Defining an Environmental Development Strategy for the Niger Delta

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DEFINING AN ENVIRONMENTAL DEVELOPMENT STRATEGY FOR THE NIGER DELTA

VOLUME II

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Representative and Organization	Date
Niger Delta Weltands Centre	17 March 1995
B. Chinsman and O.O. Okoro,	20 February 1995
- Resident Representative and Environment Officer, UNDP Lagos.	9 February 1995
J.P van Dessel - Consultant - Former Head of Environmental Studies, Eastern Region, Shell Petroleum and Development Company of Nigeria.	31 January 1995
C. Wicks and Dr. Siân Pullen - Head of International Programme and Scientist, World Wildlife Fund - UK.	25 January 1995
Dr. A.J.T. Otobo - Niger Delta Wetlands Center.	20 January 1995
Dr. M. F. Ivbijaro Commissioner, Ministry of Agriculture and Natural Resources, Delta State.	21 December 1994
J.E.E. Ighogboja - Ministry of Works, Delta State.	21 December 1994
L.E. Onyeche - Department of Fisheries, Delta State.	21 December 1994
Dr. W. I. Bell-Gam - International Centre for Environmental Education, Planning, and Training, UK.	19 December 1994
Dr. L.A. Daniel-Kalio - Crop Protection, Rivers State University of Science and Technology.	19 December 1994
N. Achebe - Director and General Manager, , Shell Petroleum and Development Company of Nigeria.	17 December 1994
P.A. Dike - Engineer, Rivers State Environmental Protection Agency	14 December 1994
Dr. N. C. Alagoa - Fisheries Department, Rivers State University of Science and Technology.	9 December 1994
M.N. Chimah - Eleme Petro-Chemicals Company Ltd.	7 December 1994
Chief H.J.R. Dappa-Biriye	15 November 1994

Representative and Organization	Date
Dr. J. Oates - Department of Anthropology, Hunter College. City University of New York	24 October 1994
I.G. Nwafor and P.A. Dike - Rivers State Coastal Zone Coordinating Committee	no date
M. J. Ayotamuno - Engineer, Rivers State Environmental Protection Agency	no date
B.A. Lawson - General Manager, Niger Delta Basin Development Authority	no date
T.T. Isoun and M. Isoun - Niger Delta Wetlands Center	no date
Flood and Erosion Department, Rivers State Ministry of Works	no date
Dr. T.K.S. Abam - Niger Delta Wetlands Center	no date

ANNEX B
GLOBAL SEA LEVEL RISE[2]

The threat of coastal erosion is increased by the prospects of a global sea level rise (SLR). In Nigeria, a one meter sea level rise could flood 18,000 km^2 of land, damage assets valued at US$9 billion, and force the relocation of up to 3.7 million people. The estimated population displacement will vary depending on the extent of sea level rise and protection measures. Table 1 shows displacement in Nigeria ranging from 100,000 to 8.5 million people given various levels of sea rise and corresponding protection measures.

Table 1: Scenarios of the Displacemnet of People for Various Levels of Sea Level Rise (SLR) in Nigeria

(Million People)

Scenario (SLR), meter	0.2	0.5	1.0	2.0
No protection	0.64	1.60	3.18	8.50
Important areas protected	0.20	0.52	1.06	1.99
Total protection	0.10	0.27	0.56	0.99

Source: French et al. (1994)

The table below illustrates the potential impacts on Niger Delta.

Table 2: Impacts of Sea Level Rise in the Niger Delta

		Present	1 m SLR	2 m SLR
Erosion rate	m/year	10-15	16-19	20-25
Area lost to erosion	km^2	26-45	55-120	130-230
Inundation and erosion	km^2	3,000	7,000	15,000
Percent of area lost	%	15	35	75
Villages impacted	No.	50	200	350
People displaced	million	0.15	1-2	2-3

Note: The Niger Delta is defined as an area of 2 million ha.
Source: Awosika et al. (1992).

Sea level rise will submerge low lying areas and increase salinity in some ecosystems. Fish populations will change by migrating while vegetation will adapt much more slowly. The

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[2] Linddal., 1995.

diverse ecosystems in the Niger delta are vulnerable to changes in salinity, but a low rate of change should make accommodation possible.

Three major response strategies to evade the cost of sea level rise are:

- **Retreat,** e.g., movement of population and investments. Relocation of a village is estimated to cost US$400,000 on average. (Relocation costs).

- **Accommodate**, e.g., conversion of activities from land-use to fishery (Indirect opportunity costs).

- **Protect,** e.g., building of seawalls and nourishment of beaches (defensive expenditures). The values at risk are investments in the oil industry (estimated US$13 billion) and other socio-economic investments (estimated US$10 billion). Some of these investments are **sunk** costs.

Two coastal engineering techniques have been considered as protection strategies:

- Seawalls, which cost between US$2 million and 18 million per km.[3]

- Beach nourishment, which costs between US$10/m^3 for beach fill with sand and US$100/m^3 for rock filling (French et al, 1994).

The cost of protection of highly developed coastal areas in Nigeria, oil development infrastructure and a total protection of all moderately developed areas at different sea level rises is estimated in the table below. Protection of the country's whole coastline is not economically feasible.

Table 3: Cost of Protecting Against Sea Level Rise (SLR)

(Million US$)

SLR Areas:	0.5 m	1.0 m	2.0 m
Only highly developed areas	220-320	560-670	1,700-1,922
Incl. moderate developed areas	610-890	400-1,780	3,537-3,992

Note: The costs occur over 50 years (2051-2100)
Source: WDR, 1992: *Development and the environment.* The World development report, The World Bank, Oxford University Press, 329 pp. (cf. French et al., op.cit.).

[3] The low estimate is from French et al. (op.cit.) and the higher is from IPCC (1990). The lower figure is based on an in-country data collection. IPCC, 1990: *Strategies for adaption to sea level rise.* Report of the coastal zone management subgroup, IPCC Working group III, The Netherlands, 122 pp.

The cost of protecting Nigeria from a sea level rise of one meter has been estimated to be US$3,162 billion (IPCC). This protection scenario only includes areas with a population density larger than 10 cap/km^2, and thus excludes the Niger delta. Another estimate for the costs of a similar scenario is US$1.4 -1.8 billion, i.e., significantly less (French, 1994).

Sea level rise places the low-lying Niger delta at particular risk. Little priority has been given in the national estimates to the prospects of the inundation in the Niger delta because of:

- The prevailing uncertainty of the eventual extent of sea level rise paired with the presumed relatively low socio-economic impact in the Niger delta (due mainly to the relatively low population density) compared with other regions.

- The low priority given to the people in the delta.

- The oil wells can be exhausted before a sea level rise becomes a problem. It is also possible to extract the oil from submerged areas.

ANNEX C
CHARACTERISTICS OF FOREST ECOSYSTEMS

Mangroves

Nigeria has the third largest mangrove forest in the world and the largest in Africa (9,730 km^2). The majority is found in the Niger Delta and estimated to cover between 5,400 km^2 and 6000 km^2 (SECAL in Sayer, Harcourt, and Collins, 1992, 231; Adegbehin and Nwaigbo, 13). According to the FAO 1979 land use survey of the delta, 30 percent of Rivers State is composed of mangrove forests (5,891 km^2) (see Table 4). Defined by regular salt water inundation, the mangroves form a vegetative band 15 to 45 km wide parallel to the coast. The mangrove region is widest on the sides of the delta, 35-45 km, and narrows towards the center to a width of 15 km, except for the channel of the Brass River which has extensive mangroves far upstream (hug, 413; Powell, 1995, 7). Creeks, which are kept open by tidal action and flooding, flow throughout the forests (The River Chiefs, 1992, 38). Delta tidal effects, most evident in the mangroves, range between 1 and 3 m. Acid sulfate, silty clay, clay loam, and peat, or chikoko, soils predominate in the mangroves. They tend to be saline and have almost neutral pH when wet. However, when the soils dry, the sulfides are oxidized to sulfuric acid, leaving a highly acidic environment (down to pH 3).

Greatly influenced by both freshwater flows and diurnal tides, mangrove forests have low species diversity and elevated productivity. In contrast to the low standing biomass, averaging 150 tons per hectare, productivity can be relatively high - 15 to 20 tons per hectare per year for river mouth and creek edges stands. Productivity is much lower for inner mangrove forests, which are composed mainly of stunted trees. Mangrove productivity is important in that approximately half of it falls as leaf litter and dead wood (Commission of the European Communities, 1992, 10). The combination of the accumulation of dead mangrove biomass and the living trees' ability to trap sediments and organic matter can increase land area. Whether they do depends on the interactions of river sediment transport, erosion by currents and waves, and the vertical movement of land. The litterfall and accumulation of organic matter are also the basis for the aquatic food chain linking decomposers to marine and estuarine fish, mollusks (such as oysters and periwinkles), and crustaceans (especially shrimp and crabs) (Ashton-Jones and Douglas, 1994, 140).

The mangrove forests of the Niger Delta principally comprise only three tree families and six species: Rhizophoraceae (*Rhizophora racemosa, R. harrisonii,* and *R. mangle*), Avicenniaceae (*Avicennia africana*), and Combretaceae (*Laguncularia raremosa,* and *Conocarpus erectus*). The distribution pattern of mangrove species depends on several factors: salinity, frequency and duration of flooding, siltation rates, soil compaction, and strength of erosion forces (Linden and Jernelov, 1980, 83). Only trees on the nutrient rich creek banks grow to large size (30m); the rest are much smaller (Powell, 1993, 6). *Rhizophora racemosa* (red mangrove), which forms a dense growth throughout the region, is the most common species, estimated to cover 90 percent of the mangrove area (NEST, 140).

