POLLUTION BY SUGAR INDUSTRIES IN KENYA

The Damage to Communities along River Nyando.

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Abstract

Water is a fundamental natural resource. It is indispensable for the welfare of human beings and their natural environment. Its importance is such that it can mean life or death, prosperity or poverty; and it can even be the cause of conflict and war. Inspite of this importance, per capita clean water availability continues to dwindle in Kenya due to problems of water catchment degradation, droughts and pollution of waterways by industries. Although localised and instantaneous environmental consequences of such devastation have received attention by journalists, scientists and regulators alike, the problems defined by lasting impacts on the rural communities along degraded waterways pose challenges much of which remain to be addressed in Kenya.

The broad purpose of this study proposal is to determine the impact of water pollution by the Sugar industries along river Nyando. The study intends to investigate the local communities' dependence on water resources from Nyando river i.e. for drinking, washing, livestock, irrigation, fisheries, recreation and other uses and how the current water pollution impacts on them. Pollution of waterways can affect the local villages drastically and the community's ability to adjust to alternative "cleaner" or "safe" water sources can impinge on household labour and time allocation, agricultural productivity, health, and may change socio-economic status of households.

Assessing the costs of environmental degradation in rural areas is important in several ways. It defines the need for environmental planning and highlights the urgency for action to improve living standards. These assessments can also be a starting point for a country to revise its natural resource management strategy and build experience.

The proposed methods for the study will cover polluted and unpolluted segments using contingent valuation, defensive or averting expenditures, health status and expenditures, travel time, Hedonic price and loss of bio-diversity. A theoretical validation to test consistency of household's behaviour within the restrictions of economic theory will be undertaken before making policy recommendations.

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1.0 *SUGAR PRODUCTION AND WATER POLLUTION*

There are six operational sugar factories in Kenya namely:- Mumias sugar company ltd., Nzoia sugar company ltd., South Nyanza sugar company ltd., Chemelil sugar company ltd., East African Sugar Industries ltd. and Miwani Sugar Factory. These companies process sugarcane into sugar and also manage their nucleus plantations. All the factories are located near permanent rivers. Water abstracted for use in the factories is allowed to flow back after "treatment". The manufacturing process of sugar consists of cane washing and cleaning, milling for extraction of the juice from the stalk, clarification, filtration, evaporation and crystallisation. The most significant factor influencing operations and waste water characteristics are mud, dirt and trash content of the cane upon arrival at the factory. Most of the sugar factories try to adhere to pollution standards but due to numerous problems, pollution to the rivers continue to occur.

1.1 *Pollution of River Nyando*

Notable environmental damage arising from waste discharges by the above factories have been reported along Nyando River where villagers downstream have complained of the discharges from the factories. These discharges have made the river water unpalatable, contributed to killing of fish and other life forms in the river, hence, a number of economic activities such fishing have since been abandoned along the river. The impact of pollution is currently magnified by the following factors:

(i) Some of Lake Basin upper regions frequently suffer severe dry spells hence reducing the amount of water available to dilute and flush discharged wastes from the system, thereby concentrating pollutants in river Nyando.

[ii] The major portion of Nyanza's rural population is located along the polluted segment since the upper zones are settlement schemes dedicated mainly for sugarcane. Most people live in the lower sections close to the river where surface water pollution is greatest.

Similar pollution problems have been reported in Nzoia and Migori rivers which receive discharges from Nzoia and Sony Sugar factories respectively and Mumias factory which discharges final effluent into the river.

1.2 *Policy Concerns in Kenya*

Achieving a universal provision of safe water and sanitation services is among the most important goals of development[2]. Pollution of any vital domestic water source is therefore a top policy issue in any country. Polluted waters means worsened health conditions and spreading of water borne diseases[3]. In this context, water pollution becomes part and parcel of the health policy in any country. In the case of pollution along river Nyando the most immediate policy concerns that arise relate to questions such as *"to what extent are the rural communities living along the polluted segment of the river worse off as compared to their upstream counterparts*?" Are the costs of pollution to these communities smaller or larger than those costs that could be borne by the factories in undertaking alternative and more efficient waste

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[2] Indeed the proportion of the population served by safe water is itself an index of environmental quality and development.

[3] The fact that water-borne diseases are widespread in developing countries, has directed worldwide interest towards mitigating unhealthy conditions by providing safe water close to the house, in amounts adequate to keep decent hygiene standards. To achieve such standards, people in the developing countries need to use considerably more water than they do at present.

management measures? As pollution controls become an increasingly important part of the government's resource management activity in Kenya, the question of the ultimate incidence of river pollution and abatement costs now assumes a larger part of national concern. Under these circumstances, a framework is urgently needed where the burden of pollution and controls of the pollution can be shifted onto the consumers of sugar.

The other policy concern is on the links between environmental degradation and an accentuation of deprivation and hardship which take forms that impinge on household members differentially. Fetching of water for domestic use in most rural communities fall upon women and children (Dasgupta 1993, pp.294). Hence when allied to other household chores and their farming obligations, the workload of women in terms of time increases drastically[4]. In view of these empirical observations, the effect of water pollution along Nyando might have increased women's work-load in a way that calls for urgent policy intervention. As this has not happened as yet, several important benefits to the affected community have already been foregone.

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[4] Estimates indicate that in many developing countries where water is supplied through a public stand post, daily usage ranges between 20 - 70 litres per capita. In areas where women walk long distances to draw water, usages are close to the biological minimum of 2-5 liters per person daily.

2.0 *RESEARCH OBJECTIVES*

In proceeding with this study, the broad objective will aim to answer the following question: What effect does the current control strategy have on ambient concentrations of pollutants on river Nyando and what is the impact of these pollutants on the villages downstream? The specific objectives of this study will include:

(1) Evaluating the extent to which river Nyando benefits the communities around it.

(2) Investigate the existing and past social norms of behaviour regarding water use.

(3) Measure the relative contribution of the quality of water i.e. "polluted" and "unpolluted" to the welfare of the communities upstream and downstream i.e. by showing the extent of costs of pollution to the downstream villages.

(4) Undertake an empirical analysis and validation of the information collected to allow identification of parameters that are essential to a valid design of sustainable household's water management practices.

