning the council water in collusion with council officers to provide car wash services etc for many years.

Disequilibria in water delivery services associated with the above institutional problems have been identified as important sources of demand for institutional change in urban water management in Kenya. In the next section we discuss the changes that have taken place or are still on going in Kenya.

5.5.3. Commercialisation of Urban Water Service Delivery

In recent years, privatization has been mooted as a viable alternative institutional framework for the management of public water services, particularly in countries where the delivery of urban water service has been fraught with bad governance. Kenya is one such country where urban water service provision has deteriorated over the years. The efforts to commercialize water in Kenya started in 1987 through the Urban Water and Sanitation Management (UWASAM) Project, a project of the Ministry of Local Government (MOLG) and the Ministry of Environment and Natural Resources (MENR) supported by the Deutsche Gesellschaft fur Technishe Zusammenarbeit (GTZ) of the Federal Republic of Germany. In its initial phase, considerable effort was expended on the creation and support of a Water and Sewerage Operations Unit (WSOU) in the Ministry of Local Government. The period between July 1987 to December 1993 was the pilot phase. The experience of the pilot phase derived from three municipalities, namely: Kitale, Kericho and Nyahururu. Based on this experience, UWASAM recommended that Water and Sanitation Departments (WSDs) be fully established in 9 Water-Undertaking Local Authorities that were receiving assistance from the UWASAM. Consequently, the project targeted Kisumu, Eldoret, Nakuru, Kitale, Kericho, Nanyuki, Nyahururu and Thika towns.

During the subsequent phase of the UWASAM Project (January, 1994 to December, 1996) the focus shifted to providing assistance to the above 9 Local Authorities to establish fully fledged

WSDs. They were the focus of systematic staff training and technology transfer; adopting cost covering tariffs and generally attending to the maintenance requirements of their systems. Nevertheless, the WSDs remained unsatisfactory in terms of service quality, water loss targets, revenue collection efficiency and flexibility in responding to consumer needs for increased demand and expansion of the distribution network. Furthermore, the WSDs were not permitted to control their own financial affairs in their respective LAs and it was considered that autonomy could only be achieved by some form of commercialization. Formation of Water Companies, wholly owned by the Municipalities, was the option advanced by the German financial Cooperation Agency, KfW. The GTZ proposed that council officers visit Chipata Water and Sewerage Company Ltd in Zambia, as a model project. In the next step, resolution was passed in a workshop held in 1995 between the pilot towns, Ministry of Water and the GTZ to the formation of Water and Sewerage Companies as step towards commercialization. A delegation from Kenya visited the Chipata between 20th –23rd May 1996 under the funding of GTZ.

Structure of the New Water Companies

For the three Local Authorities (Nyeri, Nakuru and Eldoret), the water company structures (Nyeri Water and Sewerage Company Limited, Nakuru Quality Water and Sanitation Company Limited and Eldoret Water and Sanitation Company Limited) followed the normal lines of private company with: shareholders; board of directors; and corporate management team. The corporate management team comprises: managing director, commercial manager; and technical manager. The Municipal Council exercises control over the Company through the Annual General Meeting as prescribed by the Articles to consist of the Mayor, Deputy Mayor and Chairmen of Committees. In all the three towns, the Company is wholly owned by the Council but in order to satisfy the requirements of section 4 of the Companies Act three additional subscribers who hold in trust one share each on behalf on the Council were incorporated in the list of subscribers. The subscribers to the Memorandum of Association are: The Municipal Council 4,997 (99.94%); The Mayor 1 share (0.02%); The Town Clerk 1 share (0.02%); and The Town Treasurer 1 share (0.02%). The Board of Directors brings together, on an equal basis, representatives from the State, Local Authority, and Stakeholders, thereby illustrating the "democratic" nature of the Company. The Directors of the Company as outlined in the Articles of Association are: Mayor of the Council; Town Clerk of the Council; Town Treasurer of the Council; The Managing Director of the Company Representatives of business/finance sector; Representative of Women Representative of Ministry of Water Resources; Representative of Ministry of Local Authorities; and Representative of Water Consumers.

The running of the Company involves certain key roles: Setting of strategic direction; Operational management; Monitoring and Control; Fulfillment of statutory obligations. The role of the Corporate Management Team is: Generating strategy and setting operational goals; Effective attainment of goals; Resource deployment; Performance measurement; Day to day operations; and Progress reviews. The Board of Directors acts as the ultimate authority, reviews overall strategy, monitors and controls, considers significant issues and fulfils statutory duties. The Directors appoint a Managing director to manage the Company for such remuneration, whether by way of salary, or commission, or participation in profits, or partly in one way, and partly in another, as they think fit, subject to such terms as may be agreed upon and likewise may revoke any such appointment in accordance with the terms of the agreement. Specifically the Directors: Approve corporate plan and budget; Provide management guidelines; Approve major contracts; Authorize major changes of policy; and Approve tariffs in compliance with legislation.

The experience of commercialized water services is not quite new in Kenya. There are examples of public /public water sector partnerships which have been in operation for a number of years. Examples of these include the Nyali Wells Water Company, which has been supplying water to the residents of Nyali area (in Mombasa) as purely private enterprise. There was also Karen Properties a private water company in Karen Langata area of Nairobi that was involved in the supply of water to the local residents on commercial basis. Another example of private sector participation is management contract between National Water Conservation and Pipeline Corporation (NWCPC) and JBG-Gauf Consulting Engineers in 1993 that proved too expensive – the contract fees was Kshs63million out of 88million i.e. about 70% of the revenue collected.

There are two important steps that appear to have been overlooked during commercialization of water services in Kenya. One, some type of regulatory framework should have been put in place before the process commenced. In an increasing number of countries, independent economic regulators have been set up to regulate water prices on an autonomous basis. These economic regulators are usually in charge of setting prices, but may also have other responsibilities as well as, such as establishing service performance standards (Lobina&Lall, 2000). Two, there was lack of a clear framework or criteria for choosing an alternative institutional model for urban water service provision.

5.6 Towards Appropriate Institutional Arrangement

In this section, we discuss weaknesses of the existing institutional arrangement for industrial water management. There are several problems with the existing mode of water service management in the urban areas. Some of the problems have been discussed in previous sections, however, there are two problems that are pertinent to the appropriateness of industrial water management. One is on the enforcement structure for water tariffs i.e. the philosophy, pricing objectives; enforceability etc as a tool for industrial water management. The other concerns management of water from captive sources.

5.6.1 Water Pricing and Management Institutions

There are several aspects of the pricing institution that make it inappropriate:

(i) water pricing in the urban areas is not implemented with the express goal of ensuring (industrial) water conservation, instead, the goal of water authorities is to raise revenue to support water service provision. All the local authorities place emphasis on revenue generation even though water service coverage remains low in all the urban areas[3]. An appropriate pricing arrangement should be sensitive to conservation needs and elimination of profligate use.

(ii) Where municipalities are the water service providers, their ability to influence water consumption through tariff structure is very low. This is because the final responsibility for tariff approval lies with the Ministry of Local Government and not the Local Authorities.

(iii) In all the urban areas covered, there is evidence that tariffs may not pose a credible constraint to industrial water use decisions. This is because the extent of liability enforcement for water consumption is quite limited. The existing laws or by-laws do not make it sufficiently compelling for firms to pay their water bills promptly.

5.6.2 Ground /Surface water Institutions

There is widespread conjunctive use of public and captive water use among industries in Kenya, yet the structure of surface and groundwater management remains very weak[4]. In all of the urban areas studied, the pattern of surface and groundwater exploitation by industries is quite distinct. It may be the case that groundwater and surface water withdrawals from aquifers by industries are exceeding recharge, thus threatening the long-term availability of water. Several issues arise from regulatory enforcement[5]. There are a number of issues that make the existing institutional arrangement inappropriate. *First*, under the existing a prior appropriation doctrine, firms that acquire the permit also indirectly preclude the award of subsequent permits to other firms in the same location. *Second*, older and more influential firms, have benefited from permit allocation at the expense of younger and smaller ones. *Third*, even though there are avenues for transfer of water rights to new usage, i.e. from industrial to agricultural or domestic, there are no channels for transfer of permits between users. These restrictions preclude sharing permit allocation or transfer of water services between adjacent industries. *Fourth*, the industries interviewed also complained that the regulatory enforcement approaches (i.e. licensing) for ground water access was very bureaucratic and tended to breed corruption. We discuss each of the above issues in the next section. *Fifth*, except for modest permit application charges imposed upon application, currently, there are no ground/water charges in Kenya. *Lastly*, monitoring and regulation of quantum groundwater/ surface water abstractions is very weak and nonexistent in most urban areas. The weak institutional arrangement for regulation of groundwater and surface water imply that water mining could be rampant. Ground/surface water can be a victim of "tragedy of the commons" (Narain, 1998:361).

Transferability

Transferable property rights in water have become a common prescription for improving efficiency in water allocation (Colby, 1995:485). Restrictions on transferability of water permits are restrictions on efficiency (ibid, p:488). The "prior appropriation doctrine" (in which firms acquiring the permit also indirectly preclude the award of subsequent permits to other firms in the same location) needs to be re-examined. A competitive criteria for allocating permits to industrial firms annually could be adopted. Regulation of the water can best be done at the local level by the local water authorities. Devolution of this responsibility would also eliminate the existing role conflict in which the Ministry of water is a regulator, operator and a policy maker in the water sector.

Low Monitoring of Abstractions

The major limitation of the existing institutional arrangement is that it fails to take account of the open access of the ground and surface water when regulation is weak. Mining water resources can be catapulted with public water tariff increases. This is illustrated by the experience in some of the urban areas in Kenya.

One of the factors contributing to low enforcement arise from the fact that the Ministries of Environment and Natural Resources (Water) [and to some extent Ministry of Local Government] has maintained the sanctity of certain regulatory functions on water management. These functions include ground and surface water management (and water tariff approvals in the case of Ministry of Local Government). The functions have been maintained even when times have changed and the scope of interventions required in the water sector far much exceeds the capacity of the Ministries to deal with. The existing ground/surface water management approach assumes a highly simplistic, centralized approach to the water allocation problem, and ignores the possibility of a decentralized and localized management options by Local Authorities. Currently the mandate of the Local Authorities is limited to issuance of letter of no objection for ground/surface water. This does not provide them with any motivation to carry out checks on illegal access to surface and ground water. If the Local Authorities could be mandated to regulate groundwater and surface water access then these can be regularized within the existing structures and a suitable framework for pricing and regulation determined.

The Ministry of Environment and Natural Resources (MENR) is incapacitated on the extent of the ground it can cover and the thoroughness with which information can be verified. Delays in the implementation of regulatory measures are considerable. During the last decade the financial budget available to DWR to manage the river water resources has declined. This has meant that there have been fewer funds to mobilise hydrologists and water bailiffs to undertake field-monitoring exercises. At the same time, demand for captive water resources by industries has increased substantially (for domestic, livestock and irrigation). Additionally, access to the rivers has increased dramatically due to settlement/ subdivision of riparian land, meaning that the number of commercial abstractors has grown dramatically. Since there are many industrial firms across the country, in over 100 local authorities, these local water authorities would be better placed to regulate all the water activities of the industries. There is a certain duplication of effort that can be avoided by making these changes.

> *Experience with water management calls for "decentralising water management to the lowest appropriate administrative level" (Alacåzar et al, 2001). As a rule, national governments should not implement tasks that can be done more efficiently or effectively at lower government levels, although they should ensure that these tasks are executed (subsidiarity principle).*

The above restructuring could help address the rampant problem of excludability (common property nature) facing ground and surface water due to low enforcement of the ground and surface water regulations. Furthermore, the roles and responsibilities of the Ministry of Environment and Natural Resources could be trimmed down to allow it to handle policy, planning, monitoring and evaluation of water sector only. It could then transfer its operator role to improve on the institutional efficiency in the water sector. There is also need to decentralize decision making to LA levels and empower water managers instead of attempting to create the same capacity at the MOLG level.

Pricing or Charges

A pricing framework (besides the permit application fee) for groundwater and surface water abstractions is needed. For example Renzetti and Dupont (1999) suggest that the introduction of abstraction charges that have both an annual fixed component related to "reserved capacity" and monthly charges related to actual use (even when they are based on estimated consumption) can have the potential to conserve ground/surface water while not impacting significantly on the costs of industry. They suggest that an incremental approach be adopted whereby abstraction charges are introduced, based on available knowledge, and improved (and increased over time) as knowledge related to the value of the resource is improved (and indeed as the value of the resource and competition for the resource increases over time). They illustrate that the introduction of abstraction charges could offset industrial ground/surface water demand growth by a number of years.

> *In some urban areas where the shifts to groundwater and borehole was expected to impact heavily on the Local Authority revenues (i.e. Thika town) due to changes in water tariffs, there was frantic effort to dissuade such shifts. This was done by contractual arrangements between the industrial firms and water authorities for the firms to continue consuming an agreed amount of water in return for a waiver of sewer charges.*

The above distortion was encountered because for most of the urban water authorities, the sourcing of ground or surface water by industries also represents foregone revenue since switching of water sources is feasible. There is no clear mechanism for dealing with this. Some of the water authorities (in Nairobi and Nakuru) see the need to impose a sewer charge on groundwater since the wastewater is discharged into municipality sewers, but enforcement of the sewer charge is still defective and unenforceable. This is because in most of industries covered, the captive water is not metered, making it impossible to impose an appropriate sewer charge. Most of the towns (Kisumu, Eldoret, Nairobi, Nakuru and Thika) do not impose any charge at all. Kisumu and Eldoret are complacent to this need the officials do not see the need for a sewer charge. None of the urban water authorities had the necessary capacity (officers specifically assigned to groundwater monitoring) to conduct required enforcement on the industries, hence, all the technical matters in relation borehole use are referred to the MENR, where the ultimate regulatory mandate lies.

> *It is apparent that the above incentive structure deliberately encourages consumption of ground and surface water by industries. Such a flawed incentive structure could be streamlined through proper regulatory mechanism for ground and surface water. The effect of the prevailing ground/surface water enforcement is that they render tariffs adjustment for industrial consumers defective.*

5.7 Conclusion

In this chapter we have discussed the institutional framework for water resources management in Kenya. There are a number of institutional issues that are relevant to existing water sourcing structure by industrial firms in Kenya. The first issue concerns the capacity of the water authorities to enforce pricing and regulation on the public water use. If the enforcement of water tariffs is weak, then the effectiveness of pricing as a policy instrument for industrial management may be severely limited. The second issue relates to conjunctive use of ground, surface (river) and public water sources by industries (see figure 4.1 in chapter 4). Access to the three sources by industries imply that any price (cost) increase in one source would lead to shifts to other alternative sources since in most cases they are substitutes. This raises the question of the institutional arrangement to deal with excludability i.e. how successful are the water authorities in controlling access to these captive sources. Lack of effective control may render the tariff increases for public water supply less effective in inducing water conservation behaviour among industries. These two issues are pertinent to the need for the design of a comprehensive institutional arrangement to cater for all industrial sources if the water efficiency is to be achieved. Our discussions suggest that regulatory and coordination structures for management of publicly and privately supplied water exist in Kenya. However they function poorly due to overlapping responsibility. The first problem arising from the existing institutional arrangement is that the Ministries of Environment and Natural Resources (Water) (and to some extent Ministry of Local Government) have maintained the sanctity of certain regulatory functions on water management. These functions that include ground and surface water management (and water tariff approvals in the case of Ministry of Local Government) have been maintained even when the tasks exceed the capacity of these Ministries to deal with. One of the flaws in the institutional arrangement has been an attempt by the Ministries of Water and Local Authorities to create capacity at the national level to deal with the enforcement problems at the local level instead of delegating such functions. As a result, excludability (common property nature) required for ground and surface water management cannot be maintained. As a rule, national governments should not implement tasks that can be done more efficiently or effectively at lower government levels, although they should ensure that these tasks are executed (subsidiary principle). Experience with water management calls for "decentralising water management to the lowest appropriate administrative level" (Alacåzar et al, 2001). On the other hand the Local authorities are themselves very poor water service managers, and this raises a question on their ability to take on additional responsibility of managing ground and surface water within their jurisdiction. Secondly, because of widespread conjunctive use of public and privately supplied water by industries in Kenya, a pricing framework for groundwater and surface water abstractions is needed. Renzetti & Dupont (1999) suggest that the introduction of abstraction charges that have both an annual fixed component related to "reserved capacity" and monthly charges related to actual use can have the potential to conserve ground/surface water while not impacting significantly on the costs of industry. In the next chapter, we examine the use of water by industries Kenya.

Notes

[1] Republic of Kenya,1979. *Development Plan 1979-83.* Government Printer, Nairobi.

[2] It is empowered to make loans to Local Authorities for purposes for which they are authorised by law to borrow and operates through a revolving fund - the Local Government Loans Fund. These resources are obtained from an initial grant from the Government, loans voted to it in the Development Appropriations, deposits by authorities, loan repayments and its annual surplus of income on revenue account.

[3] We have discussed pricing issues under policies in chapter 8. One issue that is clear is that declining tariff structure (i.e. in Nakuru) could not be expected to encourage any form of conservation. Yet Nakuru is one the towns worst hit by water crisis. The extent of groundwater use in Nakuru is much higher than other towns in Kenya.

[4] Over 50 percent of the industries covered were sourcing their water from both public and captive sources within urban areas.

[5] In the current study, I estimated that on average each firm uses up to $580m^3$ of water daily directly from ground or river sources. Most of them are doing so without following the requirements. Records at the Ministry showed they had not acquired the water permits.

6 Industrial Water Demand in Kenya: Eccentric Behaviour Among Firms?

6.1 Introduction

In this chapter (6), we analyze industrial water consumption behavior based on the empirical data collected from the Kenyan manufacturing firms in five urban areas (Thika, Nairobi, Nakuru, Kisumu and Eldoret). Our broad goal is to capture quantitative response and the efficiency implications of water tariffs currently employed by the water authorities. We do this by estimating the short-run price elasticity. We also examine case studies involving changes in water consumption behavior by four firms and examine the extent to which water pricing was the motivating factor in their change of behavior. We do not attempt to identify an optimal water tariff, instead, our goal is to characterize the effect of existing water pricing policies on industrial firms. The chapter is organized as follows: In section 6.2, we present our analytical framework for industrial water demand. In section 6.3 we discuss econometric modeling of industrial water demand and the estimation technique, while in section 6.4 we discuss the water price variable and the problem it poses in industrial water demand estimation; section 6.5 contains a description of the main features of water pricing in Kenya. Section 6.6 provides an overview of firm characteristics in Kenya and how they inform our analysis. Section 6.7 is on the data analysis based on a comparison of econometric results and case studies, while in section 6.8 we provide a summary and conclusion.

6.2 Analytical Framework for Industrial Water Demand

Our analytical framework for industrial water consumption proceeds from the traditional economic analysis depicting firms as rational economic units whose primary objective lies in profit maximization. In the process of industrial production, each firm chooses from a given list of factors as inputs (x_i) in a transformation process in order to create consumption commodities as outputs. Demand is assumed to be ultimately derived from the producer's goal to maximize profits by optimally choosing the amount of inputs to be used.

If we let $X_k^j \geq 0$ be the quantity of k inputs (factors) used by firm j; then there is in turn, the *factor plan* by this firm (j) in order to produce output q;

$$X^j = \lfloor x_1^j x_2^j ....x_k^j \rfloor \text{ listing j's } ....6.1$$

selection of k factors it uses in production. Where x_i's are firm j's factor inputs. Because resource use and environmental regulations are often applied to industrial processes and are applicable to plants, the appropriate unit for our analysis appears to be the plant and not the firm (we shall however use both terms interchangeably to mean the same thing).

On the output side, it is convenient to assume that each firm j produces just one good (commodity) which is measured in quantity by denoted q^j. A *production plan* [$\mathbf{q}^j\mathbf{x}^j$] for the firm is a vector associating an output level **q**, with a *factor plan* **x** for firm j (Krouse, 1990). The *technology* of the firm $f(\cdot)$ is, in turn, described by the feasibility set of such production plans [$\mathbf{q}^j\mathbf{x}^j$]. Not all the technically feasible production plans given by f(q,x) are of interest for the firm, for some may require greater factor quantities to produce a given (or smaller) output than others.

Suppose a firm to have a production technology $f(\cdot)$ depending upon non-water inputs $x_n = (n_1,....n_H)^T$ which may include capital, labor, land, and other resource inputs, with input prices $P_n = (P_{n1},.....P_{nH})^T$. If the production also depends upon water $x_w = [w_1,w_2,w_3,.....,w_m]^T$ of various qualities, $w_i = [P_{w1},P_{w2},....,P_{wm}]$, our firm's production technology can be summed as follows:

$$Q = f(x_n, x_w; P_{n,w}) \qquad ....6.2$$

A representative manufacturing firm **may wish** to choose its input levels (including all facets of its water use) to minimize its cost of production. Cost minimization assumption is important here because it underlies the firm's response to changes in the price of water. Without this assumption, we could not possibly expect firms to respond to water tariffs changes. This behavioural tendency implies that the firm's productive technology may be represented by its cost function:

$$C(p_{1n}, p_{2n}, ..., p_{Hn}, ..., p_{1w}, ..., p_{Mw}, q) = Min \sum_{i=1}^{H,M} p_{(in,iw)} X_{(in,iw)} \qquad ....6.3$$

where, p_{in} and p_{iw} are prices for the non-water inputs X_{in} and water inputs X_{im} respectively; and H is the total number of non-water inputs and M is the total number of water inputs, given that:

$$f(X_{1n}, ..., X_{Hn}; X_{1w}, ..., X_{Mw}) \geq q \qquad ....6.4$$

where the Xi and pi are input quantities and prices, respectively; q is the exogenously determined level of output, and $f(\cdot)$ is the production technology.

It is frequently the case that only observations on a subset of the firm's inputs is available. The data sets to be used in this study, for example, focus on water use but not on all the other inputs in the production technology. In such a case, it is necessary to assume that the productive technology is **separable** in its inputs (Chambers, 1988). In particular, a firm's technology is said to be *weakly separable* in the cost function and can be rewritten in the following way (where n, w are the separate cost functions):

$$C(p_{in}, p_{iw}, ..., p_{iH,iM}, q) = C(C_n(p_{in}, q), ..., C_w(p_{iw}, q), q). \qquad ....6.5$$

where, C_n and C_w are non-water and water cost functions respectively; P_{in} and P_{iw} are the non-water and water input prices. In other words, the total cost function is composed of several sub-cost functions, each of which depends only on its own price or subset on the input prices. Under the above separability assumption, $C_{iw}(P_{iw}, q)$ becomes the firm's water use sub-cost function and P_w is a vector of water use prices which may include the unit prices of intake (P_{pub}), treatment (P_{trt}), recirculation (P_{rcr}), captive (P_{cap}) and discharge (P_{dis}):

$$C_w(p_w, q) = C_w(P_{pub}, P_{cap}, p_{trt}, p_{rcr}, p_{dis}, q). \qquad ....6.6$$

Thus the firm's objective function above is reduced to minimizing the total cost of handling water, including the purchase of the water, the water treatment, exercising conservation options, recycling and wastewater treatment and wastewater disposal.

From our fieldwork data, analysis it is not possible to separate the various components of water costs and prices as indicated above since firms do not distinguish the various cost components such as treatment (P_{trt}), recirculation (P_{rcr}), and discharge (P_{dis}). However, it is possible to dis-aggregate sourcing into public and captive with the respective prices as P_{pub} and P_{cap} (we do not distinguish between borehole and river water, instead we assume that they are the same). Thus our cost function becomes:

$$C_w(p_{pub,cap}, q) = C_w(p_{pub}, p_{cap}, q). \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.7$$

There are two implications for adopting the above cost function. The resulting equation represents the firm's production technology g_i, where we isolate water use and water costs by making our analysis depend only on the prices entering into the vectors $P_{pub,\,cap}$. Result of the steps is that, the firm's demand for water can be expressed as a function of its level of output and the vector of input prices as follows:

$$X_w = g_i(p_1, p_2, \ldots, p_M, q) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.8$$

where,

X_w ≡ demand for water,

q ≡ level of output,

P_i ≡ other input prices,

P_{in} ≡ price of water intake,

P_{trt} ≡ price of treatment,

P_{rcr} ≡ price of recirculation,

P_{dis} ≡ price of wastewater discharge (sewer charge),

P_{pub} ≡ price of public water (municipal),

P_{cap} ≡ price of captive water (borehole, river)

C_w ≡ cost of water,

P_w ≡ vector for price of water,

M ≡ number of water inputs,

N ≡ number of non-water inputs

The response of the demand for water to changes in prices and output can be derived from the conditional demand function. One measure of interest here is the *own-price-elasticity of demand*, that is, the percentage change in the demand for water x_w in response to the percentage change in the price of water p_w:

$$\eta_w = p_w/x_w.\delta x_w/\delta p_w$$

where η_w is price elasticity of water demand; p_w price of water; x_w is the volume of water consumed; δx_w is the change in the volume of water consumed; δp_w is the corresponding change in the price of water. Economic theory dictates that the own-price-elasticity of demand must be non-positive ($\eta_w \leq 0$).

6.3 Modeling and Estimation of Industry Water Demand

6.3.1 An Econometric Water Demand Model

Even though the estimation of industrial water demand functions are based on production functions, the necessary data for the estimation of production functions or demand functions for inputs such as labour, capital, energy and chemicals are rarely available to water agencies (Stone and Whittington, 1984). In our case, we had annual data for labour inputs and firm output while water consumption was available on monthly basis. Thus, we could not estimate equation 6.8. Prices for captive sources of water were not available though the mere knowledge ownership of a captive source was a useful variable in formulating our demand equation. Information (or lack thereof) rather than theory has constrained the choice of our model structure. The equations employed in our study to estimate the demand function follows those developed by other studies discussed in chapter 3 (Renzetti, 1992, Nieswiadomy and Molina, 1991). The relationship between industrial water use in its fundamental form and other factors is as follows:

$$X_{wt} = \sum_{t=1}^{T} \beta_t Z_t + \quad _t \qquad \text{………………….6.9}$$

where X_{wt} is volume of public water consumed at time t, Z represents a number of variables considered relevant for analysis; t is time and _ is the error term.

A generalized model 6.9 can be developed in a number of different directions with no fundamental loss of generality. For example a demand function used in our analysis is a dynamic adjustment model a la' Nieswiadomy and Molina (1991) (Dynamic in the sense that we have a model containing a lagged dependent variable i.e. the previous month's water consumption):

$$\ln X_{wt} = \alpha + \beta \ln X_{wt-1} + \beta_2 \ln MP_{wt} + \beta_3 DOwn + \beta_4 \ln(\frac{AP_{w,t-1}}{MP_{w,t}}) + \varepsilon_t \qquad \text{.....6.10}$$

Using the above Niewiadomy and Molina (1991), we have introduced modifications to cater for firm-specific variables (see Hsiao, 1986, p:50) a la' DeRooy (1975) in our experiments to cater for technological differences between firms which affect input-output ratios, particularly when data come from firms with markedly different products and ages of capital stock. Our final equation is stipulated below while the model adopted is of a log-linear form so that the coefficients are price elasticities. Experiments were conducted for (i) industrial sectors (ii) four urban locations, and (iii) sourcing options.

$$\begin{aligned} \ln X_{wt} &= \alpha + \beta \ln gX_{wt-1} + \beta_2 \ln MP_{wt} + \beta_3 DOwn + \beta_4 \ln(\frac{AP_{w,t-1}}{MP_{w,t}}) + \\ &\beta_5 Sector1 + \beta_6 Sector2 + \beta_7 Sector3 + \beta_8 Sector4 + \beta_9 Sector5 + \varepsilon_t \end{aligned} \qquad \text{........6.11}$$

where:

X_{wt} = quantity of water demanded in *t*th month

MP_{wt} = marginal price of water in *t*th month

*D*Own = dummy variables on water restrictions and ownership (1=ownership of captive sources i.e. borehole, rivers; 0=otherwise).

Dsector*i* = dummy variables for the water using sectors (five broad sectors identified in our analysis: 1=food; 2=Wood Products and Others; 3=Textile; 4=Leather and Products; 5=Paper).

$AP_{w,t-1}$= Average water price (includes all fixed charges for water and sewerage).

$AP_{w,t-1}/MP_{i,t}$= Ratio of lagged average monthly water price of *i*th firm to current marginal price of water.

Z*t* = A vector of all the exogenous variables in the study.

6.3.2 Equation Estimation Technique

The two stage instrumental variable estimation technique used in this analysis is analogous to the one used by Hausman and Taylor (1981) in studies of labour supply, Terza (1986) for electricity and by Schneider et al (1986), Nieswiadomy and Molina (1989), and Barkatullah (1999) in water demand studies. The main reason to adopt this approach for the analysis is that it gives consistent parameter estimates in the presence of endogenous prices and therefore improves the reliability of estimates compared to ordinary least squares. It is the most common technique implemented in the studies of water demand analysis [Henson (1984); Terza (1986); and Barkatullah (1999)].

There are two stages involved in the estimation. In the first stage, the water demand X_{wt}, is estimated on the set of actual marginal prices that each industrial firm faces:

$$\hat{X}_{wt} = f(P_{wt}, Z_t) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.12$$

where:

$\mathbf{P}_{it}$ = vector of prices corresponding to the exogenous quantities

$\mathbf{Z}_{it}$ = vector of exogenous variables used in the analysis.

The predicted water consumption estimated in stage 1, X_{wt}, is used to calculate the predicted marginal price (MP_{iv}).

$$M\hat{P}_{IVwt} = f(\hat{X}_{wt}) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.13$$

In stage 2, the predicted marginal price is used in the demand model below to estimate water consumption. Additional exogenous variables are introduced in the second stage i.e. dummy for

$$X_{wt} = f(M\hat{P}_{IVwt}, Z_t) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.14$$

sector, captive sources, locations, etc.

The basic regression model for our panel data set is

$$X_{wt} = \hat{Z}_t\beta + \upsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.15$$

The random effects estimator is based upon the following decomposition of μ it:

$$\mu_{it} = \varepsilon_i + \lambda_t + \eta_{it}$$

where, ε_i is the individual effect, λ_t the time effect, and η_{it} the purely random effect.

Roughly speaking, two issues have been raised in the literature regarding whether, λ_t and η_{it} should be treated as random or as fixed for a linear static model (Hsiao, 1986:72). However, if lagged dependent variables also appear as explanatory variables, the maximum—likelihood estimator (MLE) under the fixed-effects formulation is no longer consistent in the typical situation in which a panel involves a large number of individuals such as our case.

Information on monthly water consumption mainly covers the period 1996-2000. Part of this information was obtained from Local Authorities billing records while others from firms. For some of the plants, proper records on water transactions are available directly. Historical experience, case studies on water consumption was corroborated through interviews - guided by open-ended questionnaires - with company executives and plant visits (observation). In some cases, the initial interviews were supplemented by follow-up visits to obtain a better perspective on the changes in company water and wastewater strategy over time. In addition a lot was learnt about the industries through interviews of water managers in the urban locations.

Only a few studies have used pooled cross-section and time series data. These include Lyman (1992), Nieswiadomy and Molina (1989), Moncur (1988), Hanke and de Mare (1982) and Billings and Agthe (1980). Pooled data analysis combines both cross-sectional and time-series data into one analysis. The principle advantage of this is that less data is required. However, the limitations of both cross-section and time-series analysis are carried through to pooled data analysis. In the next section we discuss how we have dealt with some of the issues.

6.4 The Water Price Variable and the Time Trend

6.4.1 Dealing with Price as a Variable

One of the key debates in the literature of water demand analysis is the choice and specification of the price variable in the case of two-part and non-linear pricing, that is, where the unit price of water is itself a function of consumption. The correct specification of the price variable in the case of increasing (or decreasing) block tariffs has been the subject of a major debate in the literature (which is still ongoing).

Under both increasing and decreasing price structures, however, the final tariff rate is still a linear function of the gross water consumed X_{wt} as indicated in the question below. Introducing this dimension creates complication in modeling industrial water demand. First it creates specification problems since we have to estimate at least two simultaneous equations with a simultaneity bias. Secondly the identification (rank and order) conditions for the new equations cannot be met.

$$P_{wt} = \alpha + \beta X_{wt}^{\gamma} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6.16$$

where, P_{wt} and X_{wt} are price of water at time t and volume of water consumed respectively at time t.