Being a pioneer, it is followed by the shorter *R. harrisonii* and *R. mangle*, which progressively prefer drier habitats. Avicennia (white mangrove) is also found on firmer ground than *R. racemosa*. *Nypa fruticans*, an exotic palm, has spread through the eastern delta and is common around the mouths of the Bonny and Imo Rivers (see the exotic species section). In degraded areas, sedges, grasses, especially *Paspalum vaginatum*, and ferns, like *Acrostichum aureum*, thrive (Sayer, Harcourt, and Collins, 1992, 232; Federal Environmental Agency (FEPA), 1992, 14). The process of succession from *R. racemosa* establishment to dry land takes approximately 100 years in ideal conditions. Water flow, erosion, and sediment deposition changes frequently disrupt succession to the extent that *R. racemosa* remains the dominant species in the mangroves. As salinity drops away from the coast, the mangrove species are eventually outcompeted by the freshwater swamp forest flora.

Table 4: Niger Delta Mangrove Forest Estimates

Forest size (ha)	Standing Volume (million m^3)	Researchers
404,500	7-9	Niger Delta Development Board (1962/3)
512,000	30-40	Niger Delta Development Board (1963/4)
404,500	5.64	FENCO (1976)
540,000	13.9	Adapted from Okigbo (1985)
540,000	16.7	Adegbehin and Nwaigbo (1990)

Source: Adegbehin and Nwaigbo, 1990.

Freshwater Swamp Forests

With the severe deforestation of other forest zones in Nigeria, freshwater swamp forests will soon become the most extensive forest zone in the country (World Conservation and Monitoring Centre, 15). Large areas remain intact because of the high cost of extracting timber, developing plantations, and clearing land for agriculture. These forests cover one third of the land area of Rivers State (Forestry Department, Rivers State, 1994). The freshwater swamp forests are most extensive in the west and central delta. In the eastern delta, the freshwater forest band is much thinner because of the higher elevations. Seasonal flooding is the dominant ecological influence on the freshwater swamp forest. Flood waters collect in countless swamps and ponds, saturating the soil for at least the rainy season. Standing water evaporates during the dry season in most areas, but permanent swamps are common in many areas, such as behind the riverbank levees. The swamp forest zone can be divided into two general ecological groups: (1) riverbank levees which are rarely flooded and have been mostly converted to agriculture, but have the best conditions for tree growth, and (2) the back swamps which can be inundated with water for most of the year.

The soils are heterogeneous in the swamp forest zone. They are cohesive when dry, but much less so when wet. During flooding periods, they become saturated and erode easily. The humid tropical environment coupled with deforestation has deteriorated soil fertility (Linden, 1993, 6). Since soils are saturated to within a few centimeters of the surface in most

locations, succession to a lowland rainforest has not occurred, leaving instead an edaphic climax of freshwater forests (Skoup and Co. Ltd., 5).

No systematic vegetation survey of swamp forests has ever been conducted; the information available is based on isolated studies and observations. The forest stands fringing the rivers and creeks are dominated by *Raphia, Calamus* and *Alchornea,* that are usually less than 15m high. Behind the fringe, a taller forest that includes many commercial species grows upwards of 45m on the levees (Table 5). *Irvingia gabonensis* (Ogbono), *Symphonia globulifera, Alstonia boonei, Berlinia* spp., *Nauclea gilletti* and *Pandanus candelabrum* (screw pine) are also common. One early study in the Mamu River Forest Reserve, which is located in the freshwater ecozone outside of the delta, found that *Anthostema aubrvanum* and *Carapa procera* comprised more than 65 percent of tree species (Skoup and Co. Ltd., 5). The secondary forest species, *Musanga cecropioides* (umbrella tree) is abundant in drier areas (The River Chiefs, 1992, 42). In small areas, *Oxystigma mannii, Raphia hookeri,* and *Pandanus candelabrum* establish essentially single species stands (NEST, 143).

Severe seasonal flooding has kept the back swamp forests from being converted to farmland. Largely unstratified, the main canopy is generally open, giving the impression of a secondary forest. Tall trees are abundant, but patchy and interspersed with dense thickets of shrubs and lianas. The trees are concentrated on the areas of higher ground. Though wide variation in species composition is common, *Mitragyna ciliata* (up to 36 percent), *Raphia* palms, *Symphonia globulifera, Pterocarpus santalinoides*, and *Uapaca* are the common swamp forest stand, with palms dominating in the wettest areas (Richards in Skoup and Co. Ltd., 6; Ashton-Jones and Douglas, 129). The dense tangle of lianas and other climbers is the most distinguishing characteristic of these forests (NEST, 144).

Barrier Island Forests

The smallest of the ecozones in the delta (1,140 km^2), the barrier island, or beach ridge island forests, are degraded in accessible areas, but large areas of high quality forest with high concentrations of biodiversity remain. For example, the Adoni area is still relatively intact. It has been proposed as a game reserve because of its remnant populations of elephants and sea hippopotami (see the biodiversity section) (Hall, 1994, 27). Similarly, the forests around Sangana and in the Olague Forest Reserve along the western coast of Delta State are in good condition.

The beach island forests are freshwater forests found between the coastal beaches and the estuarine mangroves. They typically contain a band of rainforest species growing on the inland side of the beach ridges and freshwater swamp forests created by the high freshwater table (common species are listed in the freshwater swamp forests description and Table 5). A littoral forest of small trees and shrubs with thick waxy leaves protect the rainforests from the open ocean environment (Ashton-Jones and Douglas, 1994, 146-7). The forests grow on sandy inceptisols that are well to very poorly drained depending on whether the forest is located on a beach ridge or back wetland.

Table 5: Commercial Timber Species

Scientific Name	Common Name
Mitragyna ciliata	Abura
Cebia spp.	
Gmelia spp.	
Khaya spp.	Mahogany
Nauclea diderrichii	Opepe
Terminalia spp.	
	African walnut
Militia excelsa	Iroko
Lophira alata	Ironwood
Cleistopholis patens	Otu

Table 6: Common Agricultural And Tree Crops

Agricultural Crops	Tree Crops
Cassava	Oil palm
Yam (esp. water yams)	Raphia palm
Cocoyam	Citrus fruits
Maize*	Cashew nuts
Rice	Mango
Beans*	Ogbono
Peppers	Pawpaw
Spices	Cocoa
Melon	Guava
Sugar cane	*Garcinia spp.*
Plantain	
Banana	

* Not extensively cultivated in riverine areas, but common in lowland areas.

ANNEX D
VALUATION OF FOREST PRODUCTS

The Value of Wood Products[4]

There are several uses of the forest, but the use generating the largest **direct** economic revenue is the harvest of wood, i.e., timber logs for sawn wood and wood products, smaller dimensions for fuelwood and several other uses (e.g., chewing sticks and building poles). Based on figures on the production from the forests in Delta state in 1992 and various sources of prices, e.g., a recent study on forest products in Cross River state (Omoluabi, 1994), it is possible to estimate the annual value of the wood production in Delta state (Table 7). The forest products are:

- Sawlogs
- Transmission poles
- Bamboo
- Building poles
- Fuelwood
- Chewing sticks

The unit values are estimated as approximations to the market value net of productions costs. It is a rough value, which is hampered by the variability of the pricing system, the huge transport costs, and the chain of processing adding an extensive value to the semi-processed products. The unit values are estimated as a lower bound, and the value added in the processing is not included. With the production figures from Delta State, it is possible to estimate the primary production value of woodbased forest products from the Niger delta.

Sawlogs have a market price of about ₦5,000/m^3, and mahogany is sold for about 25 percent more.[5] The stumpage value for mahogany (market price net of extraction costs) is about ₦500-1,000/m^3 (one tree yields 3 logs that are 12 feet long, i.e., approximately a total of one m^3). The timber tariff in Cross River state is reported to be ₦700/m^3, and is used as the stumpage value. Value is added from converting the logs into sawn wood, and it is assumed that the value added is equal to the stumpage price. The study from Cross River state found a profit margin in sawn wood processing of ₦1,000/m^3.

Building poles are sold in Calabar for ₦10. They are usually 3 m long and have a diameter of 6 cm, i.e., 200 poles are equal to one m^3 with a market price of ₦2,000/m^3. With a profit margin of 80 percent the net value is ₦400/m^3.

Transmissions poles were reported to have a net value of ₦500/pole in 1992 in Delta State. This value is relatively high since there are several poles in one m^3. A low estimate is to keep

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[4] Linddal, 1995.

[5] Dr. Leh, Forest Director, Rivers State (Pers. comm.).

the reported price from 1992 and assume that only two poles make one m^3, i.e., the net value is ₦1,000/m^3.

Fuelwood is sold in markets in bundles: A small bundle (10 kg) for ₦10 and a larger (50 kg) for ₦40 (prices in Port Harcourt). These prices are equal to ₦500/m^3 (with a wood density of 0.6). There is a substantial value added from splitting larger bundles. The price of roundwood billets of mangrove wood that yield 1 m^3 of fuelwood have an estimated value of ₦330/m^3 in Cross River state (including expenditures on community permits, harvesting, transport, labor and profits). The shadow price is large in terms of the substitute for fuelwood and the open access regime with regard to collecting fuelwood makes the communities continue to collect fuelwood despite a large effort. The value of collected fuelwood can also be valued at the indirect opportunity costs of the effort. An estimate based on the market prices for fuelwood is a net value of ₦50/m^3.