(5) Suggest Policy intervention measures in the affected villages.

2.1 *Study Justification*

In rural Kenya, a large number of homesteads are far from water points, especially those in the low - potential areas where rivers are only seasonal. It is estimated that less than 50 per cent of the people have access to safe water points. The level of coverage goes down as low as 25 per cent. Further, during the dry seasons, seasonal water sources often dry up, making distances to water long and often exceeding 5 Kilometres. In 1988, the National

Council for Population and Development (NCPD) conducted a demographic and health survey which assessed access to water resources by women in various parts of the country. A summary of the findings of the survey is provided below. The table demonstrates the importance of rivers as source of water in Kenya. About 37 percent of Kenyans obtain their water directly from rivers. Another 31 percent who use piped water obtain it indirectly from rivers. In total, about 68 percent of Kenyans obtain their water from rivers either directly or indirectly. Inspite of this great importance of rivers as a domestic water source especially for rural dwellers, numerous industries discharge their waste in most of the major rivers almost on a continuous basis.

Table 1.1

The Percentage of Women with access to Various Water Sources in Kenya,1988.

Location/ Province	Piped Water	Wells and B/Holes	Lakes and Ponds	Rivers	Others	TOTAL (%)
Urban	90.6	4.4	1.2	3.0	0.8	100
Rural	18.2	16.4	3.3	43.9	18.2	100
Nairobi	95.6	2.1	0.0	1.7	0.1	100
Central	37.9	15.9	2.7	36.6	6.7	100
Coast	57.1	10.1	15.7	15.7	1.2	100
Eastern	24.4	26.4	3.7	38.0	7.5	100
Nyanza	16.8	16.6	11.5	27.1	25.4	100
Rift Valley	14.3	17.2	9.4	51.9	6.7	100
Western	22.5	10.7	11.7	52.0	2.5	100
TOTAL	30.7	16.0	7.9	36.8	8.6	100

Source: Republic of Kenya, "Kenya Demographic and Health Survey Report 1989".

This study will suggest ways in which pollution by industrial dischargers can be managed in accordance with economic principles discussed

in the later part of the paper. In the best of all possible, this study will also provide policy makers with a basis on which to compel producers and consumers of sugar to face prices and costs which reflect the true cost of Nyando river resources.

2.2 *Description of the Study Area*

The study area[5] is found in Kisumu District which lies in a depression that is part of a large lowland. It surrounds the Nyanza Gulf, a protruding part of Lake Victoria at the head of which is Kisumu Town. The Nyando river, the basin of which is extended to about 3450 Km^2 has an annual run-off of about 510 million M^3. The existing condition of the water quality of the Nyando river is much serious compared with other rivers in Nyanza province[6]. The suspended solid [SS] concentration is very high - nearly 10 times of that of the other rivers such as Sondu river. Besides, heavy water pollution caused by biodegradable substances can be seen along the lower reach of the river due mainly to drainage from the agro-processing factories which are located along the middle reach of the river. The density of the population amounted to 267 persons per square km by 1988. Over 80 per cent of the active population of the Kano plain are smallholders. Crop production is geared towards the subsistence with maize and sorghum as the main food crops, in some cases supplemented by sweet potatoes and cassava. Cotton, rice, and sugar-cane are

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[5] Two maps of the study area are appended to this proposal. They appear in Appendices 1 and 2.

[6] Republic of Kenya [1992]: Feasibility Study on Kano Plain Irrigation Project. Volume I Main Text January 1992.

the most important cash crops in the area. Crop production is usually accompanied by livestock-keeping. Agricultural activities are supplemented with off-farm wage labour.

3.0 FIELD METHODOLOGY

3.1 Sample Frame

The sampling frame for the survey will consist of the households living within a 5 kilometres radius from river Nyando. The entire area along the river will be demarcated into two segments: upstream (unpolluted) and downstream (polluted) following which a sample of 150 households will be drawn upstream and another sample of 150 households will be drawn downstream. A total of 300 households will be interviewed using a random sampling procedure.

3.2 Data Schedule

The socio-economic data to be collected will concentrate on general income and expenditure patterns, and characteristics of the households. Data on household composition will consist of an inventory of the members, demographic information about the members, their present agricultural and non-agricultural activities, and about the use of drinking water, water for livestock and irrigation. Regarding household income, information will be gathered about the specific combination of resources per household; on agricultural output, available family labour etc. The remaining part of the questionnaire will consist of sections on water use, perceptions of water quality of different sources, the total amount of water used by a household and the distance to water source, household time budget, changes in water

sourcing and values attached to different water sources, parcels of land and the need for compensatory measures. Draft questionnaire for this activity has been annexed at the end of this paper. Data on pollution levels will be obtained from Kenya Marine Fisheries Research Institute (they collect and analyse the discharges from river Nyando regularly).

4.0 *THEORY AND CONCEPTUAL ISSUES ON THE IMPACT OF POLLUTION TO A RIVER*

Rivers are part of natural resources whose services are not traded in an open market. Consequently, their economic value or the cost of their destruction must be inferred. In the case of river Nyando, there are two classes of benefits which are in danger of being eroded through industrial pollution: on-site benefits that accrue to those using the river, and off-site or external benefits. The primary on-site benefits are the water provision for various uses and the recreational opportunities. Off-site or external benefits - those accruing to people outside the river area may be inferred through existence value. Other external benefits may result from trees and shrubs which can reduce air pollution and modify microclimates. The river also provide habitat for wildlife, serve monumental or memorial functions, add visual diversity, and is indeed a landmark. The benefits accruing to this local common-property resource extends well beyond the above stipulation. Common property resources provide the rural poor with partial protection from unusual economic stress (Dasgupta, P. 1993) i.e. in this case fisheries etc. For landless people they may be the only non-human asset at their disposal. It is therefore not difficult to see why common-property resources matter greatly to the poorest of the rural poor in a society.

4.1 *Erosion of local Commons: The loss to rural communities*

There are inherent difficulties of measuring environmental damage resulting from waste discharges; hence environmental authorities have to direct attention toward a policy of attaining "satisfactory" environmental quality levels (Malor, K.G. 1992). This policy focus is based on implicit premise that waste discharges can be accurately controlled by the polluting industries, thus uncertainty exists only in relation to the environmental control authority's monitoring problem. In this case, it is much easier to estimate the cost of achieving these targets than to estimate the loss from not achieving them.