In an attempt to overcome these simultaneity problems (particularly prevalent when ordinary least square regression is used), other estimating approaches have been used, including instrumental variables (see Deller *et al*, 1986, Agthe *et al*, 1986 and Jones and Morris, 1984) and two- or three-stage least squares (see Nieswiadomy and Molina, 1989, Renwick, 1996). However, Saleth and Dinar note that these corrections for simultaneity could themselves lead to other equally serious econometric problems, for example, multicollinearity in two- and three-stage estimation techniques (1997: 19).

Therefore, it appears that there is no regression technique that solves the simultaneity problem satisfactorily. Nevertheless there is a general preference for Nordin's method with the use of instrumental variable and two-stage least squares techniques in the literature, despite the limitations and potential bias of these techniques (see, for example, Nieswiadomy and Molina, 1989).

The appropriate specification of the price variable is further complicated in the case of industrial consumers. This is because of the costs of water intake are typically a small fraction of the total costs of water use. Costs related to pollution control are typically much higher (Stone and Whittington, 1984: 62). One solution may be to include a second price variable if wastewater effluent charges vary as a function of the quantity of effluent discharged. However, the cost of pre-treatment or circulation may also be important and affect water use. In this context the issues of simultaneity may be compounded because some of the unit costs may be simultaneously determined and others not. Another confounding factor may be the application of different effluent standards to different industrial premises (based on location).

Prior to the 70's, most of the studies that estimated water demand under non-uniform pricing structure used average price (AP) as the only explanatory price variable [see Metcalf (1926); Gottlieb (1963); Bain et al (1966); Young (1973); Gardner (1977); Foster and Beattie (1979); Barkatullah (1999)]. Most of these studies calculate the average price per consumer as Total

Bill/Total Consumption and argue that consumers respond to the average price rather than marginal price because they have more accurate information about their total bill than about the block nature of pricing. These earlier studies did not account for any intramarginal effects caused by block structure pricing.

Taylor (1975) introduced the concept of a "second price" (Billings and Agthe 1980), along with the marginal price (MP). He suggested that a single price variable such as the average price or marginal price is not sufficient – in fact the entire rate schedule should be represented in the demand function. Nordin (1976) who introduced a difference variable often referred to as the rate structure premium (RSP) further developed Taylor's theory. Nordin emphasized that consumers react not only to marginal prices but also to changes in consumer surplus as a result of moving from one block to the other and that these intramarginal effects should be included in the demand equation (Chicoine, Deller and Ramamurthy 1986). The difference variable in terms of consumer surplus is described as the difference in the consumer surplus under marginal pricing and the consumer surplus that is actually experienced by a typical consumer. In the case of an increasing (decreasing) block tariff, the consumer surplus is larger (smaller) than if units were purchased at the marginal price (Billings and Agthe 1980). The rate structure premium (RSP) is also called the difference variable because it is the difference between the total bill and what the bill would have been if the water quantity (X) were consumed at the marginal price (MP). The relationship between the rate structure premium and the marginal price can be specified as follows (Shin 1985):

$$AP = \frac{Bill}{X} = MP + \frac{RSP}{X}$$

$$\text{RSP} = (\text{AP-MP})^*\text{X}$$

In response to the failure of past empirical research to validate the Taylor/Nordin theory, Shin (1985) argued that the cause might be price illusion or incomplete information concerning the full budget constraint (in our case *resource*). Shin introduces a perceived price variable, in addition to the marginal price in his "price perception model." The price perception variable is a function of the average price (AP), the marginal price (MP) and a price perception parameter. He examines the price information problem that consumers face. The empirical results of the Shin price perception model suggest that consumers respond to average rather than marginal price when facing a decreasing block rate structure. Niewswiadomy and Molina (1991) also tested the price perception model for an increasing block tariff structure. They conclude that water consumers react more to marginal price than average price. Whether consumers respond to average or marginal price remains debatable, because Williams (1985) using similar data to Shin (1985) finds that consumers respond to marginal price.

6.4.2 Average Versus Marginal Prices

The present study assumes no price illusion. It develops a demand model that includes the marginal price (rather than average price) with other explanatory variables. This approach was taken after several experiments we conducted to determine the relationship between marginal and average price for different towns. We investigated the problem of endogeneity using the closeness (between the average price and the marginal price; and the water charge and the average price) defined by their coefficient correlation. If the average price is very close to the marginal price, it means that the average price does not depend much on the quantity of water used and so there is no problem of endogeneity. We found the following: In Thika (-0.311➔0.718), Nairobi (0.369➔0.695), Nakuru (-0.792➔0.290), Kisumu (0.841➔0.267) and Eldoret (-0.138➔0.835)[1]. For Nakuru and Kisumu municipality, the high coefficient correlation between marginal price and average price suggest that endogeneity is not a problem. For Thika, Nairobi and Eldoret, endogeneity seems to be a problem. However we have also computed the correlation between water charge and marginal price that appears to be strongly correlated for the three towns.

We have addressed the endogeneity problem in two ways. First, following Jones and Morris (1984), and Renzetti (1988) we estimated an instrument for the price of intake water by determining the marginal price at each firm’s observed level of consumption and then regressed this price on a set of variables summarizing the information contained in the water rate schedules. This procedure addressed the simultaneity bias but created a heteroscedasticity problem as the estimation of the price instrument equation draws observations from different block rate structures.

6.4.3 Time of Response and Time Trend

It is generally felt that there are seasonal patterns in economic time series that are not caused by calendar time or the climate, but also the behavior of firms are somehow reflected through seasonal variation (Frances and McAleer, 1999). Many economic time series are trended, and there seems to exist a consensus that these can best be described by econometric time series models with stochastic (or unit roots). An examination of the graphs of key economic variables indicates that several economic variables tend to move together (in the case of our data tariffs, water consumption, and output levels), that is, they seem to have one or more common trends. Nevertheless, our experiments showed that by introducing a trend in our econometric equations, time trend distorted rather than improved the results.

6.5 The main Features of Water Tariffs Rates in Kenya

6.5.1 The Composition of Water Prices

The cost of using water involves charges for both water supply and wastewater disposal. The commodity charge for both water and sewer is composed of a minimum charge followed by five increasing (or declining) block rates. The real price of water (defined here as the water charge) can vary substantially, both cross-sectionally (across different towns) and temporally. The marginal cost of water is calculated to be equal to the sum of both water and sewer rate blocks corresponding with annual average monthly usage per water account.

The water services in all the urban areas are subject to two-part tariffs, involving fixed and volumetric components. The variable part is either decreasing-block or increasing-block rate. There are also sewer and connection charges. Unlike the other four urban areas studied, the water tariff structure in Nakuru town is a declining block rate. All the urban areas differentiate 5 blocks with lowest block having consumption up to 10 m^3. There are different ideological positions taken when deciding on the minimum or fixed charge[2]. It is apparent that the underlying objective for water tariff measures is to raise some revenue for the Local Authorities rather than act as a policy instrument or inducement against wasteful consumption. The metering of water consumption is a prerequisite for the application of water pricing and industries are especially monitored in all the urban areas even when the water meters are defective in some case. Because they are a critical source of Local Authorities (or water company) monthly revenue, industrial water services system are always metered and regularly billed in Kenya. In some small towns such as Eldoret, the huge bills (in excess of Kshs.50,000) are hand-delivered while the cheques for industrial water users are also collected in time to pay salaries at the end of the month.

A few firms in Thika town are paying for “pure” sewer charges (based on the approximate volume of sewer discharged) as opposed to the standard sewer charge that all water consumers have to pay for as a proportion of the water consumed. Most firms using water for consumptive processes (i.e. beverage) have the potential for lowering their water costs by paying much lower “pure” sewer charges but they were not aware of the opportunity.

6.5.2 Contract and Negotiated Tariff Rates

There is “selective” application of the official (gazetted) water tariffs in most of the urban areas. In Eldoret town, the industries under the umbrella of Kenya Association of Manufacturers negotiated for a lower tariff structure (below the gazetted tariff) between 1996-1998. The arrangement was later suspended when the Local Authority realized that industries in other urban areas were paying a much higher tariff and that the authority was losing a lot of revenue by giving tariff concessions to the industries. Industries (under the Kenya Association of Manufacturers) in Nakuru town also benefited from special contract arrangements related to water services while they were able to contribute to investment costs in the water provision by the water authorities. At the same time, some firms with own supply sources have made contractual agreements with the public water authorities to consume a minimum quantity of water from a public intake in return for a waiver of sewer charges. These are not written agreements but are geared to supporting the revenue base of the Local authorities.

It is typical that when firms have incurred water bills, often some of them do not pay their bills promptly or in full. They pay long after the water has been consumed. Furthermore, some firms accumulate large unserviceable debts with the water authorities and are notoriously known to default in making payments[3]. It is also alleged that some firms collude with the water officers to have their water bills written-off and new water accounts opened. Furthermore, it is common for the industries to have multiple water meters in most of the urban areas in Kenya. It is argued that having multiple meters provides an advantage to the firms since it leads to a lower per unit charge (the reverse of "bracket creep[4]") than those indicated by the tariff blocks. The above circumstances can make the water tariff less effective as a tool for water resource conservation in industry.

6.5.3 Revision of Tariff Rates

Given the dependence on the water revenues to pay salaries and other financial needs, Local Authorities in Kenya often see the need to frequently revise the water tariffs upwards. These adjustments are usually specific to each urban area and do not occur simultaneously in all the urban areas and often have to be referred to Ministry of Local Government for approval. The water tariff changes were quite rapid between 1990-2000. In all the towns, the increase varied between 6 to10 times their 1990 levels. Except for Nakuru town that has fewer tariff adjustments, the increase in all the others took effect after every 2-3 years.

6.6 Firm Characteristics and Description

6.6.1 Type of Firms Interviewed

The plants covered belong to the following industrial categories: food processing, beverage, textile, pulp and paper, leather and tanning, wood products and chemical products. Overall, the beverage sub-sector comprising large transnational companies are the largest consumers of water in Kenya - see Table 6.1 displaying a summary of monthly water consumption and effluents discharged. The next groups are the leather and textile firms. In these manufacturing diverse processes, the implications for changing water use are radically different. For example for some sectors, there are many easy technical options for firms that use water for non-contact cooling, hence they are likely to be very price sensitive. Pricing on the input side in such industries could lead to large water savings at relatively low costs. If the bulk of the water goes for process related activities, the options might be less clear. For example, it will be necessary to change the process technology to achieve significant savings. These are likely to be expensive and less input price responsive than firms that use water for cooling water options.

6.6.2 Multiple Sourcing of Water by Industries

Our fieldwork revealed widespread conjunctive use of public, surface and groundwater by industrial firms in Kenya. Groundwater and surface water can serve as an important buffer against the uncertainty of public water supply within the urban areas (table 4.1, chapter 4). When public water supply is stochastic or constrained, the management of both groundwater and surface water sources needs to be framed as a matter involving the joint use of a substitute resource (Provencher, 1995:510). However, groundwater and surface water use in Kenyan urban areas remain largely unregulated (details are discussed in chapter 5)[5]. Firms that have self-provision facilities (groundwater or pumping from a river) are not subjected to water tariffs, but occasionally, to a limited form of charges at the time of application for a permit. The costs of installing and operating these facilities have been the principal “regulators” to groundwater and surface water use. Where the costs are low, excessive quantities of water can be used. This also implies that firms have an incentive to overexploit groundwater and rivers when water tariffs for public sources appear to be high. Indeed, where regulation is weak, groundwater and surface water is perceived by firms as common property resources. Firms using these water resources may execute myopic pumping decisions; that is, each firm pumps water until the current marginal net benefit of groundwater (surface water) equals zero. This model of behavior has been observed in most empirical studies (Provencher, 1995:507).

About 60 % of the textile firms interviewed depend on water from captive sources i.e. mainly groundwater. Several textile firms also have multiple water meters (water accounts) for public sources of water. For 3 of the industries groundwater was the main source of process water even though a public connection was also available. Indeed one firm has 6 boreholes - the largest number of bore holes a single industry has in Kenya and it also has the lowest consumption from a public source in the textile sector. Much of the surface and groundwater in Kenya is not used for the actual industrial processes, but for substantially non-consumptive uses such as non-contact cooling and cleaning (i.e. in tanneries). The remainder of the water is usually used for process-related items that are sensitive to the process technologies employed. We provided a summary of the sourcing patterns in different urban areas and sectors in Chapter 4, table 4.1.

6.7 Data Analysis and Results

We pool time series and cross sectional data for the period 1990-2000 covering 53 plants in the industries as summarised in table 4.1. As outlined in the model, all variables are in log or semi-log form[6]. All estimation and testing is done using the package Regression Analysis of Time Series (RATS) version 5.0. With 5 years (1996-2000) of monthly observations for each cross-section series, we introduce a substantial time dimension that allows us to exploit current results in the time series and dynamic panel literature. Data for 1990-1995 mainly informs us about historical factors that explain behaviour of firms. In this section of our work we display the results of our econometric estimates and provide an account for the same using historical information. We first discuss the aggregate levels estimates followed by results from specific categories. We have reported both the fixed and random effect estimates of our equations. This is because there are advantages and disadvantages to each treatment of the individual effects. A fixed effects model cannot estimate a coefficient on any time-invariant regressor, such as a dummy for sourcing of water etc., since the individual intercepts are free to take any value. By contrast, the individual effect in a random effects model is part of the error term, so it must be correlated with the regressors (Hausman and Taylor, 1981).

6.7.1 Analysis at the General or Aggregate Levels

We have summarised our field information on industrial water consumption in Table 6.1.

Several features of water consumption are important for our analysis. First, water intensities vary across firms and across sectors. The Beverage Industries (food processing) sector is the most water intensive in Kenya, followed by Leather and Textiles. Our aggregation also shows that the volume of wastewater discharged by industries in Kenya is very high, constituting over 60% of the water consumed. Wastewater from general industries is often assumed to be 80% of the projected water demand in Kenya (JICA, 1992). However, we have computed conservative estimates to conform to the realities of our field survey. There is low wastewater recycling rate among firms as wastewater discharges are mostly in excess of 50% of total consumption. This suggests great potential for water conservation among industries.

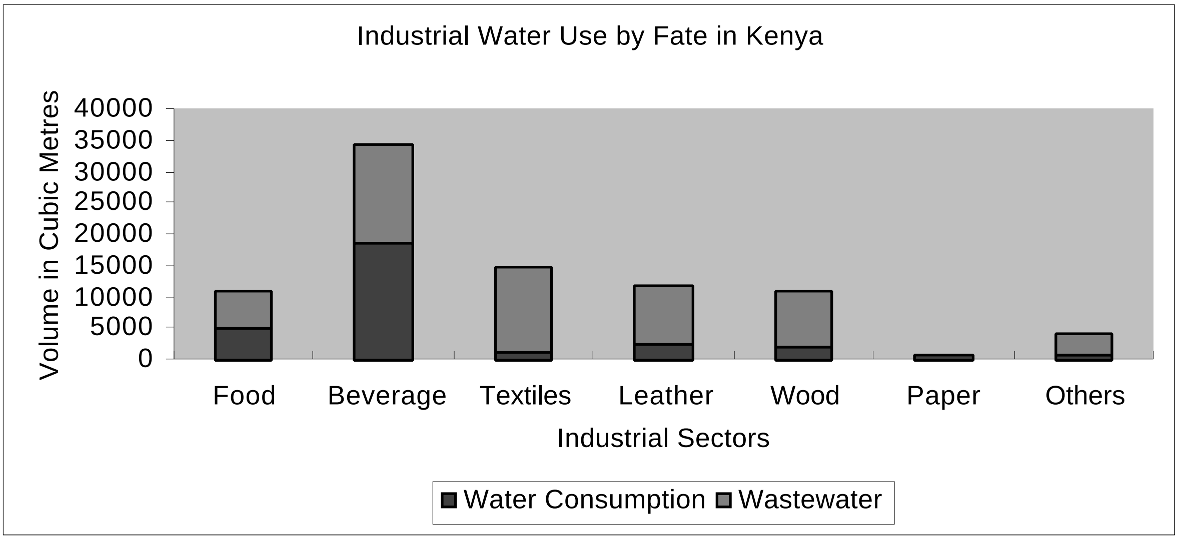
Table 6.1:Average Monthly Water Consumption and Effluent Discharged

Sector	Thika		Nairobi		Nakuru		Kisumu		Eldoret		**Average**	
	Monthly Water – M^3	Waste water per M^3	Monthly Water – M^3	Waste water per M^3	Monthly Water – M^3	Waste water per M^3	Monthly Water – M^3	Waste water per M^3	Monthly Water – M^3	Waste water per M^3	Monthly Water – M^3	Waste water per M^3
Food P.	2125	0.40	17290	0.30	--	--	4500	0.90	20340	0.50	**11064**	**0.53**
Beverage	60000	0.75	50000	0.65	500	0.20	46000	0.45	15000	0.20	**34300**	**0.45**
Textiles	23250	0.95	5355	0.95	11400	0.80	--	--	20000	0.95	**15001**	**0.91**
Leather	23350	0.80	400	0.80	--	--	--	--	--	--	**11875**	**0.80**
Wood	--	--	--	--	--	-	--	--	11048	0.80	**11048**	**0.80**
Pulp&P.	1400	0.15	790	0.15	--	--	--	--	500	0.15	**897**	**0.15**
Chemical & Others	6070	0.90	1014	0.60	--	--	--	--	5600	0.90	**4228**	**0.80**
Average	**19366**	**0.64**	**12475**	**0.56**	**5950**	**0.50**	**25250**	**0.65**	**12080**	**0.58**	**12630**	**0.63**

Source: Own Survey Data

A graphical illustration of the water consumption magnitudes involved is given in figure 6.1. From a policy perspective, the figure gives some indication of where the potential for industrial water savings lie. For example, in the pulp and paper industries the bulk of the water is used in "process" with only a very small fraction going to wastewater. This suggests that the potential for recycling is nearly exhausted and further savings can be attained through change of production technology. The situation in the other industries is radically different with the bulk of the water going to wastewater discharges. The implications for pricing can also be radically different. Firms that generate large volumes of wastewater might have easy technical options for wastewater reduction that may not be cost-sensitive, hence, pricing and regulation on the input side in these industries could lead to large water savings at relatively low costs.

Figure 6.1: Average Monthly Water Consumption and Wastewater Discharged



Note: (1) Water consumption = recycling + consumptive + losses. (2) Wastewater=discharges. (3) Total consumption = Water consumption + wastewater. Source: Own Survey Data

Econometric Analysis

During our experiments, various distortionary effects were encountered with the use of multiple dummies for sector specific technologies and the price perception variable. One general problem with the introduction of the specific individual firm production technology as a dummy is that the variable captures other firm attributes such as operational styles, and effects of omitted variables that have nothing to do with firm specificity. Part of these is absorbed into the intercept term. Thus, firm specific dummies have eventually been dropped from our reported results displayed in Tables 6.2. Overall, our econometric model appears to capture well the information on pricing, sourcing patterns, and trends in water consumption. Our results show that:

(i) previous levels of consumption are an important or significant explanatory variable to current levels of industrial water consumption. This finding points to the thesis that firms are or may be tied to "routinized" way of production where current water usage patterns are more or less based on previous styles of use. Nevertheless, the results also imply that unless water tariffs are sufficiently high, firms will not respond in a significant way at the aggregate level.

(ii) estimated short-run price elasticity is negative [(-6.5033), (-6.1381)], however it is not significant. This result is not surprising given the weak enforcement of water tariffs among the local authorities. Furthermore, the estimated large volumes of wastewater discharged by industries also support the weak elasticity.

(iii) existence of ownership or a captive source (such as borehole, river) does not influence industrial firms' water consumption patterns in a significant way. Furthermore, the coefficient of captive-ownership is positive when our theoretical anticipation showed that it should be negative[7].

We find that the price elasticity estimates for industrial water demand are substantially larger than those of other studies by Schneider et al (1991), -1.162; Renzetti (1988), -0.12 to –0.54: Williams and Suh (1986), -0.438; DeRooy (1974), -0.354 to –0.894; Elliot (1973), -0.734; or Turnovsky (1969), -0.473 to –0.839. Most of these estimates are however not significantly different from zero at the 5% level. Theoretically, the relatively high price elasticity of industrial water demand reveals that industrial users are prone to switching to alternative source of supply or recycle water in the production process in adjustment to changes in prices (Williams and Suh, 1986). However, such a thesis is not supported by the coefficient of captive ownership in our results. Results from our aggregate estimates are, therefore, inconclusive relative to the effects of marginal price of water on industrial water usage in Kenya.

Table 6.2: Results of the Aggregate Model for the entire economy

Panel Regression	Fixed Effects		Random Effects	
Variable	Coefficient	T-Stat	Coefficient	T-Stat
Constant	18.866	1.609e-04	14.571	0.040
LLVOL	2.762	0.552	3.093	0.619
LNPRICE	-6.503	-0.650	-6.138	-0.618
OWN	862.432	0.005	862.384	1.704
Dependent Variable	LNVOL			
Total Observations	2176			
Usable Observations	1717			
Skipped/Missing	459			
Degrees of Freedom	1666			
Centre R^2	0.989			
Uncentred R^2	0.989			
Regression F(50,1666)	3042.693			
Significance Level of F	0.000			

Where: LLVOL=log of lagged water volume; LNPRICE=log of price; LNVOL=log of water volume; OWN=captive source ownership; LNVOL= log of water volume.

The distribution of industrial accounts cross-sectionally, coupled with a large variation in water usage over time may have led to the insignificance of the price variable. The changing composition of industrial accounts may have been responsible for much of the variation in the dependent variable, causing the effects of the marginal price of water to be insignificant. Only a much more detailed analysis of individual industrial sectors or firms may lead to a determination of the influence of price on water demand by industry. In the next section, our model estimation is conducted at a disaggregated level.

6.7.2 Demand for Water by sector

The results of our model estimation give a more dramatic picture when viewed from a sectoral perspective. A summary of the estimates is displayed in Table 6.3. The results do suggest that except for the leather products sub-sector, industrial firms in Kenya are sensitive to changes in water tariffs. Elasticity estimates are significant at 5-10% levels of confidence and have the correct signs. In the next sub-section we turn to the discussion of econometric results for the individual sectors.

Table 6.3: Short-Run Elasticity as Estimated from Best Model

3 DIGIT ISIC CODE	SECTOR (1)	Lagged water usage coefficient (2)		Price of water coefficient (short-run elasticity) (3)	
		Fixed	Random	Fixed	Random
311 &313	Food and Beverage Industries	0.7259*	0.7516*	0.4851*	0.0971*
321	Textiles	0.5544*	0.6931*	-0.0113	0.1194
323	Leather Products	-0.4345*	-0.2956*	0.2271	0.0329
341	Pulp and Paper	16.9839	19.1403	-1489.3075*	-1453.7702*
352/351	Wood, Chemical Products/Others	-0.1419	0.0619	-0.2151	-0.0179

Source: Survey data.*Significant at 5% confidence level; **Significant at 10% level.

Pulp and Paper

In all the pulp and paper firms studied, primary activity involves waste paper recycling to make ribbed wrapping, gumming kraft, fluting media, cover paper, liner board, manila envelopes, test liner, m.g. pressings, grey boards, waxed paper, white lined shipboards, fine boards, toilet / tissue paper and packaging materials. Our survey showed wide fluctuations/ variations are experienced in monthly production with similar variations in water consumption (partly due to power rationing and market conditions i.e. demand for products). However in all cases covered, there is widespread similarly in water usage across the firms. Pulp and Paper is the sector most sensitive to water tariff changes – having price elasticity of -1453.7702. We attempt to account for this significant response to water tariffs. Full results are displayed in Tables 6.4 below.

Table 6.4: Paper and Products

Panel Regression	Fixed Effects		Random Effects	
Variable	Coefficient	T-Stat	Coefficient	T-Stat
Constant	5314.786	0.012	5170.386	2.431
LLVOL	16.984	0.276	19.140	0.323
LNPRICE	-1489.308	-2.987	-1453.770	3.047
OWN	2703.145	0.005	2694.202	1.764
Dependent Variable	LNVOL			
Total Observations	239			
Usable Observations	192			
Skipped/Missing	47			
Degrees of Freedom	140			
Centre R^2	0.989			
Uncentred R^2	0.990			
Regression F(51,140)	254.669			
Significance Level of F	0.000			

Where: LLVOL=log of lagged water volume; LNPRICE=log of price; LNVOL=log of water volume; OWN=captive source ownership; LNVOL= log of water volume.

Currently, Pulp and paper industries are only a modest consumer of water and low discharger of wastewater. This is because nearly all the water consumed is utilized in a closed-cycle system. All the firms visited appear to have adopted production technology geared to conservation of water resources. Within the Paper Mills and Allied sub-sector, the highest water intake from public sources is about 1400 m^3/month while the lowest is 160 m^3/month. Consumption is marked by wide water use efficiency.[8] In our study, the most efficient firm consumes only 0.19m^3/tonne followed by another firm consuming 790 m^3/month with efficiency of 0.73 m^3/ton. A third firm consumes 500 m^3/month and uses 9m3 to produce a tonne of output. The least efficient firm uses 33m^3 to produce a tonne of output. The two most efficient firms are located in Nairobi and the least efficient ones in Thika and Eldoret. However, we need to caution that both the Eldoret and Thika firms produce relatively similar products (grey boards), though in all these firms, the primary activity involves waste paper recycling.

> *In the case of Eldoret Paper Mills, since 1990 there had been effort to reduce per unit water consumption in a bid to lower water costs. The investment in water saving practices (vis a viz captive investment) was motivated by several factors. According to the General Manager, the plants' position was made precarious by the fact that captive sourcing of water is not feasible from its current location. The firm is located very far from rivers; secondly, groundwater quality is very poor, making it less viable for any firm to venture*

into groundwater extraction in Eldoret town. The other important factor was that the firm had no alternative option for disposing its wastewater and they had to discharge directly into the municipal sewer and face the sewer charges. From May 1998, The Mill undertook investments to improve its water and general operational efficiency. The capacity to recycle wastewater was improved significantly with an investment of about Kshs835,000 that included the cost of borehole construction and storage tanks for roof catchment water[9]. This led to a dramatic reduction in monthly water consumption by about 75% (from a monthly water bill of Kshs350,000 to about Kshs.75,000 only (1998) and to Kshs30,000 in August 1999). Interviews of both the General Manager, Factory Engineer and Water and Sanitation Company Eldoret further indicate that when water consumption dropped dramatically at the firm, the Municipal Council (the local water authority) was prompted to make several inspections of the firm to confirm that the company had not resorted to illegal means of acquiring water (such as by-passing the water meter or that the water meter was still in good condition – not tampered with)." The decision to and the timing of investment in water saving may have coincided with water tariff changes in Eldoret but was not a direct result of the tariffs implementation after 1995. It was part of the broader and long-term scheme by the firm to improve its production efficiency.

On the other hand, Thika Paper Mills changed ownership and acquired new management in the late 1980s. Water consumption trends by the Thika Paper Mills, also shows a systematic downward trend in water consumption from the Municipality throughout the 1990s from a monthly consumption of about 2200m^3 to about 1000m^3 in April 1998. Where as this shift in consumption has occurred over a period when water tariffs were also being revised upwards in Thika, the main cause for the decline in public water consumption is that there was restructuring by the new managers in order to improve on production efficiency. The firm owns captive water sources – a borehole and pumping machines along the river. These water sources were important when the old production technology requiring large volumes of water was in use. Information on the exact quantities of water pumped from the river by the company are very scant though a survey by the Thika Municipal Council in 1994 showed that the Mills was abstracting up to 600m^3/day. During our visits to the firm, we were informed that recycling of water is nearly 100% and that new water was only being pumped to replace water lost in process i.e. via cooling and evaporation.

The above two firms (Thika and Eldoret) are a classical illustration of how water consumption has changed over time with water tariffs adjustment. In both cases there has been remarkable time-lag (covering several years) in the efficiency improvement restructuring. Several underlying factors catalysed the shifts to lower water consumption:

(i) The two firms were operating is a very competitive market environment in which the individual player could only survive through production efficiency.

(ii) Globally, production technology within the paper sector has changed dramatically over time, thus allowing for significant gains in technology investments to be undertaken in Kenya also.

(iii) In view of the above, the response to water tariffs captured in the sector cannot be justifiably attributed to water tariffs adjustment (above).

Because the pulp and paper industries in Kenya already recycle significant amounts of their wastewater, and because restructuring of technology appear to have been undertaken fairly recently, prospects for attaining further water savings and wastewater regulation appear diminished.

Leather Processing

Our model results for the leather-processing sub-sector are summarised in Table 6.5. The results show that:

(i) ownership of captive source is a significant variable in the sector's water consumption. Of the four firms surveyed, three were abstracting water from rivers and borehole. One firm that did have a captive source is located in the heart of Nairobi's industrial areas where ownership of boreholes by older firms in the same location precludes it from acquiring a permit. The firm had the lowest water consumption level (most efficient) among leather processing plants.

(ii) The issue of contractual arrangements for industrial water usage in Thika might also have contributed to the positive coefficient of the ownership variable.

(iii) Elasticity estimates for the sector are theoretically inconsistent results, and insignificant.

(iv) The current water consumption is negatively related with the previous levels of consumption and it has a significant coefficient.

Table 6.5: Leather and Tanning

Panel Regression	Fixed Effects		Random Effects	
Variable	Coefficient	T-Stat	Coefficient	T-Stat
Constant	9.015	0.021	9.753	6.653
LLVOL	-0.436	-2.529	0.296	-2.067
LNPRICE	0.227	0.443	0.033	0.113
OWN	4.778	3.633	2.568	4.763
Dependent Variable	LNVOL			
Total Observations	147			
Usable Observations	107			
Skipped/Missing	40			
Degrees of Freedom	103			
Centre R^2	0.744			
Uncentred R^2	0.995			
Regression F(50,103)	3.376			
Significance Level of F	0.000			

Where: LLVOL=log of lagged water volume; LNPRICE=log of price; LNVOL=log of water volume; OWN=captive source ownership; LNVOL= log of water volume.

Water Practices in Leather Processing

Leather processing, is a water intensive activity, however there seem to be dramatic variations among the plants surveyed. There are several factors underlying these differences. For example, one of the firms is Nairobi is engaged in contract tanning and is located at the heart of Nairobi's industrial area which is also prone to water shortages. The firm has to pay for water and sewer charges at a much higher rate than all the other firms who have their own captive supply sources. The Nairobi firm has applied for groundwater permit several times but their request has not be approved since several other firms have boreholes within the same locality. The other three firms have the option of pumping water from their own sources and do not pay for sewer services since they discharge directly into Thika River and Nairobi (Athi) river. During our visits to the tannery factories, it was evident that water spillage was a problem in some of the firms – as some of the firms acknowledged, the water spillage was a major source of wastage in the factories. Again, the most common response to this issue was that:

> *"We are to install water meter on all the drums in future. This will ensure correct water usage and advise excess waste. Also repairs are being done now and again to eliminate water spillage."*

Way back in July 1994, a Thika firm conducted an in-house study to try and determine technical options for tanning in a bid to cut down on water consumption. This was done with the help of production consultants whose analysis showed that the company had two options for leather tanning (see these options in table 6.6). By adopting option A it could have been possible for the Thika firm to reduce the daily water consumption by about $500M^3$ - a half of what it pumps from river Thika river daily or improve on the efficiency levels to between 59-110 M^3/ton of output. To date, the company still uses the water intensive option B. As the Technical Manager explained:

> *"The main problem is with power, and also quality: water consumption at the initial stages has significant effect on quality. This has been witnessed especially where you don't wash the materials properly. Note the main areas of water saving are in washes and soaking, which also happen to be the very critical processes in leather manufacturing. This is the main reason of not switching from B to A in our firm."*

One possible explanation why the company has not found it compelling to switch options is because the alternative option is only viable if the company was buying water from a public source or paying for sewer services. However this argument does not hold when we consider that a similar firm in Thika, with the same production capacity was able to undertake the necessary restructuring to improve water efficiency. In any case, both firms have previously benefited from massive technical assistance from UNIDO as opposed to the Nairobi firm that has not received such support. There is awareness among the tanneries regarding the technical options for reducing water consumption. However, these options are not being pursued because of the abundance of cheap supply of water. It is apparent that when the substitute sources of water become more expensive, some firms will upgrade their production technology to consume less water. The Thika firm has decided to wait for the technological options to become commercially viable before they can invest in water-saving technology.