Chewing sticks are sold in bundles of 20 sticks for ₦10-15 per bundle. The value added is a large proportion of the product value. The market price for a log for chewing sticks is about ₦500 in Ghana (Falconer, 1992). This price includes large transport costs and the fact that the species used for chewing sticks are being over-exploited in Ghana. The net price in Nigeria is assumed to be ₦100/log, and since there are about 20 logs for one m^3 the net price is ₦2,000/m^3.

The only data on the value of a **bamboo** pole is a net price of ₦2.5 in 1992. With a small adjustment for changing price levels the net price is set at ₦5 per pole.

Table 7: An Estimate of the Annual Value of Wood Products in Delta State

Product	Harvest	Price	Value
Sawlogs	46,000 m^3	700 ₦	32.2 mio. ₦
Building poles	50,000 m^3	200 N	10.0 mio. ₦
Transmission poles	20.000 m^3	1,000 ₦	20.0 mio. ₦
Fuelwood	1.7 mio. m^3	50 ₦	85.0 mio. ₦
Chewing sticks	8,250 m^3	2,000 ₦	6.5 mio. ₦
Bamboo poles	1.2 mio. poles	5 ₦	6.0 mio. N
Total annual value (Delta state)			169.7 mio. ₦
Total annual value in Niger delta[6]			500.0 mio. ₦
Value of annual direct production per ha (excluding mangroves)			400 ₦/ha

Note: Quantities are as reported for 1992 in the Delta State (TFAP report)
Source: Adapted from Linddal, 1995.

[6] One third of the Niger delta is assumed to be in Delta State.

Value added to the products comes from: (i) splitting the fuelwood into smaller bundles, (ii) converting logs into sawn wood, (iii) producing the chewing sticks from logs, or (iv) substituting other building materials with poles, bamboo and raffia roofing. The forest production is a source of input to several economic sectors. Shortage of forests products can have severe economic impacts in traditional economies or when processing sectors lack a raw material and consumers must use more expensive substitutes, e.g., imported goods.

Box 1
Sustainable Mangrove Management in Malaysia

An example of a successfully managed mangrove forest is found in Malaysia (Vanclay, personal communication, 1995). The mangrove is managed in plots of 5-10 ha in a 25 year rotation. The products are not merely firewood; poles and building materials are also produced from thinnings. At the end of the rotation, with a tree height of about 20 m the plot is clearfelled, and the final crop is converted to a high-quality charcoal. The bark is stripped on site and used as tannin for dyeing fishing nets. The stems are burnt in permanent kilns to produce high quality charcoal that is exported to Japan for medicinal purposes. Similar charcoal produced in the Niger delta could have various industrial uses in Nigeria or in export markets. Carbon from good quality charcoal is, for example, used for purifying polluted ground water in urban areas in developed countries. The mangroves are managed in a mosaic pattern, and the forest is left in 10 meter wide bands along rivers and creeks in order to minimize the environmental impacts. Regrowth is natural and an inventory controls whether the regrowth is sufficient. If not, additional seeds are captured in the river with nets and sown in the plot. There are few problems with weeds. A fern is the main problem and the plot occasionally has to be sprayed with herbicides. The mangrove forest is probably the best managed forest in Malaysia with some of the plots now in their third rotation.

Linddal, 1995.

The Value of Non-Timber Forest Products (NTFPs)[7]

The traditional uses of the forest for gathering of a variety of products other than wood are, together with fishing activities and small-scale farming, essential activities for the inhabitants of the delta (Table 8). NTFPs are derived from animal and plant sources, and support many activities of the communities and other economic sectors in Nigeria. The uses of the forest resources are so diversified that no precise assessment is possible.[8] NTFPs from fauna are: bush meat, skins and trophies, medicinal parts, snails (periwinkles), fish, and live animals. The major plant NTFPs are: fruits, leaves, medicinal barks, spices, roots etc, which are used for food, medicinal purpose, building/construction, traditional/cultural uses or arts/crafts. The people use NTFPs: (i) as a food supplement, (ii) for traditional medicine, (iii) for a variety of other purposes in the household, (iv) for building materials, (v) as material for fishing

[7] Linddal, 1995.

[8] Two recent studies have been used to some extent as background papers for this section on NTFP. The best Southern Ghana: Falconer, J., 1994: *Non-timber forest products in Sourthern Ghana*. Main report, 244 pp.

equipment, (vi) as road and path surfacing with shells from periwinkles, oysters, and palm fruits, and (vii) as a source of income.

Table 8: Some NTFPs (Mainly Edible) Commonly Gathered in the Niger Delta

Raffia palm:

Used for palm oil and gin production. Gin costs ₦40/bottle in Port Harcourt and ₦30/bottle in local markets. Raffia leaves are used for roofing (large bundles of raffia for matting are sold for ₦10-20).

Ogbono (bush mango) (*Irvingia gabonensis*):

The seeds are used for cooking (like okra). Seeds are sold for ₦200/kg in local markets. In Yenegoa the price of one cup (less than 100 gr.) was ₦20. A rice bag of ogbono (50 kg) in Yenegoa was bargained from ₦6,500 to ₦5,000, i.e., ₦100/kg. The price in Asaba is ₦20 per cup but the market is small, because ogbono is traditionally not eaten in this area. The price in Lagos is ₦600/kg. Ogbono is sold (grounded) in Europe.

Giant snails:

In Yenegoa 5 snails (small) are sold for ₦20. In Port Harcourt the price for five is ₦35 and one for ₦10. In Asaba snails are sold for in bundles of five for ₦20. In Lagos one snail is sold for ₦20. The price of the snails varies according to size of the snail and location of the market.

Spices:

Various types are sold for ₦150/100 gr. at the market in Yenegoa. Cola nuts are exported to other states. Leaves are collected for wrapping materials such as cola nuts and other products transported to other locations.

Mangrove salt:

Mangrove salt is produced from mangrove wood in the coastal regions. It is a specialized activity confined to a small number of communities. For example, in the Apoi area half the community is engaged in this activity. The mangrove salt is supposed to have medicinal functions.

The gathering of several NTFPs, in particular those which are edible, is seasonal. The exploitation depends on the life cycle of the particular products, on accessibility (e.g., restricted or improved by flooding), and on effort expended for other seasonal activities. Other products such as building materials can be collected all year round. The gathering of

NTFPs is a harvest of renewable resources. Some NTFPs are not destroying the productive resource directly (e.g., ogbono are collected seeds) while others are (e.g., chewing sticks or snails). However, there are no known cases of these resources being exploited beyond a sustainable level.

An economic valuation of NTFPs without any prior inventory of production levels or the consumption pattern must be taken with caution. The economic assessment can be estimated on the basis of assumed potential yields per area converted into an economic figure. Another approach is to estimate the collection per family and convert it into value per area. The latter gives a lower bound of the potential value because the NTFPs are not collected equally intensively over the whole delta. There is a difference between the actual and potential value. An assessment of the *actual* value of NTFPs, requires an assessment of the harvest level. This harvest can be above the production level of the reproducible resource, but is likely to be less when exploited by traditional uses. The **potential** value is estimated on the basis of a sustainable harvest level, and this is the value that is lost if an area is converted.

The revealed market prices can be used as a proxy for the value for those main NTFPs that are collected for sale. There are, however, many other NTFPs that are collected only for domestic use and thus not subject to trade. Another and more precise valuation would be based on the cost of a close substitute, i.e., if the NTFPs were not available, the community will purchase other commodities instead with an incremental cost in terms of money and effort (i.e., the cost of an indirect substitute). For medical plants the benefits are relief, but also the saved costs of modern medical treatment and transport to a medical centre (in some situations modern medical treatment has no substitute). A third approach is simply to value the NTFPs according to the shadow value of the effort put into collecting them, i.e., if the community used less time collecting a particular NTFP, what is the value from an alternative activity (i.e., an indirect opportunity cost). It is assumed that the costs of collecting the NTFPs are relatively low. The effort (time) used to collect NTFPs has decreasing marginal returns due to the spatial distribution, i.e., a community collects the nearest NTFPs first.

The value a family (10 members on average) can obtain from gathering NTFPs for domestic use is estimated on the assumed consumption and the value of the product based on either a market price or the assumed cost of substitutes (Table 9).

Table 9: Estimated Collection and Value of Some NTFPS for a Family (10 Persons)

Product:	Annual value:
Directly:	
Ogbono	
estimated 100 kg * ₦10	1,000 ₦
Giant snails (or periwinkles in mangroves)	
estimated 1,000 * ₦3 per piece	3,000 ₦
Bush meat:	
estimated consumption: 30 kg * ₦100/kg[9]	3,000 ₦
Raffia, cane, fibers, leaves:	
estimated for fishing material, food wrapping, etc.	3,000 ₦
Spices, nuts, fruits etc.:	
100 kg * ₦50	5,000 ₦
Indirectly:	
Other products for the household:	
Saved costs for substitutes	5,000 ₦
Medical plants:	
Relief, savings medical care and transportation	10,000 ₦
Total for a family of 10 members	**30,000 ₦**

It is assumed that the population density is at least 1 to 1.5 persons/ha in the delta, i.e., when a family of 10 members can earn ₦30,000 a year from NTFPs, it implies that the forest has a minimum average value from the actual use of NTFPs of ₦2,000 per ha/year. This is presumed to be a lower bound because: (i) the potential value of the forest when all available resources are harvested up to the sustainable level would probably be larger,[10] (ii) it is an average value while the use is concentrated around villages, and (iii) other uses of NTFPs may exist. The diversity of the ecosystems in the delta and their diverse uses imply that the crude assessment of ₦2,000/ha does not hold for the mangroves, but mainly is an estimate for the more dense population in the freshwater swamp forest.