Realistically, the industrial dischargers are faced with a stochastic[1] pollution control problem due to their inability to control with any great degree of accuracy the quantity and quality of wastes associated with any specific levels of their production activities. Stochastic events include equipment malfunction, variations in input quality, and process upsets. As a result, firms do not have complete control over their emissions. In line with the remarks by Forster A. Bruce (1988) sufficient condition for success of economic instruments depends upon the specification of the production and pollution discharging technology. In the case of Nyando river monitoring of individual polluting actions is difficult since the dischargers are dispersed and pollution there is non-point, while the damage cannot generally be inferred from observed ambient pollution because (i) ambient pollutant levels have a random distribution that is contingent on the level of abatement undertaken and/ or (ii) the actions of several polluters contribute to the

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[1] Emphasis on "Stochastic" is necessary to create a distinction from the images invoked by Hardin G. (1968) "the tragedy of the commons".

ambient levels and only combined effects are observable. In view of limitations imposed by the above factors, the damage caused by the stochastic events can only be inferred using some proxies, say, comparing upstream and downstream estimates of contingent valuation, defensive or averting expenditures, health status and expenditures, valuing changes in travel time, Hedonic price and loss of bio-diversity and recreational possibilities.

5.0 *EMPIRICAL METHODOLOGY FOR MEASURING POLLUTION DAMAGE*

5.1 *Welfare Loss Measurements*

The only way to make a judgement whether welfare has increased or not (Maler K.G., 1992b, pp.3) is by explicitly introducing ethical values on distribution of welfare. This can be done through a social welfare function. Let there be H individuals that are affected by a particular change and let each individual has a utility U_i. Let there be a function $W(U_1, U_2, U_3, U_4, U_5 \ldots\ldots U_H)$ which is increasing in all its arguments. We will interpret this function as a social welfare function if it represents the preferences of a "decision maker". We know from Arrow's impossibility theorem that it is impossible to derive the social welfare function from individual preferences in a way that is consistent with some reasonable conditions. However, Sen has argued that there quite often exists information that would make aggregation of individual preferences possible. One can therefore interpret the welfare function either as an aggregate of individual preferences (given Sen's assumptions on information) or representing the preferences of some individual or organisation.

Consider a change in society from A to B. This change implies that the

individual utility level will change from UhA to UhB, and that the social welfare will change with:-

$$\Delta W = W(U_1^B, \ldots\ldots, U_H^B) - W(U_1^A, \ldots\ldots\ldots\ldots, U_H^A)$$

If $\delta W > 0$, then social welfare will increase in society according to the applied welfare function. The objective of valuation is to find out whether δW is significantly positive or negative. The sections that follow attempt to measure welfare changes as a result of pollution.

5.2 *Valuing Water: Willingness to Pay for River Water*

Modelling WTP for river water fulfils two functions in this study. First, it permits the identification of those factors influencing WTP, giving some indication of their impact i.e. of pollution. Second, it forms part of the overall validation for the values placed on "polluted" waters downstream and "unpolluted" waters upstream.

5.2.1 *Validation of Contingent Valuation Estimates*

A frequently used theoretical validation technique involves modelling the dependent variable using a method such as ordinary least squares (OLS) regression. In this way, a priori expectations about the resulting equation, for instance which dependent variables should be significant and what direction their coefficients should be in, can be tested. The WTP of a household for river water is modelled as a function of those variables that might be assumed to influence such demand. The general model is:

$$WTP_{ij} = F(Y^{ij}, T_{ij}, S_{ij})$$

where

$WTPT_{ij}$ = ith respondent's willingness to pay for water at location j;

Y^i = income of ith respondent;

T_i = vector of preferences or tastes of ith respondent;

S_i = vector of relevant socio-economic characteristics of ith respondent.

Using the marginal effect approach, the values attached to water downstream can be compared with those of the upstream to see the effect of pollution. The hypothesis to be tested with regard to WTP is the embedding effect a la Harrison (1992). This effect, long discussed in the CVM literature, occurs when the WTP for one good is found to be insignificantly different from the WTP for a more inclusive good. The latter good may be more inclusive with respect to geographic coverage, time, or any other attribute. The essence of this is also to detect alleged arbitrariness into the entire valuation process. In this study the reported WTP for river water upstream (unpolluted) should be significantly different from the reported WTP for river

water downstream (polluted).

5.3 *Defensive or Averting Expenditures by the Affected Villages*

For almost every kind of environmental unpleasantness we face, there are averting expenditures we can make to reduce, and sometimes completely remove the damage. Economists have long been aware that averting behaviour is both possible and practiced, and they have often suggested that expenditures on such behaviour can be used as a measure of the costs imposed on society by various forms of pollution[8].

Recent studies analyse the benefits of environmental improvements when households make defensive expenditures to alleviate pollution effects. If the household can take defensive measures against pollution, it can choose "the quality of its personal environment" by choosing a level of defensive expenditures. Evidence of defensive or averting expenditures such as use of water purifiers, moving away from pollution source, installation of new water points, boiling of water etc can be sought and their costs estimated. A comparison of levels of defensive or averting expenditures can be used as a measure of cost of pollution.

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[8] The divergence between averting expenditure and the total costs of pollution arises from the fact that some consequences of pollution cannot be averted due to limits of technology and income.

5.3.1 *Validation*

It is postulated that the averting expenditure would be a function of:

$$AX = F(IHIY^{+}, AW^{+}, EDU^{+}, PI^{+}, ALT^{-}, WQUANT^{+}, WTP^{+}, \ldots\ldots)$$

where

AX = Averting Expenses

IHIY = Household Income

AW = Awareness regarding the state of pollution

EDU = Level of formal education

PI = Intensity of Pollution

ALT = Existence of alternative water sources

WQUANT = Quantity of water used by the household

WTP = Willingness to Pay for improvement of water services

However, as suggested by Bartik J. Timothy 1988. the defensive expenditure model relies on important assumptions that may prove questionable in some of these applications. These assumptions are:

(a) Defensive expenditures are perfect substitutes for pollution reduction and have no value other than alleviating pollution.