Table 6.6: Tannery Water Options

Alternative A		Alternative B	
Process	Daily Volume-M^3	Process	Daily Volume-M^3
1st Soak	74	Pre-soak	185
2nd Soak	74	Main soak	148
Washings	74	Liming 1& 2	56
Liming	28	Washings	93
Washing	37	Fleshing	13
Fleshing	13	Washing	37
Washing	19	De-liming	9
De-liming	46	Bating	46
Washing	32	Washing	93
Pickling + tanning	37	Pickling + chrome tanning	23
Re-tanning and dyeing	100	Re-tanning and dyeing	100
Sarring	5	Washing	93
Cleaning equipment + floor	50	Cleaning	100
Total water consumption on wet blue production	489	Total water consumption	946

Our explanation to the results obtained for the leather-processing sub-sector is that current water pricing levels and the regulation of captive sources does not provide disincentive to profligate use of water.

Food Processing sub-Sector

In the food-processing sector (including beverage), price elasticity is positive and significant. This is theoretically not plausible. Ownership of captive sources has a positive and significant influence on water consumption.

Table 6.7: Food Processing

Panel Regression	Fixed Effects		Random Effects	
Variable	Coefficient	T-Stat	Coefficient	T-Stat
Constant	-0.819	-0.002	0.805	1.822
LLVOL	0.726	23.885	0.752	25.542
LNPRICE	0.485	4.996	0.174	3.278
OWN	0.714	3.402	0.621	3.129
Dependent Variable	LNVOL			
Total Observations	837			
Usable Observations	611			
Skipped/Missing	226			
Degrees of Freedom	560			
Centre R^2	0.916			
Uncentred R^2	0.994			
Regression F(50,560)	122.376			
Significance Level of F	0.000			

Where: LLVOL=log of lagged water volume; LNPRICE=log of price; LNVOL=log of water volume; OWN=captive source ownership; LNVOL= log of water volume.

Nearly all beverage firms had a captive source while a Nairobi Brewery relies on groundwater as its main source of water. The firms indicated that they preferred self-provision to deal with the stochastic factor in the local authorities water supply. Even though the beverage industry is characterised by little possibility for water substitution since water forms a significant part of their products, in most of the firms covered, more than 50% of the water intake is used on in-house operations such as cleaning/washing. For example, a JICA study in Kisumu Breweries showed that only 10% of the water it consumes is used directly for production. An additional 40% is used for cleaning bottles and containers and needs not to be clean (JICA, 1998). The brewery commissioned a feasibility study for developing their own water supplies. The cheapest option was one of abstraction from Lake Victoria, in which the cost at the facility would have been Kenya Shillings 100 per cubic meter. However since the brewery found the tariff rate to be relatively low, they entered into a contract with the Local Authority to guarantee their supply. The JICA report shows that more than half of the water consumed by the brewery is used wastefully (used for general purposes) since it needs not be treated at all and could be sourced from groundwater, which the firm finds expensive to operate (JICA, 1998).

Wood and Other Sub-sector

In the other sub-sector category, we have a mixture of industries comprising the Chemicals & Petroleum Products. The composition is constituted by plastics industry, soaps, cosmetics and other toiletry preparations. Wood, chemical and other sub-sectors also have very high proportions of wastewater i.e. 80 percent each, suggesting a huge potential for water recycling.

Table 6.8: Wood Products and Others

Panel Regression	Fixed Effects		Random Effects	
Variable	Coefficient	T-Stat	Coefficient	T-Stat
Constant	10.508	0.046	7.874	8.490
LLVOL	-0.142	-1.621	0.062	0.824
LNPRICE	-0.215	-1.214	-0.018	-0.119
OWN	-2.990	-5.691	-1.846	-4.673
Dependent Variable	LNVOL			
Total Observations	239			
Usable Observations	180			
Skipped/Missing	59			
Degrees of Freedom	128			
Centre R^2	0.941			
Uncentred R^2	0.997			
Regression F(51,128)	40.172			
Significance Level of F	0.000			

Where: LLVOL=log of lagged water volume; LNPRICE=log of price; LNVOL=log of water volume; OWN=captive source ownership; LNVOL= log of water volume.

Textile sub-Sector

Seventeen textile firms were examined in four urban areas (thus comprising the largest single sector examined in my study). The textile industry in Kenya has had mixed performance in the last decade with some public owned companies virtually closing down due to mismanagement while others suffering from excessive competition from imported clothings. A few of the textile industries are constantly on the list of water payments defaulters in their municipalities. Comparison of unit water consumption is very difficult, if not impossible since all the textile firms engage in multiple products such as woven fabrics, knitting yearn, knitwear, suitings & blankets, towels etc to name a few. These are often expressed in dozens, meters, kilograms, pieces etc making it difficult to consolidate production data.

Table 6.9: Textiles

Panel Regression	Fixed Effects		Random Effects	
Variable	Coefficient	T-Stat	Coefficient	T-Stat
Constant	3.592	0.011	2.002	4.137
LLVOL	0.554	12.199	0.693	18.747
LNPRICE	-0.011	-0.069	0.119	0.986
OWN	-0.568	-1.759	-0.227	-1.216
Dependent Variable	LNVOL			
Total Observations	423			
Usable Observations	363			
Skipped/Missing	60			
Degrees of Freedom	312			
Centre R^2	0.874			
Uncentred R^2	0.993			
Regression F(50,312)	43.292			
Significance Level of F	0.000			

Where: LLVOL=log of lagged water volume; LNPRICE=log of price; LNVOL=log of water volume; OWN=captive source ownership; LNVOL= log of water volume.

6.7.3 Price Elasticity for Different Urban Areas

Results of the model estimates for industries in different urban locations are presented in Table 6.10.

Table 6.10: Short-Run Elasticity as Estimated from Best Model

TOWN	Lagged water usage coefficient (2)		Short-run price response (3)	
	Fixed	Random	Fixed	Random
THIKA	0.3851	0.4820	-0.5441	-0.510
NAIROBI	0.3424*	0.4445*	-1.1851	-0.7713
NAKURU	--	--	--	--
KISUMU	-0.0114	0.1027	0.7379	0.7909
ELDORET	0.4086	0.5592	-0.1920	0.0520

Source: Survey data. *Significant at 95% confidence level.

The results suggest that in Thika both the lagged water usage and price response have the expected signs (+ and -). However, these factors are not significant in explaining patterns of water consumption. The results for Thika also indicate that availability of captive sources do not significantly influence the patterns of water consumption by firms there. This is contrary to our expectations. In Nairobi, lagged water consumption is a significant factor in explaining the patterns of industrial water use. However, even though elasticity has the correct sign, it is not significant is explaining firm response. In Kisumu and Eldoret, the price elasticity of industrial water is positive, though insignificant. The price elasticities for the different urban areas reflect to some extent, the effectiveness of the pricing structure in enforcing water conservation among firms. It is apparent that when our analysis is viewed from an institutional perspective, then only Nairobi city has scored some modest credit. This might reflect the fact that even though Nairobi has the lowest water charge, firms are less profligate in the use of water. This observation is confirmed by our earlier analysis for Paper industry and Leather tanning which showed the firms in Nairobi to be relatively more efficient in water use intensities. Nairobi is also prone to frequent water shortages and these results might reflect the fact that firms regard water as a credible infrastructural constraint.

Table 6.11 Glossary of Variables Used in Water Demand Estimation

Variable	Description
X_w	demand for water
N	number of non-water inputs
M	number of water inputs
P_w	vector for price of water,
C_w	cost of water,
P_{cap}	price of captive water (borehole,river)
P_{pub}	price of public water (municipal),
P_{dis}	price of wastewater discharge (sewer charge),
Dsector*i*	dummy variables for the water using sectors (five broad sectors identified in our analysis: 1=food; 2=Wood Products and Others; 3=Textile; 4=Leather and Products; 5=Paper).
P_{in}	price of water intake,
P_{trt}	price of treatment,
P_{rcr}	price of recirculation,
Q	level of output
P_i	other input prices,
LLVOL	log of lagged water volume
LNPRICE	log of price
LNVOL	log of water volume
OWN	captive source ownership
LNVOL	log of water volume.
MP_{wt}	marginal price of water in *t*th month
AP	Average Price
MP	Marginal Price
Own	dummy variables on water restrictions and ownership (1=ownership of captive sources i.e. borehole, rivers; 0=otherwise).
$\mathbf{Z}t$	A vector of all the exogenous variables in the study.
$AP_{w,t-1}/MP_{i,t}$	Ratio of lagged average monthly water price of *i*th firm to current marginal price of water.
$AP_{w,t-1}$	Average water price (includes all fixed charges for water and sewerage).
X_{wt}	quantity of water demanded in *t*th month
RSP	Rate Structure Premium

6.8 Summary and Conclusion

In this chapter, we set out to examine the effect of pricing on the firms' water consumption activities in Kenya. We have conducted experiments using two-stage least squares (2SLS) techniques to estimate price elasticity for public water intake across firms in various towns. Even though the elasticity is negative, the marginal price of water is an insignificant parameter for industrial water demand at the aggregate level. However, our results for the aggregate levels also show that captive sourcing options might influence consumption patterns in a significant way.

Analysis by urban locations (i.e. individual urban areas) also shows price elasticity of industrial water demand to be insignificant. The largest influence is captured for Nairobi, but the value is insignificant. Furthermore, Nairobi has the lowest water tariff structure among the urban areas in Kenya, followed by Thika. This result is unexpected. This is. Kisumu and Eldoret have price elasticities that are theoretical inconsistent.

Among the industrial user sectoral categories, our results show the pulp and paper to be the most responsive, followed by Textiles. Food and beverage sector have negative but insignificant elasticities. The significant price elasticity estimates in pulp and paper sector is not corroborated with the evidence gathered during field visit. Although there has been a shift in water consumption, this has resulted from dramatic efficiency enhancing technological changes within the sector other than changes in water tariffs. Thus, the elasticity was a by-product of other factors.

> *Overall, the sectoral results show that there is little potential for use of water tariffs in stimulating industrial responses in specific sectors in Kenya.*

We attribute the low elasticity of industrial water demand to a number of factors: First, water tariffs are weakly enforced making them less effective as tools for water resource management in industry. Secondly, cost-recovery measures still aim to encourage industrial water consumption as tendencies to engage in contractual public water consumption within firms suggest. Industries are encouraged to consume public water in return for waivers on sewer charges incurred on groundwater usage. First, most of the water consumption levels are tied to pre-negotiated supply arrangements i.e. in the case of Nakuru, Thika, Kisumu, and to some extent Eldoret.

There is a predominance of private intake systems among large firms even in cases where the public supply seems less stochastic. There is also an apparent over-capitalization by firms on water sourcing. We observe different motivations for this apparent over-capitalization. Kisumu, Nakuru, and Nairobi City are prone to stochastic public supply. Furthermore, our analysis shows Nairobi's water charges to be the lowest and least compelling for firms to invest in expensive water gadgets, hence, water supply constraints rather than costs are culprits in the overcapitalization. In some cases, firms have installed water supply equipment for "eventual failure" of the public supply. This situation suggests the fact that water gadget costs may be a very small fraction of the average firm's costs in Kenya (everywhere in all firms).

Notes

[1] The first and second value in the brackets are the correlation coefficient for average price, water charge and marginal price for water respectively.

[2] We have discussed these issues extensively in chapter 2 on water sector policy instruments in Kenya.

[3] This is mostly the case for the former state owned textile and food processing firms.

[4] Less than frequent reading of meters or lumping all the water consumption in one month result in higher per unit charges.

[5] The water code requires groundwater and surface water users to secure water permits from the Water Apportionment Board.

[6] Important reasons for use of the log transformation are that exponential growth in levels becomes linear growth in the transformed series, the variance can be stabilized, aberrant observations can become influential, and the parameters in linear models for log transformed time series can be interpreted straightforwardly as constant elasticities.

[7] Renzetti (1993) has modeled the supply choice between public and self-provided using probit and witching regression models. The maximum likelihood estimates provide insights into the decision-making process.

[8] Measured here as the quantity of water used (cubic metres) to produce a tonne of output.

[9] The borehole was mainly meant to serve as a reservoir to capture rain water and roof catchment waters.

7 Regulating Industrial Wastewater in Kenya: An Appropriate Institutional Framework

7.1 Introduction

In the previous chapter (six), we analyzed firms' response to water tariffs by estimating water demand models. The estimation of the model was preceded by analysis of the appropriate institutional framework for the implementation of water tariffs in water authorities (in chapter 5). Water tariffs and wastewater regulation are administered jointly by the same authorities, hence, we proceed to analyse the institutional framework for regulation of industrial wastewater standards in Kenya in this chapter. The goal of the chapter is to assess the appropriateness of the institutional arrangement for wastewater regulation. The chapter is organised as follows: In section 7.2, we discuss our conceptual framework for analysis of the appropriate institutional arrangement for industrial wastewater regulation. Section 7.3 looks at the objectives and goals for industrial wastewater regulation. In section 7.4, we look at the organizational arrangement for regulation and in section 7.5, we discuss the choice of regulatory instruments in Kenya. In section 7.6, we discuss the enforcement of wastewater standards by the regulatory authorities. Section 7.7 contains a discussion of the appropriateness of the institutional arrangement. We conclude in section 7.8. At each stage of our work we discuss the strength and weaknesses of the existing structures and take up alternative framework that could have worked better.

7.2 Conceptual Framework for the Appropriate Institutional Arrangement

7.2.1 Defining Institutions and Regulation

The concept of institutions has already been defined and discussed extensively in Chapter 4 hence our attention will focus more on defining regulation. Based on the definition provided earlier, we do interpret institutions as the "rules of the game in society" that provide constraints on action (Ostrom, 1990) or a la' North (1991) who sees "institutions" as formal rules and conventions, including informal codes of behavior or norms, emerging to regulate human (in this context industrial) behavior and interaction. We have defined regulation in chapter 3 and extended its application here.

7.2.2 Appropriate Institutional Arrangement

Our primary contention is that industrial firms are rational entities that respond to the institutional arrangement both strengths and weaknesses (i.e. of the organisations and instruments). If the arrangement provided a credible threat of punishment firms can be expected to comply with the wastewater standards. A discussion of these issues is developed in chapters 3 and 8. In addressing the appropriateness of the arrangement, we examine aspects of *agency behaviour* that renderes it defective for enforcing compliance. Appropriateness of the institutional arrangement depends on several parameters. These parameters were examined in chapter 3 where we provided a summary in Table 3.1; they include the efficiency with which the regulatory agencies organise their enforcement i.e. their ability to overcome budgetary constraints, the choice of regulatory instruments and their styles of enforcement; and synergy of the organizational arrangement (institutional structure), the regulatory instruments chosen with industrial behaviour. An appropriate institutional arrangement for wastewater regulation is one that traverses the narrow social, political, and cultural interests and is devoid of regulatory capture, principal agency problems. As discussed in chapter 3, the objective of regulatory enforcement in Kenya seems consistent with the law enforcement goal of "maximizing compliance". The appropriateness of the institutional structure is therefore analyzed on the extent to which it impedes or facilitates compliance objective.

7.3 The Objectives and Goals for Industrial Wastewater Regulation in Kenya

Any study of the appropriate institutional framework for wastewater regulation should start first with a more basic understanding of the objectives of regulation. In this section, we discuss the wastewater standards and their objectives in Kenya.

7.3.1 Wastewater Standards

There are two broad categories of wastewater standards in Kenya; those stipulated by Ministry of Environment and Natural Resources (MENR), usually applicable to discharges into streams and large water bodies. They are enforced by the MENR upon the Local Authorities and the industries directly in a case where the industries discharge into such water bodies. Another set of standards are those stipulated by the Local Authorities by-Laws and enforced by the Local Authorities upon the industries and usually applied to firms discharging into public sewer network. The two standards are related in so far as Local Authorities set the targets for the performance of their Sewer Treatment Works on the basis of MENR discharge standards while they in turn stipulate in their by-laws, industrial wastewater standards compatible with capacities of their treatment facilities. There are limits set for wastewater pollutant levels based on a number of parameters that every wastewater disposing plant should take into account. The main parameters include: Volume of the effluent; Bio-chemical Oxygen Demand (BOD)[1]; Chemical Oxygen Demand (COD)[2]; Toxicity (COD): Suspended Solids[3]; Permanganate Value (PV)[4]; Dissolved Solids[5]; Synthetic detergents/other chemicals among other parameters. The standards include a generalized wastewater quality standard and some specific standards for specific industrial sources (e.g. paper mill, sugar factory). A summary of these standards is given in table 7.1. The MENR standards could vary between geographical localities depending on the perceived degree of dilution offered by the receiving stream and the water use downstream from the discharge point. These standards are "reviewed and appraised" periodically in the light of quality of sewage and similar standards in other countries and from the viewpoint of sewage treatment process.

Table 7.1: Industrial Wastewater Standards in Kenya

Parameter	Ministry of Water	Thika	Nairobi	Nakuru	Kisumu	Eldoret
BOD_5 at 20°C mg/l	Not to exceed 20 mg/1	500	450	500		700
Suspended Solids	Not to exceed 30 mg/1	500	300	600	600	500
pH[6]	6.0 - 9.0	6.0-9.0		6.5-8.0		6.0-9.0
Mercury	Not to exceed 0.05 mg/1			0.01		
Phenols	Not to exceed 2 mg/1			10		
Temperature	25°C + 2°C	30 °C	35°C	35°C		35°C
COD	Mg/l	1000		1000		1200
Ammonia	Mg/l	20		10		
Settleable solids	Ml/l	1				1.0
Transparency	cm					30

Source: Ministry of Water, Records; Various Local Authorities By-Laws.

The above standards reflect differences in the LA by-laws. Some LA by-laws are more stringent on the industrial wastewater quality than others.

7.3.2 Objectives for Wastewater Standards

The objectives for industrial wastewater standards differ between the discharge points and the enforcement agencies. In the urban case, the local authorities goal is to ensure water conservation by reducing the final pollution load into the municipal sewer treatment works i.e. for better performance of the municipality sewage treatment works. The Local Authorities consider the technological attainability of some of the targets and may become lenient on enforcement where targets are easier to attain. The underlying issue here is that municipalities will find it increasingly costly to treat industrial wastewaters to conform to the MENR standards unless the effluents undergo some pre-treatment. Emphasis on the extent of pre-treatment varies from one town to another. The other objective is to ensure that the industries have a fair responsibility for their wastewater reception, conveyancing, treatment and disposal.

In the case of MENR wastewater standards, the primary objective is to ensure that the industrial effluent including the treatment product and residuals have no unacceptable effect on the environment, or in the receiving water bodies or does not impair other uses of the receiving waters downstream of the discharge since usage of waters downstream is widespread in Kenya. An important goal linked to standards is the protection of the water bodies that finally receive the wastewater. For example lakes (i.e. Nakuru and Victoria) vary in the extent of their ecological sensitivity to wastewater pollution because of the large volumes of water. On the other hand, the lakes are a home to wildlife (of flamingos and other wildlife supportive of tourism sector) and may remain fragile to long-term consequences of pollution. The MENR has thus attempted to develop standards that take into consideration of these broader ecological functions, in particular, the broader socio-economic impact on the "downstream" users. On the other hand, enforcement of standards comprise secondary objectives specific to each region i.e. often, the enforcement of these standards emphasize the need for a balance between environmental issues and economic growth (i.e. creating jobs) in the industries. There are several weaknesses with the structure of the wastewater standards in Kenya:

(i) The standards themselves remain questionable. Ideally, there should be scientific basis for wastewater standards in various locations. However, often, the "Royal Commission Standards" have been adopted in Kenya. Their validity have been highly questionable on the basis of differences in environmental conditions between Britain and Kenya.

(ii) In addition, the receiver characteristics are not studied seriously to clearly understand the effect of the wastewater quality on the stream, river or lake as a base-line for future impacts on the water bodies (rivers and lakes). There is still lack of information on assimilative capabilities of streams, rivers and lakes that are potential receivers of wastewater generated by the industries. Also lacking are the National Wastewater Quality Objectives upon which the enforcement of the standards should be pursued.

(iii) The multiplicity of standards creates a problem for enforcement in several ways: (a) it leads to shifting goalpost and a double standard among the enforcement agencies. (b) the multiple standards provide a leverage or latitude for industrial firms with several disposal options to shift their practices in a way that makes enforcement difficult. (c) it creates a feeling of unfairness in the enforcement among industries. (d) it is more demanding institutionally since lack of uniformity calls for additional capacity.

The second weakness calls for uniform standards while the third one calls for differentiated standards. These variations make it difficult to decide on clear choices.

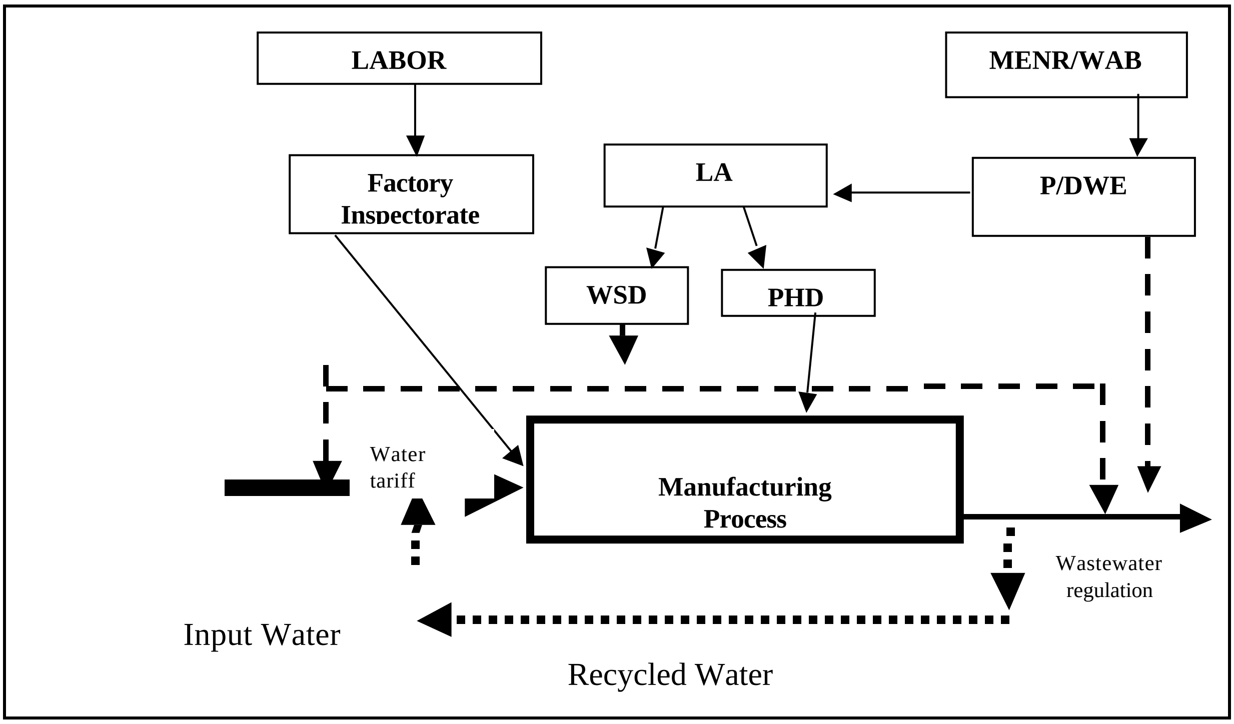
Table 7.2 Summary of the Underlying objectives for Enforcement in Urban Areas

	Target Water Resource under protection	Perception of threat posed to downstream water	Perceived marginal damage & benefit	Local/Downstream Interest in water quality	Overall influence on Enforcement
Thika	Thika, Komu Rivers	Direct	High	High	High
Nairobi	Nairobi, Njiru, Athi Rivers	Indirect	Low	Medium	Low
Nakuru	Lake Nakuru	Indirect		High	High
Kisumu	Lake Victoria	Indirect	Low	Medium	Moderate
Eldoret	Sosiani River	Direct	High	High	High

7.4 The Organizational Arrangement for Wastewater Regulation

Most countries have multiple and extensive central government agencies in water sector management. Where the task of industrial wastewater regulation is concerned, there are widespread variations across countries. In Kenya, there are three main agencies in the enforcement structure; Ministry of Labour, Local Authorities, and Ministry of Environment and Natural Resources (MENR). We have summarised the organization structure for enforcement in Figure 7.1.

Fig 7.1: Organisational Hierarchy for Wastewater Regulation in Kenya



7.4.1 Delineation of Responsibilities

Ministry of Environment and Natural Resources (MENR)

According to the provision of Section 158 of the Water Act, the Ministry of Environment and Natural Resources (Ministry of Water Development) is currently mandated to deal with all aspects of water conservation, management and development of the water resources. This includes water pollution control for both surface water and groundwater. The Water Act provides the main legal framework for control of water pollution and wastewater regulation countrywide. Within the ministry, water pollution issues are handled through the coordination of the Water Apportion Board, the Provincial /District Water Engineer Offices and the Water Quality and Pollution Control Section in the Water Resources Division.

MENR deals with the industries that discharge into public waters such as rivers, lakes etc. while The overall enforcement strategy by the MENR is to concentrate control of wastewater pollution in the priority areas, such as Nairobi, Nakuru, Thika and Kisumu. Especially, the firms whose wastewater is discharged into reservoir or river courses being used for water supply are to be controlled severely. Although national standards (as defined by laws and regulations) are more or less uniform, their implementation is a function of local conditions. Local monitoring and enforcement of national standards effectively determines the "price of pollution" in each area, which means, local enforcers could redirect resources in a way that approximates optimal behavior. Ignoring the tradeoffs taking place locally could undermine and render ineffective regulatory and policy reform that is strictly national[7].

Local Authorities

The local authorities are empowered to control the purity of water supplies, both by water undertakers and traditional supplies, to prevent pollution by wastes and control the construction/ operation of drainage works and sewers. In addition to health inspectors appointed by local authorities, the Director of Medical Services in the Ministry of Health also appoints health inspectors in certain districts. Thus, the leading agency remains to be Ministry of Water Resources (MENR), wherein the leadership is held by the Water Quality and Pollution Section in the same ministry. A separate legal provision is linked to the disposal of industrial wastewaters. According to this legal provision, the wastewater may be returned to the body of water sanctioned by the Water Apportionment Board (WAB) in the Ministry of Environment and Natural Resources (MENR), provided that it is purified to a level acceptable to WAB and suitable for further water use by downstream users.

The Water Act provides powers and responsibilities upon some Local Authorities, to safeguard the quality of water resources in the areas of their jurisdiction. Thus the Ministry shares its responsibility with Local Government Authorities in the larger urban centres. The responsibility for monitoring the wastewater within the Municipality rests with Water and Sanitation Departments and to a lesser extent the Pollution Control Section of the Ministry of Water. However monitoring of wastewater outside the Municipality remains the responsibility of the water ministry that has the overall responsibility for pollution control nationwide. Municipalities, Urban and Town Councils are expected to limit wastewater pollution occurrence within their areas of jurisdiction.

The Public Health Act also prescribes wastewater quality and the (Section 129 and 130) the implementation and enforcement of the Act and its subsidiary legislation (eg. The Drainage and Latrine Rules) are practically undertaken by Local Authorities (municipal, urban, and area councils). In addition to the health inspectors appointed by Local Authorities, the Director of Medical Services, Ministry of Health, also appoints health inspectors in certain districts. The ministry intervenes in any situation that impinges on public health, in this respect, the duties of public health authorities extend to the industrial sector. Furthermore, the Factories Act (CAP 514, section 53 of 1990) also addresses industrial pollution that includes wastewater pollution.

Local Authorities focus on the industries that discharge into sewer systems. Much of the wastewater regulation within urban areas seems to be handled by the Public Health administrations and Water and Sanitation Departments (WSDs) within the urban areas i.e. with limited collaboration from MENR. The prime responsibility of municipalities in wastewater water regulation is the management of the sewer systems, and to a large extent, wastewater quality regulation of discharges into their sewage systems. In cases where the Public Health Department (PHD) is involved, their concern is much more on the activities of the industries rather than management of sewer systems, which falls under the jurisdiction of WSDs.

Ministry of Labour

The Ministry of Labour, Factories Inspectorate Department is charged with the task of ensuring a clean and safe working environment for factory workers. The work of Factories Inspectorate takes three dimensions, namely, industrial health, safety and welfare. The health aspect covers cleanliness, overcrowding, ventilation, lighting, drainage of floods and sanitary conveniences.

Apart from the above organizations that are traditionally responsible for wastewater regulation, the recent enactment of the Environmental Management and Co-ordination Act 2000 in Kenya has provided a new framework under which environmental issues (including industrial wastewater) are to be addressed in the country by the National Environmental Management Authority (NEMA). Furthermore, the new Act confers on citizens' rights of enforcement in the area of environmental liabilities. According to this Act, any person may bring a civil action if their right to a clean and healthy environment has been violated. Clearly, there is a multiplicity of Acts and Organizations that interact with industrial firms in a bid to regulate their activities creates many enforcement problems and are inefficient particularly where their activities are disintegrated. We have explored these problems in section 7.7.1.

7.5 The Choice of Regulatory Instruments

Wastewater regulatory instruments can be classified according to three criteria: (i) whether they dictate abatement decisions or simply create financial incentives for firms to abate, (ii) whether they require the regulator to monitor emissions, and (iii) whether they involve government investment in abatement infrastructure (Blackman and Harrington, 1998). Regulatory instruments that dictate abatement decisions such as those applied in Kenya are known as "command and control" (CAC) regulations. Examples include wastewater standards and technology standards. The three criteria discussed above imply a classification scheme that is summarized in Table 7.3 (Eskeland and Jimmenez, 1992).

Table 7.3. The Menu of Wastewater Regulatory Instruments

Instrument	Direct	Indirect Instruments	Measures
Economic Incentives	Effluent fees Marketable permits Trade effluent charges	Environmental taxes Violation penalties Sewer charges	
Command and Control	Effluent Standards	Technology standards	Monitoring, Inspections, Warning Letters Court Action
Government Investment	Road paving Waste disposal plants	R&D in clean technologies	

The prevailing neo-classical view is in favour of using the economic or market to based institutions to address industrial wastewater quality. However the main policy instrument for enforcement of wastewater standards in Kenya is command and Control. Several urban areas studied have proposed the use of economic instruments such as trade effluent charges or effluent fees, financial penalties of violations, but implementation of these instruments has been problematic. Command and Control (CAC) are also conventional in industrialized countries, the instruments often have little impact in developing countries because they require a central authority capable of establishing rules for the conduct for polluting sources, monitoring performance with respect to those rules, and enforcing compliance. In many developing countries, financial and institutional constraints undermine these capabilities – technical capability is limited, funding is chronically scarce, production is often dominated by hard to monitor small-scale firms, weak institutions, weak complementary judicial, and public sentiments that favour economic development over the environment (Blackman and Harrington, 1998:2).

While CAC measures are deemed important, especially in prohibiting certain types of industrial behaviour that have proved harmful to the environment, experience shows that they are not enough to ensure the attainment of the policy objectives of those measures. Most often, the measures promote rent-seeking. Rules and regulations are circumvented since monitoring and enforcement costs are often high. The problem is further aggravated by conflicts over jurisdiction arising between the government agencies concerned over duplication of responsibilities in the enforcement of certain standards and regulations. Monitoring compliance with the regulations is time-consuming for regulatory bodies personnel. The time spent in monitoring could be better utilized in initiating, supporting and implementing an environmental protection programme.

There are plans to introduce pollution charges in some of the towns but these ideas are still at formative stages. A pollution charge or tax can be defined as “price” for the use of the open environment. The main types of charges are (i) effluent charges that are based on the quantity and quality of the discharged pollutants. (ii) user charges paid for the use of common (treatment) facilities. In the case of Kenyan towns, there are plans to use trade effluent charges. Generally, there are policy statements in a number of development plans (Republic of Kenya, 1994) in support to polluter-pays-principle but these have not been translated into action. At the same time, there have been suggestions on use of subsidies but the institutional mechanisms for their introduction have not been developed. These include tax incentives (accelerated depreciation, investment tax credits, tax exemptions and deferrals, import tax exemptions, etc.), grants and low interest loans designed to induce polluters to invest in equipment to reduce their pollution load.