A survey [11] of studies on extractive value from tropical forests or other products than timber (i.e., NTFPs) reveals that the value of NTFPs ranks from US$5 to US$422 per ha annually

[9] A study from Ghana reports an average value of ₦130/kg (5 cedis to ₦1) for bush meat. The average value for a grass cutter is 2,000 cedis (₦400) in Ghana (Falconer, 1994, op.cit.). A similar price level was observed in Asaba (Delta State) for an informal sale.

[10] Assuming that only half of the area is used intensively for collection of NTFP, the potential average value could be ₦4,000/ha.

[11] Lampetti, J.A. & J.A. Dixon, 1994: A guide to non-timber forest benefits. Environment department, The World Bank, Washington, D.C. [draft].

with a majority of the estimated values clustered around US$70 per ha/year (Lampetti and Dixon, 1994). The value estimated in this study is around US$30-90 per ha/year.

ANNEX E
PLANTATIONS AND LARGE SCALE AGRICULTURAL DEVELOPMENT

Risonpalm is one of the largest developers in Rivers State. It has converted over 20,500 ha of forest and small holder farmland into oil palm monocultures. If its full project portfolio is completed, 38,000 ha, or over 2 percent of the state will be planted in oil palms. Delta State has a similar oil palm plantation program covering 7,000 ha, with plans for another 20,000 ha, but no information is available on it (Ministry of Agriculture, Delta State, 1994b, 1994). The environmental impact is expected to be nearly identical to the effects of Risonpalm because of the similar ecosystems. If completed as envisioned, which is now unlikely, Risonpalm's activities are expected to permanently alter 78,000 ha either by directly clearing land or by changing the hydrological regime (Guardian, 1994e, 3). Major plantations are distributed in four locations in the state: Yenagoa, Elele, Ubima, and Bori (Table 10).

The primary environmental impact of the projects is the destruction of large areas of forest and swidden agriculture. Although project locations are mostly secondary and bush-fallow forests, project managers do not discriminate between forest quality and have slated other primary forests for development. Environmental assessments are not conducted.

The current focus for Risonpalm is the development of the lowland Yenagoa plantation. The original proposal called for clearing the fully gazetted Upper Orashi Forest Reserve (9,696 ha) which is one of the most biologically important sites in the delta (see biodiversity section). It would also have disturbed water flow into the Lower Orashi Forest Reserve, located downstream of the project. Managers scaled down the project after community protests caused the European Union to cut back funding. Outside of the reserve, timber species and valuable tree crops, such as natural oil palms, mangoes, and ogbono, which are harvested by farmers, are being cleared by the project. To dry the plantation site, the parastatal has completed 90 percent of a 24 km dyke (originally proposed to be 80 km long) and numerous drainage canals. Farmers are complaining that the plantation canals flood fields adjacent to the project (Powell, 91). Downstream users will also be affected; the dykes will block sediments to downstream areas forcing farmers to purchase fertilizers to keep yields constant. Fisheries may also be disturbed.

The company has not been able to afford the inputs necessary to attain yields anticipated in feasibility studies. Use of NPK fertilizer has decreased and the company is not able to purchase magnesium sulfate fertilizer which is required at Ubima and Elele. Similarly, managers apply less pesticides because of the high cost. Currently, they only spray for weed control and during outbreaks of foliage eating insects, which occur on 4-5 year cycles. Given the frequent flooding and high groundwater table, if fertilizer and pesticide use increases, migration into drinking water and other water sources will be extensive. By inducing Risonpalm to limit applications of pesticides, the high cost of inputs reduces their

environmental impact, which include water contamination and eutrophication for fertilizers and health impacts on non-target organisms, including humans. Nonetheless, workers on the Yenagoa plantation held a strike in 1993 because of the large amounts of pesticides they were required to apply (Ashton-Jones and Douglas, 1994, 176). Local communities have also reported that pesticide applications at the oil palm nursery have caused large fish kills (Powell, 91). Risonpalm officials confirmed that pesticides are intensively applied at the nurseries.

Table 10: Risonpalm Plantations

Location	Proposed Area (ha)	Current Area (ha)	Smallholder Area (ha)
Yenagoa	9,000	1,500	2,000
Elele	6,500	6,500	0
Ubima[3]	15,000	15,000	0
Bori	6,000	unknown	unknown
TOTAL	**36,500**	**23,000+**	**2,000**

Source: Risonpalm, 1994; Guardian, 13 March 1994;

Economic Analysis Of Oil Palm Plantations.[4] Data on a typical stand of oil palm plantation is used to assess the economic value of land with oil palms. Figure 1 shows the annual production (harvest) of palm fruits (tons of ffb, fresh fruit bunch) from one ha of a Tenera hybrid (*Pisifera x Dura*). The rotation is 30 years and the average annual production over the rotation is 10.5 tons of ffb. This is the production level in the upland; lowland plantations can yield 30 percent more.[5]

The establishment costs are assumed to be ₦10,000/ha in the upland and ₦50,000/ha in the lowland.[6] The higher costs in the lowland are due to drainage, forest clearing and soil preparation. There are 140 palms planted per ha (spacing are 8 times 8 meters). 2 kg of fertilizer (NPK) are added per palm annually from the 5th year. The price of fertilizer is 500 N per 50 kg. At Bori there was on average 1 worker employed per 10 ha. The labor costs are about ₦3,000/ha annually. It is assumed the annual labor costs per worker, including administrative staff, etc., is ₦30,000/ha.

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[3] The World Bank assisted the development of the original estate of 10,000 ha with a $30 million loan between 1978 and 1985 (loan 1591-UNI) (Project Completion Report, 1988).

[4] Linddal, 1995.

[5] In Malaysia the potential yields from reclaimed mangrove soils can be as high as 55 tonnes of ffb/ha/yr compared with the production of 20 tonnes of ffb/ha/yr on upland soils (FAO, 1994, op.cit.).

[6] Risonpalm reported the cost of establishment and called the cost for lowland plantations alarming.

The palm fruits are pays commonly processed at the estate's mill and the economic transaction is internal. Based on the prices Risonpalm external suppliers to the mill, it is assumed that the value of palm fruits is ₦500-1,000 ton of ffb.

Using this information, the land value of the oil palm plantation is calculated as the present value in year zero of the future income from an oil plantation in perpetuity. The interest rate is 10 percent. The land value is the present value of the cash-flow of one rotation divided by an annuity (with periods of 30 years).[7]

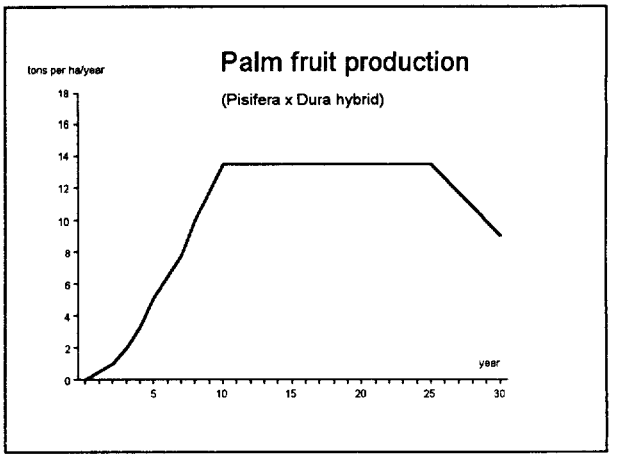

Figure 1: Example of the Annual Production of Palm Fruits in 30 Year Rotation

An upland plantation has, with the given assumption, a land value between -₦16,500 and ₦19,000/ha depending on whether the price is ₦500 or 1,000/ton of ffb. The break-even price for palm fruits (the land value is being zero) is ₦729/ton. For the lowland plantation with a higher establishment cost but 30 percent higher yield the land value is between ₦-47,600 and ₦-2,100/ha with a break-even price equal to ₦1,023/ton of ffb. The assessment of the land value reveals that an oil palm plantation is more profitable in the upland than in the lowland due to larger establishment costs. The difference is only comparable if the opportunity costs of land are equal or zero. Developers might argue that the **financial** value of land (the opportunity costs) is higher in the upland than in the lowland. The uplands are utilized for agricultural production while the lowlands are supposed to have no direct economic value at all. The no-value perception of the lowlands entails part of the ramifications ensuing the development of the Yenegoa estate. The lowlands has an opportunity value of cleared forest and socio-economic impacts even though these values are not couched in economic terms.

For a plantation of 10,000 ha the value of the land for the oil plantation is between ₦210 and ₦310 million higher in the uplands depending on the price of palm fruits and other assumptions. In order for a plantation to be more profitable in the lowland compared with the upland, the difference in the opportunity value of land in the upland must be between ₦21,000 and ₦31,000/ha higher than for the lowland. Apparently there is no clear economic justification for establishing oil palm plantations in the lowlands compared with the suitable locations in the uplands.