(b) There are no significant adjustment costs associated with reducing the level of investment in defensive measures.

5.3.2 *Defensive or Averting Expenditures and Willingness to Pay*

Courant N. P. and Porter C. R. 1981 have considered the relationship between the willingness to pay for environmental quality and averting expenditures - that is, the costs of measures undertaken in efforts to counteract the consequences of pollution. The major results are: (a) Averting expenditures are not in general a good measure of willingness to pay; (b) averting expenditures are not always even a lower bound on willingness to pay; (c) even when averting expenditures are a lower bound, the difference between the level of such expenditures and willingness to pay cannot be attributed to the unavertable "aesthetic" consequences of pollution.

5.4 *Using "Travel Time" and Household "Time-Budget" to Value Water*

An important indicator of reduced productivity of the river resources a la Jodha N.S. (1992) is when local people must spend greater time and longer distances to collect water from alternative sources or use a lesser quantity of water today compared to the past. The travel time method estimates the value households place on river water, based on travel habits to fetch water. It measures the demand function for travel to draw water which implies that travel are function of price and perhaps other variables that might shift the demand function such as income, age, household size, distance, etc. In the case of river Nyando, the travel time of river pollution might be explained by shifts to new water points (hence imposing new travel costs) net the travel time and cost of fetching water from the river. This entails measuring the resulting change in time. The value of water in this case would equal to the total time taken times the opportunity cost of labour i.e. wage rate for unskilled labour. Users close to new water sites would also be expected to

make more use of water, because its implicit price, as measured by travel time, is lower than for the more distant users. Thus the ultimate results in this approach enables construction of a demand curve based on (a) costs of getting to the site, and (b) foregone earnings or opportunity costs of time spent (and an associated consumer's surplus).

Based on a framework developed by Whittington Dale, Mu Xinming and Roche Robert 1990, a village typically chooses from among a limited number of water sources. Because different water system improvements result in different time savings, the choice of water service level involves a trade-off between increased costs and the benefits from reduced time spent hauling water by members of the community. For example, yard taps or house connections reduce the time spent collecting water the most, but they are also the most expensive service option. Handpumps and public fountains are often cheap in terms of capital and operating and maintenance costs, but water must be carried from the source to the home. More handpumps or public foundations in a village can reduce the average travel time from houses to sources, but this also increases total capital costs.

The choice of which technology is most appropriate for a given community may thus be heavily influenced by the perceived magnitude of pollution of one source i.e. the river and the value of time which households assign to the time savings for different sources. Since each source is different in terms of price, collection time, and taste, the utility that a household derives from using one source will be different from the utility derived from using the others. The indirect utility function is defined using: price of water, P; collection time per litre - travel time for the household to the source and return, and fill time at the source, COL; and taste, T.

Based on random utility framework, Whittington et al 1990 postulated the utility function for households h choosing water source i:

$$U_{ih} = V_{ih}(\text{TIME, CASH, TASTE, INCOM, WOMEN, EDUCT})$$

where

TIME = total time spent collecting water per day, including travel time, queue time, and fill time (minutes per day).

CASH = total amount of money paid for collecting water per day, i.e., the cash price times the amount of water consumed per day

TASTE= household's perception of the taste of water from open wells - equal to one if the taste is poor, zero otherwise

INCOM= total annual household income (in thousand of Kenya shillings)

WOMEN= number of adult females in the household

EDUCT= number of years of formal education of family members

and used discrete choice model to derive an estimate of the value of time spent hauling water. They conclude that if the value of time is defined as the marginal rate of substitution between the time spent collecting water and the money paid for the water, it can be calculated from two of the estimated parameters of the conditional multinomial model.

The importance of the above exposition lies in what has already been alluded to where as suggested by Bartik J. Timothy 1988 in the defensive expenditure model which relies on several important assumptions. In the case of travel cost the assumptions that may prove questionable are that:

(a) The choice of alternative water point downstream is strictly because of the need to avoid polluted river water.

(b) All the travel adjustment costs are associated with shifts away from

polluted river.

5.4 *Hedonic Price models*

The theory of hedonic prices is based on an alternative consumer theory in which goods and services are defined by the attributes embodied in them, and the values of these goods and services are the sum of the values of the attributes which they contain. The theory of hedonic prices applies to agricultural commodities as well as to manufactured goods. Implicit price for each of the characteristic of a goods quality can be calculated with reference to changes in price due to changes of the characteristics. When goods or services contain an environmental characteristic the same logic follows -- the market value of the environmental characteristic is "embedded" in the market price of the good or service which contains the characteristic. The hedonic methods include two valuation techniques: property-value approach, and wage-differentiated approach.

To determine the effect river to pollution to land values, Hedonic price models can be estimated to determine the relationships between land values etc with proximity to river, household size, age of household head, income. tenure arrangements, etc. The property value differentials approach pioneered by Rosen S. (1974) provide a measure of benefits or costs that can be attributed to certain variables. It is generally recognised (Frankel, M. 1985) differences in amenity levels across space give rise to differences in property values, and that the latter differences provide a basis for estimating the implicit worth of the amenity. The vehicle for analysis in this case is a closed-river basin with spatial distributions of amenity levels. Questions addressed in this regard include the following: Does amenity level change with the segments

of the river (polluted and unpolluted) and how does the spatial distributions of amenity levels cause shifts in land price? This approach consists of two steps. In the first, property prices are regressed against "Land" characteristics including distance from the river. The regression model is usually of the form:

$$P_i = F(S^i, L_i)$$

where

P_i = sale price of ith piece of land and;

S_i = structural attributes of ith house;

L_i = locational attributes of ith parcel of land. (distance to park, etc)

Hedonic property value approach has been used to value the proximity to natural water bodies and water-related open space, coastal waterfront, and proximity to wetlands. According to Garrod G.D. and Willis K.G. 1992, the general model for rural property value can also be expressed as:

$$P_i = f(AC_p, B_p, CC_p, LAD_p, Q_p, S_p, SE_p, Y_p)$$

where

P_i = the market price of the ith property

AC_i = a vector of variables indicating the proximity to public amenities to the ith property

B_i = a vector of external variables which may affect the value of the ith property

CC_i = a vector of the countryside characteristics in the neighbourhood of the ith property