7.6 Enforcement of Industrial Wastewater Standards

7.6.1 Monitoring/Inspections at the National Level

(a) Vetting of Industry Production Plans

At the national level, in pursuant of the broad regulatory function, the Water Pollution Control Section of the Ministry of Water Development has developed a procedure for vetting any new industrial firms. Proposals for industrial ventures that are presented to the Ministry of Industry are referred to the MENR (Ministry of Water Development) for clearance and matters related to wastewater disposal have to be addressed. In order to evaluate the environmental suitability of the proposals, the Pollution Control Section requires information on: Technical drawings of the factory layout including water supply and sewerage; A detailed description of all the different industrial processes to be carried out; Quantities of wastewater produced and the expected physico-chemical characteristics which may be obtained from simulated operations; A flow-scheme indicating the different streams of waste-water proposed pre-treatment/treatment process, storage, recycling, daily volumes and fluctuations, final discharge points; and Any other relevant information. This marks the first step towards regulating the industrial wastewater in Kenya[8].

> *The primary principle here is that wastewater from each firm should be treated at its own treatment works before release from the factory. Hence, the subsequent enforcement activities in Kenya tend to focus on wastewater discharge points rather than the actual entities discharging the wastewater.*

A major weakness in this process is that, since the requirements are placed at the planning stages, most industries end-up commission their plants without completing their physical structures as laid out on the plants. No certification of the wastewater treatment plants is required before production can commence. Industrial location policy particularly in relation to protection of rivers could become handy at this stage but often other matters of property rights (such as land ownership) predominate. This has been the case in Thika (Ruiru) town.

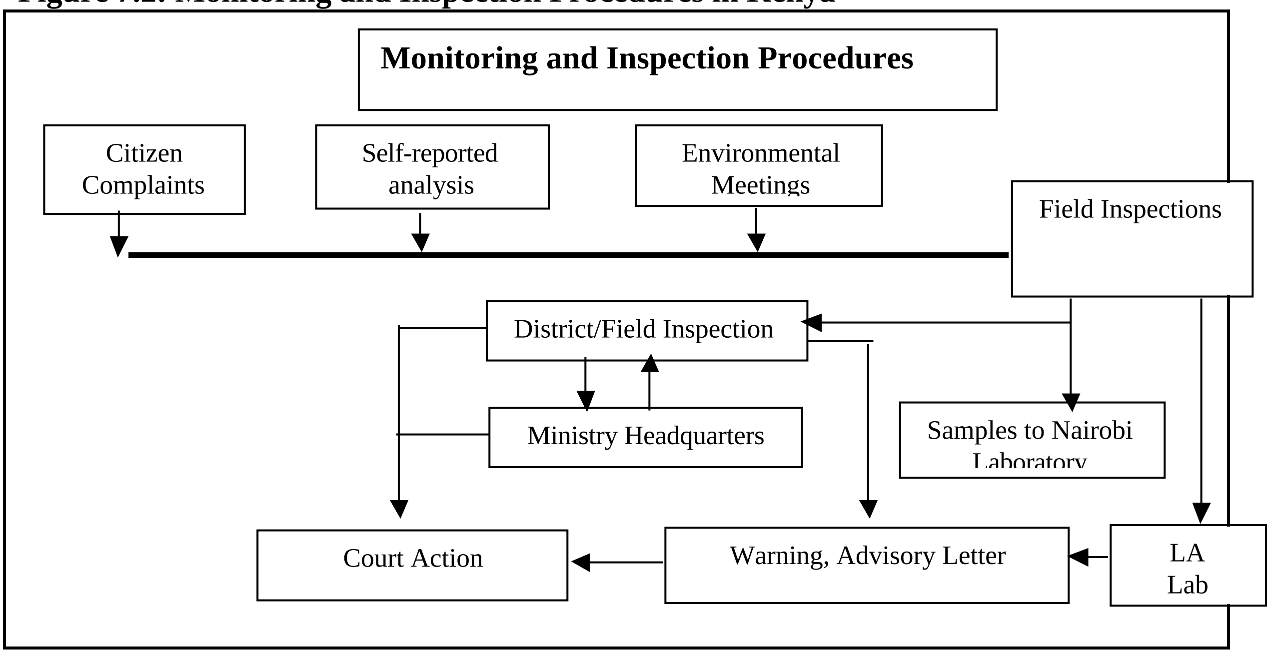
(b) Monitoring of Industrial Discharge in Water bodies and STWs

Over the years, the development of sewerage and wastewater (Sewer Treatment Works - STWs) facilities was recognized as being part and parcel of the development of water facilities in Kenyan urban areas. Such development could also reduce the risk of health hazards associated with uncontrolled sewerage disposal systems which if otherwise not taken care of, would result in environmental pollution particularly of Kenya's water resources (Republic of Kenya, Development Plan 1984-1988, p.160). By 1984 a total of 41 urban sewerage schemes had been undertaken by the Ministry of Water on behalf of the Municipalities and urban centres in terms of design construction supervision and actual construction. Between 1984-88, the Ministry gave priority to the implementation of about 17 schemes. However, by 1984, it was noted that the design standards for both urban and rural water supplies appeared to be too high in relation to the needs and the costs. In view of this, the Government undertook to review these standards with an aim of making them cost-effective and promoting large coverage with the available resources (Development Plan 1984-1988, p.161). Between 1974-1984, the Ministry of Water had also constructed 120 monitoring stations and 7 global environmental impact assessment stations under the Water Quality and Pollution Control Programme. The network covers aquifers, lakes, streams and rivers. The National Water Quality Monitoring Program facilitates the acquisition of data which is used: for checking whether the regulatory agency requirements are complied with; in determining equitable charges where joint treatment is involved; in providing data for the design of adequate treatment processes; for planning of water use and conservation; for determining the treatment efficiency and for trouble-shooting and process failures; and to design treatment plant expansion. Laboratory facilities for the analysis of raw water and waste water samples have been established both at the national and provincial level. The Ministry's staff are required to work closely with other departments, ministries, and organisations which have similar monitoring responsibilities in environmental protection.

(c) The judicial Steps in Enforcement

There are three (3) judicial steps in the enforcement of industrial wastewater standards in Kenya. We have summarised these steps in Figure 7.2. The first step involves monitoring and inspection of the firms. The inspection could be triggered by citizen complaints, environmental meetings self-reported samples or own field inspection by enforcement officers in Ministry of Environment and Natural Resources or Local authorities (LA). In the case of Local Authorities (LA), samples are delivered to own laboratory (lab) within the town and further action (i.e warning letters, or even court action) may follow after the analysis. In the case of MENR enforcement, the samples collected are taken to Nairobi for analysis. The MENR enforcement officers on the ground can issue warning letters but they have to consult with the parent ministry in Nairobi before taking any court action. The second and third judicial steps are warning or advisory letters and court action respectively.

Figure 7.2: Monitoring and Inspection Procedures in Kenya



7.6.2 Industry (Firm) Level Monitoring/Inspections

Monitoring and Field Inspections

There are sporadic monitoring (field inspections and waste water sampling) activities in all the urban areas. Apart from these sporadic inspection activities, complaints made by citizens or highlighted in newspapers regarding environmental incidents also give rise to enforcement. There are dramatic variations in the enforcement strategies for different urban areas.

A very frustrating aspect of monitoring is that since the discharge points are mostly within the industrial premises, the monitoring officers require permission to enter these premises. Often the monitoring officers have been kept waiting at the gate for long hours while consultation is going on as to when they should be admitted. This has proved de-motivating for the enforcement officers. Some enforcement officers have alleged that some firms take very long to admit them because the firms dilute their wastewater. According to some enforcement officers "the industries (industry owners), are often very arrogant and uncooperative[9]. They do not trust government officers and believe that any officer sampling concentrations of pollutants around their factories intends to take punitive measures against them. Rather than spend a lot of money on effluent or wastewater treatment facilities, some firms would rather give a small amount of money to the enforcement officers to obtain their "silence", some firms are owned by politically powerful or enjoy political patronage, making it very difficult to make an inspection, let alone give a warning letter or court prosecution. This experience scares off enforcement officers as some of them claim to have been threatened with sacking after inspecting some firms - the enforcement officers (in one town) know that they have to engage in selective enforcement. This has caused apathy among some enforcement officers. Majority of firms however can be inspected without any threat of serious consequences.

It is scientifically impossible to tell just from appearance of the wastewater whether a firm is compliant or not. Laboratory tests have to be conducted on the samples collected. Unfortunately for most local authorities, the laboratories are ill equipped and hardly in any shape to test the effluents from Sewer Treatment Works regularly, let alone handle the complex wastes from industries. When there is lack of financial resources, most of the enforcement officers limit the number of samples they collect from discharge points. In such instances detection of violation or compliance is based on suspicion. Often some enforcement officers try to guess whether a violation of standards has been taking place before they conduct sampling. In the case of MENR, all the samples they collect from urban areas have to be transported to Nairobi for analysis. In many cases it takes months for the analysis to be done, in a number of cases, the results are never returned from Nairobi to the towns.

Self-Reporting as way of Monitoring

Thika and Nakuru by-laws require firms to self-report their compliance status. The apex of enforcement activities in Thika is the District Environmental Committee/meetings where all industries are challenged to justify or defend their compliance status on various environmental parameters (wastewater quality being one of them). Nakuru town has an organized Inter-Ministerial Working Group (IWG) for coordination and supervision of the various institutions that are geared towards environmental protection and management of Lake Nakuru[10].

The strategy for self-reporting in Nakuru town embodies a unique framework which gives the industries an incentive to participate in self-reporting through what is known as "pollutant release and transfer register". Because Lake Nakuru is a habitat to flamingoes and other wildlife, the Kenya wildlife services (KWS) underscores the importance to monitoring pollution loads into Lake Nakuru. Pollutant Release and Transfer Register (PRTR) is a concept packaged to pursue this goal, Nakuru being the first urban center to initiate and implement this Wastewater Pollution Control Method in Africa. The project was initiated by the government (through the Directorate of Occupational Health and Safety Services) and World Wide Fund for Nature (WWF) as a follow-up step on Agenda 21 (Principle 10 for sustainable development) of the UN Conference on Environment and Development held in Rio de Janeiro in June 1992. By definition, Pollutant Release and Transfer Registers (PRTR) are publicly accessible catalogues of release transfer of potentially harmful chemicals to the environment by industrial activities.

They provide baseline on wastewater pollutants from which waste reduction initiatives can be developed. The information they provide is of value to a wide range of groups; the industries themselves can save money by cutting down wastage of variable chemical feedstock, emergency services, town planners, community groups, NGOs etc.

Turning back to the by-laws in Thika and Nakuru which require firms to self-report their compliance or violation status to government regulators, rather than subject themselves to probabilistic enforcement, two generic questions underpin this approach: firstly, when is it efficient for an enforcement regime to elicit self-reporting by violators? Secondly, what is the optimal structure of an enforcement regime with self-reporting? Although the study of self-reporting in the theory of optimal law enforcement is not new, the literature on this topic is quite small and recent (Kaplow and Shavell, 1994; Malik 1993; and Innes 1999). In prior work, Kaplow and Shavell (1994) and Malik (1993) identified economic advantages of self-reporting that include (i) directly economizing on enforcement costs by making the detection of non-reporting violators easier and (ii) reducing regulators reliance on poor auditing technologies. Innes (1999) has argued that self-reporting enjoys additional economic advantages of (i) increasing ex-post benefits of clean-up/remediation by increasing the likelihood that clean-up occurs, and (ii) often indirectly economizing on enforcement costs by permitting the costless imposition of stiffer non-reporter penalties that reduce the government monitoring required for a given level of violation deterrence. Self-reporting can be a very important strategy for enforcement of wastewater standards. In countries where public interest on compliance is high, self-reporting, accompanied with public disclosure programs have direct incentives to the firms[11]. For example Lanoie, Laplante, and Roy (1998) have examined the reaction of capital markets to the release of information pertaining to the environmental performance of the plants – upward when the information reveals superior performance and vice versa.

However, experience in the urban areas surveyed showed the self-reporting strategy to be unreliable. In several incidents, enforcement officers have filed complaints similar to the following inspection report from one industry:

> *"The deputy production manager informed me that they analyse waste water from lagoons, once every day. The parameters they analyse are BOD, COD, pH, and S.S. He also produced some results that were well within our standards set for industries. However I was set aback when I was taken to the lagoons. First, there was no access to them since they were overgrown with bush. This contradicts the earlier statement made by the production manager that samples are taken every day for analysis, because this can not be done without forming a path round the lagoons. In this connection I tend to think that the results shown to me were fake or far-fetched."*

From the literature reviewed in this section, self-reporting can be a useful strategy where there is *truthful* reporting. However truthful reporting requires an "incentive" or "punitive" scheme for it to function. In the case of Thika and Nakuru, there are no clear penalties, both explicit and implicit, levied when a firm (i) fails to report at all (ii) fails to accurately report its violation, over and above penalties that may be assessed on a firm which accurately reports its behavior. Furthermore, the process also appears to be muddled with controversies because of LAs inability to scientifically demonstrate that actual violations do occur and that there is no truthful reporting by some industries. Thus self-reporting cannot be a dependable enforcement strategy in the urban areas surveyed since it is incomplete.

Of course, self-reporting does not entirely remove government enforcement costs. Instead, the government enforcement authority now has a new type of monitoring to consider - auditing self-reports and imposing a penalty if the polluter is found to be lying (Cohen, 1998). Malik (1993) considers the effect of self-reporting on enforcement costs. He finds that for a given level of firm effort, a self-report scheme involves less government monitoring (auditing), but more frequent imposition of sanctions. Self-reporting is found to reduce costs when (i) the cost of monitoring/auditing is high, (ii) the maximum feasible fine is low, or (iii) the desired effort level is high (Malik, 1993: 253). Self-reporting is likely to increase costs if (a) the cost of collecting penalties is high (since the government is now more likely to impose penalties than to monitor pollution directly), or (ii) the regulator's monitoring technology is extremely accurate. In the case of Nakuru and Thika, no strategic effort has been made to realign enforcement effort to the needs created by self-reporting (apart from the advisory effort received in Nakuru).

The manner in which monitoring and inspections are conducted in all the urban areas also raise questions as to the effectiveness of the instrument in inducing cleaner and more efficient water use practices. In all the urban areas, the inspections are hurriedly conducted and the enforcement officers are ushered to specific discharging points where they can either sample the wastewater or assess the compliance status as their mandate stipulates. Heyes & Rickman (1999) show that increasing the thoroughness of inspections induces firms to substitute towards more transparent technologies, whereas increasing their frequency causes substitution the other way. In some instances in Kisumu and Nairobi, firms had set up “sanitized areas” that are essentially dummies –operationally redundant but environmentally – benign parts of a plant where the enforcement officers could be shown during inspection. All these experiences rendered inspections defective in changing the behaviour of firms.

Informal Monitoring and Inspections

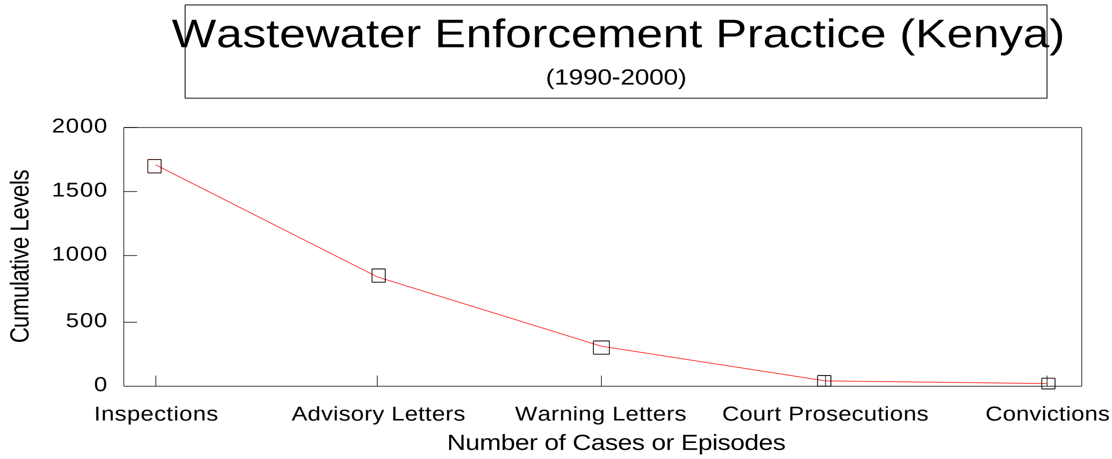
In most of the towns surveyed, industries discharge directly or indirectly into the public water bodies i.e. Lake Nakuru (Nakuru), River Sosiani (Eldoret) and Thika River (Thika) and citizen complaints or press reports have been an important source of low-cost information to the regulatory authorities, since polluting facilities are often apparent to the neighbourhood even if they are invisible to the government agencies. Recent literature has provided compelling social and political arguments for agency responsiveness to citizen complaints. However scepticism also abound on the complaint-driven monitoring: (i) The citizens often lack sufficient information to distinguish between “nuisance” emissions and those which are truly hazardous as certified by BOD, TSS, COD etc measures. Thus colourless, odourless toxics and heavy metals may escape notice altogether,(ii) most of the complaints come long after the damage has been done i.e. by observing the impact of wastewater violation rather than actual violation[12]; Furthermore, as Dasgupta and Wheeler (1996) indicate, (iii) some individuals or communities may have higher propensities to complain than others, regardless of the objective situation. If regulators respond passively to complaints, aggressive plaintiffs may capture most of the available enforcement resources. Nevertheless, given the resource constraints facing the enforcement authorities in most urban areas, and the fact that they too are constrained not to conduct BOD, TSS, and COD analysis regularly, citizens complaints remain an important aspect of monitoring in Kenya.

7.6.3 Warning and Advisory Letters

Warning and Advisory letters were a major tool of enforcement in Thika, Nakuru, and Eldoret and to a smaller extent Kisumu. Nairobi city had the lowest number of such letters. We have provided samples of a warning letters[13] and advisory letter[14] elsewhere to avoid ambiguity in definition. Overall, the number of warning and advisory letters sent to firms is very large (see Table 8.6, chapter 8). Though the letters varied a great deal in content, we could categorise them as follows.: (i) those advising firms of what steps to take in order to improve their wastewater quality, (ii) reminders to firms to meet their obligations as earlier agreed (iii) threats of action if measures are not taken (iv) statutory notices that court action is imminent unless remedial measures are undertaken within a stipulated period. Some of the letters to the firms were indeed complaints on the manner in which the enforcement officers are received or perceived by the industries as they carried out inspections. Such letters revealed a lot of frustration meted out by the industries to the enforcement officers. In some towns, MENR enforcement officers resorted to informing the industries in advance on an impending field inspection activity in order to avoid a repeat of the frustration i.e. of having to be kept waiting at the gate for many hours or denied entry altogether. It is unlikely that by giving prior information about an impending inspection the enforcement officers could obtain results reflecting the true compliance status of the firms.

A number of other weaknesses were evident from the manner in which the letters were issued.: (i) Some firms had received an unfairly large number of such letters – probably reflecting the fact that they were more accessible than the others, (ii) There was no clear procedure for administering the letters warning letters i.e it is not clear on what level of infringement warranted such letters, (iii) There was no clear procedure or steps to follow after a warning letter i.e. a warning letter was not an indicator that court action would follow if infringement continued. As a result of lack of enforcement policy, some firms had received multiple warning or threatening letters while no penalties or court action had followed. This seemed to undermine the efficacy of warning letters as tools of enforcement. Other firms had been taken to court without any sequence of warning letters preceding such action.

Figure: 7.3



Administration of warning letters seemed to present a particular problem for the MENR enforcement officers (vis a viz Local Authority). For example, whenever a district pollution control officers writes to a firm, that letter is copied to nearly twenty other departments in the hierarchy (i.e. to the provincial water engineer; MENR headquarters; the town clerk; the district commissioner etc). While these letters were copied to many departments to add credence to the threat, the cost of administering single warning letter by MENR was much higher than for the Local Authorities. Thus, the structure of enforcement in MENR with multiple involvement of other agencies at different levels impeded the administration of enforcement.

Different Styles of Enforcement: Negotiations

There were important institutional and procedural differences in the enforcement of wastewater standards in different towns of Kenya. While some elements of the institutional design were due to the peculiarities of the respective urban-area (such as the existence of donors, NGOs, tourist attractions), there were others such as the negotiated approach that should serve as a model to the others to learn from. For example unlike the other towns, in Thika town, besides the conventional enforcement mechanisms, there was also a “negotiation-oriented approach” to wastewater regulation. Regular meetings are held between different government departments and the industries. In those monthly meetings, compliance status and problems encountered by firms are discussed. Regulatory negotiation is the most well known consensus-based procedure for developing rules. Many cases of direct negotiation and “Coasian” bargaining between firms and enforcement agencies have been known around the world (Pargal and Wheeler (1996), Hettige, Huq, Pargal and Wheeler (1996)). Even though the negotiation process shows that there can be positive dialogue between violators (firms) and regulators (enforcement authority) rather than relying on strict judicial monitoring and enforcement of standards, the process can be problematic in a number of ways: (i) As is well known, it is entirely possible that a negotiated regulatory process might be "captured" by particular interest groups of firms (Stigler 1971, Peltzman 1976). (ii) In countries where regulatory negotiation and other consensus based decision processes are applied, the focus is often on regulatory requirements such as the performance standard to be attained by firms. We consider the approach in Thika to have been inappropriate to the above framework because of the following experiences: (a) There was no clear framework or policy for the negotiation procedure, hence, the process was turned into a forum for firms to express their grievances or provide excuses and negotiate postponement of compliance. For example,

> *“in one of those meetings, one industry representative reported that they did not have a wastewater treatment plant because they did not have room in their compound to put up one. He said they were in the process of negotiating for acquisition of land that they could use for setting up the treatment plant within Thika Municipality … In a separate meeting, a textile firm reported that the dyeing process which generate effluent are operated twice every month since January, 1995, and it is only during these occasions that wastewater is generated. He said that the wastewater is pretreated in two ponds prior to discharge during those occasions; however the Ministry of Water representative insisted that he had visited the wastewater treatment plant, and his*

impression was that it had been abandoned. He challenged the textile firm to inform him when the dyeing processes take place so that he can sample the wastewater for analysis".

The meetings also provided a platform for the industries to learn "new survival tactics" as they gauged the mood of the enforcement officers. For example a typical excuse provided by firms for most of violations in Thika town was that "the wastewater treatment plant had broken down and that the firms had ordered for spare parts from overseas. It was further alleged that until the delivery of spares are made at unspecified time, firms would not be able to operate their wastewater treatment plant". This could have been a genuine excuse for a few firms but most found it a convenient excuse to give during the meetings (Minutes of the Environmental meetings, Thika). In the next section, we look at the last stage of regulatory enforcement.

7.6.4 Court Prosecutions and Penalties for Violations

Court prosecutions represent the ultimate step in the enforcement process for wastewater regulation. In this section, we examine the enforcement under Ministry of Environment and Natural Resources, and the Local Authorities in Kenya. Procedurally, when firms fail to comply with advisory, warning, and statutory notices, then they should be eligible for court action. If the polluting agency has obtained a water permit for abstraction of water from a river or ground source, the WAB may withdraw the water permit until the situation is rectified.

According to enforcement agencies, initiation of a court prosecution should punish infractions, avoid recurrence, and deter others from committing the same infraction. The use of court system in achieving such aims in practice is dominated by two key factors: low number of posecutions and failure of the courts to impose fines that reflect the nature of the offence. Our statistics in Table 8.6 and Figure 7.3 show that the number of substantiated infractions is much higher than the number of cases prosecuted. The evidence of the agency's failure to prosecute imply that prosecutions are taken for less than 10% (i.e. 7.2% of the recipients of warning letters) of the worst infraction incidents.

Under the existing legislation, gazetted enforcement officers of the Ministry of Environment and Natural Resources (MENR-Ministry of Water Development), Ministry of Health, and Local Authorities may institute legal proceedings where an individual (firm) has been identified as responsible for having polluted or caused the pollution of a water body. Where a local authority which is a water undertaker fails to discharge a responsibility relating to controlling (industrial, domestic or otherwise) pollution within its area of jurisdiction, the Minister (for MNER) may, on the advice of Water Apportionment Board, withdraw the delegated responsibility. In extreme cases, the WAB may, on the advice of the Director of Water Development, withdraw or cancel a water permit where a given individual or industry fails to comply with anti-pollution measures issued to them even after having been convicted in court.

Two basic requirements must be fulfilled by the enforcement officers for a court action to materialise. These should include (i) properly sampled evidence against the firm in question and (ii) availability of gazetted court prosecutors. For a wastewater sample analysis to be admissible in court as an exhibit or evidence, several agents who should include a representative of the firm should have witnessed its collection at the discharge points. The sample ought to have been stored or handled in an appropriate manner prior to testing - mostly by refrigeration. While only Nairobi has refrigeration facilities for MENR, courts require that there must be proof that the final results of analysis of the same sample is what is being produced as evidence in court. A common experience with the enforcement officers is that this last condition is very difficult to fulfil especially when firms decide to challenge the evidence. It is a tedious and expensive requirement that cash strapped enforcement authorities cannot fulfil.

The other condition that impedes court action among MENR enforcement officers is one requiring that prosecution to be conducted by gazetted prosecutors from MENR, Ministry of Health with Local Authorities. There is a shortage of court prosecutors in all the urban areas in Kenya. For example, MENR has gazetted prosecutors in Kisumu (1) and Nairobi (3) but none in Nakuru, Eldoret, and Thika. This implies that at best the enforcement officers in Nakuru, Thika and Eldoret towns can only give warning letters and await MENR headquarters decision in Nairobi on what steps to take next. In a few cases, the prosecuting officers were “borrowed” from different government departments. Our interviews showed that some cases failed to take-off because the prosecuting officers form other departments failed to turn up in courts. The enforcement officers interviewed indicated that lack of legal mandate for them to prosecute firms was de-motivating to them.

Enforcement of court proceedings is constrained by the political nature of the court institution in Kenya. Although enforcement officers are free to decide what kind of violations warrant prosecution, the ultimate penalties are constrained by the court system. Firms have several options when faced with court action. Records from the five urban areas show that: (i) the firms might readily plead guilty for the offence (particularly in violations that have attracted widespread public outcry and media attention) and a fine is imposed – about 56% of firms enter a guilty plea (ii) firms can decide to challenge the authenticity of the wastewater samples results, it is often impossible to convince the court that the sample collected at the discharge points are indeed the same sample being produced in court as exhibits. About 44% of firms decide to challenge the evidence. (iii) firms can deny culpability particularly where other firms share discharge points such as rivers. Our interviews showed that the courts for lack of sufficient evidence dismiss 21% of the prosecuted violations. For the 79% that are convicted, 50% of them are given a suspended sentence i.e being asked to take remedial measures.

Apart from producing evidence, records from MENR show that courts often insist that the prosecutors illustrate the extent of damage arising from violations. In one of the reports noted at the Ministry offices, officers expressed frustration with the legal requirement of gazetting the Ministry's officers in conducting prosecution in any court of Law: "The pollution cases we take to court are highly technical and very complicated to the ordinary Court Prosecutors. They hardly can understand the impact of the pollutants to the water resources" the report observed. Yet, this is usually what the courts require them to illustrate. In view of this experience, most enforcement agencies will not resort to court action unless they are satisfied that there is sufficient, admissible, and reliable evidence that the offence has been committed and there is a realistic prospect of conviction. If the case does not pass this evidential test, the enforcement agency will resort to other measures, no matter how important or serious the infraction may be. Thus *whilst the adoption of such a high threshold for instituting a prosecution is likely to lead to a positive success rate, it also leads to the low level of prosecutions brought by the enforcement agency.*

Court action in Kenya would probably be much more effective in regulating the behaviour of firms if administrative decisions by the enforcement officer are made less contestable in court, particularly those that arise from violations that have triggered public outcry. This would also eliminate the need for expensive monitoring technology to obtain accurate information on firms' compliance status.

The other issue with the court cases is that the fines are often very low. Until the recent enactment of Environmental Management Co-ordination Act 2000, the maximum stipulated penalty under the law was Kenya Shillings one thousand only (US$>20). It was thus cheaper to offend than prevent commission of an offence. Since courts have a free hand in exercising discretion i.e. they can take into account a number of aggravating and mitigating factors. If the courts were harsh, they should order closures until the abatement gadgets are installed or remedial measures taken. From our field observations and interviews of the officials, most violations still continue even after court action. All the court cases traced are those initiated by the MENR (some of which were eventually prosecuted by Public Health Officers from the Local Authorities).

Suspension and Revocation of Water use Permit

One of the enforcement tools that is currently available to the MENR (Ministry of Water) for the enforcement of standards is the suspension of firms' water use licence whenever violations were "sufficiently of concern". Our analysis in chapter five showed that over fifty percent of firms were obtaining their water either from the boreholes or from rivers. For firms whose main source of water are rivers and boreholes, revocation and suspension of a water permit (or licence) could be an effective tool, much more effective than court action because (i) it poses a credible threat to production as firms can stop production altogether when access to water is denied, (ii) suspension of a permit does not require any court decision and it can be handled administratively within MENR. (iii) Furthermore, it does not require skilled or technical personnel such as court prosecutors to enforce. Ironically, the power of revocation is used extremely sparingly even though the enforcement agency has absolute control over this. It remains the most difficult instrument to enforce in Kenya due to economic, social, and political factors. Over the last 10 years, it appears that only 6-8 episodes of threats have been made by the enforcement agencies over the use of this instrument. The evidence we have suggests that only two instances were carried out during the last ten years (revocation and suspension each). From a deterrence perspective, it might seem to make sense to proceed with permit revocation/suspension only when the court system does not appear to achieve compliance. But there is no compelling evidence that this is the enforcement agency policy in Kenya; all we know is that the two cases were not pursued through the courts before the action was taken.

7.6.5 Economic Instruments/Financial Penalties Under Local Authority Enforcement

Sewer Charges

One of the most distinctive features of the Urban Water Provision in Kenya is the sewer charge that accompanies all water consumption within the municipalities. The sewer charge is meant to finance nearly 100 per cent of expenditures including the construction and operation and maintenance of Wastewater Treatment Plants. In most cases, the sewer charge is volumetric and is as high as (50-100%) the cost of water itself. Ideally, the charge should follow the rule that the polluter pays particularly for industrial firms but this is not the case. In any case very little of the money collected is injected back into the Sewer Treatment Works. One argument that the industries have presented to the Local Authorities over the years is the fact that they (the industries) pay a sewer charge commensurate with the quantity of water consumed, yet they have to comply with wastewater standards. The sewer charge as we saw in chapter five, is quite high in some towns. However the biggest challenge posed is that where as firms have an obligation of observing the wastewater standards discussed in an earlier section, Wastewater Treatment Works (STW) (the primary responsibility of Local Authorities) should be capable of producing an effluent up to the standards stipulated by the MENR i.e. British Commission Standards of 20mg/l Biochemical Oxygen Demand and 30mg/l Settleable Solids before these are discharged onto the public water bodies (rivers, lakes etc). However, none of the Local Authorities in our study are able to meet these standards. Furthermore, none of the Sewer Treatment Works are operated properly as they are subject to frequent breakdowns, theft and vandalism. In Kisumu for example, treated effluent of Conventional STW has consistently recorded more than 200 mg/l of BOD and more than 400 mg/l of SS. This is almost same level as raw sewage generated from domestic water user and it is discharged into lake Victoria. The fact that Local Authorities (STWs) do not meet the required MENR standards greatly undermines their role as regulatory authority for the enforcement of industrial wastewater standards. Indeed one of the questions consistently asked by the industries surveyed is why there should be enforcement of standards at all or sewer charges if the wastewater only runs through the STW with minimum treatment.

Violation Charges

All the Local Authorities by-laws stipulate financial penalties that violating firms should pay. For example in Thika and Eldoret, a firm which contravenes or fails to comply with the wastewater by-laws or any of the conditions imposed by the council on water is guilty of an offence and is liable to[15]: (i) in the case of a first offence, a fine not exceeding two thousand shillings (US$30) or imprisonment for a term not exceeding six months or both such fine and imprisonment. (ii) in the case of a second offence…one thousand shillings or to imprisonment for term not exceeding nine months or both such fine and imprisonment; and (iii) where an offence is of a continuous nature, the offender shall in addition to the penalties prescribed …pay an additional fine or five thousand shillings for everyday during which the offence continues. In Eldoret, the penalties stipulate that (a) an extra five shillings (Kshs) will be added on to the rates for effluents exceeding any of the following limits based on grab sample analysis done by the Council once every six months; (b) while a penalty of Kshs 100,000 (one hundred thousand) per month will be charged on effluent exceeding any of the limits given below (i.e. for various toxic chemicals). Experiences in Thika and Eldoret towns suggest that these “market instruments” are prone to serious difficulties especially because they demand credible and scientific procedures to implement[16]. In both towns, the penalties have remained "paper tigers" in the bye-laws that have not been implemented. There is a parallel between the national justice system and the mechanism for the enforcement of by-laws. In Nairobi city, there is a special court dealing with the prosecution of civil violations. Similar tribunals exist in other Local Authorities. However, where criminal liability such as illegal water connection is concerned, ordinary court systems apply. The main limitation of the ordinary courts is the lack of capacity to prosecute and rampant corruption among council officers.