The production of wild palm fruit also has an economic value. It may produce 350 kg of ffb/year (Ashton-Jones and Douglas, 1994), although an **average** production of more than 50 kg of ffb/tree annually from wild palms is not likely. The production per tree in the plantation

[7] The method used is known from forest economics to assess the value of land for growing trees, and it is known as the *Faustman formula*. The annuity factor is $(1-e^{-r*30})^{-1}$, and r is the interest rate.

is about 100 kg of ffb/year when it is at the highest level. Assuming that an average of 50 kg of ffb/tree can be produced annually in the wild, there are 10 productive trees per hectare at any time,[8] and the palm fruit can be sold for a value of ₦500/ton of ffb collected. The annual value of wild palm production is thus ₦250/ha. The value of the land for palm production at 10 percent interest rate is thus ₦2,500/ha. If the price was ₦1,000/ton of ffb the value of the "wild" production would be ₦5,000/ha. These values are almost comparable with plantations, but the production in the plantations may be more uniform, more efficient and produce palm oil of higher quality.

One ton of palm fruit yields about 180 to 210 kg of palm oil. The value of a ton of palm fruit converted to palm oil is about ₦4,000/ton (the market price for palm oil is ₦20,000/ton). Residues from the production also have an economic value: palm kernel (livestock feeding), shells (road material or fuel agent) and palm ash (ingredient for soup). The stem of the oil palm in the plantation has no use but is normally burned on site after the rotation as fertilizer supply and to avoid the spread of diseases.

Lowland Plantations. The development of oil palm plantations in the lowland leads to more serious environmental and socio-economic problems as compared with the upland plantations. The location is preferable due to the fertility of the soil and the fact that water is not in deficit. Despite these advantages, the incremental costs of site preparation (e.g., drainage and flood control) make the economic advantage arguable.

Niger Delta Basin Development Authority Agricultural Projects. The Niger Delta Basin Development Authority (NDBDA) is the major large scale crop development agency in the delta, concentrating on irrigated rice projects. The Authority's plans for new irrigation projects appear to be on a much larger scale than its budget (Table 11). Although the Peremabri scheme has slowly been implemented, the other projects are at pilot or feasibility stages. In the past the agency ran the irrigated farms, but now restricts its involvement to developing the project and providing services to farmers. The Authority reports that it has recently begun conducting EIAs of its projects, but none have been completed. Unlike the Risonpalm plantations, no environmental evaluations by external organizations have been performed at the project sites. Potential impacts include:

- Cleared primary and secondary forests, including loss of biodiversity and valuable timber and tree crop species;
- Modification of hydrological regimes disturbing downstream ecosystems and users;
- Pollution from fertilizer and pesticide run-off;
- Schistosomiasis in rice-farming populations;

[8] An inventory of the swamp forest in Cross River state found an average number of 58 oil palms per hectare (Dunn et al., op.cit).

- Reduced fisheries productivity; and
- Higher risk of income volatility and crop failure because of monoculture cropping.

Table 11: Niger Delta Basin Development Authority Irrigation Projects

Location	Proposed Area (ha)	Area Cleared (ha)	Cultivated Area (ha)	Land Classification[9]
Peremabri (Rivers St.)	2,500	340	100	Primary Forest
Isampou (Rivers St.)	4,000	50	25	Primary Forest
Kolo (Rivers St.)	2,000	0	0	Primary Forest
Ewu (Delta St.)	100	50	30	Primary Forest
Koko (Delta St.)	2,000	24	0	Primary Forest
TOTAL	**10,600**	**464**	**155**	

Source: NDBDA, 1994.

[9] The land classification was provided by NDBDA officials.

ANNEX F
EXOTIC SPECIES

Nypa Palm. Nypa palm *(Nypa fruticans)* was introduced to Calabar in 1906 (Adegbehin and Nwaigbo, 1990, 15). It is common only in the mangroves of the eastern Delta. Compared with water hyacinth, nypa palm has expanded very slowly: spreading from Calabar to the Bonny area over the past eighty-five years.

Although almost no uses are made of the palm in Nigeria, it is widely utilized in Asia for sugar, vinegar, thatching, hats, beverages, and medicines (Hamilton, Dixon, and Miller, 1989, 262). In Southeast Asia, nypa leaves are extensively used as thatching material. A case study from Southeastern Bangladesh explains that permits to harvest nypa leaves are sold in open auctions. The purchasers divide the permits up and sell them by boat loads to actual collectors. The extraction of nypa leaves is now completely regulated by the forestry department through officers who issue the permits for collection and supervise the operation (Linddal, 1995, 36). As some of these uses become exploited in Nigeria, the species may be viewed as less of a scourge. For example, Delta communities have begun using it for thatching and for fishing poles. Another value of nypa palms is that they are effective for coastal and lagoon erosion control (Bamidele, 1994).

Researchers at NIOMR have determined that nypa palm out competes mangroves in the recolonization of exposed waterfronts and degraded sites (NIOMR, n.d., 3). The species will not expand into intact mangroves because it requires scarified mud to establish (Bamidele, 1994). Consequently, actions which directly degrade mangrove ecosystems, such as oil activities and extensive cutting near population centers, increase the spread of nypa palm. While some researchers believe that the species requires a high level of nutrients, it has established in remote areas away from the nutrient rich waters downstream of Port Harcourt (Bamidele, 1994). In addition to restricting mangrove regeneration, nypa palm does not provide a good nursery for marine fish. Fishermen state that in contrast to Rhizophora species, they do not find shell or fin fish near the nypa palm roots (Otobo, 1994). Thus, activities which degrade mangroves and allow Nypa palms to invade may be reducing marine fish stocks.

Water Hyacinth. Between its introduction in 1984 and 1991, water hyacinth *(Eichhornia crassipes)* expanded over 800km from Lagos to Akwa Ibom State (Epelle and Farri in Egborge, 1993b, 2). Remote sensing imagery from those years confirms the general absence of the plants in 1984 and their abundance in 1991 (Eedy, 1994). It is a serious problem in ten LGAs in Rivers State (Rivers SEPA, 1993, 12). Using a defensive expenditure approach, the World Bank report, *Towards the Development of an Environmental Action Plan for Nigeria,* estimated that water hyacinth control would cost US$50 million annually and that the species negatively effects about 5 million people (Western Africa Department, 1990, 39). Since the delta includes over half of the southern freshwater systems, it will incur the majority of these

costs. The major problem with water hyacinth is that as it encroaches on open water, rivers become very difficult to navigate. Fishing is further impeded because the plant becomes entangled in fishermen's nets. Other potential problems are the infestation of irrigated fields, fish ponds, and irrigation channels, as well as a breeding habitat for mosquitoes (Western Africa Department, 1990, 16). Concerns that the plant depletes oxygen levels and reduces fish populations in rivers have not been investigated. It is known that the species provides protection from human predation and a habitat for a large variety of organisms that commercial fish consume, including algae, nematodes, insect larvae, crabs, shrimps, and fish, which could lead to an increase in fish biomass (Egborge, 1993b, 6). Fishermen have also reported that fish tend to congregate near the hyacinth mats.

If current rates of expansion continue, the species can be expected to cover large portions of the freshwater streams and rivers in the delta within the next 3 to 5 years. Some streams and ponds in the western delta are already completely blanketed. The expansion of the species towards the coast is constrained by salinity, with the plant unable to survive salinity levels above 10 percent. It is most common in eutrophic conditions: high nitrate levels, warm (24-33°C), mostly acidic (pH 4-6.8) and not fully oxygenated waters (Egborge, 1993b, 3). Since it thrives in eutrophic waterbodies and can reduce BOD loadings, water hyacinth is used as a biological wastewater filter in the United States and India (NEST. 1991, 160). Of the two major exotics, nypa palm and water hyacinth, the latter is considered to be much more of a threat to local communities because of its rapid expansion rate and its impact on navigation and fishing activities.

Other Exotic Species. In the lowland rainforest ecozone, the exotic weed, siam weed (*Chromalaena odorata*) restricts the regeneration of trees and shrubs during fallow periods (Ashton-Jones and Douglas, 1994, 4). The marine fern (*Acrostichum aureum*) is reported to be degrading mangrove forests (Daniel- Kalio, 1994). Sea urchins are reported to have migrated up the Bonny River. The spines are injuring fishermen and destroying their nets (Powell, 1994). The Indo-pacific fish, *Butis koilomatodon*, has moved into the delta, but the impact is not known (Powell, 1993, 60).

ANNEX G
ASSESSMENT METHODOLOGIES

Industrial Pollution Assessment Methodology[11]

In cooperation with the FEPA Zonal Office and the Rivers State EPA, about 80 manufacturing industries were contacted for collection of primary data, such as: number of employees, consumption of raw materials, products manufactured, production capacity and more specific process related information. The 80 manufacturing industries contacted represent nearly all the major manufacturing activities in Port Harcourt. Most of them are located in the Trans Amadi Estate area.

The method is based on an estimation of waste generation from production figures and generally accepted coefficients for air emissions, water effluents and waste generation. Coefficients have been elaborated from a great number of studies on production methods and waste generation within different sectors of manufacturing industries. The outcome of all calculations is:

- air emissions expressed as load of particulates, nitrogen oxides (N-oxides) and non-methane volatile organic carbon (NM VOC);
- water effluents expressed as biochemical oxidation demand (BOD_5), suspended solids (SS), oil, nitrogen (N) and phosphorus (P); and
- waste generation expressed as putrescible waste, non-hazardous solid waste, hazardous solid waste, non-hazardous sludge and hazardous sludge.

Initially all information has been classified according to international standards[1] (ICIS-numbers). In Appendix 3, all categories of economic activities found in this study are listed with indication of categories where tools for estimation of effluents and emissions are available.