LAD_i = local authority district containing the ith property

Q_i = the quarter of the year in which the ith property was purchased

S_i = a vector of the structural characteristics of the district containing the ith property

SE_i = a vector of variables describing the socio-economic characteristics of the district containing the ith property

Y_i = the year in which the ith property was sold

The hedonic theory gives no guidance on the proper functional form of the relationship among characteristics. but it is often presumed to be linear for simplicity. The general approach is to regress housing or land prices on a group of explanatory variables, such as house age, and a number of location variables, including one or more "environmental variables" such as water and air quality, or proximity to an environmental amenity. It is anticipated that proximity to river Nyando will exert negative influence on the price of land. This can be captured by estimating the demand for land along the river and comparing the gradients of price change upstream and downstream. The price gradient should be lower downstream and greater upstream. However, practical problems may preclude the use of the above method especially in the context of river Nyando where estimating S_i would be problematic. A more serious problem involves specifying the current list of variables to explain variation in land price due to the "noise" effect of other variables.

5.5 *Productivity and Loss of Bio-diversity*

A drastic decline in the number of products or species in the river following the disappearance of a number of species i.e. fisheries which the villagers used to gather from the river in the past may also be a major indicator of environmental degradation of the river.

5.6 *The Effects on Health and Health Expenditures*

Dasgupta P. (1993) has discussed an analytical framework in which a person's health can be considered as an output. In this framework, the commodities and services and the background environment that go to determine a person's health are seen as inputs. If we think of safe water as a critical input to health especially with distinction to water borne diseases, then differences in incidence and episodes (and resulting health expenditures) of waterborne diseases downstream and upstream are good estimators of the impact imposed by current water sources. The costs of these are much higher when a person struck by such diseases is constrained in his ability to engage in productive or remunerative work. There is substantial literature on the association between poor water, inadequate sanitation, and ill-health. However, there is still much controversy about the aetiology and method of transmission of these diseases is poorly understood, and some controversy about the relative importance of the different factors which are statistically and observationally associated with ill-health in actually causing various diseases and infections. In view of this empirical positions, the incidence or episodes of disease will be used as an indicator of environmental quality rather than incidence of water-borne and water-washed diseases (Anderson D. and Cavendish W. 1992).

6.0 *OPPORTUNITIES FOR POLICY INTERVENTIONS*

The government relies on regulations such as licences or standards to achieve her pollution objectives. Fines on polluters are used occasionally but are generally not directly related to the level of pollution. They are more

related to the frequency of violation than to the intensity of toxity. In practice, the success of current policies has been limited as in most parts of Kenya, pollution is increasing. Differences in implementation of environmental requirements across the country reflects differences in administrative or financial revenues available to monitor polluters.

6.1 *Industrial Pollution Standards in Kenya*

There are set limits of pollutants discharge levels based on a number of parameters which every effluent plant design in industries can take into account in Kenya. These parameters include:

- Volume of the effluent.
- Bio-chemical Oxygen Demand (BOD).
- Toxicity (COD).
- Suspended Solids.
- Synthetic detergents/other chemicals.

The standards for discharge into streams are applicable where dilution of effluent to receiving stream is assumed to be more than 1:10 and the standards applied are as follows:-

Table 6.1: Industrial Environmental Standards in Kenya

Parameter	Maximum Pollution Limit
BOD (5 days 20°C)	Not to exceed 20 mg/1
Suspended Solids	Not to exceed 30 mg/1
PH	6.0 - 9.0
Mercury	Not to exceed 0.05 mg/1
Toxic and heavy metals	Not to exceed 0.1 mg/1
Phenols	Not to exceed 2 mg/1
PV (4 Hrs)	Not to exceed 25 mg/1
Temperature	25°C + 2°C
Total Coloforms	1000/100 mls
Oil and Grease	Trace

Source: Ministry of Water, Records.

The above mentioned standards have been varied by the Ministry of Water, Pollution Control Department depending on the degree of dilution offered by the receiving stream and the water use downstream from the discharge point. The above standards compare favourably with international standards/ guidelines given in the table below.

Table 6.2: International Effluent Limitations/Guidelines

Harvesting Method	BOD_5 Max. Daily	TSS Max. Daily	pH
1. Raw Sugar Cane Processing			
Mechanical or combined hand/ mechanical	0.20	0.46	6 - 9
Hand	0	0	6 - 9
2. Crystalline and Liquid Sugar Refining			
Crystalline	0.18	0.11	6 - 9
Liquid	0.30	0.09	6 - 9
3. Ethanol Production	30 - 60 mg/L	30 - 60 mg/L	6 - 9

Source: The World Bank 1988. Environmental Guidelines. Environment Department. September 1988.

There are substantial differences in the processes, as well as in the quality and quantity of waste effluent among the sugar industries which the above standards may fail to accommodate. In all cases, organics and solids are the pollutant of significance. Pollution loadings are generally expressed in terms of biochemical oxygen demand (BOD_5) and total suspended solids (TSS). The hydron ion concentration (pH) is also important in measuring pollution effects of these wastes. Flows resulting from the production of sugar, spanning from the harvesting of cane to the refined product, are amenable to a number of techniques for reducing or eliminating waste discharges which may vary between industries. These include both in-plant and end-of-pipe procedures. Another important industrial activity along Nyando which should be investigated in isolation is Agro-Chemical Food Company (ACFC) which produces ethanol.

Agro Chemical and Food Company (ACFC)

Ethanol, an organic chemical, is commonly used as an industrial solvent, in medicine, and in the manufacture of alcoholic beverages. It can be used as fuel but is costlier than hydrocarbon fuels. Ethanol (ethyl alcohol) can be produced by fermentation from three main types of biomass raw stocks but the main one used by Agro-Chemical and Food Company in the Nyando basin is the sugar bearing materials such as sugarcane and molasses. Ethanol production produces a number of waste products having an impact on the environment. No extremely toxic waste streams are associated with the biomass conversion though occasionally some heavy metals may be found. The most commonly used method, resulting in minimum ethanol loss, is to withdraw it from the bottom of the still during or after distillation (thus the term stillage). This waste can have a biochemical oxygen demand (BOD_5) as high as 40,000mg/ liter and contain about 10 percent of solid material. All these possibilities may render a general industrial pollution standard inapplicable. There may be a need for industry specific to address water pollution problems in Kenya.