The effluent charges being proposed in some of the towns (either “trade effluent” or charges for violation) are considered a limited tool for many sources of pollution owing to the information requirements needed to set an optimal charge to change behaviour. The charges are likely to be inefficient because of moral hazard: the inability to monitor perfectly firm efforts to control pollution. In an attempt to reduce the moral hazard problem, Segerson (1988) suggested that regulators could design a charge system based on overall ambient concentration of a pollutant in a region. Xepapadeas (1991) also recognised the possibility of moral hazard in the use of non-compliance fees and proposed a theoretically plausible incentive scheme with questionable political appeal (Hanley, Shogren and White, 1997:79). Drawing on Holmstrom’s (1992) work on behavioural incentives within the firm, Xepapadeas developed an incentive mechanism to induce polluters to supply the target level of pollution. Relying on a combination of subsidies and random fines, the mechanism works as follows. If total ambient concentration exceeds the target standard at a common site, the regulator selects at least one polluter at random and fines him. The regulator then redistributes a portion of this fine minus the damages to society from non-compliance back to the other firms. The random penalty mechanism increases the expected costs of shirking and, if designed properly, will induce the target control level without actually having to monitor the actions of any firm. This random penalty mechanism is more attractive relative to the sophisticated systems of charges in Eldoret and Thika for two reasons. First, the information required to implement the mechanism is less than that required for the non-compliance charges. Secondly, the mechanism is budget balancing, and does not require revenues beyond the welfare gains generated by abatement. However, Herriges et al (1994) demonstrate that the random penalty scheme will work only if all the firms are risk-averse.

Trade Effluent Charges

The “trade effluent” charges as “the extra sewerage (wastewater) charges paid to the service provider (WSP) in order to reflect the additional costs created by the treatment of highly polluted or difficult to treat sewage (wastewater).” Since 1970s, there have been joint efforts by Sewerage Division of the Ministry of Water Development and the Ministry of Local Government to develop a system of enforcing wastewater standards in Local Authorities by charging the industries on the basis of treatability of their wastewater i.e. possibly using the modified Mogden formula for charging purposes. Crude forms of the application of this charge are found in the by-Laws of Thika and Eldoret towns. The development of this trade effluent charge is still inhibited by many factors including resistance by industries and politicians. Indeed tension between the above “Pigouvian” regulatory approach and the “Coasian” regulatory approaches to resource management has become increasingly evident in water policies (Colby, 1998 p.476). The Pigouvian approach internalises externalities through taxes while Coasian approach attempts to internalise externalities through bargains with the authorities (Perman, et al, 1996: 217)[17]. While the Pigouvian approach places responsibility for an externality on its generator (the polluter), in contrast, the Coasian approach assumes that an externality is reciprocal (i.e., both polluter and pollutee cause the externality). At the heart of these controversies are disagreements over the appropriate balance between effluent charges and the laws promulgated to protect or enhance broader social values in water. Public policy could err, on the one hand, by "over-regulation", so that excessive external costs are imposed on third parties and the net social benefit of a transfer are negative. Critics of the enforcement of the levy system indicate that the application of the “Pigouvian” instrument can be relatively arbitrary with personal ties between regulators and plant managers and other forms of favouritism commonly cited (Dasgupta et al, 1997a).

7.6.6 Monitoring, Warning Letters and Court Action: Too Much Discretion in Kenya

The enforcement arm of a regulatory agency often has more in common with police or other law enforcement agencies in government. Thus, an alternative view of regulatory enforcement is that it is a pure law enforcement function designed to achieve the highest possible level of compliance. In contrast to "maximizing social welfare," which would require the agency to balance the cost of compliance against the benefits of compliance, "maximizing compliance" ignores costs altogether. Two main problems emerged with the enforcement of the inspections, warning letters and court action. Because of the resource constraints imposed by the process: (i) there was extensive use of discretion in the enforcement, and (ii) rent-seeking emerged as a problem in some towns. Our field survey shows that the regulatory authorities extensively exercised discretion in enforcing wastewater standards in the urban areas. This is not meant to imply that the behavior of the enforcement authorities is arbitrary or otherwise inappropriate. The type of discretionary enforcement that we found reflected selective and "some prudent" enforcement due to resource constraints in some towns. For example not all the repeated violators received a warning letter or a subsequent court prosecution. Some enforcement officers found it convenient to prosecute some but not all of such offenders. These were probably based on the size, and reputation of firms. In other locations, legal, bureaucratic and political factors were all given considerations. Interviews with enforcement officers suggest that in any given period, even when financial resources were available, the plants chosen for inspection were random in some towns and not others. Interviews with the MENR and Local Authority enforcement officers also indicate that inspections were motivated by diverse considerations. A problem of rent seeking and extortion was rampant in two towns, particularly involving the enforcement officers from Local Authorities and not the government Ministry.

7.7 The Appropriateness of the Multiple Agency Arrangement

In this section, we consider the appropriateness of the institutional arrangement for wastewater regulation. We discuss the theoretical question of the effect of multi-agency enforcement on compliance, enforcement difficulties encountered, the opportunities lost and the future of the multi-agency framework in Kenya.

Multiple Agency Enforcement and Compliance

The multiplicity of enforcement agencies on wastewater regulation in Kenya present numerous difficulties and raise questions on the appropriateness of the institutional arrangement. The fact that there are many acts, rules, regulations and by-laws with regard to the multiplicity of agencies involved in the regulation of industrial wastewater means that there are widespread variations in interest and focus across the country. We have summarized the distribution of these multiple agencies and levels of enforcement in table 7.4.

Table 7.4: Levels of Enforcement Activities of Different Agencies

Parameter	Thika	Nairobi	Nakuru	Kisumu	Eldoret
LA –Water & Sanitation Department		√ (2)			
LA – Public Health Department	√ (2)		√ (3)		√ (3)
MENR – District Water Office	√ (1)	√ (4)	√ (4)	√ (3)	√ (2)
Environment Sanitation				√ (4)	
Labour/ Industry Inspectorate			√ (1)		
NGOs – WWF for Nature			√ (2)		
Other Departments Involved					
LVEMP				√ (2)	
KEMFRI					

Extent of involvement (1) very high (2) high (3) medium (4) low: LVEMP =Lake Victoria Environmental Management Project; KEMFRI=Kenya Marine Fisheries Research Institute; WWF= World Wide Fund.

Some urban areas have a high number of agencies interested in wastewater regulation and high levels of activities by the agencies involved.

To address the issue of appropriateness of the multiplicity of agencies in Kenya, we focus on two pertinent questions that have only seldom been discussed in the literature. First, what is the extent to which enforcement and compliance differ with the level of government? Secondly, should monitoring and enforcement be delegated to local jurisdiction, or remain with the national enforcement agency? Another significant gap in our knowledge relates to the interaction of the various institutions that affect compliance behaviour – how does their interaction affect the level of compliance. To answer the first question, a summary of enforcement instruments in the five urban areas is presented in Table 7.5. From that table, we observe that while MENR specialises in command and control instruments, Local Authorities appear more inclined to use economic instruments, defective as they may be. This inclination can be explained by the attitude of the Local Authorities to expand their revenue base.

> *There is an apparent conflict of interest between environmental enforcement and revenue generation among the local authorities.*

For example, our discussion in chapter 5 indicated that much of this revenue is not re-injected into the water and sanitation services as they should be. MENR is much more effective in their enforcement strategy than the Local Authorities who have more options for enforcement but do not have the necessary capacity for enforcement.

Current theoretical models of enforcement suggest that, other things being equal, a broad-based enforcement agency is likely to be able to achieve higher rates of compliance than a group of smaller ones. An agency that covers a wide geography and/ or a variety of media is more likely to be able to identify and exploit *synergies* i.e. by implementing compliance-enhancing deals than one with a narrower range of jurisdiction (Heyes and Rickman, 1999:373). The broad based institutional arrangement should have a clear local emphasis. A good example of this type of research is Burby and Paterson (1993), who study compliance under two different enforcement agencies, a state-level enforcer and a local enforcement authority. Burby and Paterson are interested in whether delegating enforcement authority to the local level will result in more or less compliance. On the one hand, a decentralized enforcement agency might be overly concerned with local issues such as employment and zoning restrictions. Thus, we would expect less stringent enforcement and compliance with local authority monitoring. On the other hand, a local enforcement agency might have the advantage of being familiar with the facilities and individuals within the firm, and are more likely to gain the cooperation of local managers – an argument that is defective in the case of Kenya.

Table 7.5. Summary of Enforcement Instruments in Kenya

		Ministry of Water (MENR)				**Local Authorities**		
		Main strategies	Extent of Usage	Impleme-ntability	Effecti-veness	Extent of Usage	Impleme-ntability	Effectiveness
Command and Control	Monitoring and Inspections	Self reporting (a) Sampling (b)	Moderate (b) Low (a)	Moderate (b) Low (a)	Low	Low	Moderate (b)	Poor
	Warning Letters	Selective	High	High	Low	High	Low	Low
	Court Action	Fines (a) Closures (b)	Moderate(a) Poor (b)	Low	Moderate	Poor	Poor	Poor
	Water Permit	Cancellations	Low	Poor	High			
Economic Instruments	Financial Penalties	Violation penalties				Proposal in 2 towns	Poor	Could be effective
	Sewer Charge	% of water consumed				All towns	High	Moderate
	Trade Effluent Charge	Water volume &				Proposal in 2 towns	Poor	Could be effective

Notes: (1) High (2) Moderate (3) Low (4) Poor

Our field observations support a centralized, and broad based enforcement authority for several reasons: First, we consider that most of the problems encountered during enforcement to emanate from a low level of implementation rather than any serious deficiencies in the legal provisions. We attribute the low level of enforcement to (i) the multiple agencies with different mandates, each agency trying to define the laws and activities on the basis of its narrow mandates. No agency expressed interest in correlating their tasks with the others; (ii) the division of responsibilities among multiple agencies, with little coordination, made it procedurally difficult to harmonize operations, thus leading to lack of interest among some departments that felt disadvantaged[18]. (iii) there was a notable absence of what can best be described as the "philosophy of enforcement" (or internal policies and principles) by the various government departments – a shortfall that we attribute to apathy emanating from multiplicity of agencies. This apathy was greater at senior levels - to some extent this was reflected by the comparatively junior grade officers responsible for enforcement while the senior officers engaged in non-enforcement activities.

There are several examples of impediments posed by multiple agencies in Kenya. The regulatory statutes for each enforcement agency influence judgement during enforcement. Some enforcement officers judge a firm to be non-compliant if in its officially analysed wastewater discharge, any of the parameters violates the stipulated concentration standards. Other officers are more lenient and they considered a number of parameters violated. Yet these judgments varied greatly between and within Ministry of Water (MENR) and the Local Authority. As a result of the multiplicity of judgements, firms are shifting allegiance between the Local Authorities and MENR depending on which enforcement agency was perceived to have better terms. Firms in Thika town were even taking advantage of the situation by providing misleading information to both agencies. The existence of a multiplicity of agencies provided the perfect environment for firms to cheat about the activities that had been sanctioned by other agencies. In our opinion, a broad based agency could also provide the following advantages to regulatory enforcement in Kenya:

(i) Since regulatory enforcement is information intensive, effective enforcement is impossible unless regulators have reliable data. Integrated information systems and the capacity to set priorities that reflect comparative benefits and costs can be enhanced through a broad-based structure. Currently, data collected on factory emissions are held by separate agencies with different responsibilities i.e. in Kisumu four departments/agencies - Lake Victoria Environmental Management Project, MENR, Local Authority and the Kenya Marine Fisheries Research Institute; in Nakuru – Kenya Wildlife Services, Ministry of Labour (Factory Inspectorate), MENR and the Local Authority. All this information is not collated for an enforcement strategy. Agencies responsible for different monitoring and enforcement have no obligation to talk with each other.

(ii) Each of these agencies generally had little capacity for assessing the benefits of alternative programs and using their data to establish priorities for enforcement i.e. few trained inspectors are available.

(iii) Because they are small in size, each of the agencies encountered serious enforcement problems often meeting political resistance. Mobilizing political and community support would be effective with a broad based approach.

Under the above conditions, it is hard to implement wastewater regulatory enforcement and indeed, it is counterproductive to advocate industrial wastewater compliance under conditions that guarantee failure and risk discrediting a potentially effective regulatory tool.

> *Fragmentation of responsibilities inhibited exploitation of existing synergies between industrial wastewater generation, planning, and other economic activities. Wastewater and water pollution are pre-eminently issues that traverse cross-sectoral boundaries such as urban development, water management and industrial policy. The appropriate arrangement of institutions that will be entrusted with the different functions of pollution control is partly determined by the existence of synergies with existing activities. A typical case, for example, is on the location of industries upstream a water treatment (supply) works in Thika (Ruiru) town. Much of the enforcement crisis could be resolved by either re-locating industries downstream the waterworks or relocating the works upstream where there is no concentration of industrial or human activities. This is a matter that should have been addressed in the industrial location policies or urban development (planning).*

Overcrowding and Frustration of Industries

Some industries expressed frustration with the criss-crossing by government enforcement agencies as they conduct inspections. This problem was more severe in towns with multiple enforcement agencies for different aspects of industrial regulation. This frustration could be avoided by harmonizing the activities of different government agencies. For example, in their routine visits to factories, Factory or Public Health Inspectors (or Public Health Department either from Ministry of Labour or Health) confine their work to the internal working environment within the factories. This confinement is completely unnecessary since the mandates of the department could be expanded to include related functions such as monitoring of wastewater. It is also ironical that a factory inspector from one government department takes as a serious issue, the health effects on workers of dangerous emissions /effluents, while the same inspector is entirely unconcerned with the final effluents leaving the factory. The expertise available in the Inspectorate could be utilised by widening the department's scope to cover internal and external hazards related to industrial operations. There is an economic advantage in so doing in that a large amount of duplication of effort could be avoided. On some days, the industries were hosting up to 3 government agencies dealing with different aspects of regulation, i.e. wastewater, health and water. Experience in Thika town where an officer was in charge of several aspects of industry showed that industries could be more tolerant and cooperative when they are dealing with fewer government departments.

Lost Opportunities for Regulatory Dealing

Among the existing enforcement agencies dealing with industries in Kenya, their focus extends beyond wastewater compliance. Their interests cover air pollution, and the general working conditions in the industries. A unified approach in enforcement could create deeper knowledge of how well the individual industries are performing in all the other parameters. For example in Thika where Public Health Department rather than Water and Sanitation Department (Pollution Control Unit) has been active in enforcement, there has been "regulatory-dealing"[19]. One advantage of regulatory-dealing is that the firm and enforcement agency (i.e. LA) interact in more than one (indeed nearly all the environmental) domain. This has arisen because "a single agent" is responsible for enforcing more than one aspect of regulation (those regarding airborne emissions, waterborne discharges, noise, hygiene etc at a single plant) or because it enforces the same regulation at more than one constituent plant of a multi-plant firm. When penalties do not permit full-compliance to be achieved, the agency may be able to improve upon the overall level of compliance generated by a policy of full-pursuit (penalising all violations with certainly) by engaging in "regulatory dealing".

The future of Multi-agency Framework

Since 1990s, extensive debates on the appropriateness of the institutional arrangement for wastewater management and future of wastewater regulation by Municipalities have been going on especially with the introduction of commercialized water companies in some of the municipalities (this was extensively discussed in chapter four). There have been arguments in favour of consolidation of these functions under a single agency such as the NEMA (National Environmental Management Authority) that is yet to be instituted although the Act allowing its formation was approved in 2000. Cohen and Rubin (1985) proposed an alternative approach to private enforcement, whereby government enforcement agencies turn all of its monitoring and enforcement activities over to private parties. The payment the private enforcer receives is based on the net social benefit of enforcement. In theory, their proposal would overcome both of these objections. However, even in an era of privatization, the practical and political difficulties of implementing this proposal would appear to be insurmountable in Kenya.

7.8 Conclusion

Industrial wastewater problems are not handled well by markets, implying that government regulation has at least the potential for playing a beneficial role. However, this potential will not be realised if the regulations are ill conceived or not effectively enforced (Magat & Viscussi, 1990:331). In this chapter, we have examined the experiences of wastewater regulatory institutions in Kenya. These experiences are instructive to put in appropriate effort in order to improve industrial compliance with wastewater standards. Our analysis shows several weaknesses in the process. First, we consider that most of the problems encountered during enforcement of wastewater standards to emanate from a low level of implementation rather than any serious deficiencies in the legal provisions. We attribute the low level of enforcement to (i) the multiple agencies with different mandates, each agency trying to define the laws and enforcement activities on the basis of its narrow mandates. (ii) the division of responsibilities among multiple agencies, with little coordination, made it procedurally difficult to harmonize operations, thus leading to lack of interest among some departments that felt disadvantaged. (iii) there was a notable absence of what can best be described as the "philosophy of enforcement" (or internal policies and principles) by the various government departments – a shortfall that we attribute to apathy emanating from multiplicity of agencies. This apathy was greater at senior levels - to some extent this was reflected by the comparatively junior grade officers responsible for enforcement while the senior officers engaged in non-enforcement activities. (iv) No agency expressed interest in correlating their tasks with the others. Current theoretical models of enforcement suggest that, other things being equal, a broad-based enforcement agency is likely to be able to achieve higher rates of compliance than a group of smaller ones. An agency that covers a wide geography and/ or a variety of media is more likely to be able to identify and exploit *synergies* i.e. by implementing compliance-enhancing deals than one with a narrower range of jurisdiction (Heyes & Rickman, 1999:373). The analysis in this chapter would appear to support a centralized, and broad based enforcement authority in Kenya.

Notes

[1] **Biochemical Oxygen Demand (BOD_5)** test is dependent on the activities of bacteria which in the presence of oxygen metabolise organic matter. The amount of oxygen required to support this biological activity in standard temperature and time (20^oC for 5 days) is a measure of the oxidisable organic matter in the sample. However this method has limitations since it depends on living organisms interferes with the results. These would include the presence of toxic metal ions, cyanides etc. The test does not exhaustively oxidize the oxidisable organic matter due to the slow nature of oxidation of living organism. Furthermore this test cannot be used as rapid assessment of sewage strength due to the length of time it takes. However the BOD_5 test is still widely used to determine the strength of sewage and can therefore give some indication of how much oxygen will be required for oxidation of wastewater by bacteria.

[2] **Chemical Oxygen Demand (COD)** is defined as the amount of oxygen equivalent to the organic matter content of a sample susceptible to oxidation by a strong chemical oxidant. Potassium chromate is generally used. Limitations of this test include the fact that straight aliphatic organic compounds are not totally used. COD is increasingly becoming a method of choice in oxygen demand determinants because of the relatively short time in which results can be obtained. Further, it gives an idea of the toxic conditions and the presence of biologically organic substances present in the sample compared to BOD.

[3] **Suspended Solids (SS)** is one of the most important tests for sewage and other effluents. It is indeed a major indication of the efficiency of settling tanks. In well designed, operated and maintained settling tanks, the suspended solid removal can be between 50-90%. The efficiency of the tanks can be measured by determining suspended solids of raw sewage vis a vis that of the final effluent.

[4] This test measures the oxygen taken up by a sample under test from dilute solution of sulphuric acid. It is a quick method of determining the amount of oxygen that may be required to break down organic matter present. However the accuracy of the test is compromised by the fact that complete oxidation may not take place within the 4 hours the test is conducted. For more accurate results, other tests particularly Biochemical Oxidation

Demand (BOD) are preferable.

[5] **Dissolved Solids (DS)** exist in soluble molecular or ionic form and cannot be removed by settling or filtration during biological treatment processes, e.g. in trickling filters and stabilization ponds. Dissolved solids are converted, to a limited extent, to carbon dioxide or settleable micro-organisms (biomass).

[6] **pH**: The acidity or alkalinity of an aqueous solution depends on the hydrogen ion concentration or the pH. All living organism will only survive within a specified range of pH. If the pH of a wastewater is less than 5 or greater than 10, there may be fair amount of interference with the aerobic biological processes and with the organisms found in receiving streams.

[7] This observation supports the finding of Wang and Wheeler (Pricing Industrial Pollution in China, Policy Research Working Paper 1644, World Bank) that local enforcement of uniform national standards determines the effective "price of pollution" in each area. It supports the public interest theory of regulation, which views the regulator as an agent whose objective is to maximize social welfare.

[8] It is obvious that the Ministries of Water; Industry could easily impose a minimum technology requirements upon potential polluters at this stage – an instrument which would be easy and cheap to administer but this is overlooked. Instead approvals are granted even for very old machineries with a definite consequence of low wastewater quality.

[9] For example, in a filed report at Ministry offices, the officers are consistently being asked a humiliating question “why do you keep coming”.

[10] Lake Nakuru National Park contains a wetland of international importance, including the lake itself, which was designated a Ramsar site in 1990. Lake Nakuru is an important feeding ground for one or two million lesser flamingo (*Phoenicoterus minor*) and more than 450 other bird species. The park also supports large mammal populations including the threatened Black Rhicocerous (*Diceros bicornis*), and over 400 species of flowering plants. Each year Lake Nakuru National Park receives over 200,000 visitors, making it the second most visited park in Kenya.

[11] It may be useful to distinguish between *structured* information programs whereby the information release is part of a clearly articulated strategy undertaken by the regulator to reveal the environmental performance from *unstructured* information of the type one finds in newspapers, on a more ad hoc basis.

[12] The most common impacts captured during our field survey were deaths of fish along Thika River; Deaths of Flamingoes and Waterbucks around Lake Nakuru and Livestock deaths downstream Sosiani River.

[13] "Please refer to a letter Ref. no. MWD/…/DCON/186/4 of 7th April, 19.. which addressed to you by the District Water Engineer, … District and copied to this office, among others on the above subject and note that the design plans referred to by the District Water Engineer must be submitted urgently and that no activity likely to generate polluting effluent should be started without the necessary anti-pollution measures having been taken to the satisfaction of this Ministry. In this connection, you should further note that lack of co-operation and compliance on your part may lead to the Ministry taking legal action against you. Please take the necessary action accordingly."

[14] "On 2nd July 1998, your industry was visited by our Pollution Control Officers for the Inspection of your effluent treatment system and the manner of storage of raw material that your industry recycles to produce drums and containers. During the inspection, it was ascertained that the effluent treatment system has been converted into a septic tank for human waste disposal in addition to serving the raw material before processing. This office recommended the system solely for taking away the said wastewater. At no time did we ever recommend the utilisation of the system for treatment of human waste or any other related purpose….. Besides the improper utilisation of the effluent treatment system, it was also ascertained that contrary to our advice that you use proper containers preferably high tensile polythene bags for storage of your raw material, you continue to store the

material haphazardly all over the place outside the factory making the place look like a refuse dump. The raw material as we know it is actually very dirty as the containers mostly come from refuse dumps where all manner of filth is likely to be present. During the rains the filth washed off the containers down into Ruiru river which is only about 20 metres away from the factory."

[15] These effluent By-laws became effective from 25th March 1995 when they were signed by the minister for local government.

[16] Especially because there is a serious mismatch between these charges and the maximum penalties payable under the law.

[17] These water pollution levies are not a true Pigouvian charge since they are assessed on effluents which exceed established discharge standards for pollutant concentration in waste-water.

[18] For example on 5th January 1996 Ministry Headquarters wrote to Kisumu municipality (with copy to district water engineer and others): Please refer to a letter ref: .. addressed to the Managing Director of Latanners Limited and copied to you… This Tannery is within your Municipal jurisdiction. It is your responsibility to ensure that the management complies. Please take necessary action. Yet our survey showed that the Municipal council took no action or interest.

[19] A regulatory deal involves the agency agreeing (perhaps tacitly) to tolerate non-compliance in some sub-set of domains in “exchange” for compliance in others.

8 Industrial Water Management in Kenya: How Far Can Wastewater Regulation Take Us?

8.1 Introduction

In chapter seven, we discussed the institutional arrangement for industrial wastewater regulation in Kenya. Our purpose in this chapter is to evaluate the different enforcement instruments described in chapter 7 by applying monitoring, inspections, warning letters and court prosecutions to firm wastewater behavior. Rather than attempt to identify an optimal policy for wastewater regulation, our goal here is to measure the effects of these regulatory instruments available to the wastewater enforcement authorities (monitoring, inspection, warning letters and court actions) on firms. Our empirical results would still have implications for the wastewater policy design. The chapter is organized as follows: In section 8.2 we discuss wastewater treatment technologies among industrial firms in Kenya and in section 8.3 we look at the status of wastewater treatment facilities in industries. Section 8.4 discusses disposal patterns of industrial wastewater while section 8.5 covers enforcement activities. In section 8.6, we compute and analyze violation rates based on various inspection reports and section. In section 8.7 we discuss the analytical framework for firm response to wastewater regulation. 8.8 displays the model results on firm response to regulatory instruments. In section 8.9 we provide an overview of reactions to various enforcement activities. We conclude in section 8.1.

8.2 Wastewater Treatment Facilities/ Technologies in Kenya

The level of sophistication of wastewater treatment plants required varies with the type of industrial activity and scale of production. It should be remembered that even within the same sub-sector, there can be dramatic differences in the type of goods produced, the toxicity of wastewater and thus the requisite wastewater pre-treatment facilities. This variation was more pronounced among the food processing industries surveyed. Most firms have installed wastewater abatement gadgets that are summarized in Table 8.1 below.

Table 8.1: Wastewater Treatment Facilities/ Technologies

Wastewater Treatment	Number Visited	Number with wastewater treatment	Number of wastewater treatment facilities working during survey	Type of Treatment
Food Processing	10	7	4	[a], [b], [d], [c], [f]
Beverage Industries	7	6	4	[a], [d]
Textiles	16	12	6	[a], [c], [g],[d]
Leather Products	5	5	4	[a], [b], [d], [c]
Wood Products	1	1	0	[c], [a]
Pulp and Paper	5	4	4	[c], [a]
Chemical Products and Others	7	4	2	[c], [d], [a], [e], [f]
Total	53	38	24	
Percentage of Total	100	72	45	

Note: Types of Treatment include:- Physical: [a] =settlement; [b]=floatation; [c]=screening:- Biological: [d]=aerobic[1]; [e]=anaerobic[2] :- Other: [f]=deep well injection; [g]=precipitation with chemicals; [*]=municipal sewer. *Source: Own Survey Data*

There are dramatic variations in the cost of these plants with aerobic processes employed in leather tanneries, textile and some beverage industries having the highest costs. Among the food processing firms, the most common treatment facilities observed were physical and involved screening and settlement. In the beverage industry, the beer brewing plants had elaborate facilities as opposed to the soft drink plants. One brewery was discharging directly into a municipality sewer treatment works after contracting the municipality to undertake treatment of its wastewater in return for a capital contribution made towards rehabilitation of the treatment works. Even though the quality of influents tended to be the same across all of the tanning plants, the forms of pre-treatment facilities varied a great deal – for example, two firms were discharging directly into municipal sewer systems. In one of the plants, pre-treatment involved an aerobic process with a substantial investment while in the other the treatment involved screening. There was no possible way the later could achieve the requisite BOD standards. The above variations were also notable among the textile firms. In some of them, the treatment was basic involving screening while in others they were elaborate. Our interviews and information from enforcement records also showed that most of the above treatment plants are not properly designed and their capacities are based on mere approximations – hence they are prone to frequent technical problems. As the summary in table 8.3 shows, even though 72 percent of the firms surveyed had facilities, only 45 percent of the facilities were operating at the time of the survey. Most firms had seepage pits as alternative buffers to oxidation ponds.

8.3 Status of Wastewater Treatment Facilities

The proportion of firms with wastewater treatment facilities is highest at Thika and lowest in Kisumu. All firms in Thika had facilities while only 73 percent of these were working during the survey. In Kisumu only one (1) plant at the Kisumu brewery (25 percent of the facilities) was operating.

Table 8.2: Status of Wastewater Treatment Facilities

3 DIGIT ISIC CODE	SECTOR	THIKA	NAIROBI	NAKURU	KISUMU	ELDORET	TOTAL NUMBER
311	Food Processing	4	1		2	3	10
		(4)	(1)		(0)	(2)	(7)->(70%)
		[3]	[0]		[0]	[1]	[4]->(57%)
313	Beverage Industries	1	2	1	2	1	7
		(1)	(2)	(1)	(2)	(0)	(6)->(86%)
		[1]	[1]	[1]	[1]	[0]	[4]->(67%)
321	Textiles	5	4	3		4	16
		(5)	(2)	(2)		(3)	(12)->(75%)
		[3]	[1]	[1]		[1]	[6]->(50%)
323	Leather Products	2	3	1			6
		(2)	(2)	(1)			(5)->(83%)
		[2]	[1]	[1]			[4]->(80%)
331	Wood Products					1	1
						(1)	(1)->(100%)
						[0]	[0]->(0%)
341	Pulp and Paper	1	3			1	5
		(1)	(3)			(0)	(4)->(80%)
		[1]	[3]			[0]	[4]->(100%)
352/351	Chemical Products/Others	2	2	4			8
		(2)	(1)	(1)			(4)->(50%)
		[1]	[0]	[1]			[2]->(50%)
		15	15	9	4	10	53
	TOTAL	(15)	(11)	(5)	(2)	(6)	(38)->(72%)
		[11]	[6]	[4]	[1]	[2]	[24]->(63%)
Firms with Facilities %		100	73	56	50	60	72
Firms with working Facilities %		73	40	44	25	20	45

Note: Curly Brackets show number or %age of firms with treatment facilities; Box brackets show the number or %age of firms with operational facilities. Source: Own Survey Data

Several factors explain the variations in the status of wastewater treatment facilities. First, we observed a general tendency for the larger firms to own treatment equipment probably because of the visibility of their actions. This scenario was true across all sectors. Secondly, our statistical evidence suggests links between enforcement levels (activities) and the operational status of the equipment – the two appear to be highly correlated in all urban areas. However, based on our interviews, the status of the treatment equipment (whether operational or dormant) could be attributed to the attitude of the management towards their externalities rather than enforcement, thus this correlation could be spurious. In some instances, the treatment facilities were kept deliberately closed to minimize on running costs. For example, it was common for the plants to by-pass the treatment works. In one inspection report from a Textile factory, the enforcement authority states:

> *"I carried out the inspection …at the time of inspection, dyeing process was going on. The effluent was however not being treated through the treatment plant as expected. Instead, it was discharging through a ravine leading into the River. A look at the treatment plant showed that it had not been used for some time."*

Third, the operational status was also influenced by the disposal options available for firms. We examine this pattern in the next section.

8.4 Disposal Patterns of Industrial Wastewater

All firms in urban areas had the option of discharging into three points: the open streams, municipal sewer or both. However, wastewater disposal patterns varied a great deal across the urban areas. In Thika 40 percent of the firms were discharging their wastewater into the municipal sewer, 7 percent were discharging into a nearby river or stream, while the remaining 53 percent were discharging into both the river and municipal sewer. In Nairobi, 73 percent were discharging into the municipal sewer, 7 percent into rivers/ nearby streams, and 20 percent into both municipal sewer and open streams. In Nakuru 78 percent were discharging into municipal sewer and the other 22 percent into both municipal sewer and open streams. In Kisumu, 50 percent in Municipal sewer and the other 50 percent into rivers and municipal sewers. In Eldoret, 60 percent and 40 percent were discharging into municipal sewer and both streams and sewers respectively. A summary of the modes of disposal is provided in Table 8.3.

In general, 60 percent of the firms were discharging into municipal sewers alone, 13 percent into streams alone, while 27 percent into both sewers and streams.