The method does not consider pollution outlets from accidents or emissions related to power generation. Power generation may be of quite different origin in enterprises working with the same category of production. This may be especially true for Nigeria, which has very unstable public power generation, forcing the private sector to generate much of its own power.

In Annex Tables A.16, A.17 and A.18 (pages 108, 111, and 114), respectively, data on air emissions, water effluents and waste generation for all identified industries in Port Harcourt are represented. When production figures were not available, the yearly production has been

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[11] Grevy, 1995.

estimated from number of employees or was defined in accordance with the output from an average industry within the respective category of industry.

The applied method also includes information about production processes which may differ considerably and have a considerable impact on pollution loads. In many cases it has been necessary to make a best estimate to provide the necessary information. The production is assumed to take place uncontrolled without any treatment or abatement precautions. An exception is NAFCON where some processes in fertiliser production are assumed to be controlled. For pollution from NAFCON it should be stressed that even if N-oxides from the production are not emitted, other nitrogen components, like NH_3 and HNO_3, will be emitted into the environment, but such components are not included in the following overall calculations. At the refinery a CO boiler is assumed to be present, eliminating NM VOC from air emissions. Other components such as heavy metals, phenols and many other hazardous components are not indicated in overall estimates. For many other industries, hazardous components are excluded from the present calculations. Generally, the method describes only discharges under normal conditions and do not consider pollution from accidents.

In Nigeria, using UNDP's Urban Management Programme criteria for industry size it has been estimated that the distribution between size categories can be described as shown below:

8 percent by numbers represent large enterprises with more than 50 employees;

40 percent by numbers represent small enterprises with less than 50 employees; and

52 percent by numbers represent very small enterprises with less than 10 employees.

In Trans Amadi Estate, at least 25 enterprises can be categorized as large enterprises with an average number of employees of around 230. Assuming a similar distribution of enterprises in Port Harcourt with respect to size categories a total number of enterprises can be calculated to around 310. This number is close to the number of enterprises found in FEPA files in the Zonal Office in Port Harcourt.

Assuming an average number of employees in small and very small enterprises of 20 persons, the relation between numbers of employees in large enterprises and enterprises with less than 50 percent of employees (92 percent of industries) can be expressed as 5,750/6,200 or 0.9. From this estimate NAFCON, the refinery and number of people occupied in oil company headquarters have been left out.

Production and the corresponding pollution is related to number of employees which is also the concept behind development of the Winvent waste generation model. For Port Harcourt this would mean that pollution loads presented in Tables X-X should be multiplied by 2 for most components, except for hazardous sludge amounts mainly produced within the refinery sector. Nevertheless, one of the questions to be raised on this issue is to what extent pollution loads from small enterprises can be distinguished from general household solid waste generation, septic effluents and use of solvents by consumers.

Vehicular Emissions Assessment Methodology[12]

Statistical information about traffic volumes in Nigeria was not available. For this report, it has been necessary to partly assess aspects of traffic volume in Nigeria, Rivers State and Port Harcourt from statistical data from other African countries,[13] which is not very appropriate on all topics, and the World Bank report, World Road Statistics: 1989-1993. More detailed information of impacts is mainly based on surveys in Lagos City (Ogunsola et al., 1994).

For an evaluation of traffic pollution in Nigeria, some information on traffic volume must be generated. The main figures concern population size, fuel consumption, consumption of fuel per kilometre and vehicles per 1,000 inhabitants. Other figures may be calculated indirectly, e.g., annual average distance driven by one car and the yearly traffic volume. For Nigeria only population size and yearly consumption of gasoline and diesel is available.

In Table 12, population size and fuel consumption for some African countries is shown in accordance with statistical data cited by International Road Federation (IRF).

Table 12: Fuel Consumption in Some African Countries

Country	Population million inhab.	Gasoline Consumed (1,000 tons)	Diesel Consumed (1,000 tons)
Nigeria, 1989	91.3	4,366[14]	2,383
Kenya	27.3	376.7	537.3
Madagascar, 1989	13.0	75.3	181.3
Togo, 1991	4.1	20.2	70.7
Zimbabwe, 1992	10.8	1.1	2.9
Ghana, 1989	16.7	92.2	61.0

Data for Nigeria has not been provided by IRF. Other data from African countries has been selected from different tables representing statistical data for about 20 African countries.

From Table 12, it is evident that there is only vague correlation between population size and fuel consumption even in neighbouring countries. It might indicate a different practice for reporting fuel consumption or even wrong estimates. With respect to diesel, it is indicated that only part of the consumption is related to transportation. As an average, for 20 African countries, about 50 percent of the diesel consumption can be referred to transportation with

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[12] Grevy, 1995.

[13] World Road Statistics 1989-1993. Edition 1994. International Road Federation (IRF). Washington D.C. 20024, 525 School Street, S.W.

[14] Nigeria. Issues and Options in the Energy Sector. A joint report with the World Bank Western Africa Department of Industry and Energy Division. July 1993.

cars. The remaining half of diesel consumption can in most countries mainly be accounted for in generators for production of electricity.

In Table 13, vehicles in use, traffic volume, number of cars per 1000 persons is cited to show the scatter of existing information from selected countries.

Table 13: Number of Cars, Traffic Volume and Number of Cars per 1,000 Inhabitants in Some African Countries

Country	Vehicles (number)	Traffic Work (million vehic. km)	Vehicles (per 1,000 persons)
Nigeria, 1990		Not available	Not available
Passenger cars	-		
Busses	64,000		
Lorries	-		
Kenya, 1989			11.9
Passenger cars	150,681	1,034	
Busses	12,340	245	
Lorries	114,876	3,586	
Madagascar, 1989			34.2[16]
Passenger cars	37,363	21,383[15]	
Busses	2,586	7,760	
Lorries	25,044	7,143	
Togo, 1991			1.48
Passenger cars	5,056	335,0	
Busses	31	-	
Lorries	197	-	
Zimbabwe, 1992			32.7
Passenger cars	310,412	6,620	
Busses	-[17]	-	
Lorries	30,182	1,200	
Ghana, 1989	Not available		Not available
Passenger cars		5,160	
Busses		-	
Lorries		-	

Statistical information from 18 Central African countries on number of cars per 1,000 inhabitants varies between 1.18 in Togo and 78 in Namibia with a simple average of about 20

[15] Not reliable.

[16] Calculated.

[17] Included in number of passenger cars.

four-wheeled vehicles per 1,000 inhabitants. The same average can be calculated from the table above showing the spread of information.

In Table 14, the annual average distance travelled by vehicles in some African states is presented.

Table 14: Annual Travelling Distances for Different Types of Vehicles in Some African States

Country	Average annual distance
Nigeria	Not available
Kenya 1989	
Passenger cars	6,860
Busses	19,891
Lorries	113,755
Madagascar, 1989	
Passenger cars	Not reliable
Busses	Not reliable
Lorries	Not reliable
Togo, 1991	
Passenger cars	Not reliable
Busses	Not reliable
Lorries	Not reliable
Zimbabwe, 1992	
Passenger cars	20,000
Busses	50,000
Lorries	40,000
Ghana, 1989	
Passenger cars	Not available
Busses	Not available
Lorries	Not available

There is no consistency between the statistical information presented in Table 5.3 and the same information which can be calculated from Table 5.2.

From statistical data on vehicular traffic in 18 African countries, it can be at least stated that:

- The average number of four-wheeled vehicles in central African countries is about 20 per 1,000 inhabitants.

- An average African private car drives less than both vans and lorries per year.

- All types of vehicles are driven considerably longer than European vehicles per year (about 15,000 km per year).

The following assumptions have been made concerning the assessment of traffic volume in Nigeria:

- The average number of vehicles per 1,000 inhabitants in Nigeria is above the average for other African states and is assumed to be 30 vehicles per 1,000 inhabitants.

- All private cars are assumed to use gasoline, and busses and lorries use only diesel.

- An average Nigerian car is assumed to run considerably more than an European car per year corresponding to 30,000 km/year.

- The distribution of traffic volume by private cars and busses and lorries respectively is mirrored in a yearly consumption of gasoline of 4.336 million tons and 2.383 million tons of diesel which equals 6.719 million tons or 9.132 million m^3 of fuel/year.

From these assumptions the following statements can be made:

- Number of cars in Nigeria is 2.76 million.

- The total traffic volume for Nigeria is 82,200 million cars*km.

- Fuel consumption for an average Nigerian car is 9.0 km/litre.

Fuel consumption of 9 km/litre refers to values generally being used elsewhere for traffic volume calculations for urban driving (WHO, 1982). For validation of data refer to Box A.5.

For assessment of traffic volumes in Rivers State and Port Harcourt, the following assumptions have been made:

- Cars travelling in Rivers State and Port Harcourt rely on the same assumptions as for the whole of Nigeria.

- The traffic volume for whole Nigeria, Rivers State and Port Harcourt correlates only with population figures.

- The traffic volume for gasoline and diesel powered vehicles depends on the relation between gasoline and diesel consumption.

- The population figure for Nigeria is 91.4 million. The population in Rivers State amounts to 4 million people and the number for Port Harcourt is 850,000.

From these assumptions, traffic volumes can be calculated as shown in Table 15.