6.2 Pollution Management and Water Protection

6.2.1 Indigenous Management Practices

Unlike global commons, the problems of managing local commons is often not the village users, but other agencies (Dasgupta P. 1993 pp.290) in many developing countries. Traditionally local commons such as village ponds and tanks, pastures, water-shed drainage and riverbeds, and sources of fuelwood

were not open for use to all in any society. In most cases they were open to those having historical rights, through kinship ties and community membership. Those having historical rights of use tended, not surprisingly, to be very protective of these resources. Empirical investigations in India (Dasgupta, P. 1993) found, for example, that downstream villages had an elaborate set of rules, enforced by fines, for regulating safe usage of water. In many villages there existed an intricate set of social sanctions imposed upon those who violated norms designed to protect their source of fresh water.

6.2.2 Legislative Provisions for Water protection

The Law has the potential to provide the structural framework and controls necessary for rational, informed and wise decision-making as it relates to the use and management of natural resources. Thus, sound environmental law could provide incentives for (1) the rational use and protection of natural resources; (2) the prevention of environmental damage; and (3) the promotion of environmentally-sound policy and planning for development.

On Water protection, Section 3 of the Water Act vests the ownership of every body of water in the Government. Water is defined as either being surface water i.e., rivers, lakes, ponds, swamps, and marshes or ground water in the form of a spring, stream, lake or swamp in or beneath a water course. The Water Act manifests little concern for water quality. It makes knowing or negligent water pollution an offence (section 158) but its main thrust is not preventing or redressing the pollution of water (Bragdon, S.H., 1992:76). By virtue of Section 145(1) power is given to a water undertaker to make necessary regulations "for the purposes of protecting against pollution, any

water whether on the surface or underground, which belongs to him or which for the time being he is authorised to take." This section is reactive and fails to assert that the body of water under question shall not be exposed to any use likely to degrade it. Section 158(1) states that it is an offence to cause a source of water supply for human consumption or domestic use to become polluted. Like section 145(1), this section is reactive. It establishes criminal liability that comes into play after the offence has been committed (Bragdon, S.H., 1992:76).

According to Bragdon, the major gaps in legislative coverage relate to (1) Citizen Rights: Existing statutes that relate to environmental matters do not confer any rights or remedies on private citizens whose rights or interests are injured by acts or failure to act. (2) Environmental Quality Standards: Key areas, such as ambient air pollution, have no explicit environmental quality standards. (3) Environmental Impact Assessment: No agency has legal authority to carry out and apply environmental impact assessment.

6.2.3 Economic Instruments for Pollution Control

The traditional approach to environmental management (use of standards) specifies the technologies that firms must use in reducing pollution. Unfortunately, this "command-and-control" approach fails to take advantage of important information. Firms, not regulators, have detailed knowledge about pollution control costs that is crucial to finding the least cost ways of cleaning the environment. Indeed, in some cases, stringent technology-forcing standards have a perverse effect as they deter the purchase of newer, cleaner technologies by raising their costs relative to extending the life of existing assets. For example, rigid new source performance standards probably

leads to dirtier air than would have otherwise resulted by substantially raising the cost of constructing new plants. The key to avoiding such perverse results is to devise incentive systems that will limit overall levels of pollution while fostering technological innovation to reduce abatement costs.

Kenya's Seventh National Development Plan for 1994-1996 notes that health and environmental damage costs have so far been largely transferred to others, especially to the Government and later generations. Under the economic principles, polluters will increasingly be confronted with the full costs of their activities under "polluter-pays" approach[9]. The other range of options to be considered during the plan period 1994-96 include effluent or emission charges on water effluent; toxic releases: solid waste disposal: reduction of tax benefits and subsidies promoting unsustainable development such as below-cost use on sale of energy, minerals, ground water or forest resources; and the introduction of new tax benefits to support sustainable development, such as, accelerated depreciation allowances and tax write-off for pollution abatement equipment and environmentally sound technologies among others[10].

The search for cost-effective and implimentable measures for pollution control has been expanding. The early work by OECD in developing the principle that " the polluter pays" has evolved into an active literature examining the tradeoffs between the use of command-and-control [CAC] and the market-based incentive [MBI] systems. It is increasingly realised that most

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[9] Under this phrase, it is not clear what the polluter will be paying for i.e. whether the polluter will pay compensation to those affected, for costs of abatement or for contravening emission standards etc.

[10] Republic of Kenya: The Seventh National Development Plan for 1994 - 96. Government Printer.

countries need a combination of both approaches and that each will be most effective in certain situations. Tietenberg's work on tradeable permits and their use is an interesting example of the search for cost effective means of pollution control. With increasing interest in privatization and the increased use of markets, it is very important to understand which approach is most effective in each situation[11].

In contrast to the traditional regulatory approach, which makes mandatory particular forms of behaviour or specific technological choices, the economic incentive approach allows more flexibility in how the environmental goal is reached. By changing the incentives an individual agent faces a decision scope where, the private choice can be made to coincide with the best social choice. Rather than relying on the regulatory authority to identify the best course of action, the individual agent/industry can use his or her typically superior information to select the best means of meeting an assigned emission reduction responsibility. This flexibility achieves environmental goals at lower cost, which, in turn, makes the goals easier to achieve and easier to establish[12].

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INSTITUTE FOR DEVELOPMENT STUDIES
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QUESTIONNAIRE FOR THE BASELINE SURVEY ON
WATER USE AND POLLUTION ALONG RIVER NYANDO

Location..... Zone: [I], [II], [III], [IV]

Interviewer's name..... Quest.No. .....

PART I: *OCCUPATIONAL AND DEMOGRAPHIC DATA*

A1.1 *Name of Respondent:* .....

A1.2 *Age of Respondent*.....*Years Sex: [F].[M]*

A1.3 *Is respondent also the head of household [ ] Yes [ ] No*

A1.4 *If Yes, what kind of work does the respondent mainly do?*

[ ]Works in own farm/ home (state)

[ ]Employed in .....

[ ]Works elsewhere (state).....