The factors underlying the choices for different modes of wastewater disposal are interesting variables for our analysis. This is because firms that discharge into rivers etc face stiffer standards and have to expend more money on capital goods and use much more land to build pretreatment facilities. On the other hand, firms using the public sewer have to pay sewer charges and make minimum investments to comply with the stipulated standards and by-laws. In view of these differences:

i) Firms with large volumes of wastewater to dispose might find it advantageous to dispose off the effluents in a way that minimizes their costs i.e. into rivers.

ii) Dirty firms (pollution intensive firms) should find it less costly to discharge into municipal sewers since the wastewater standards are lower.

In relation to the first case (i), there was a pattern in Thika town for firms with self supplied water, to avoid paying sewer charges by preferring to discharge into streams and rivers. On the other hand, sewer charges would be based on quantities of water consumed and the municipal authorities attempt to monitor these quantities of water. Such firms prefer own disposal to avoid paying the sewer charges. In the process, the firms find that they have large volumes of wastewater to dispose in rivers and open streams. The main problem with this choice is that the firm had to contend with Ministry of Water' wastewater standards which were much stringent than for the firms discharging into municipality sewers. For this reason, violation of standards was more likely for firms discharging into streams. Another reason for preferring streams is that it proves rather tricky for the enforcement officers to detect a violation once the discharge had entered the streams/rivers. What the firms needed to do is optimize on the timing of the discharge to avoid detection (i.e. by discharging at night or during weekends). In relation to the second case (ii), we do not observe a systematic pattern of dirty industries preferring to discharge into municipal sewers.

> *Disposal patterns among the dirty firms (mainly leather, chemical, wood and paper) were much more dependent on their location, with the firms located close to rivers having the tendency discharge into rivers rather than sewers in both case i & ii.*

Table 8.3: Wastewater Disposal during the Survey

3 DIGIT ISIC CODE	SECTOR	Recipient (Percentage)	THIKA (28)*	NAIROBI (28)	NAKURU (17)	KISUMU (8)	ELDORET (19)	TOTAL NUMBER (100)
311	Food Processing	Muni. Sewer (a)	2			1	2	5
		River/stream (b)	1					1
		Both (a) & (b)	1	1		1	1	4
		Sub -total	**4**	**1**		**2**	**3**	**10**
313	Beverage Industries	Muni. Sewer (a)	1	1	1	1	1	5
		River/stream (b)						
		Both (a) & (b)		1		1		2
		Sub-total	**1**	**2**	**1**	**2**	**1**	**7**
321	Textiles	Muni. Sewer (a)	1	4	3		2	10
		River/stream (b)	1					1
		Both (a) & (b)	3				2	5
		Sub-total	**5**	**4**	**3**		**4**	**16**
323	Leather Products	Muni. Sewer (a)		1				1
		River/stream (b)	2	1				3
		Both (a) & (b)		1	1			2
		Sub-total	**2**	**3**	**1**			**6**
331	Wood Products	Muni. Sewer (a)						
		River/stream (b)						
		Both (a) & (b)					1	1
		Sub-total					**1**	**1**
341	Pulp and Paper	Muni. Sewer (a)		3			1	4
		River/stream (b)						
		Both (a) & (b)	1					1
		Sub-total	**1**	**3**			**1**	**5**
352/351	Chemical Products/ Others	Muni. Sewer (a)	2	2	3			7
		River/stream (b)						
		Both (a) & (b)			1			1
		Sub-total	**2**	**2**	**4**			**8**
	TOTAL	Muni. Sewer (a)	6	11	7	2	6	32
		River/stream (b)	4	1	--	2	--	7
		Both (a) & (b)	5	3	2	--	4	14
		Total	**15**	**15**	**9**	**4**	**10**	**53**

Source: Own Survey Data

Another group of firms maintained two disposal points (both sewers and rivers). A possible explanation is that firms would attempt to dispose the very dirty effluents illegally into the streams while a cleaner effluent would be discharged into the municipality. Several firms deliberately diverted their factory effluents to by-pass treatment facilities or quickly emptied the contents of their treatment works into streams when it was perceived that detection was unlikely, this included mid-night dumping.

8.5 Enforcement Activities

Table 8.4 provides a summary of letters, court cases and penalties in various towns and sectors. The table shows that Thika town had the highest number of inspection reports, suggesting a high level of enforcement of standards. Eldoret, Nairobi, Nakuru follow this, while Kisumu had the least number of reports. We have mentioned earlier that not all the samples forwarded for Analysis in Nairobi are returned, from our field interviews, we estimate that about 30 percent of these samples are never returned. Furthermore, only a fraction of the samples collected is forwarded for analysis. In several instances, the samples are collected to serve as a threat to the polluting firms. Again we estimate that 50% of the collected samples are not taken anywhere for analysis. There are numerous allegations of extortion and bribery relating to sample collection. Some firms alleged that the enforcement officers collect the samples in order to solicit bribery from them. For example we learnt through our correspondents that corruption was particularly rampant in one urban area where a small number of firms were paying enforcement officers for protection against payment of sewer charges.

Table 8.4: Enforcement Activities in the Urban Areas[4]

3 DIGIT ISIC CODE	SECTOR	THIKA	NAIROBI	NAKURU	KISUMU	ELDORET	TOTAL NUMBER
311	Food Processing	(29)*	(6)		(23)	(25)	(97)
		[3]**	[2]		[4]	[2]	[11]
		0***	2		3	1	6
313	Beverage Industries		(5)	(7)	(3)	(6)	(21)
		--	[1]	[--]	[--]	[--]	[1]
			0	0	0	0	0
321	Textiles	(42)	(5)	(9)		(34)	(91)
		[4]	[--]	[--]		[--]	[4]
		3	0	0		0	3
323	Leather Products	(17)	(34)	(7)	(9)		(59)
		[2]	[4]	[--]	(1)		[6]
		0	4	0	0		4
331	Wood Products					(9)	(9)
						[1]	[1]
						0	0
341	Pulp and Paper	(9)	(4)			(7)	(20)
		[1]	[1]			[--]	[2]
		0	0			0	0
352/351	Chemical Products/Others	(7)	(10)	(5)		(8)	(30)
		[2]	[2]	[--]		[--]	[4]
		0	0	0		0	0
		(104)	(64)	(28)	(26)	(88)	(290)
	TOTAL	[12]	[10]	[--]	[4]	[3]	[29]
		3	6	0	3	1	13

Note: *Figures in curly brackets show Warning Letters or statutory notice, **Figures in box brackets show Court Cases and ***figures without brackets show court Convictions, Closures or Forfeiture of Water Permit.
[4]For all the industries in the urban areas as far as the available records show - inclusive of the 53 surveyed. Source: Own Survey Data.

8.5.1Enforcement by Sector

On the basis of the information on inspections, letters and court action, we have computed various parameters for the sectors studies. These are summarized in Table 8.5.

Table 8.5: Comparison of Enforcement by Sector/Industry

Sector	Number of Firms surveyed	Inspections (approx)	Advisory Letters	Warning Letters/ Statutory notice	Court Prosecutions	Convictions	P_d	$P_{p\|d}$	$P_{c\|p}$
Food	10	574	244	97	6	6	0.594	0.018	1
Beverage	7	87	53	21	4	3	0.851	0.054	0.750
Textile	16	466	215	91	10	7	0.657	0.033	0.700
Leather	6	271	174	59	6	6	0.860	0.026	1
Wood & Products	1	41	11	9	1	0	0.488	0.050	0
Pulp and Paper	5	105	73	20	2	2	0.886	0.022	1
Chemicals & Others	8	158	77	30	4	3	0.677	0.037	0.750
Total	53	1702	847	327	33	27	0.689	0.028	0.818

Note: Probability of detection (P_d) is defined here as the sum of advisory letters and warning or statutory letters divided by inspections. Probability of prosecution given detection ($P_{p|d}$) is defined as court prosecutions divided by the sum of advisory letters and warning or statutory letters. Probability of conviction given prosecution ($P_{c|p}$) is defined as convictions divided by court prosecutions. Source: Own Survey Data

Our findings suggest that given the levels of inspection across sectors:

(i) Detection was much more likely in the pulp and paper, followed by leather industries. This observation seems to indicate concentration of enforcement activities in these sectors.

(ii) Prospects for prosecution upon detection were however highest among wood and chemicals, suggesting that regulatory authorities are much more efficient in monitoring certain discharge points. Even though the results suggest that, *ceteris paribus*, plants whose emissions are most likely to impose high environmental damages are facing a higher probability of being inspected and warned; the probability of an inspection appears to be an increasing function of the final discharge point for the plant i.e. whether a stream or municipal sewer. Moreover, we suspect that these outcomes are heavily influenced by the primary motivation of the enforcement agencies. One of our findings is that much more attention by the enforcement officers was devoted to ensuring that the firms got pollution equipment in place rather than seeing that it is operated correctly.

Conviction upon prosecution is much more likely among the leather tanneries than any other industries.

8.5.2 Enforcement by Towns

Our results as summarized in Table 8.6 suggest the following:

(i) Given the levels of inspections, detection of violation was much more likely in Eldoret followed by Kisumu, Nakuru, Thika and finally Nairobi.

(ii) A detected violation is much more likely to be prosecuted in Nairobi, followed by Thika, Kisumu,

(iii) A prosecuted firm is much more likely to be convicted in Kisumu, followed by Nairobi, Eldoret, Thika and finally Nakuru.

Table 8.6: Comparison of Enforcement by Towns

Sector	Number of Firms surveyed	Inspections (approx)	Advisory Letters	Warning Letters/ Statutory notice	Court Prosecutions	Convictions	P_d	$P_{p\|d}$	$P_{c\|p}$
Thika	15	634	316	114	13	8	0.678	0.030	0.8461
Nairobi	15	509	221	64	10	6	0.559	0.035	0.800
Nakuru	9	155	61	28	--	--	0.574	0	0
Kisumu	4	203	146	26	4	3	0.847	0.023	0.750
Eldoret	10	201	103	95	6	4	0.985	0.030	0.833
Total	53	1702	847	327	33	27	0.689	0.028	0.818

Note: Probability of detection (P_d) is defined here as the sum of advisory letters and warning or statutory letters divided by inspections. Probability of prosecution given detection ($P_{p|d}$) is defined as court prosecutions divided by the sum of advisory letters and warning or statutory letters. Probability of conviction given prosecution ($P_{c|p}$) is defined as convictions divided by court prosecutions. Source: Own Survey Data

8.6 Violation Rates of BOD and TSS from Various Inspection Reports

Violation Rates for BOD are much higher than those for TSS. This is probably influenced by the wastewater characteristics of the industries. In the case of treatment of BOD tends to be much more demanding than for TSS.

Table 8.7: Violations of BOD and TSS from Various Inspection Reports – 1990/2000.

	Thika		Nairobi		Nakuru		Kisumu		Eldoret	
	BOD_5	TSS	BOD_5	TSS	BOD_5	TSS	BOD_5	TSS	BOD_5	TSS
Food Processing	1/3	0/3	0/4	0/4	--	--	9/12	9/12	7/15	3/15
Beverage Industries	--	--	--	--	--	--	--	--	0/9	1/9
Textiles	72/127**	2/127	2/4**	0/4	0/3	0/3	--	--	7/18**	0/18
Leather Products	13/23	13/23	5/9**	7/9	4/7	5/7	--	--	--	--
Wood Products	--	--	--	--	--	--	--	--	4/4	4/4
Pulp and Paper	3/19	2/19	--	--	--	--	--	--	1/5	0/5
Chemical Products and Others	4/8	3/8	3/5	3/5	5/6	5/6	--	--	4/6	2/6
Total	93/180	8/180	9/22	10/22	9/16	10/16	9/12	9/12	23/57	10/57
Violation Rates	0.51	0.04	0.41	0.45	0.56	0.63	0.75	0.75	0.40	0.18

Note: Aziz din violates persistently i.e. (3/3) since it does not have pre-treatment facilities, while Deras only (1/5), Kamiti (1/1) of the 9 times. ** COD values used in Textile sector. Source: Own Survey Data.

Our results in Table 8.7 also suggest that BOD violation rates are highest in Kisumu town followed by Nakuru, Thika, Nairobi and Eldoret respectively. This summary does not however tell us that violation rates are location specific. In terms of industrial sectors (see Table 8.8), BOD violation rates are highest in Wood & Products, followed by Chemicals & Others, Leather, Textile, Food, and Pulp and Paper respectively. Again the summary in Table 8.9 does not imply that violations are sector specific as the summary is much more influenced by the monitoring and sampling patterns by the individual enforcement agencies.

8.6.1 Violation Rates Versus Sanction Parameters

Comparison Across Sectors

In Table 8.8 we have displayed a summary of BOD and TSS violation rates and the sanction variables. The BOD and TSS violation rates tend to move together with BOD violations tending to be much higher than TSS. This is also explained by industry characteristics and the fact that detection of both violations occur at the same time i.e. during the same episodes of inspection. We have modelled the link between sanction variables and violation rates in section 8.7. What is visible here is that the two variables are highly correlated and our econometric results do change significantly when either of the two is used as a dependent variable.

Table 8.8: Comparison of Violation Rates and Sanction Variables

Sector	Number of Firms surveyed	BOD Violation Rates	TSS Violation Rates	P_d	$P_{p\|d}$	$P_{c\|p}$
Food	10	0.500	0.353	0.594	0.032	0.545
Beverage	7	--	0.111	0.851	--	0.000
Textile	16	0.532	--	0.657	0.013	0.750
Leather	6	0.564	0.384	0.860	0.026	0.667
Wood & Products	1	0.900	0.900	0.488	0.050	0
Pulp and Paper	5	0.167	0.083	0.886	0.022	0
Chemicals & Others	8	0.640	0.520	0.667	0.037	0
Total	53	0.498	0.164	0.689	0.028	0.818

Note: Probability of detection (P_d) is defined here as inspections divided by the sum of advisory letters and warning or statutory letters. Probability of prosecution given detection ($P_{p|d}$) is defined as court prosecutions divided by the sum of advisory letters and warning or statutory letters. Probability of conviction given prosecution ($P_{c|p}$) is defined as convictions divided by court prosecutions. Source: Own Survey Data

Comparison Across Towns

Table 8.9: Comparison Violation Rates and Sanction Variables by Towns

Sector	Number of Firms surveyed	BOD Violation Rates	TSS Violation Rates	P_d	$P_{p\|d}$	$P_{c\|p}$
Thika	15	0.517	0.044	0.678	0.030	0.846
Nairobi	15	0.409	0.455	0.559	0.035	0.800
Nakuru	9	0.463	0.625	0.574	0	0
Kisumu	4	0.750	0.750	0.847	0.023	0.750
Eldoret	10	0.404	0.175	0.985	0.030	0.833
Total	53	0.498	0.164	0.689	0.028	0.818

Note: Probability of detection (P_d) is defined here as inspections divided by the sum of advisory letters and warning or statutory letters. Probability of prosecution given detection ($P_{p|d}$) is defined as court prosecutions divided by the sum of advisory letters and warning or statutory letters. Probability of conviction given prosecution ($P_{c|p}$) is defined as convictions divided by court prosecutions. Source: Own Survey Data

8.7 The Analytical Framework for Firm Response to Regulation

8.7.1 Analytical Framework

(a) The Theoretical Basis for Regulatory Enforcement

Given that firms' select privately optimal level of wastewater treatment x, if we let a firms' net profits, $\prod^R$, be written as

$$\prod^R = \prod^r - z(x)$$

where $\prod^r$ is the profit before wastewater abatement, and z(x) ≥ 0 is the cost of abatement such that costs decrease with increased infractions (wastewater pollution), z'(x)_dz/dx<0, where marginal costs equal zero, z'(x')=0, at a threshold level of wastewater pollution, X'. Therefore the firm's marginal benefit from increased wastewater pollution equals –z'(x). Let society's net gains, $\prod^s$, given the damage by firms' wastewater pollution, be written as

$$\prod^s = \prod^R - M(x)$$

where, $\prod^s$, is the gain given no wastewater pollution, and M(x) is the monetary equivalent of the damage suffered where damages increase with increased wastewater pollution, M’(x)_dM/dx>0. The society’s marginal cost of increased pollution is therefore equal to M’(x) (Hanley, et al., 1997:30).

Fig. 8.1. Illustrative social (society’s) and private (firms’) optimal level of wastewater abatement

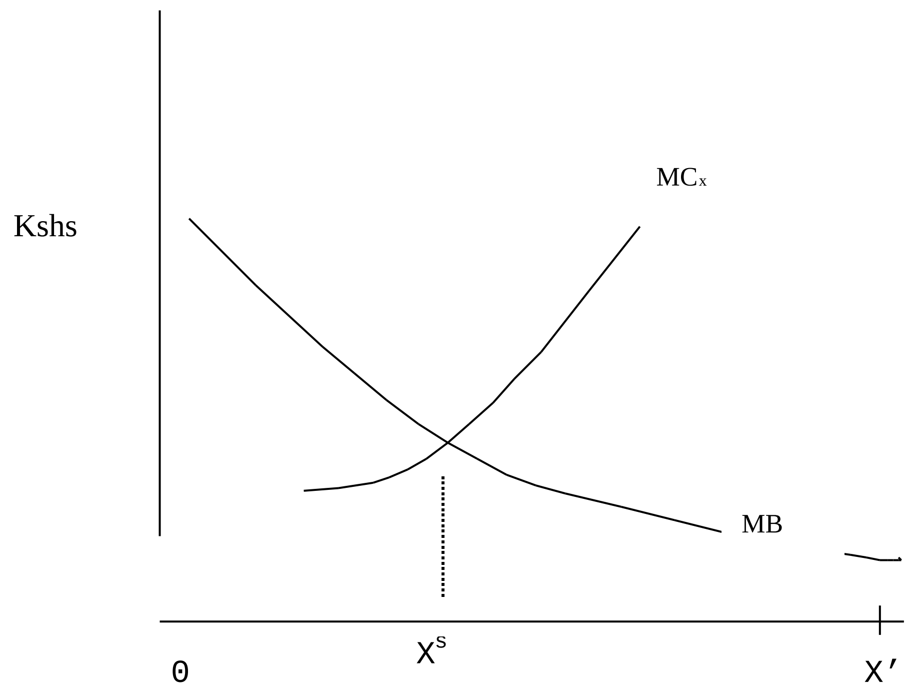


Figure 8.1 shows the firm’s optimum, x’, and the society’s optimum, x^s, level of wastewater pollution. The social optimal level of wastewater infractions is determined by taking account of the firms’ impact on society. The social optimum requires that firms’ marginal benefit be balanced against the society’s marginal costs, -z(x)=M’(x), represented by X^s in figure 8.1. If firms ignore the negative impacts on society, they will continue to pollute until their marginal benefits from wastewater pollution are zero, -z’(x)=0.

The starting point in our analysis is to recognise that wastewater standards are not self-enforcing and that securing of compliance by firms involve efforts by the regulatory agencies to discourage firms from operating at x’. Enforcement involves (substantial) resources, while perfect compliance is neither possible nor desirable, rather, the goal of the system should be optimal compliance, that is, the point at which the marginal social benefits accruing from compliance are equivalent to the marginal costs incurred in securing that level of compliance (x^s).

If we identify the social benefits of compliance as the reduction of unprevented damage costs, the losses which would not have been incurred if there have been compliance, and the costs as comprising mainly those incurred in administrating the system of enforcement, then the principal economic goal of enforcement policy is to minimise such costs. To understand the relationship between these two costs, and therefore to explore the means of achieving the minimisation goal, we adopt a simplified version of the familiar Becker deterrence model, assuming that individuals and firms comply with regulatory obligations if the benefits derived from contravention are exceeded by the costs.

This condition can be expressed as:

$$\Pi_{nc} < pD$$

Where Π_{nc} is the profit to the offender from the contravening activity, p is the probability of apprehension by a public agency and D the direct and immediate costs to the firm resulting from such apprehension.

Some aspects require clarification before we proceed further. First, the *p* and *D* variables reflect the potential offender's subjective perception of the probability of apprehension and of the associated level of costs respectively, rather than their objective values; and the accuracy of such perceptions will be a function of the offender's information costs (Ogus and Abbot, 2001). It follows, too, that *pD* should be weighted to reflect the degree of risk aversion (if any) towards the consequences (Polinsky and Shavell, 1979). Secondly, since *p* refers to apprehension by the public agency and not, more narrowly, to a formal determination of liability (or guilt) by the court or agency with power to impose a penalty, *D* covers as far wider range of costs than any formal sanction. It thus includes the "hassle" costs of pressure by an agency to comply, legal and other defence expenditures and any stigma or loss of reputation resulting from the apprehension and subsequent events.

There are, of course, various strategies that can be employed by an enforcement agency; it can select a process leading to a particular sanction, for example a criminal penalty or revocation of a licence; and it can determine how far to proceed within any such process, for example, merely issuing a warning or instituting formal procedures. Different probabilities and associated costs attach to these possibilities, whether they are sequential or alternatives. It thus becomes preferable to rewrite the condition for compliance as:

$$\Pi_{nc} < p_1D_1 + p_2D_2 + p_3D_3 + p_4D_4 + \ldots + p_nD_n$$

where, each element in the right-hand side of the inequality represents the probability and associated costs of a different predictable event in the enforcement process.

The procedure of increasing severity that may be undertaken by the enforcement agency once a contravention has been identified. The logic is that the agency proceeds through these stages of enforcement until it is satisfied that it has secured a particular offender's compliance. In general, the costs (D) to the offending firm increase with each higher stage. At the same time, viewed ex-ante, the probability (p) that that stage will be reached, is reduced. At the apex we have a formal conviction and (generally) the imposition of a formal sanction.

The cornerstone assumption in the economic analysis of compliance behaviour by firms is that individual firms are economic (rational) decision units responding to the costs and benefits of participation in legal and illegal activities. Firms are assumed to subjectively weigh the potential gains and losses of committing a regulatory infraction. A firm's "gain" function can be represented by $\Pi_{nc} = (C_\Pi + V_\Pi)$ where C_Π (current compliance gain levels) and V_Π (current violation gain levels) are respectively assumed to be known with certainty and that based on convexity assumption for analytical convenience, each is increasing at a decreasing rate in the amount of abatement effort.

The return to non-compliance (x') is however made uncertain because the violator could be detected and punished. The violator faces four sources of uncertainly corresponding to the four stages in the judicial process: (i) detection with a warning (verbal or written), (ii) prosecution, (iii) conviction, and (iv) punishment. Even with a conviction, the ensuing penalty is not known with certainty. It may take the form of an indefinite closure, a fine, forfeiture of water permit, or indeed the violator may get off with simple warning. It is assumed that although a potential violator does not know *ex ante* the form of punishment, he does know its magnitude and assigns a *subjective probability* that it may be awarded upon conviction. In addition to punishment costs, there is a cost to the defendant at each prior stage of the judicial process. The direct and immediate cost of detection *D* that could include any immediate exchanges (written, verbal), water permit suspension, or temporary closure (depending on the level of attention attracted by the violation). There are also direct prosecution costs *A* that would include attorney and /or court costs.

Given the above set of possibilities, the expected gains of firm *i* should it commit regulatory infractions can be specified as follows (Furlong, 1991):

$$\begin{aligned} E(\Pi_{nc}) = {} & (1-p_d)\Pi\left[V_\Pi + C_\Pi\right] + P_d\left[1-p_{p|d}\right]\Pi\left[V_\Pi + C_\Pi - D\right] + \\ & P_d P_{p|d}\left(1-p_{c|p}\right)\Pi\left[V_\Pi + C_\Pi - D - A\right] + P_d P_{p|d} P_{c|p}\Pi\left[V_\Pi + C_\Pi - D - A - P_{f|c} f\right] \end{aligned} \tag{8.1}$$

where

$E(\Pi_{nc})$= aggregate expected gains at infractions (non-compliance)

C_Π = gain levels in compliance

V_Π = gain levels in violations

A = prosecution costs

D = direct and immediate cost of detection

P_d = the subjective probability of detection,

$P_{p|d}$ = the subjective probability of prosecution

$P_{c|p}$ = the subjective probability of conviction given prosecution

$P_{f|c}$ = the subjective probability of being fined upon conviction

f= the level of fines

(b) Analysis of Firm' Behaviour

Gain level in compliance depends on the abatement costs of the firm and it is linked to the type of industry, scale of production etc. If these costs (i.e. of running the facilities) are low, it will not be lucrative for the firm to violate, hence the expected gains at non-compliance will be high, thus $\partial E(\Pi_{nc})/\partial C_\Pi \leq 0$. On the other hand, if the gain levels in violations is high (i.e. due to high costs of running facilities), then the expected gains from regulatory infraction are high, thus, $\partial E(\Pi_{nc})/\partial V_\Pi \geq 0$. We examine the effect of monitoring, warning letters and court prosecutions.

(i) Monitoring, Inspections and Detections

The levels of monitoring and inspections determine the probability of detecting violations. If the level of monitoring and inspections is high and the threat of facing a penalty is real, then compliance by firms is likely. If the direct and immediate cost of detection is high, the aggregate expected gains at non-compliance are low, thus $\Rightarrow \partial E(\Pi_{nc})/\partial D \leq 0$. If the level of monitoring and inspections are high while the threat of a penalty is low, then regulation is not a real constraint to the firm which might prefer to face the penalty. Thus $\Rightarrow \partial E(\Pi_{nc})/\partial D \geq 0$. If the level of monitoring and inspections are low and the penalty is high, then the firms know that the probability of being caught is very low and they will be less obliged to comply. thus $\Rightarrow \partial E(\Pi_{nc})/\partial D \geq 0$. When the probability of detection are high, the aggregate expected gains at infraction (non-compliance) are low, thus $\partial E(\Pi_{nc})/\partial P_d \leq 0$. All the other parameters behave as follows: $\partial E(\Pi_{nc})/\partial P_{p|d} \leq 0$; $\partial E(\Pi_{nc})/\partial P_{c|p} \leq 0$; $\partial E(\Pi_{nc})/\partial P_{f|c} \leq 0$; and $\partial E(\Pi_{nc})/\partial f \leq 0$.

Immediate compliance following monitoring is in general not preferable if the probability of enforcement through penalties is too small. Concealment effort which may be legal or illegal may be the best option for some firms which do not want to either face repeated warning letters or any form of prosecutions. The amount of concealment effort that the firm undertakes to avoid the detection of any wastewater discharge exceeding the level permitted by the government depends in general on the depth of future inspections by the authorities and the cost of doing that for the firm. Firms may change their decision rules regarding water consumption quantities and wastewater volumes/quality more slowly than the shocks through monitoring, inspections, and warnings may warrant. And of course investments decision take time to be implemented. Even if a violation is correctly detected through monitoring (i.e., the regulator judges there is a violation while indeed there is one), it does not necessarily follow, as implicitly assumed (in literature) that the regulator will try to obtain compliance through legal prosecution. There is ample evidence that regulatory authority may prefer to obtain "voluntary" compliance from polluters, legal action may thus be a last resort. Thus the authority may sound a word of caution to the firms (in writing or phone etc) regarding their compliance status. This may or may not trigger a change in the decision rules for compliance on the part of the firms. Exact decisions for compliance will vary between firms but some of them might feel the need to protect their own reputation by avoiding public prosecutions.

(ii) Court Prosecutions

Court prosecutions are the ultimate actions that the regulatory authorities can take to control wastewater. If a firm is deemed by the wastewater control authority to be in violation of the wastewater restrictions and it is prosecuted in the courts, if convicted, the court has a considerable amount of flexibility as to the type and level of penalty to impose on the firm. When the prosecution costs are high, the aggregate expected gains at non-compliance are low, thus $\partial E(\Pi_{nc})/\partial A \leq 0$. As most often described in wastewater regulations, upon conviction the court may impose a fine of which only the maximum is determined by law. The court may (in addition) also require the firm to remedy the problem by installing the appropriate effluent control equipment. In the context of this paper, this means there is a positive probability that the firm will have to incur the total costs of complying with the standard in every period after conviction. The financial penalties associated with non-compliance may be much greater than is indicated by the fines actually assessed since these fines do not reflect the potential losses due to non-compliance. Depending on the financial penalties incurred, firms may choose to take measures to avoid a repeat of the legal process. The final response to court prosecutions are therefore difficult to anticipate and will vary from firm to firm.

In our analytical framework, it is straightforward to establish that the elasticities of $E(\Pi_{nc})$ with respect to sanction variables P_i i.e. the risk of detection (P_d), prosecution ($P_{p|d}$), conviction ($P_{c|p}$), and fines ($P_{f|c}$) can be ranked. In particular, defining $\eta \equiv -[P_i/E(\Pi_{nc})][\partial E(\Pi_{nc})/\partial P_i]$ it can be shown a la' Furlong (1990:119) that: $\eta_{Pd} > \eta_{Pp|d} > \eta_{Pc|d} > \eta_{Pf|c}$. The overall theoretical framework is premised upon an individual firm's subjective beliefs in the magnitude of enforcement instruments. However, in reality, these may differ markedly across individual firm's ability to avoid detection or conviction.

8.7.2 Empirical Approach

To test for the firm response to enforcement activities and effectiveness of the regulatory instruments in Kenya, we need to model (i) the linkage between the violation rates (supply of violations) and the policy instruments i.e. the sanction variables i.e. with respect to the risk (probability) of detection (P_d), prosecution ($P_{p|d}$), conviction ($P_{c|p}$), and fines ($P_{f|c}$). Previous studies have used empirical information on observed violations, number of prosecutions, the proportion of prosecutions that result in conviction as indicators of probabilities for various enforcement variables (i.e. Furlong, 1991; Polinsky and Shavel, 1979; Laplante and Rilstone, 1996; and Lanoi and Fearnley, 1998). In Kenya, a number of factors appeared to determine the status of wastewater activities by industrial firms. First, because of their activities, firms in certain sectors such as the dirty industries (i.e. leather and tannery) appeared prone to infractions than others (i.e. food and beverage). Secondly, water consumption levels also appeared to be an important factor since the large water consumers also had problems with installing elaborate abatement facilities sufficient to avoid infractions. Their wastewater problem was much more visible and posed greater concerns for the authorities. Third, the most important aspect of our study was to examine the effect of various sanction variables predominantly used during regulatory enforcement in Kenya. Our discussion in chapter 7 showed that the main tools included are inspections, warning letters upon detection, prosecution, and ultimately fines upon conviction. During the interviews, the firms also displayed a general understanding and prospects for dealing with each of the enforcement sanctions. In view of the above field experience, the basic equation of interest in this paper is of the following nature (Furlong, 1991; Polinsky and Shavel, 1979; Laplante and Rilstone, 1996; and Lanoi and Fearnley, 1998):

$$\begin{aligned} VIORATE_{it} &= \alpha_0 + \alpha_1 WAT_t + \alpha_2 INSP_{it} + \alpha_3 INSP_{i,t-1} + \alpha_4 P_{d,t-1} + \\ &\alpha_5 P_{p|di,t-1} + \alpha_6 P_{c|pi,t-1} + \alpha_7 P_{f|c,t} + \alpha_8 ds_{it} + \varepsilon_{it} \end{aligned} \tag{8.2}$$

where

i=1,2,3, ...N stands for plants;

t=1,2,3,….T stands for time;

$VIORATE_{it}$ Represents regulatory infractions

$INSP_{it}$	represents the number of inspections performed at plant *i* at time t;
$INSP_{i,t-1}$	is cumulative inspections performed at plant *i* up to time t-1;
P_d	Probability of detection
$P_{p\|d}$	Probability prosecution
P_c	Probability of conviction (not appearing in the equation)
$P_{c\|p}$	Probability of conviction given prosecution
$P_{f\|c}$	Probability of fines
WAT	Volume of water used
ds_i	Firm specific effects and;
μ_{it}	are the usual error terms

Definition: $P_{f|c} = P_{c|p}(P_{p|d})$ and $P_c = (P_d)P_{c|p}(P_{p|d})$

Our theoretical prediction on firm specific characteristics developed earlier implies that firms with higher volumes of wastewater, hence higher costs of treatment (assuming uniform wastewater toxicity), will find it more beneficial to violate the regulatory standards. Thus we expect that beverage and textile firms, by having the largest wastewater would have the largest motivation to violate the standards.