Table 15: Estimated Traffic Volumes Separated into Areas and Types of Fuels

Area	Population (million)	Total Traffic Volume (1,000 km)	Specified Traffic Volumes (1,000 km)	
Nigeria	91.4	82.2 million	Gasoline	52.2 million
			Diesel	29.0 million
Rivers State	4.0	3.6 million	Gasoline	2.3 million
			Diesel	1.3 million
Port Harcourt	0.850	0.76 million	Gasoline	0.49 million
			Diesel	0.27 million

The figures for Port Harcourt do not take into account long distance driving out of Port Harcourt or varying distribution of cars in urban and rural districts.

Box 2
Validation and Crosschecking of Traffic Data

The most precise figure on traffic that should be validated is fuel consumption. Consumption of fuel by an average car should be in the range: 8-12 km/l of fuel.

Given
Population size of Nigeria: 91.4×10^6 inhabitants
Fuel consumption in Nigeria: 6.749×10^6 tons/year

Conversion of fuel consumption: Density of fuel, 0.739 tons/m^3
Fuel consumption: $(6.749 \times 10^6$ tons/year$)/(0.739$ tons/$m^3) = 9.132 \times 10^6$ m^3/year

Assumptions
Distance driven by an average car per year: 30.0×10^3 km/year
Number of cars in the population: 30 cars/10^3 inhabitants

Calculations
Number of cars in Nigeria: $(91{,}4 \times 10^6) \times (30/10^3) = 2.74 \times 10^6$ cars
Traffic volume: $(2.74 \times 10^6) \times (30 \times 10^3) = 82.2 \times 10^9$ cars*km

Validation
Fuel consumption per car per litre = $(82.2 \times 10^9)/(9.132 \times 10^9) = 9.0$ km/litre

Remarks
Fuel consumption for an average car of 9.0 km/litre is within the reliable range of 8-12 km/l and is generally applied elsewhere for describing urban driving (WHO, 1982).

ANNEX H
INDUSTRIAL SUBSECTOR POLLUTION INFORMATION

Information on Effluents from Major Industries[44]

Steel Works. Able to produce I million tons of steel annually, the government owned Delta Steel plant located near Warri is the largest steel plant in West Africa. However, capacity utilization did not exceed 20% between 1986 and 1991 (Western Africa Department, 1994d, 62). Wastewater from steel facilities tends to be high in suspended solids, metals, acids, oil and greases, and dissolved iron. Coke operations can produce over 50 organic and inorganic wastewater pollutants depending on the specific characteristics of the plant. Many of these chemicals, such as cyanide, thiocyanate, ammonia, sulfides, and chlorides, can be present in toxic concentrations. Pollutants in wastewater from steel plating operations include metals and anions, such as phosphates, chlorides, and metal complexing agents. Depending on the gas cleaning system installed for the blast furnace, wastewater parameter values change. The parameters of concern are fluorides, suspended solids, ammonia, sulfides, arsenic compounds, and pH (World Bank, 1988, 152). Waste metallic compounds from the smelting process can also be dispersed into nearby water bodies (Ndiokwere and Ezihe, 1990, 292). The final cleaning processes before shipping the steel can add significant quantities of acid, alkaline, and solvent liquid wastes to waterbodies (World Bank, 1991, 136). Iron and steel producers in Nigeria, including the Delta Steel facility, have difficulty complying with effluent limits for suspended solids, phenols, ammonia, and cyanide. Heavy metal and organic pollutants also contaminate receiving water bodies.

Metal Fabrication and Finishing. According to available information, fourteen metal fabricating plants, but no foundries operate in Rivers State (Table A.14). Missions assessed waste loads at the nine facilities in Port Harcourt which fabricate steel and aluminum products. Several enterprises employ well over one hundred workers. No information on metallurgy facilities in Delta State has been found. The metal working and finishing industries dispose of potentially harmful levels of cyanide, metals, oils, caustic soda, and acids. Table 16 is provided to give a sense of the wide variety and concentration ranges for pollutants in the plating and electroplating industry. It is expected that sludges and liquid wastes are disposed untreated as is the case in other developing countries (Benavides, 1992, 15).

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[44] See Table A.24 for production data and Tables A.36-37 for pollution data for specific facilities in Port Harcourt.

Table 16: Effluent Ranges for Plating and Electroplating Industries
(mg/l)

Pollutant Parameter	Subpart			
	Common Metals Plating	Electrolyses Plating	Anodizing	Coatings
Copper	0.032-272.5	0.002-47.90		
Nickel	0.019-2,954	0.028-46.80		
Chromium, Total	0.088-525.9		0.268-79.20	0.190-79.20
Chron-tium Hexavalent	0.005-334.5		0.005-5.000	0.005-5.000
Zinc	0.112-252.0			0.138-200.0
Cyanide Amenable	0.003-130.0	0.005-1.00	0.004-67.56	0.004-67.56
Fluoride	0.022-141.7	0.110-18.00		
Cadmium	0.007-21.60			
Lead	0.663-25.39			
Iron	0.410-1,482			0.410-168.0
Tin	0.060-103.4			0.102-6,569
Phosphorus	0.020-144.0	0.030-109.0	0.176-33.00	0.060-53-30
Total Suspended Solids	1-9970	.1-39.00	36.1-924.0	19.1-5275

Source: World Bank, 1988.

Synthetic Fibers and Plastics. Although the national industrial pollution study did not determine the synthetic fibers and plastics subsector to be one of the most critical sources of pollution in Nigeria, it is an important industry in the region with 14 plants in Port Harcourt. Only one has more than 100 employees. A newly established plant, run by Polo Packaging, with a yearly production capacity around 120,000 tons of polypropylene bags and packaging material, is also assumed to have several hundred of employees. It is not known to what extent enterprises are actually modifying or only fabricating plastic products from imported raw materials. At least for polypropylene products, some production, or modification, of raw materials is expected to occur. If no modification of synthetic fibres or plastic raw materials occur, then the pollution load within this category of industries is overestimated, but for most enterprises manufacturing of polypropylene has been anticipated which generally is not especially polluting. It is uncertain what role the Eleme petrochemical plant will have concerning production of synthetic fibres and plastics.

Generally, enterprises working with synthetic materials have a very bad reputation in Port Harcourt. The major pollutants from the production of synthetic materials are air emissions of VOC and water effluents with high concentrations of BOD_5 and suspended solids. Depending on the product, a number of organic chemicals, including acids and pigments may be

discharged. Trash from production is reported to be burned in open pits at some of the enterprises.

Oil Service Industry. Seven oil service companies are included in the Port Harcourt Assessment (Tables A.16-18). Oil service companies are probably very common in Port Harcourt, but their pollution levels are not known. Generally their activities are performed in the delta, but storage of fuel, cement, and drilling fluids are probably mixed and to some extent produced in Port Harcourt. Equipment maintenance and cleaning is also performed in Port Harcourt.

Oil Industry and Oil Companies. Only few oil companies were included in the Port Harcourt industrial pollution assessment (Table A.14), but it is known that all the major oil companies have their Rivers State headquarters in Port Harcourt, including NNPC. The Shell Petroleum Development Company (East) employs around 7,000 people in Port Harcourt. Most of the pollution from oil companies in Port Harcourt is a consequence of high concentrations of employees and is included as part of the total septic loads from densely populated urban area.

Food Processing. Port Harcourt has 12 food processing plants. The facilities tend to be relatively large, with two employing 400 workers. Although this group of industries is very diverse, all dispose of large amounts of organic wastes which cause oxygen depletion, turbidity (suspended solids), and sometimes also abnormal pH. The vegetable oil industries discharge kernels and cotton seed cake, and sugar wastes. Mills must dispose of grain bran, husks, and chips. Similarly, cassava, yam, and plantain processing generates large quantities of solid waste.

While the environmental impact of food processing wastes in the Niger Delta has not been studied, reports on similar facilities in other parts of the country show a consistent pattern of discharges greatly above the FEPA limits. BOD_5 and temperature levels are often extremely high. Similarly, dissolved oxygen commonly drops to zero near outfalls (Ogedengbe, Fapohunda, and Gotau, 1984, 58-60). In addition to high organic loading, one study found diluted food processing effluent with chlorine levels in excess of 5000 mg/l; the national standard is 1 mg/l (Olawuni in Industrial Control Unit, 1986, 195-6).

The palm oil industry which operates in both states is a major contributor to air and water pollution in the region. Risonpalm operates the largest mills in the delta at Ubima and Elele. Communities manage small mills along the major distributaries of the Niger and dump their wastes directly into the water. Palm oil effluent is comprised almost entirely of biodegradable organic matter so the critical effluent measurements are pH, BOD_5, COD, and suspended solids. Averages and ranges for palm oil mill wastes internationally are presented in Table A.17. The values are far in excess of most Nigerian effluent standards for the food processing industry and illustrate the water contamination potential of this common industry.

Table 17: Typical Palm Oil Mill Waste Effluent

Parameter	Average	Range	FEPA Guideline
pH	3.7	3.5-4.5	6
BOD_5 - mg/l	25,000	20,000-35,000	15
COD - mg/l	45,000	30,000-60,000	
NH_3N- mg/ 1	30	20--60	
Org.N - mg/l	600	500-800	
$N0_3$ -mg/l	30	20-60	20
Tot. Sol. - mg/l	35,000	30,000-40,000	
Susp. sol. - mg/l	25,000	20,000-30,000	
Ash. - mg/l	4,500	4,000-5,000	
Oil/Grease - mg/l	7,000	5,000-10,000	15
Starch - mg/l	2,000	-	
Protein - mg/l	3,000	-	
Tot. Sugar - mg/l	1,000	-	
Flow - kg/kg FFB	0.6	-	
Empty Bunches - kg per kg FFB Processed	0.25	-	

Source: World Bank, 1988.