[ ]Not working

A1.5 *If No, how is the respondent related to the household head?*

[ ] Spouse [ ] Son [ ] Daughter [ ] Other

A1.6 *If (A1.4) is No. what kind of work does the household head mainly do?*

[ ]Works in own farm

[ ]Employed in .....

[ ]Works elsewhere (state where).....

[ ]Not working

A1.7 *What is the age of the head of household?.....years.*

A1.8 *What is the highest level of education the respondent attained?*

[ ]None [ ]Lower primary (1-4)

[ ]Upper primary (5 - 7)

[ ]Secondary school

[ ]Diploma college

[ ]University

A1.9 *What kind of work does household head's spouse mainly do?*

[..]Employed in.....

[..]Works in family farm

[..]Never works

A1.10 *Approximately how long have you lived at your present home or current location? .....years.*

A1.11 *How many people including yourself are in this household?*

A1.12 *For the other members, how many of these are:*

Young females .....

Adult females .....

Young males.....

Adult males.....

A1.13 *How many persons in your household are direcly dependent on household resources ? .....*

A1.14 *What is the approximate non-farm annual household (considering both household head and spouse) income (KShs)?*

[..] Under 5.000 (state where possible).....

[..] 10,000 - 15.000.....

[..] 15,001 - 20,000.....

[..] 20,001 - 25,000.....

[..] 25,001 - 30,000.....

[..] 30,001 - 35,000.....

[..] 35,001 - 40,000.....

[..] 40,001 - 45,000.....

[..] 45,001 - 50,000.....

[..] Over 50,000.....

A1.15 *Does the household receive money regularly from places other than those already indicated (i.e. remittance from other relatives)*

[ ]Yes [ ]No

If yes how much per month? .....

From.....(indicate source).

PART II: *SOCIO - ECONOMIC DATA*

B2.1 *Land:*

1. Size of land holdings ... . hectares or ..... acres

2. Area under cash crops ..... hectares or ..... acres

3. Area under food crops ..... hectares or ..... acres

B2.2 *Do you have a title deed for your piece of land? [ ]Yes [..]No*

B2.3 *List the agricultural crops on your farm and their acreage:*

[..] Sugar cane/acreage.....

[..] Maize/acreage.....

[..] Beans/acreage.....

B2.4 *[a] Do you use hired labour in your farm? [..] Yes [..] No For which activities do you use family or hired labour?*

	Family	*Hired*
[a]	*Ploughing .....*	*.....*
[b]	*Weeding.....*	*.....*
[c]	*Harvesting.....*	*.....*
[d]	*Grazing.....*	*.....*
[e]	*Planting.....*	*.....*

B2.5 *Approximately how much do you earn from agriculture annually?*

Kshs.....

B2.6 *Number of livestock owned by household:*

[a] Cattle ....

[b] Goats .....

[c] Sheep .....

[d] Chickens ..

[e] Others (specify) .....

B2.7 *Livestock keeping [Dairy animals] based on:*

[ ]Open grazing

[ ]Zero grazing

[ ]Not applicable

B2.8 *Does the household own the following gadgets:*

[ ] *Radio*

[ ] *TV*

[ ] *Bicycle*

[ ] *Motor cycle*

[ ] *Vehicle*

B2.9 *What type of housing does the household have?*

[ ] *grass thatched*

[ ] *Iron roofed with mud walls*

[ ] *Iron roofed with block walls*

PART III: *HOUSEHOLD TIME BUDGET*

On a day-to-day basis (particularly on a normal working day), how much time does the household spend on the following activities?

Activity	Time spent daily or weekly (state)		
	Household Head	Spouse	Children
Fetching water			
Fetching firewood			
Working on the Farm (shamba)			
Working elsewhere to earn a living			
Cooking			
Obtaining food from the market			
Others.....			
Others.....			

PART IV. WATER-USE INFORMATION

W3.1 *Rank the following sources of water according to the intensity of their usage in a year and indicate the time it usually takes you to fetch water from this source and return:*

	Overall Rank	Time	Drinking/ Cooking	Washing	Livestock	Distance Kilometres
River						
Bore-hole						
Roof catchment						
Pond						
Piped Water						
Nearby Private Home						
Other[specify]						
Other (specify)						

Ranks: 3-rarely used, 2-used only when a regular source is disrupted, 1= used regularly.

W3.3 *Is the time spent fetching water today:*

[..]Same as 10 years ago?

[..]Longer than 10 years ago?

[..]Shorter than 10 years ago?

W3.4 *What is the total quantity of water used yesterday for:*

(a)cooking? .....buckets/jerricans

(b)livestock? .....buckets/jericans

(c)Gardening? .....buckets/jericans

(b)washing?.....buckets/jericans

W3.5 *Please rank the persons who fetch water for the household regularly:*

[..]Husband

[..]Wife

[..]Male Children

[..]Female Children

W3.6 *How many day's supply is fetched in each episode?*

(a) cooking? ..... *(b) livestock? .....*

(c) washing?.....

W3.7 *Do you ever purchase water Yes[ ] No[ ]*
If yes state the (a) Quantity .....(b) Amount Paid.....

W3.8 *Does the household use more water today than several years ago?*
[ ]More [ ]Same [ ]Less

W3.9 *Does the family buy more water today than several years ago?*
[ ]Yes [ ]No

W3.10 *Do you encounter any scarcity of water during the year?*
[ ] Yes [ ] No

W3.11 *If Yes, for which source and use is scarcity most acute during the year?*

	Distance in Km.	Cooking	Drinking	Cleaning	Livestock	Garden/ Irrigation
River						
Bore-hole						
Roof catchment						
Pond/ Well/ Spring						
Piped Water						
Nearby Private Home						
Other(specify)						
Other (specify)						

W3.13 *What is the usual mode of transporting water in your household?*
[..] Bicycle [..] Over-head
[..] Donkeys [..] Vehicle or motorcycle
[..] Handcart or Wheelburrow
[..] Others (state).....

W3.14 *Of the water source you use most, the main reason is (please rank):*
[..] proximity [..] turbidity [..] taste [..] diversity of use (bathing sites etc)

W3.15 *At what time of the day is the fetching of drinking water preferred?*
time.....why?.....

W3.16 *At what times of the day and months of the year is the quality of water supply good? day .....year.....*

W3.17 *At what time of the day and month of year is the quality of water*

supply poorest? day.....year.....