8.7.3 Assumptions and Issues in Model Estimation

For the purpose of estimation, we have assumed that: (1) the firm specific effects are random; (2) the error term is uncorrelated with the variables and well behaved; (2) all the right-hand side variables in the sanction equation are doubly exogenous – that is, uncorrelated with the firm specific effects as well as with the error term. This is a very drastic assumption given our awareness that the beverage sub-sector has the highest levels of water consumption and waste generation. (3) Also assumed away are the lock-in-failures or threshold effects where firms or cities are ”locked in” complex systems of current technology and where the associated infrastructure, skills, knowledge, and capabilities are dominant. The water management systems face lock-in failures. Most of the urban water supply, storm water and “wastewater” management systems are based around technologies or systems of the past. (4) Several other assumptions are also implicit in our model i.e. one or more of the following contingencies must occur if the compliance condition is to be met: Firms are highly risk averse, hence, the potential firms' subjective perception of the formal sanction likely to be imposed is very high. The potential of a firm significantly over-estimates the probability of a conviction and formal sanction is also high.

The most obvious question that arises in the context of our model concerns the possible *endogeneity of sanctions* and the consequent impact on the least squares estimates. For example, while we are generally interested in estimating the response of firms (violation rates) to enforcement (sanction variables etc), a major difficulty is that "enforcement or level of sanctions" at any given time *t* may itself be a function of violation or compliance at time *t* (that is the enforcement authority may observe non-compliance at time *t*, and then decide whether or not to inspect at time *t*). In other words, inspections may themselves be *endogenous* and correlated with the same variables that determine current pollution levels[3]. If this is the case, least-square estimates will be biased in general. In fact, both Magat and Viscussi (1990), and Laplante and Rilstone (1996) have rejected the hypothesis that inspections were exogenous. As a result, Magut and Viscussi (1990) have included in their analysis a vector of only past enforcement effort (inspections). Laplante and Rilstone (1996) on the other hand have preferred to estimate an inspection equation and use it to re-estimate their basic inspection model by instrumental variables using expected inspected as instruments. Interestingly, these last authors have found that the probability of an inspection in any given period is a decreasing function of past inspections – the regulator's monitoring strategy thus being akin to one of sampling without replacement. To control for this (and to identify the resulting parameters), it is necessary to model the sanctions using some variables that do not enter the basic model. Interviews with the Ministry of Water and Local Authority enforcement officers indicate that inspections are motivated by several considerations. First, the volume of wastewater discharged seems to be a factor: small water consumers are less likely to be inspected than larger consumers. Secondly, there seems to be an effort to visit as many plants as possible, thus an obvious implication of this "sampling without replacement" strategy is that a plant knows that, all things being equal, the probability of an inspection even when a firm is a major water consumer is inversely related to the number of previous visits.

By response to wastewater regulation (VIORATE), in this study, we look at control of three main measures of water pollution. The first, biological oxygen demand (BOD)[4], is not a direct measure of water pollutant, but measures the effects on the environment of a number of pollutants. The second, total suspended solids (TSS), is a direct measure of the presence of solid waste emissions in the water supply. The two measures are often correlated, but constitute separate policy goals and require, to some extent, different abatement technologies. In particular, elimination of TSS requires a primary treatment based on gravity, while elimination of BOD requires both a primary and secondary treatment based on biological processes. The third measure is COD chemical oxygen demand.

8.8 Response and Effectiveness of Regulatory Instruments

8.8.1 Discussion of Results of our Model

The Supply of Violations

A summary of wastewater violations is displayed in table 8.10. The results are displayed in two columns (1), and (2). In the first column (1), we display the model results when all the sanction variables (P_d, $P_{p|d}$, and $P_{c|p}$) are used in our estimation equation. In the second column (2), we replace $P_{p|d}$, and $P_{c|p}$ by $P_{c|d}$, since the latter results from the former. Our results show the test for the response to enforcement on the violation rates for absolute discharges of BOD standards.

Table 8.10
Tobit Estimates of Supply of
Wastewater Violations by Sector

	(1)	(2)
Constant	0.1193	0.1079
$INSPECTION_{it}$	- 0.1713	- 0.1149
$INSPECTION_{i,t-1}$	- 0.2080	- 0.1965
P_d	- 0.1141	- 0.0181
$P_{p\|d}$	- 0.0911	--
$P_{c\|p}$	- 0.0042	--
$P_{c\|d}$	--	- 0.0041
Textile	0.1421	0.0119
Leather	0.3643	0.2006
Food	0.1152	0.1616
Beverage	0.0411	0.0321
Pulp	0.1461	0.0133
Wood	0.3316	0.4756
Other	0.0521	0.2355
WATER	0.6144*	0.4414*
Log Likelihood Function	19.334	17.284
Number of Observations	53	53

Note: Significant at 95 percent level. Probability of detection (P_d) is defined here as inspections divided by the sum of advisory letters and warning or statutory letters. Probability of prosecution given detection ($P_{p|d}$) is defined as court prosecutions divided by the sum of advisory letters and warning or statutory letters. Probability of conviction given prosecution ($P_{c|p}$) is defined as convictions divided by court prosecutions.

From the model estimates, the perceived magnitudes of the expected inspections, prosecution fines, are each estimated to reduce infractions as indicated by the negative coefficients associated with in all the three columns. However, a given increase in the expected inspections, detections, prosecutions, and fines do not have an increasing or larger effect along the progression. This does not make any intuitive sense. Furthermore, none of the estimates of the deterrent effect of penalties on violation rates is statistically significant. The violation rates are strongly correlated with the water consumption levels suggesting that higher water consuming firms in Kenya are much more likely to violate wastewater standards than otherwise. Sector specific dummies have a positive coefficient but none of these are significant. This implies that we could not use industrial sectors in Kenya as a basis for predicting wastewater standards infractions.

Elasticities of Wastewater Violations

A comparison of the relative impacts of different explanatory variables on the violation rates is provided in Table 8.11, where elasticities for selected variables are presented. From among the policy variables, inspections induce the largest violations response (in terms of elasticities). A one percent increase in inspections is predicted to deter 0.061 percent of violations.

Table 8.11
Elasticities of the Supply of Violations with Respect to Sanction Variables (Absolute Values)

	(1)	(2)	Mean
$INSP_{it}$	0.061	0.077	0.0205
$INSP_{i,t-1}$	0.017	0.022	0.0194
P_d	0.002	0.003	0.0118
$P_{p\|d}$	0.010	--	0.0931
$P_{c\|p}$	0.003	--	0.0124
$P_{c\|d}$	--	0.006	0.0910

Note: Significant at 95 percent level. Probability of detection (P_d) is defined here as inspections divided by the sum of advisory letters and warning or statutory letters. Probability of prosecution given detection ($P_{p|d}$) is defined as court prosecutions divided by the sum of advisory letters and warning or statutory letters. Probability of conviction given prosecution ($P_{c|p}$) is defined as convictions divided by court prosecutions.$INSP_{it}$ represents the number of inspections performed at plant *i* at time t; $INSP_{i,t-1}$ is cumulative inspections performed at plant *i* up to time t-1;

Elasticities for detection, prosecution and fines are considerably smaller than that for inspections. The ranking of elasticties in Table 8.11 generally does not conform to the theoretical predictions at the beginning of the paper.

8.8.2 Discussion of Results

The decentralized nature of polluting activity, some of which is clandestine, the institutional requirements mentioned earlier make violation levels more difficult to monitor. The assessments of wastewater regulations indicate that regulations are ineffective in promoting their objectives for two general reasons: First, is, the ineffectively designed regulatory strategies. Thus, even though there is compliance with the regulatory requirements with each intervention, little or no beneficial effect has been observed. For example, there is a mismatch in the hierarchical steps of the judicial process, thus making industrial firms indifferent to threats of the most severe penalties. In all circumstances, the *expected gains from violation* are quite high. Thus, some firms violate, expecting the most severe penalty at some point, and will continue polluting after facing the penalties. One other defect is the misplaced focus on the requirement that firms install pre-treatment gadgets. Since many firms have managed to install "some form" of these facilities, enforcement efforts of the regulatory agencies have been shifted to monitoring the appropriateness and the working conditions of these facilities. Most firms observed, had changed their behavioral game-plan upon installation of such facilities. The installations, although they are perceived as the first step towards compliance, do not lead to automatic compliance as most of them remain ineffective due to (a) poor design, (b) high cost of operation and maintenance that firms avoid. The overall implication is that installation of pre-treatment facilities has not produced any reductions in violations.

The second problem with regulatory enforcement is lack of clear procedure for enforcement. For example, even though there exists extensive regulatory requirements, they are traditionally enforced unsystematically and with laxity – i.e. while in some cases a negotiated approach is adopted, in yet another scenario, convicted firms get away with a simple warning. Indeed, inspection rates are very high but the penalties are very small that there are very few incentives for compliance. A related question for example is that of how many warning letters should lead to an automatic statutory notice or court action – for a number of firms which have received such letters, it is still unknown as to whether a court action will ever come. Since the enforcement effort is so extensive, it does appear to affect the firms' behavior positively while the morale of the authorities is impaired. Firms know that prosecution and meting out the penalties will be very difficult. On the other hand regulators know that moving beyond administration of warning letters to violating firms will pose a daunting task to them in courts.

8.9 Reactions to Various Enforcement Activities

8.9.1 Reactions to Wastewater Standards

Industries in Kenya have responded differently to the enforcement of wastewater standards in various towns. Levels of response vary with scope and magnitude of the perceived constraint and the size of the firm. Some large firms have attempted to influence the policy makers to alter the wastewater standards in their favour i.e. to the levels are attainable with their production technologies at reasonable costs. We highlight such large firms in the beverage industry as described below.

One of the constraints to the development of Castle Brewery in Thika at the time of inception was that the existing waste-stabilisation ponds at the Sewer Treatment Works (STW) were already overloaded and could not take extra load from the Brewery. Consequently, Castle Brewery agreed to underwrite the cost of the augmentation /rehabilitation of STW on behalf of the Council, and an agreement on a water and sewer tariff rebate over a period of time to recover costs agreed upon. As a component to this development, on 15th September 1999, the Ministry of Water advised Thika municipal council to revise its effluent by-laws of 1996 when it was imminent that Castle Brewery wastewater could not be treated to the standards stipulated in the by-laws. Consequently, the council was asked to revoke the earlier maximum limit for Settleable Solids from 1 ml/litre to a new maximum value of 10ml/litre. Furthermore, the council was also requested to relax the BOD & COD limits control by-laws subject to an agreement on appropriate sewer charges. The MOGDED formula was proposed as the basis for the extra tariff for effluents exceeding the standards. This case suggests the extent to which Castle Brewery strived to ensure that the wastewater standards and costs of treatment are brought to acceptable range.

The Case of Kenya Breweries Ltd in Nairobi:, Established by the Hurst brothers in December 1922, the Breweries at Ruaraka has been producing for more than half a century without wastewater treatment facilities. The current daily water requirement stands at 8970 m^3 with a corresponding effluent load of 7430m^3 /day. Apart from the supply from the City Council mains, the breweries have six boreholes for a total monthly supply of 81000m^3 (18 million gallons) for industrial use. Some water is taken up in the process and some evaporate through the system, however the biggest volume of the water (80%) finally discharges as wastewater into Ruaraka river. Although the breweries indicate that the effluents are intermittently discharged, whatever the style of discharge, the wastewater is evidently too strong in terms of its pollution load.

Records (at the Ministry) on enforcement and "consultations" between the Ministry of Water Development (MOWD) and the breweries showed that the Company hoped that the Nairobi City Council would accommodate their wastewater within the city sewerage system. In September, 1980, the Brewery commissioned an expert from Brewing Consultants - Allied Breweries of the U.K. to carry out an effluent survey of the Company's operations with a view to identifying and quantifying the sources of effluent, their relationship to each other and make recommendations as to the Company's future effluent policy. At the time, the brewery had only 1 borehole with a yield of 135 m^3 (30000 gallons) per month while the rest of water was from the City Council. Based on the above consultancy, the Company applied for five additional boreholes with a total yield of 81000m^3 (18 million gallons) per month and made a commitment to embark on pollution reduction once the groundwater permits are granted by Ministry of Water Development[5]. One of the reasons advanced for this dramatic shift to groundwater sourcing was that Company's production had fluctuated with the Nairobi City Council water supply shortages and that the new move would help eliminate this dependence[6]. In any case the Company promised that the additional boreholes would not lead to overall increase in the volume of water consumed.

After persistent appeals from the Ministry of Water Development enforcement officers, the Brewery decided to invest in minimal effluent load reduction through a number of measures. On the basis of the above consultancy work, (a) *Lauter tun - Strainmaster - Whirlpools* -a decanter was installed to clarify the effluent and re-circulate the clear liquor recovered into the process stream. The sludge consisting of residual spent grains was sold to farmers as animal feed. (b) *Yeast Beer Mixture* - A frame and plate filter was installed to recover the residual beer in the yeast. This beer was formerly going down the drain as effluent. With the above installations, the BOD concentration was reduced from 1546 mg/l to 700 mg/l. Through both of the above measures the Brewery reduced the BOD concentration in the effluent down to approximately 600 mg/l and suspended solids to 130 mg/l. The Brewery then maintained that any further reduction could only be achieved at extremely high cost that they were not prepared to meet.

On 11th June, 1985 the Breweries wrote to Nairobi City Council requesting to discharge the effluents into the city sewers. Although the average concentration was expected to be close to a BOD of 610 mg/l and TSS of 130 mg/l., in September 1986, the effluent concentration had BOD of 1546 mg/l and TSS of 1135 mg/l. The Company indicated that any further reduction in the effluent BOD would be very difficult to achieve; and in any case, these were the limits being achieved at the Kisumu brewery plant to the satisfaction of the Local Authority in Kisumu.

On 20th March, 1992 the Ministry of Water Development wrote a reminder to Kenya Breweries that the issue of the discharge of untreated effluent into Ruaraka river had been going on for quite a long time and had continued albeit for the fact that the Ministry started drawing attention to the need to reverse the worsening pollution threat from as early as 1985. The Ministry directed the Brewery to deliberate on the matter, take appropriate action to implement the following alternative actions and respond within 30 days:

(i) As a first alternative measure, the company was asked to arrange to have the effluents channelled into the City Commission sewers after complying with the City Commission requirements.

(ii) As a second alternative measure, the company should arrange to treat the brewery effluent to the more stringent standards specified by the Ministry, after which they would be allowed to discharge the effluent into Ruaraka river.

Due to limitation of land, the company felt they could not install a facility capable of achieving the standards in alternative (ii). In a joint meeting held in July 1992, between City Commission, Pollution Control Section of Ministry of Water Development, and Kenya Brewery Ltd., KBL officials maintained that industries in Ruaraka region should be mobilised by the City Council or Ministry of Water to come up with a joint treatment facility or at least share the blame in polluting river Ruaraka. Eventually, the parties reached a consensus that it was virtually impossible to treat the Brewery effluent to the Ministry of Water standard required for discharge into the Natural Water Course[7]. It was agreed that the Brewery try to achieve the standard required for discharge into the Council sewer. In order to reduce the effluent load on BOD and COD, there was consensus that three projects be implemented: (i) *Recovery of waste Yeast* which was expected to reduce the BOD & COD load by 23.3% and was to be achieved by installing a plant for recovery and drying of yeast. (ii) *Recovery of suspended solids* to reduce the effluent load on suspended solids by 11%. (iii) *Recovery of sugar liquid waste from spent grains* by installation of a filter process in order to reduce the BOD load by 27.9 % and the suspended solids by 34.1%.

The first component with a capital input of Kshs40million was announced. Process modification was to be carried out to eliminate the use of *Collecting Vessels (C.V.'s)*, thus eliminating the BOD load from this plant. A new modern beer filter was ordered at a cost of Kshs.12 million to dispose the *filter powder* dry. This was to reduce the amount of filter powder suspense in the effluent by 70 percent. A project was to be introduced to dry the yeast in order to reduce the BOD load and suspended solids in the effluent. However, citing lack of foreign exchange in the country at the time for purchase of equipment overseas, the company requested for three years to implement the above but the Ministry was dissatisfied with and rejected the lengthy timeframe within which the project was to be implemented. Kenya Breweries was advised to undertake full implementation and commissioning of the in-house installations within 18-24 months from the date of the meeting. Liberalization in the early 1990s, coinciding as it did with the end of apartheid in South Africa, and the subsequent entry of Castle Brewery into the Kenyan market, led to a rapid erosion of Kenya Breweries market dominance in Kenya, particularly because a prolonged fiscal crisis in Kenya led to extraordinary increases in taxes on bottled beer. To date, no action has been undertaken by the

Company on wastewater abatement.

Lessons Learnt from the Nairobi Brewery Experience

- The enforcement approach was much more persuasive rather than regulatory – each step was negotiated while the threat of punishment was kept very remote even though the company was obviously violating the standards. This soft-approach was perhaps motivated by the Company's huge financial contribution in terms of tax revenue to the exchequer.

- As a response to the enforcement activities, the brewery was not keen to invest in "end-of-pipe" retrofit technology. Instead, they preferred a massive program of long-term nature to upgrade their production technology. Today, the Company has not fulfilled the promised drastic measures, they attribute their inaction to changing economic environment that has become more competitive with the entry of other firms in the market. However the Company's complacence could also be attributed to the fact they perceive Ruaraka river as a common repository in which concerted measures involving all firms in the region should be undertaken for the sake of fairness.

- The above experience suggests that, in practice, wastewater regulation is almost never a "pure" administrative process in which violations are unambiguously observed and rules are uniformly enforced with subsequent steps of warning letters and prosecution. Because industries are a prime generator of income and employment, regulatory enforcement is often subjected to political pressure for leniency even when violations are severe. Even when they are unencumbered, regulators can be generally reluctant to impose penalties that will bankrupt or shut down factories.

- The above experience also seems to point to the principal agency problem and the resulting defects in the enforcement mechanism. Firms are bound to relax in order to continue reaping profits when their economic contribution to the economy invoke leniency on the part of the enforcement agents.

8.9.2 Monitoring and Inspections

Our earlier indicator of *probably of detection* ($P_{d)}$ in table 8.5 suggests that on average, for each inspection there was an 84 percent chance of detection. In general, an episode of detection becomes very difficult to define. One weakness with this definition is that a lot of verbal warnings upon detection are omitted from our calculation. Technically, there should be scientific evidence of violation for example in terms of BOD, SS levels. However what was observed deviated from this scientific ideal. For example, one enforcement officer reported that:

> *"In some of the plants, treatment ponds become completely anaerobic and smell terribly. The same can be felt some 500-600 metres away. Final effluents become completely black and there is no sense in sampling the effluent for analysis." In some of the plants (i.e food processing in Kisumu), the treatment plants cannot handle the large amount of very strong effluents hence a by-pass has to be created to avoid damaging the ponds.*

Such cases are automatically counted as violations even without scientific proof that the effluents being discharged are against the stipulated standards. Depending on the discharge points, inspections, monitoring activities, time of discharge i.e. night, or in the case of textiles mainly during dyeing process, violations can be difficult to detect. Since there are no immediate penalties upon detection (in most cases a warning letter is issued thereafter), the *direct and immediate cost of detection* to firms are negligible, even though to the enforcement officer, there time, and effort, logistical support involved.

Experience from Monitoring and Inspections

Ironically, a comparison of the influents and effluents from the wastewater treatment facilities showed the influents to be cleaner than the effluents (particularly from lagoons). This point shows the pathetic state of some of the treatment facilities. We also learnt from the enforcement officers that some of the treatment facilities are revived when officers are waiting at the company gates to gain entry to conduct inspections.

Some firms make false declaration regarding water consumption needs when applying for registration at Ministry of Water. For example, during inspections, a number of these firms insisted that the Ministry of Water Development had exempted them from constructing effluent treatment works.

> One food-processing firm Bidco Oil Refineries had insisted that they were employing a dry process in their production and did not require a wastewater treatment plant. It was soon realized that they were discharging the effluents containing oil into a storm drain behind their premises, eventually discharging into an adjacent swamp. The firm became arrogant in dealing with the enforcement officers and took many hours to admit the inspection officers at their premises. When the firm eventually applied for a groundwater permit in 1995, they were asked by the Ministry headquarters to repair all blocked sewers in the factory premises, scoop and clean trapped oils and finally obtain letter of consent from the Local Authority allowing them to discharge effluent into their sewer. This proved a daunting task for the firm that had frustrated the enforcement officers for many years.

One textile firm in Thika when caught by-passing the effluent treatment works argued that they had an underproduction and the wastewater being discharged from the plant would not be sufficient to warrant the operation of the treatment works. They were advised to accumulate the discharge to raise enough volumes. In the next inspection visit that followed shortly after, all the lagoons had been drained but it was evident that the aerators and other facilities had not been used at all in a long time.

It was common in all the towns that when firms perceived that a severe action would follow a protracted chain of warning letters, the treatment works were revived. When the inspections were less frequent, the facilities were quickly turned off.

8.9.3 Reactions to Warning Letters and Statutory Notice

Magat and Viscussi (1990) restrict attention to BOD emissions and suggest that firms' reactions to TSS regulations may be similar. However, Lanoie et al (1998) suggest that this may not be the case. For BOD, firms seem to respond by announcing investments, but these investments do not seem to have much effect on effluents. This in turn suggests that policy may have placed undue emphasis of the abatement technology itself rather than its results. In our survey, we observed that much more attention has been devoted to ensuring that polluters get pollution equipment in place than to seeing that it is operated correctly. Thus:

(i) Most firms surveyed also seemed to respond by announcing investments, but these investments did not seem to have much effect on effluents.

(ii) Another common behavior noted among the firms was for them to declare that they had engaged consultants for the design of their wastewater treatment works. In most cases it took several years for the consultants to come up with the requisite designs. For example, in one consultative meeting held between Del Monte and Ministry of Water on 20th November 1997, regarding the treatment of wastewater, Del Monte indicated that they had engaged a consultant from Italy to recommend the necessary measures to institute. By 18th June 1998, the Ministry had not received any further communication and they decided to make a follow up. In the meantime the Ministry advised Del Monte to undertake continuous monitoring of the effluents to minimise public outcry. During the one-year period when Del Monte was self-reporting on their compliance status daily, it is surprising to note that not a single violation was reported. This appeared to ridicule self-monitoring and reporting as an enforcement tool since Del Monte had not succeeded in finalising their deal with the Italian consultant.

(iii) A number of firms had shoddy waste treatment plants for which they heaped blame on design engineers and bad advise from the enforcement officers. For example, as stated in one correspondence "the idea of adding 4 new ponds in a series on their own claiming that they are based on the design by Engineers is not bad but it is doubtful as to whether they are aimed at achieving a given wastewater standards (just merely to increase the number of ponds in the hope that they may achieve the required effluent standard)".

(iv) Some firms remained completely defiant and sought protection through political patronage when phased with the threat of punishment. For example, one firm Lattaners Ltd in Kisumu was discharging untreated effluent and the owner claimed that he had authority from Nairobi to do so. He refused to respond to any activities by the local enforcement officers and instead referred the officers to the Ministry Headquarters in Nairobi where he had patronage. When the officers made a follow-up they were cautioned for handling the members of the public (the proprietor of Lattaners Ltd) crudely. Thus the officers became disillusioned with enforcement.

Textile mills produce high BOD and COD, colored waste, alkali waste (high pH) and high temperature waste. Using water to dye Acrylic Yarns and humidification of the factory, Spinners and Spinners Ltd was treating its wastewater on a "short-term" basis by passing the effluent through soft stones and charcoal to absorb the dye. This was followed by lagooning the wastewater for 24 hours before disposal. Consuming about $200m^3$/day the discharge was $120m^3$/day allowing 30-40% usage in the process by absorption and evaporation. For many years, the enforcement authority had struggled with Spinners to see that soft stones and charcoal are used for dye removal are replaced. With the expansion of production capacity, the firm was advised to construct proper treatment facilities to avoid seepage of wastewater to the ground. It took over one year for the firm to secure quotations. Even when the facilities were completed it took a whole year for it to be commissioned, during which time the authorities were becoming fatigued by constant correspondence threatening more severe action. When the facilities were commissioned, the game-plan for Spinners changed. In order to suppress the costs of treatment, the spray aerators installed for reducing BOD in the lagoon were not operational contrary to expectation; Alum dosing for coagulation and lime dosing for pH adjustment was not taking place; and the excuse had become – one or the other component was being imported for the equipment work properly.

Jetlak Food Ltd, was served with statutory notice on 17th September 1999 by the District

Public Health Officer (on advise of the pollution control office). During the ensuing events, the firm was desperate to engage exhauster services to exhaust their septic tanks. They approached the Council for the services but were informed that the exhauster was still under repair. They then requested the council to permit them to independently exhaust the septic tanks through a private exhauster service provider, to which the council refused citing dumping regulations. Even though the statutory notice a compliance duration of 7 days, they had to wait for 10 days for the service to arrive. In subsequent event, when Jetlak was found to be violating, they made a counter claim that they had seem a council exhauster discharging domestic sewer upstream and they were therefore not responsible for the pollution of the river. In one incident, a factory Manager cautioned the Provincial Water Engineer: “I hope you are fully aware of the consequences of withdrawing our water permit” apparently cautioning that dire consequences would befall the engineer if he dared withdraw the water permit.

8.9.4 Reactions to Court Prosecutions

From tables 8.6 and 8.7, we observe that the *probability of prosecution given detection* is very low Kenya. The decision to prosecute is a lengthy one, many cases are referred to the headquarters repeatedly before such a decision can be made. However in instances where public outcry instigates the process, evidence is collected hurriedly and prosecution can be sure to follow. Firms should have received multiple warning letters before the decision to prosecute can be reached. To most firms *the prosecution costs* comprise mainly the legal (lawyers) fees and the costs attending court hearings i.e. transport, other manpower costs. Some firms engage lawyers to put up a strong defence, others encourage their lawyers to take a cost-minimization approach. For example convictions are always likely since most firms prefer to enter “a guilty” plea probably to cut down of the prosecution costs. This practice raises *the probability of conviction given prosecution.* Often the *probability of being fined upon conviction* is also very low. For example, of the 33 firms who have faced some court prosecution before, there been 27 convictions (80 percent). Of these 27, only about half of them have been fined. Others have been acquitted or ordered to take remedial measures within a given duration. Often the firms got away with a simple warning. In any case, the fines have been very low as they are limited by the Law and are not in excess of Kshs 3000[8]. The experience with court prosecutions violates our initial assumptions that court action is the apex of regulatory enforcement.

Reactions to Court Prosecutions

One food processing plant (Del Monte) as a result of radio broadcast about fish kill in River Thika, the Ministry of Water Development sent a chemist and a technologist both attached to pollution control to Thika for investigation. A senior public health officer attached to Thika Municipal Council joined them. They learnt that some wastewater was also used for irrigation and they were able trace the channel that by-passed the treatment plant to farms close to the river. The enforcement officers were able to link the factory wastewater with the pollution of the river. In defence, the company explained that their treatment plant was not working since its spare parts ordered from USA had not arrived. He also explained that they were treating the wastewater through chemical tanks in which soda ash is added to neutralize acidity. In spite of the overwhelming evidence against the firm, the judge ruled that the wastewater samples had been handled inappropriately, making it difficult to confirm whether it had come from the Del Monte. “In my considered view, all fairness and natural justice to the company, the samples should have been taken in presence of representative of the company, …., as laid down in drugs, chemicals and substances Act. I therefore, have no option but to dismiss charges on all counts and acquit the company” said the judge in his ruling.[9]

One textile firm in Thika was using $800m^3$ of water daily for the process and another $100m^3$ daily for domestic purposes. The domestic waste was discharged into Thika Sewage Works while the process water into the river. Along with the effluent from the process wastewater, there was oil resulting from spillage at the Boiler yard since Fuel oil is used as the main energy source in most of the firms. The firm was convicted in a Magistrates Court at Thika in a criminal case no. 395, for polluting River Thika and was ordered to construct Effluent Treatment Plant and the court directed the firm to comply within a period of 36 months. Upon the expiry of 36 months, the enforcement authority wrote a reminder to the firm. The formal reply from the textile firm was “no amount of pressure will make it possible for the company to invest over Kshs.8 million for the required facilities” apparently implying that the firm would rather face another court charge than oblige with the court orders. Since the company refused to abide with court orders, the municipality council then threatened to disconnect water within 90 days and the firm undertook remedial measures. This experience suggests that some compliance can be achieved through “sanctioning access to water” and without recourse to action.

In a criminal case number 3355 involving a food processing company, the firm had entered “a not guilty” plea and a hearing date fixed. Finally, before hearing could start, a plea of guilty was entered so the prosecution only gave the facts of the case and no witnesses were called. The firm was fined a total of Kshs.1600 for the two counts. The maximum fine for the offences committed was Kshs.1000 per count. In another criminal case number 1849, a paper mill was charged and a plea date fixed for a month later. A plea of not guilt was then entered. Hearing date was set for 4 months later but postponed until after 3 months. Before hearing could begin, a plea of guilty was entered and the company did not refute facts of the case that were then given by the prosecution. The company was given a conditional discharge, that is, not to commit a similar offence within a period of six months with effect from the date of discharge.

We can make several observations regarding the court prosecutions:

1. One general observation about court cases is that there was a common trend for firms enter a “guilty” plea when they expected that the case was going to take long (with higher legal charges) hence they preferred to face the penalties which in all cases could not exceed Kshs.3000.

2. Several firms indicated that even if they thought they were not guilty of the offence, they still found it appropriate to enter a guilty plea to save company resources (time, financial).

3. In a majority of firms’ violation that led to court prosecutions, the firms “relaxed” once a court verdict had been announced, not expecting further regulatory activity for a while, while they continued with violations. Some of the firms even resorted to more convert activities to conceal their activities. The evidence below attests to these facts:

One food processing plant (Del Monte) claimed that they had resorted to using the wastewater for irrigation purposes. However, several months later, it was discovered that the wastewater was being channelled into Samuru River, through their pineapple plantation, and finally discharging into Thika River. This was in spite of the legal charges preferred against them early in the same year. Unlike the previous case, the Ministry threatened to withdraw their Water Permit no. 11477 which would have terminated Del Monte' rights to abstraction of water from Thika River. In an incident involving another food processing factory, even after the water permit had been cancelled, the Acting General Manager declared that it was not possible to stop the factory even if the water permit was cancelled. The loss in foreign exchange would be too high, while it was cheaper to continue defying and to pay additional fines.

A Few Exceptions

We have already alluded to pockets of exemplary response the enforcement of wastewater standards in urban areas. Example of this was Eldoret' Highland Paper Mills whose housekeeping and in-process changes led to a dramatic drop in water consumption and consequently the reduction in wastewater volume.

> *In Deras Tanneries in Nairobi, the quality of wastewater is consistently of good standard. A visit to the factory revealed it was much cleaner than the rest of the factories in the sector. Two workers are permanently deployed to run the wastewater treatment facilities. We attribute this performance to a number factors. One has to do with the environmental consciousness of the owner-manager. The factory was collecting pig-droplets over 100 kilometres away for the treatment of wastewater. Ironically another tannery of similar size was closed down completely in Nairobi due to poor environmental performance[10]. Despite advice by the enforcement officers, the factory had refused to use pig-shits due to religious reasons as the owners were Moslems. The other reason for impressive performance by the factory was the careful use of groundwater. At the time of the survey much of pumping was done using either generator or expensive electricity due to power shortage. However the company was spending good sums of money to evade paying sewer charges.*

At KAPA oil refineries, the reduction in both waste volume and strength could be attributed to the following measures (KAPA) i.e. from 17000m^3 to 900m^3. They undertook improvements in the edible oil washing operations, after the addition of caustic soda to neutralize the free acidity. With the use of more efficient equipment, the previous method of double washing has been changed to a single washing operation that requires much less water. A side effect of this approach is to reduce the amount of oil that is lost in each operation.

Table 8.12
Glossary of Variables Used in the Estimation

Constant	Definition
$INSP_{it}$	represents the number of inspections performed at plant *i* at time t;
$INSP_{i,t-1}$	is cumulative inspections performed at plant *i* up to time t-1;
P_d	the probability of detection
$P_{p\|d}$	the probability of prosecution given detection
$P_{c\|p}$	the probability of conviction given prosecution
$P_{c\|d}$	the probability of conviction given detection
VIORATE	violation rate
WAT	quantity or volume of water used
ds_i	a dummy variable indicating the sector
du_i	a dummy variable indicating the urban location
Text.	a dummy variable indicating the textile industry
Leath.	a dummy variable indicating the leather industry
Food	a dummy variable indicating the food processing industry
Bever	a dummy variable indicating the beverage industry
Pulp	a dummy variable indicating the pulp and paper industry
Wood	a dummy variable indicating the wood industry
Other	a dummy variable indicating the other industries
Thika	a dummy variable indicating Thika town
Nairobi	a dummy variable indicating Nairobi city
Nakuru	a dummy variable indicating Nakuru town
Kisumu	a dummy variable indicating Kisumu town
Eldoret	a dummy variable indicating Eldoret town

8.10 Conclusion

In this chapter, our goal was to examine the firms' wastewater compliance behavior in response to specific sanction variables such as detection, court prosecutions and convictions. We have employed both case study approach and econometric methods to explore our goal. We started with a hypothesis that firms will rationally respond to incentives for participating in illegal activities. A question then followed on the extent to which sanctions provide the requisite incentives. The general predictions derived from our theoretical analysis are supported by case studies other than the econometric analysis. Our analysis shows that all industrial firms react to the enforcement of sanctions by declaring some action. During the interlude, they learn the behaviour of the enforcement authority and the threat posed by future violations. If they perceive this threat to be small, they will engage the authority in protracted correspondence. The tendency for the firms is to relax once they perceive that the pressure has reduced. Furthermore, our analysis also shows that firms are more predisposed to respond to other instruments more than the official chain of judicial sanctions stipulated among the instruments. For example, firms react to a threat of water disconnection much more readily than a threat to legal action.

In view of the case studies, our contention is that the firms are much more responsive to enforcement, only that we attribute the non response to the fact that regulatory enforcement does not pose a credible "cost threat" to firms since the sanctions are not graduated. First, we observe that 72 percent of the firms have installed some form of pre-treatment facilities, being the first step towards compliance. Secondly, about 63 percent of the installed gadgets are actually in operational status while the rest are dysfunctional. Third, 95 percent of the firms with operational gadgets constantly engage enforcement officers in a hide-and-seek game with firms violating standards most of the time. Furthermore, we find that penalties to violations are not a result of any systematic patterns or episodes (i.e. frequency and intensity) of violations by firms. They are much more on the stochastic side. Yet still, we have not observed any graduated sanctions between the levels of violations and penalties meted out, a connection that could have made enforcement more deterrent. For example, there are no indications that higher levels of sanctions have higher cost or deterrent effect on firms. Also stochastic are monitoring patterns for compliance among firms. We could expect more polluting firms to incur greater attention. Apparently, firms that are in compliance are those whose wastewater quality is predisposed to compliance i.e. tends to be clean while another small number of complying firms trace their behaviour to other unique circumstances.

Our general view is that securing compliance with wastewater (environmental) standards in Kenya is still an ambitious task. Current enforcement practices in Kenya have inherent institutional weaknesses. Because of limited resources and the resulting need to establish priorities, the existing activities need to be refocused to address the weakness. One such priority would be to settle on one common penalty such as the use of water permit as a sanction against violation. This would eliminate the need for court action and numerous warning letters.

But wastewater violations can also be associated with psychic costs among firms. Many firms do not believe that violation is ethically wrong. There is a decline in the attitude among firms in times of economic hardships that what matters is the contribution to the economy irrespective of their compliance status. For example there has been a large increase in violations in the 1990s by the firms. We observe that the likelihood of deterrent action on firms also went down dramatically in the 1990s perhaps due to economic hardships and political uncertainly in Kenya. On the other hand, the decline in punitive measures could be explained by the growing frustration among the enforcement officers that the sanctions or court deterrents were basically ineffective; the alternative view is that some violating firms were contributing significantly to economic upkeep (taxes, employment) and they needed some rewards "in terms of soft regulatory enforcement" by the government.

Notes

[1] **Aerobic** A process that requires free oxygen to proceed. Aerobic systems are similar to septic systems in that they both use natural processes to treat wastewater. But unlike septic (anaerobic) treatment, the aerobic treatment process requires oxygen. Aerobic treatment units, therefore, use a mechanical mechanism to inject and circulate air inside the treatment tank. The majority of the municipal sewage treatment plants are aerobic biological plants, and waste from the light chemical industries may not be amenable to this type of treatment. Further, depending on composition and concentration, the chemical waste may upset the treatment process within the sewage treatment plant. Aerobic processes have been employed by municipal and industrial wastewater treatment systems for the removal of organics, the biological conversion of ammonia to nitrates, reduction of sludge mass and volume, and reduction of pathogenic organisms. Aerobic digestion consists of two steps; direct oxidation of biodegradable matter, and subsequent oxidation of microbial cellular material.

[2] **Anaerobic** A process that occurs in the absence of oxygen. Anaerobic digestion is the solubilization and reduction of complex organic substances by microorganisms in the absence of oxygen. The products of digestion are methane, carbon dioxide, trace gases and stabilized biosolids. The microbial population responsible for this conversion can be divided into three groups: solubilization, acid formation and methane formation (methanogens). Proteins, lipids, carbohydrates and complex organics are solubilized by hydrolysis. These products are converted into short-chain organic acids, such as, acetic, propionic and lactic. These acids are then converted into methane and carbon dioxide. The acid forming bacteria are tolerant to environmental changes such as pH and temperature. In contrast, the methane forming bacteria are intolerant to environmental changes.

[3] This scenario is similar to the one encountered in chapter 6 when estimating industrial demand for water, with price and water consumption level (quantity) suffering from simultaneity.

[4] 5-day BOD, often also abbreviated to BOD_5.

[5] This would bring borehole consumption to about 21 million gallons per month.

[6] The underlying reason was to cut down on the cost of water from Nairobi City Council in return for investments on cleaner production facilities.

[7] The issue of a joint treatment facility has also been raised in Thika by a group of textile firms. For example in 1980s and the early 1990s the textile firms unsuccessfully approached the Municipal Council of Thika to look into a possibility of acquiring external capital in order to construct a joint effluent treatment facilities for the textile sector within the sewer treatment works of Thika. This loan capital would have been guaranteed by the government but the loan recovery and repayment done by the industries.

[8] Under the current Environmental Management and Coordination Act, the fines have been revised to a maximum of Kshs500,000.

[9] This extract is based on court proceedings records at Ministry of Water.

[10] Reasons for this was mainly public outcry due to both air pollution and wastewater quality. The factory was discharging in a nearby stream located in a residential area. The smell and corrosion of buildings in the neighbourhood was unbearable.

9 Summary, Achievements and Recommendations

9.1 Summary

The use Pricing and Regulation as policy instruments for water resources management has become an important issue of debate in recent years. Our study set out to pursue the following objectives: (i) examine the current sourcing, water use, and effluent disposal by the industries and how these practices are linked to the water tariff changes and wastewater regulation in Kenya; (ii) investigate how changes in water tariffs and regulatory instruments correspond with any behavioural patterns of industrial firms; (iii) demonstrate the effectiveness of the policy instruments by analysing the role of the institutional setting in the enforcement of water tariffs and waste-water regulation. In pursuance of the above objectives, the dissertation was organised along chapters that covered a number pertinent problems. We began by discussing water resource endowment, its distribution in urban and industrial sector and the implications of water availability for sustainable industrial development in Kenya (chapter 1). This was followed in chapter 2 by a discussion of the water policy trends in Kenya. In chapter 3, we examined the theoretical and empirical literature on industry response to water tariffs and regulation, while in chapter 4, we discussed the methodology for our study. The rest of the 4 chapters organized empirical information on firm response to tariffs and regulation and the institutional arrangement in each case.

9.1.1 The Water Situation in Kenya

In order to analyze the implications of sustainable industrial development on water use in Kenya, our discussions began from a broader platform in which global trends in industrial resource-use practices was partially examined. The main conclusions to chapter one are that (i) Kenya's water resource situation is precarious, warranting urgent policy measures. (ii) The scale of severity is visible in the lack of water services, with between 12 and 14 million people without access to safe water and over 20 million without adequate sanitation. (iii) there are increased conflicts (between rural-urban and within urban areas) due to imbalances in water allocation; On the other hand, due to industrial water practices, (iv) The extent of water resources degradation is becoming drastic, impacting most heavily on the majority of the population in rural areas where there is greater dependence on open water resources. In view of these factors, Kenya's water policy needs to be made appropriate to these emerging contexts. A policy framework embracing both water consumption and wastewater practices by industries in necessary for the security of water availability in the future.

9.1.2 Existing Water Sector Policies in Kenya

The current thrust on Kenya's water policy is articulated in several documents such as the Sessional Paper No.1 of 1999 on National Water Policy on Water Resources Management and Development; *The Policy Framework Paper (1996): Economic Reforms for 1996-1998; and* the Eighth National Development Plan (1997-2001) which articulates deliberate policies and promotional institutions for industrialization. The plan seeks to establish harmony between resource (water) conservation and industrialization for sustainable development. The three policy papers cover two main aspects of water sector management: a) cost-recovery - that water tariffs in urban areas would be set to recover full costs - capital, operations and maintenance costs; b) institutional: the role of local authorities in which only those Local Authorities with the necessary administrative and technical capacity would be allowed by the government to be water undertakers. The other issue raised in these policy documents is the amendment of the existing water act (see Table 9.1).

Traditionally, regulatory and pricing instruments are a central feature of water resource management in Kenya. The centrality of pricing and regulation has also been brought to the fore, in light of global trends for production inputs that have embraced "dematerialization". These developments put water management and water policy in Kenya at a crossroads not just because of the water endowment realities, but also due to success elsewhere where water abundance has been "induced structurally". These experiences illuminate the need for Kenya to reflect on the effectiveness of the existing water policy instruments. On the other hand, in all the empirical studies focusing on industrial *response* to water tariffs, measurement of *price elasticity* of water demand has been the central approach in indicating the direction of firm *response*. The existing policy documents underscore the government's commitment of not just strengthening the use of pricing (through cost-recovery) but also to adopting a new institutional approach in water sector management, one that entails playing a diminishing role in the direct implementation of water supply and sanitation i.e. by adopting a regulatory/ enabling role rather than direct intervention (from a direct to an indirect actor). For example, *privatisation* has been identified and proposed as the most promising option in addressing institutional deficiencies, low productivity, poor water pricing and unsuitable financial position that has be-devilled most of the municipal water services.

Table 9.1: Summary of Water Sector Policies in Kenya

<table>
<tr><th></th><th colspan="3">Policy Document</th></tr>
<tr><td>Subject</td><td>Current Development Plan 1997-2001</td><td>Policy Framework Paper 1996</td><td>Sessional Paper 1999</td></tr>
<tr><td>Amendment of Water Act</td><td></td><td colspan="2">Promises a Draft Legislation to amending the Water Act consistent with the times. Review of the Water Act to address all the legislative water issues especially legislation with regard to transfer of water facilities from one institution to another.</td></tr>
<tr><td>Cost Recovery</td><td colspan="2">Implementation of the policy of charging urban consumers water tariffs at levels that are sufficient to cover capital amortization and O&M costs. Reiterates GOK commitment in implementation of the policy of charging urban consumers water tariffs sufficient to cover capital and amortization (O&M).</td><td></td></tr>
<tr><td>Institutional</td><td colspan="3">Role of government in the water sector to be redefined with emphasis on regulatory and enabling functions as opposed to direct services. State pledges to hand over all water schemes to alternative operators. i)Urban Water and Sanitation to be handed over to autonomous departments within the Local Authorities. (ii) GoK pledges to encourage the full participation of the community and the private sector in water development. Having realized that a department of a LA cannot be financially independent effectively, it was proposed that formation of a company owned by the LA but ran independently.</td></tr>
<tr><td>Approach</td><td>Need to apply alternative management options and technologies with a view to ensuring sustainable water projects and the development of water resources by various stakeholders.</td><td></td><td>Need for an integrated and comprehensive approach to water resource management and planning.</td></tr>
</table>

So far the privatisation implementation strategy in Kenya has been formulated to guide the “general” economic management that is not specific to water sector. Part of the selling points to which most proponents of privatisation are quick to point are the "efficiency" and "mobilizing private investment" arguments which justify private sector involvement in delivery of urban infrastructure and services (see, Cointreau-Levine, 1994). The private sector and community participation are to be the prime movers in the process to guarantee sustainability while the government's role would be largely to provide policy guidelines for the sector. However the policy statements in favor privatization in Kenya fall short of stipulating the specific institutional ideals for water management. The privatization experiences of a number of African countries shows that, while the motivations are probably much more diverse and complicated than the governments openly admit, they do publicly acknowledge that the mobilization of private investment rather than efficiency concerns is the dominant motivation. In Kenya, 'the major reason for advocating privatization of municipal services appears to be the lack of resources by urban governments'. Privatization is seen primarily as a way to help relieve" the local authorities of the financial burden' in providing such services.

The Policy on Industrial Water Management

Many of the policy documents in Kenya are littered with indications of government policy for industrial water management. For example some of the following concepts have become common in the policy documents within the last 10 years: (i) self-provision by industries; (ii) polluter pays principle; and (iii) subsidies and tax concessions.

(i) Self-Provision

Since 1989, the Government expressed commitment to encourage the private sector to upgrade their role in water development and conservancy. Each industrial set-up has been encouraged (in the policy documents) to install water conservancy devices (Kenya Development Plan 1989-1993, p.88). In 1994- development plan, there was observation by the government that since most industries were located and continued to be established in the urban centers where industrial water demand posed a challenge for urban water supply development, there would be a deliberate effort to encourage industries to develop their own water supplies either to satisfy their entire demands or as a supplement to available public water in order to alleviate constraints in urban water supplies. Although the objective seemed sound in so far self-sufficiency and lack of infrastructural capital could be overcome, the policy seemed flawed in several ways:

- First it placed very little emphasis on efficiency objective as it seemed to focus on addressing water supply bottlenecks rather than demand management.

- Secondly, shifts to self-provision would also go counter efficiency since water resources can be misused if there are large variations in the cost of abstracting from multiple sources (i.e. due to differential in the cost of supply i.e. from groundwater is low), unless a proper institutional framework is put in place to check against this behavior.

The evidence we have provided in chapter 5 suggests that indeed an appropriate institutional arrangement was lacking. There has also been repeated mention of encouraging recycling of industrial water (Kenya Development Plan 1989-1993, p.236), though in principle, any tangible government action programme does not back these expressions.

(ii) Polluter Pays Principle, Concessions on Technology

As a strategy to deal with water degradation through industrial wastewater, in recent years, the term "polluter-pays-principle" litters much of the policy documents in relation to industrial wastewater discharges in Kenya. A new institutional framework, Environmental Management Authority, constituted under the Environmental Management and Co-ordination Act, 2000 is envisaged to provide a broad framework under which punitive and compensatory financial penalties will take precedence in the enforcement of wastewater behavior among firms. For example a firm to whom such penalties is served is expected to: a) award compensation to other persons whose environment or livelihood has been harmed; b) face a charge which represents a reasonable estimate of the costs of restoring the water resources (environment). According to this Act, every owner or operator of trade or industrial undertaking shall discharge any effluents or other pollutants originating from the trade or industrial undertaking only into existing sewerage systems and the relevant Local Authority operating or supervising such sewerage shall issue, at prescribed fee, and the necessary licence for discharge. Many issues are still obscure in the implementation of this proposed policy as the underlying goals are not clearly defined and the extent to which enforcement capacity and the political will, will provide a shift from the conventional (current) *Coasian* approach to an approach that has extensive *Pigouvian* inclinations. There have also been policy statements in relation to encouragement of importation of cleaner production technologies and tax concessions on pollution reducing gadgets such as abatement machinery in Kenya. Ironically, as a general rule, *observance of "polluter-pays-principle" advocated by the various policy documents in Kenya does not lend credence to subsidies and tax-concessions since, theoretically, they assist the polluters in bearing the costs of pollution control by means of subsidies and tax advantages.*

Thus there is an apparent contradiction in the existing policy statements for dealing with industrial wastewater management in Kenya. Again these policy statements are not yet backed by any active measures on the ground.

9.1.3 Literature and Methodological Questions

In all the existing studies on industrial water response to tariffs, there is considerable methodological controversy and little agreement on the following key methodological considerations: (i) the choice of the appropriate equation form, (ii) the specification of the price variable and (iii) the choice of estimation technique. All the existing approaches impact significantly on the empirical results. Very few industrial water demand studies have been undertaken in developing country contexts, let alone in the sub-Saharan Africa. This means that an understanding of industrial water demand in Kenyan context could not rely on the empirical findings of such studies. Thus, rather than depend on *price elasticity studies* of the developed countries to determine industrial firm behaviour (based on the historical record), we found it is more practical to adopt a "third best" methodological approach that extends beyond econometric analysis. In view of the gaps in the methodological approaches, we settled on more than one research method to examine the influence of pricing and wastewater regulation in Kenya, a phenomenon classed as *methodological triangulation*. Methodological triangulation involves mixing of quantitative with "moments of qualitative methods". It also concerns the mixing of the conflicting paradigms on which quantitative and qualitative methods are based (chapter 3). The framework sought to trace prices and evaluation of the response of the industries over time, both econometrically and by first hand experience by firms through case studies. The main advantage of our approach over the purely econometric approach is that we have made a concerted attempt at opening up the "black box" of the firm and explaining response to pricing and wastewater regulation by eliciting cases and explanations from the firms.

9.2 The Achievements of the Dissertation

9.2.1 Sourcing and Disposal of Water by Firms

Industrial water consumption in Kenya is marked by a predominance of conjunctive sourcing of water – where both public and private intake systems are common among firms even in cases where the public supply seems less stochastic. Over 50% of the firms use both sources of water. There is an apparent over-capitalization by firms on water sourcing even in industrial sectors using small quantities of water. This is also confirmed by the extent of *sleeper licences.* There are different motivations for this apparent over-capitalization. Kisumu, Nakuru, and Nairobi City are prone to mild "stochastic" public water supply (industries are often given priority in supply times of scarcity). In some cases, firms have installed water supply equipment for "eventual failure" of the public supply. This situation suggests that water gadget costs may be a very small fraction of the average firm's costs in Kenya (everywhere in all firms). We do not observe a systematic linkage between between water tariffs; and current sourcing, water use, by the industries in Kenya. For example, our analysis shows Nairobi's water charges to be the lowest and least compelling for firms to invest in expensive water gadgets, hence, water supply constraints rather than costs are culprits in the overcapitalization. Our conclusion is that:

> *Due to small costs it imposes, most firms prefer to operate with a slack (abundance) in water supply. This is explained by the predominance of the installed capacity for private water provision. Some of the installed capacity is sleeper as they only catered for contingency arrangements.*

9.2.2 Response by Firms to Tariffs and Wastewater Regulation

Response to Tariffs

Our econometric analysis suggests a very weak linkage between water tariff changes and industrial water consumption in Kenya. Furthermore, historical information also suggests that industrial firms in Kenya do not respond to upward changes in water tariffs by cutting down water consumption. Instead,

> *they explore investments into alternative sources of water such as ground or surface. Most firms interviewed have a desire to operate with abundant (excess) stocks of water supply, hence, minimizing water input usage is not a central issue in firm production decision-making. This observation is also supported by over-capitalization of water gadgets in most of the firms.*

Similarly, when firms are faced with constrained access (i.e. due to scarcity), they respond by exploring alternative sources such as groundwater and surface sources, rather than investing in water saving processes. Evidence of technological options has been identified only in cases where firms were interested in the overall efficiency of production in order to make the firm more competitive. Only when technological options extending the benefits to overall production efficiency does it become *viable response* for firms to consider switching their behavior. Thus, behavioral changes in water consumption are tied to *technological options* and not levels of *water tariffs and wastewater regulation* per se. This observation seems to point to the conclusion that *response* can be linked to broader forces that are independent to both water tariffs and wastewater regulation.

We attribute the low price elasticity of industrial water demand in Kenya to a number of defects:

- *First*, water tariffs themselves may be defective in signalling the critical nature of the resource. Our analysis of the institutional arrangements (chapter 5&7) suggest that water tariffs and wastewater regulation are ***poorly enforced***, making them less effective as tools for water resource management in industry.
- *Secondly*, even though the existing tariff enforcement are geared to cost-recovery measures, the local authorities still aim at encouraging industrial water consumption by providing concessionary tariff rates to industries. Evidence of this is the tendency by some local authorities to engage in concessionary contractual arrangements with industrial firms. For example, industries are encouraged to consume public water in

return for waivers on sewer charges incurred on groundwater usage. Some of the industrial water consumption is tied to pre-negotiated supply arrangements i.e. in the case of Nakuru, Thika, Kisumu and to some extent Eldoret.

- *Third*, the main problems compounding the effectiveness of the water tariffs is the fact that the tariffs levels themselves do not pose a credible threat for firms to consider water tariffs a real constraint. Although the water rates in different urban areas and different users vary widely, the frequent revisions only appear marginal and less purposive. Thus, they cannot be regarded as an instrument for water management.
- *Fourth*, the primary goal of industrial water tariffs enforcement by the local authorities in Kenya is not to ensure water conservation. Instead, industries are deliberately encouraged to consume as much water to provide water revenue for the Local Authorities (see chapter 5&6).
- *Fifth*, complimentary water sources are poorly regulated, thus eliminating possibilities for "reduction of water consumption" as a viable alternative to changes in water tariffs. Our econometric results for specific sectors (i.e. food, wood, leather, and paper) appear to support this thesis (chapter 6).

Response to Wastewater Regulatory Enforcement

In analyzing response to wastewater regulation, we started with a hypothesis that firms will rationally respond to incentives for participating in illegal activities. A question then followed on the extent to which the sanctions provide the requisite incentives or dis-incentives. The general predictions derived from our theoretical analysis are supported by case studies other than the econometric analysis. Our analysis shows the following:

- That most industrial firms react to the enforcement of sanctions by declaring some action. During the interlude, they learn the behaviour of the enforcement authority and the threat posed by future violations.
- When firms perceive the future threat to be small, they will engage the authority in undue correspondence.
- The tendency for firms is to relax once they perceive that the pressure has reduced.
- Furthermore, our analysis also shows that firms are more predisposed to respond to

other instruments than the official chain of sanctions stipulated among the instruments. For example firms react to a threat of suspension or revocation of water permits much more readily than a threat to legal action (see chapter 7).

In view of our case studies, our contention is that the firms are much more responsive to enforcement,

> *only that we attribute the non-response to the flaws in the regulatory enforcement process which does* ***not*** *sustain a credible "cost threat" to firms.*

First we observe in chapter 8, that 72 percent of the firms have installed some form of end-of-pipe pre-treatment facilities, being the first step towards compliance. *Secondly*, only about 63 percent of the installed gadgets are actually in operational status while the rest are dysfunctional. *Third*, 95 percent of the firms with operational gadgets constantly engage enforcement officers in a hide-and-seek game with firms violating standards most of the time. Furthermore, we find the intensities of penalties to violations to be unsatisfactory since they do not increase in their punitive effect from one level to another (the consequences of action is not any severe than a statutory notice). The enforcement process is also unsystematic (i.e. frequency and intensity) with court actions not commensurate with frequency of violations. They are much more on the stochastic (random or arbitrary) side. But wastewater violations in Kenya are also associated with psychic costs among firms. Even though they are aware of the damaging consequences of their actions, many firms do not believe that violation of wastewater standards is ethically wrong. This may be particularly the attitude among firms in times of economic hardships when matters of employment, income, and contribution to the economy irrespective of their compliance status are critical.

9.3 Policy Recommendations

9.3.1 Allocation and Pricing of Water: Institutional Needs

There are a number of institutional issues that are relevant to existing water sourcing structure by industrial firms in Kenya. The first issue concerns the capacity of the water authorities to enforce pricing and regulation on the public water use. If the enforcement of water tariffs is weak, then the effectiveness of pricing as a policy instrument for industrial management may be severely limited. The second issue relates to conjunctive use of ground, surface (river) and public water sources by industries (see figure 4.1 in chapter 4). Access to the three sources by industries imply that any price (cost) increase in one source would lead to shifts to other alternative sources since in most cases they are substitutes. This raises the question of the institutional arrangement to deal with excludability i.e. how successful are the water authorities in controlling access to these captive sources. Lack of effective control may render the tariff increases for public water supply less effective in inducing water conservation behavior among industries. These two issues are pertinent to the need for the design of a comprehensive institutional arrangement to cater for all industrial water sources if the water efficiency is to be achieved. Our discussions suggest that regulatory and coordination structures for management of publicly and privately supplied water exist in Kenya. However they function poorly due to overlapping responsibility and governance problems for the local authorities.

The main problem arising from the existing institutional arrangement is that the Ministries of Environment and Natural Resources (Water) (and to some extent Ministry of Local Government) have maintained the sanctity of certain regulatory functions on water management. These functions that include ground and surface water management (and water tariff approvals in the case of Ministry of Local Government) have been maintained even when the tasks exceed the capacity of these Ministries to deal with.

> One of the problems arising from the existing institutional arrangement is that the Ministries of Environment and Natural Resources (Water) (and to some extent Ministry of Local Government) has maintained the sanctity of certain regulatory functions on water management. For example the existing ground/surface water management approach assumes a highly simplistic, centralized approach to the water allocation problem, and ignores the possibility of a decentralized and localized management options by Local Authorities. If the Local Authorities could be mandated to regulate groundwater and surface water access then these can be regularized within the existing structures and a suitable framework for pricing and

regulation determined. One of the major flaws in the existing institutional arrangement has been an attempt by the Ministries of Water and Local Authorities to create capacity at the national level to deal with the enforcement problems at the local level instead of mandating the local authorities to create the necessary capacity at the local level to handle the emerging water problems.

As a rule, national governments should not implement tasks that can be done more efficiently or effectively at lower government levels, although they should ensure that these tasks are executed (*subsidiary principle*). Experience with water management calls for "decentralising water management to the lowest appropriate administrative level" (Alacåzar et al, 2000). However, in the Kenyan case, we are faced with a dilemma because:

the Local Authorities in Kenya are themselves very poor water service managers, and this raises a question on their capacity to take on additional responsibility of managing ground and surface water within their jurisdiction.

Secondly, because of widespread conjunctive use of public and privately supplied water by industries in Kenya, a pricing framework for groundwater and surface water abstractions is needed. Renzetti & Dupont (1999) suggest that the introduction of abstraction charges that have both an annual fixed component related to "reserved capacity" and monthly charges related to actual use can have the potential to conserve ground/surface water while not impacting significantly on the costs of industry.

A broader framework for water pricing is needed in Kenya. Such a framework entailing first tier pricing, in which water as a resource is priced, could ensure that all water resources whether public, surface or ground water have a first tier ***price*** *for all economic users.*

The first tier charge could include the water resource management charge i.e. to cater for planning and implementing catchment management strategies, monitoring and assessment of water resources availability, quality and use, water quantity management, management of water use permits, water resources protection, quality management and water pollution control and water conservation and demand management. Public water supply should also face a first tier charge imposed on the local authorities. This type of charge would be an access charge for any water resource intended for economic usage.

Another problem seem to lie in the rigidity in the allocation mechanisms. A new approach to allow and encourage a move towards a more competitive use or allocation of these water resources and ensure greater flexibility will be imperative. For example the general policy framework for groundwater development is not flexible enough to provide guidance for the different needs of industries. Furthermore, even though there are channels for enforcing liability upon public water users (defective as they may be) there are no mechanisms for penalizing illegal or unlicensed groundwater use. This can explain why there is reluctance among the industries to install meters on surface and groundwater usage. A policy on *sleeper licenses* is still needed. *Sleepers* (unused allocations) could be withdrawn or be transferable and conjunctive use licences phased out to avoid not only the undesired capitalization in the urban water service, but also to promote fair allocation to all firms that require the permits (considering the existing criteria that constraints neighboring firms).

To improve on the existing water licensing policy, Licences to use water could be granted for a period of time appropriate to the particular use. Long term industrial uses that involve substantial infrastructure investments with long time horizons can be given longer-term licences. Holders of licences should be able to apply for a licence renewal during the period that the licence is valid. New applications can be considered at the same time as applications for renewal. Where new applications compete with existing uses, the criteria that will guide the granting of renewals or new allocations will include the Reserve, equity and the optimum use of water. So far, the proposed system could function on a purely administrative basis but water pricing could also be used to assist in the allocation process of the licences. The system would also be compatible with provisions for creating a market in water use allocations.

Wastewater Management

We consider that most of the problems encountered during enforcement to emanate from a low level of implementation rather than any serious deficiencies in the legal provisions. We attribute the low level of enforcement to (i) the multiple agencies with different mandates, each agency trying to define the laws and activities on the basis of its narrow mandates. No agency expressed interest in correlating their tasks with the others; (ii) the division of responsibilities among multiple agencies, with little coordination, made it procedurally difficult to harmonize operations, thus leading to lack of interest among some departments that felt disadvantaged. (iii) there was a notable absence of what can best be described as the "philosophy of enforcement" (or internal policies and principles) by the various government departments – a shortfall that we attribute to apathy emanating from multiplicity of agencies. This apathy was greater at senior levels - to some extent this was reflected by the comparatively junior grade officers responsible for enforcement while the senior officers engaged in non-enforcement activities. (iv) While the legal enforcement process to the enforcement is very limiting in terms of burden of proof, the *value* of the process is further diminished when the penalties meted out to the guilty firms is very low.

Industries surveyed also expressed frustration with the criss-crossing of their premises by multiple government enforcement agencies from different departments as they conduct inspections. This problem was more severe in towns with multiple enforcement agencies for different aspects of industrial regulation. This frustration can be avoided by harmonizing the activities of different government agencies. For example, in their routine visits to factories, Factory or Public Health Inspectors (or Public Health Department either from Ministry of Labour or Health) confine their work to the internal working environment within the factories.

The current water policy remains isolated due to lack of synergy with the other sectors. For example relocating the culprit factories to new industrial estates could eliminate some of the existing wastewater quality problems. Synergy is likely to be exploited by a centralised regulatory authority that can negotiate with other departments.

> *We recommend that a broad-based enforcement agency is likely to be able to achieve higher rates of compliance than a group of smaller ones. An agency that covers a wide geography and/ or a variety of media is more likely to be able to identify and*

exploit existing synergies i.e. by implementing compliance-enhancing deals than one with a narrower range of jurisdiction. Our field evidence above support a centralized, and broad based enforcement authority.

Current theoretical models of enforcement suggest that, other things being equal, a broad-based enforcement agency is likely to be able to achieve higher rates of compliance than a group of smaller ones. An agency that covers a wide geography and/ or a variety of media is more likely to be able to identify and exploit *synergies* i.e. by implementing compliance-enhancing deals than one with a narrower range of jurisdiction (Heyes & Rickman, 1999:373). Our analysis would appear to support a centralized, and broad based enforcement authority for wastewater management in Kenya.

In most countries, controls relating to wastewater pollution are predominantly confined to regulation at the point of production, not discharge. These tend to take the form of mandatory technology standards, required capital equipment, or effluent standards required from plant units of given sizes. Technology standards specify the actual pollution control equipment to be installed by a range of industrial sectors. For many years however, the Kenya government has been torn between use of standards and technology policy for industrial water management. There has been over-emphasis on the end-of-pipe abatement technology (at the point of discharge),

thus leading to the current state of affairs comprising piecemeal and fragmented efforts by industries to adopt requisite technology.

Furthermore, the standards or regulations at the point of discharge do not generate financial incentives to improve the overall production technology by firms i.e. adoption of water saving technology, since they encourage window dressing activities aimed to appease the enforcement officers. From chapter 7, we have seen that many of the wastewater abatement equipment installed by firms are not put to proper use once installed. This suggests that a closer focus on wastewater standards rather than abatement practices (technology) could be more desirable. Furthermore, it shows that overall technology standards (instead of abatement technology) could be more effective than end-of-pipe concerns. Even though the current policy stance in Kenya is inclined to *Pigouvian* approach, it might remain impossible to implement due to political factors and lack of enforcement capacity. The tax concessions being proposed could be prone to many forms of abuse i.e. rent seeking and patronage among enforcement agencies in Kenya. In view of these factors:

> *Second best approaches aiming at promoting sound industrial practices i.e. cleaner production technology, industrial ecology, metabolism etc. should be inculcated in Kenya since they embrace a broader value to industrial production and efficiency.*

9.4 Areas for Further Research

This study has concentrated on water pricing and regulation, emphasizing firm response to their enforcement. There are other factors that could trigger processes that are important to industrial water and wastewater efficiency. Some of the evidence gathered during fieldwork suggest that market conditions rather than prices are much more likely to induce efficiency enhancing technological restructuring that are beneficial to water consumption efficiency. For example, industrial firms facing "turbulent" market conditions are more likely to turn to efficiency enhancing technological options and production re-organization. On the contrary we could expect firms that are enjoying stable market environment to be able to make sufficient profits to re-invest in efficient technology. These issues could be the subject of further research, particularly in relation to the Kenyan data.

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