PART V: *ESTIMATES OF HEALTH IMPACT AND EXPENDITURES*

W3.18 *Are the following water related ailments a problem in your household?*

[..] Diarrhoea [..] whipworm
[..] ascariasis [..] schistomiasis
[..] hookworm [..] trachoma
[..] amoebiasis [..] Bilhazia
[..] dysentry
[..] others(state).....

W3.19 *Indicate the number of episodes in three months in which the following ailments are a problem in your family?*

[..] Diarrhoea [..] whipworm
[..] ascariasis [..] schistomiasis
[..] hookworm [..] trachoma
[..] amoebiasis

W3.20 *About how many days in a year do you/does your spouse and other family members stay at home or in bed due to the above diseases?*

[..]Self.....days
[..]Spouse.....days
[..]Others.....days

W3.21 *Who does your work when you are unwell?*

[..] Spouse
[..] Male Children
[..] Female Children
[..] Hired labour
[..] Not Applicable

W3.22 *Approximately how much do you/ does your employer normally pay for treatment outside home [inclusive of fares and hospital fees] on each episode of your sickness? Fares.Kshs..... Hospital fees Kshs.....*

PART VI: *WATER AND ENVIRONMENTAL POLLUTION*

V4.1 *Is there much visible contamination from the river? [..]Yes [..]No*

V4.2 *How would you describe the condition of the river water?*

	Currently	Previously	Most of the time
Turbidity (clearness)			
Hardness			
Odour (smell)			

Ranks: 1=very low (unobservable), 2= Moderate (observable but not severe), 3=Severe.

V4.3 *State other forms of contamination in the river known to you:*

[..]mud

[..]taste

[..]colour

[..]hardness

V4.5 *Have you experienced any of the following problems with the untreated water from the river?*

[..] Bleaching of clothes

[..] Skin Irritation

[..] Colouring of the clothes

[..] Any other problems

(state).....

V4.6 *Do you encounter any problems when your livestock drink water from the river? [..]Yes [..]No.*

If yes which ones?.....

V4.7 *Do you know of any other environmental problems which you may associate today with the use of untreated water from the river? [..]Yes [..]No. If Yes, which one? .....*

V4.8 *Has the water quality in river Nyando hampered your agricultural activities in any way? [..]No [..]Yes If yes state how..... .....*

PART VII: *WILLINGNESS TO PAY FOR WATER*

V5.1 *If you were to be supplied with <u>piped water</u> at home or within reasonable proximity from your house, how much would you be willing to pay per month for all your household water needs? Kshs.....*

V5.2 *If you were to be supplied with <u>borehole water</u> at home or within reasonable proximity from your house, how much would you be willing to pay per month for all your household water needs? Kshs.....*

V5.3 *If the present river water was to be cleaned, hence the water be provided clean, free of any form of pollution, how much would you be willing to pay per day for water from the river? Kshs.....*

V5.4 *Suppose that a permit were needed for you or members of your household to draw water and bathe from the river. The permit would be valid for one year, and the money raised from permit sales would be used to improve water quality in the river. Would you pay for such a permit? [..] No. [..] Yes.*
If Yes, what is the maximum amount you would pay to get a permit for:
[..]Bathing?....Kshs.....per month.
[..]Drawing water?.....Kshs.....per month.

V5.5 *You have made your trip to fetch water from your regular water source. Once you have reached that area, you found that a local authority has imposed a service charge on the water use. What would you be willing to pay as a charge to draw a bucketful of water from this source? Kshs.....*

PART VIII: *WILLINGNESS TO ACCEPT COMPENSATION*

V6.1 *You have made your trip to fetch water from your regular water source. Upon arriving at the water point, you are told by local authorities that*

the water facilities are closed for improvement. You are told that you would be compensated for not being able to actually draw the water. How much compensation would you ask for in this case? Kshs.....

V6.2 *You have made your trip to bathe from your regular water source. Upon arriving at the water point, you are told by local authorities that the water facilities are closed for improvement. You are told that you would be compensated for not being able to actually bathe in the water. How much compensation would you ask for in this case? Kshs.....*

V6.3 *How much lumpsum compensation do think you should receive from the upstream polluters per year for the inconvenience caused to you? Kshs.....*

V6.4 *Suppose that your household received a permit, valid for one year, to fetch water and bathe from the river. Now suppose you could sell this permit. If you did you could not draw water from the river. What is the smallest amount you could sell the permit for (you could sell it to anyone) for:*

[..]Bathing? Kshs.....[..]Drawing water? Kshs.....

PART IX: *DEFENSIVE OR AVERTING EXPENDITURES*

V7.1 *What do you do to improve the quality of water before use?*

[ ] Boil

[ ] Sieve

[ ] Add Chemicals

[ ] Nothing

V7.2 *State any other gadgets you have acquired to improve on the quality of the water from the river and the cost of such gadgets:*

(1).....Kshs.....

(2).....Kshs.....

(3).....Kshs.....

(4).....Kshs.....

V7.3 *State all the gadgets you have acquired to improve on the supply of water and the cost of such gadgets.*

(1).....Kshs.....

(2).....Kshs.....

(3).....Kshs.....

(4).....Kshs.....

PART IX: *LOSS OF BIODIVERSITY (FISHERIES AND OTHER LIFEFORMS)*

F9.1 *As far back as you can remember, do you think there has been a decline in fish stocks or other life forms in the river?*

[..] Yes [..] No.

F9.2 *If Yes, state the other aquatic species you knew which are now extinct from the river. 1.....2.....3.....*

4.....5.....6.....7.....

F9.3 *How would you rank the following as the possible causes of extinction of the above:*

[....] Pollution of the river.

[....] Overexploitation.

[....] Destruction of river channels downstream.

[....] Fluctuations in the river levels.

F9.4 *Describe as concisely as possible how the above changes have affected your life.*

F9.5 *Give a historical account on the abundance of fisheries beginning from early 1960s to date.*

F9.6 *Give a historical account on the water management strategies beginning from early 1960s to date.*

PART XI: *GENERAL OBSERVATIONS*

G10.1 *What changes if any do you think should be made in the river Nyando water supply system?*

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G10.2 Any general remarks:.....

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