Textiles. Although textiles are Nigeria's second largest industry, only three textile plants are known to operate in the two states. The largest of the mills is located outside of the delta in Asaba; it employs around 900 workers and produces 50,000 m of cloth per year from 175 tons of cotton per month. Fiber residues make textile wastewater high in BOD and suspended solids. It also contains a wide variety of chemicals including dyes, surfactants, oxidizing and bleaching agents, reducing agents, silicates, and inorganic salts (Ibidapo in Industrial Control Unit, 1986, 140). Effluent from textile factories often contaminate water with oils, greases, and waxes (Akintunde in Industrial Control Unit, 1986, 90). The dyeing process is the most hazardous, contributing chromium, lead, zinc, and copper to wastewater (Benavides, 1992, 9). In general, the industry has done little to treat its wastewater and contributes heavily to aquatic pollution. The Asaba facility uses 2 million liters of water per day (including water pumped to near by communities) and discharges 1.7 million liters of wastewater. The alkaline wastewater contains at least caustic soda (4 tons/month released), dyes, and suspended solids (Datta, personal communication, 1994). At facilities in other parts of Nigeria that have been assessed for waste generation, effluent standards (including BOD^5, COD, color, pH, and alkalinity) are greatly exceeded (FEPA, 1991, 88; Osibanjo in Industrial Control Unit, 1986, 277). A study on industrial pollution of the Kaduna River found that four of the seven largest polluters were textile facilities (Osuide, 6, 1990). However, this situation may gradually be changing as firms begin to comply with environmental regulations. For example, the General Cotton Mill facility in Onitsha, just upstream from the delta, which employs 1,500 workers, currently discharges 250,000 l/day of untreated effluent into a settling pond which overflows into the Niger River. However, it is developing treatment options to comply with International Bank for Reconstruction and Development (IBRD) guidelines as part of an approved International Finance Corporation (IFC) loan (IFC Project Summary, 1992, 3).

Petroleum Refineries and Petrochemical Facilities. Three of the four Nigerian refineries are located in the Niger Delta at Warri and Port Harcourt (two). The newest Port Harcourt refinery was commissioned in 1989 and is capable of producing 150,000 bpd. The older Port Harcourt refinery has been shut down for repairs since 1989 (ESMAP, 23). Except for the new Port Harcourt refinery, which is operated by a foreign company, Nigerian refineries are very inefficient compared with their developed country counterparts. For example, the operating costs for the Warri refinery were US$22 per ton while a typical Western European refinery would cost US$13 per ton to operate. The high energy consumption of the Nigerian plants causes most of the inefficiency: the Warri refinery uses up 11% of crude throughput just to operate (West African Department, 1989, 17). Marginal pollution output would decline dramatically if the refineries were simply more efficient. However, since they do not pay the full price of their oil inputs or have to maximize profits, they have little incentive to stop wasting energy.

The government also operates a petrochemical plant in conjunction with the Warri refinery, which produces linear alkyl benzene, solvents, carbon black, and polypropylene. Production began in 1987, but capacity utilization has been kept very low by a shortage of inputs from the refineries (Economist Intelligence Unit, 1993, 30). A gas-based petrochemical plant at Elelle was expected to open in early 1995.

The new oil refinery near Port Harcourt has its waste water outlet into Okrika Creek. The refinery consists of 2 separated production lines. One line, or refinery, is a very simple hydro skimming plant, which has been out of production for a long period and may never return to operation. The other refinery is a high cracking facility. The production capacity of the later is around 120,000 barrels/day. Table 18 lists median effluent characteristics for different refining operations. The major pollutants emitted from refineries are oil and grease, ammonia, sulfides, organic acids, chromium, and other metals. Spills of raw materials or leaks during processing can cause serious surface water, soil, and groundwater contamination (World Bank, 1991, 157). From descriptions of operating conditions at the Nigerian refineries, it is probable that they greatly exceed the international averages. From a trip to Okrika River it could be seen that the treatment facilities at the new Port Harcourt refinery are not satisfactory. Lumps from oil spillage can be directly observed and oil films cover the water surface (Grevy, 1995). Concentrations of dissolved petroleum hydrocarbons have been found to be elevated near refineries in the region (10 - 50 mg/l), which supports the inference that little or no wastewater treatment is performed (Ibiebele, 1986).

Table 18: Median Waste Flows and Loadings for Petroleum Refinery Operations Following Oil/Water Separation[a]
(Net kg per 1,000 m3 of feedstock[b c])

Parameter	Process Category				
	Topping	Cracking	Petrochemical	Lube	Integrated
BOD_5	3.4	73	172	217	197
COD	37	217	463	543	329
TOC	8.0	41	149	109	139
TSS	12	18	49	72	58
O/G	8.3	31	53	120	75
Phenols	0.03	4.0	7.7	8.3	3.8
NH_3 - *N*	1.2	28	34	24	20
Sulfides	0.05	0.94	0.86	0.01	2.0
Total Cr	0.01	0.25	0.23	0.05	0.49
Cr+6	0.00	0.15	0.13	0.02	0.30
Flowc	7	93	109	117	235

[a]From EPA Doc. 440/1-74-014a.
[b]Feedstock-Crude oil and/or natural gas liquids throughput.
[c]Except flow, which is m^3 per 1,000 m^3 of feedstock.
Source: World Bank, 1998.

Paint. Three medium- to large-scale paint manufacturing facilities are known to operate in Rivers State (Table A.14). Paint wastes include a high proportion of hazardous wastes, such as pigments, metals, resins, solvents, and additives in wastewater and sludges (Ibidapo in Industrial Control Unit, 1986, 136). No pollution data specific to the Nigerian paint industry has been located.

Breweries. Only one brewery is reported to operate in the delta region (Pabod Breweries). It generates 150,000 m3/day of wastewater, high in organic wastes like sugar, yeast, and beer and malt residue. More hazardous chemicals in the effluent are caustic soda, hypochlorites, and peroxides (Agunbiade, 1989, 18). Although the environmental impact of the Niger Delta brewery has not been assessed, four other Nigerian breweries have been found to dump untreated wastewater in the nearest water body and consistently exceed BOD_5 and chemical oxygen demand (COD) standards (Akintunde in Industrial Control Unit, 1986, 89; FEPA, 1991, 85).

Fertilizer. The National Fertilizer Company of Nigeria (NAFCON) facility, located in Onne near Port Harcourt, is one of only two fertilizer plants in the country. It produces urea, ammonia, and compound fertilizers, like NPK. Output averages just over a million tons annually and the number of employees is around 2,500 (NAFCON, 1990, 7). NAFCON is one of the few parastatals that is operating at a high capacity utilization rate (96% in 1991) (Western Africa Department, 1994d, 62). Effluent treatment systems are reported to function only intermittently (Isoun, 1994). Consequently, the fertilizer plant pollutes the Okrika River

with nitrogen compounds It is uncertain, however, if effects in the river are caused by eutrophication as a consequence of fertilizer enrichment or pH induced reactions related to acids or ammonia spills with waste water. The limited ability of the river to flush amplifies the pollution damage (Isoun, 1994). Nutrients, such as nitrogen compounds, are not toxic in quantities that can be assimilated by the receiving waterbody, but when thresholds are exceeded, they cause acute oxygen depletion and fish kills. This scenario occurs frequently in the Okrika River and is believed to be related to NAFCON's nitrogen compound releases. In 1988, an accidental discharge from the plant caused a massive fish kill that damaged the local artisanal fishing industry (FEPA, 1991, 71). Seven major spills of what was reported as urea in 1992 also killed large numbers of fish in the immediate area surrounding the outlet. The number of major spills dropped to two in 1993 (Rivers SEPA, 1994, 17).

Upstream and Neighboring Industries. The Asaba-Onitsha-Enugu axis, just north of the delta has a relatively high concentration of industry. One study of industries in that area, focusing on Anambra State, reported wastewater effluent levels that greatly exceed Federal Environmental Protection Agency (FEPA) guidelines (Nwokedi, Obodo, and Nwankwo, 1992). However, since the researchers did not analyze downstream water quality, whether the industries degrade water quality in the Niger River and Delta is not known. The only parameter measured downstream at Onitsha, pH, was found to be neutral to slightly acidic throughout the year. For over a decade, the government has been constructing a steel plant at Ajaokuta in Kogi State. If it is ever completed, the facility will produce twice the output of the Delta Steel plant and will generate considerable pollution, some of which will flow downstream into the delta. Vincent Standard Steel, one of only two electroplating and galvanizing companies in Nigeria, is located in Onitsha and contributes to water pollution in the delta (IFC Project Summary: Vincent Standard Steel, 1991).

In conjunction with German contractors, the government of Nigeria is constructing an aluminum smelter in Akwa Ibom, just across the Imo River from Rivers State. The major environmental and health concern of aluminum production is the release of aluminum, copper, and fluoride compounds into the environment. If adequate air and water pollution management is not practiced, vegetation damage, health impacts, and fish stock reductions can be expected.

Information on Air Emissions from Major Industries

Localized air pollution problems of particular concern are particulates (e.g., cement kiln dust), nitrogen compounds (especially from the fertilizer plant), multiple pollutants from the NNPC refineries, and emissions from steel production. In addition to industry specific pollution, industrial furnaces, boilers, and thousands of private electrical generators contribute to air pollution (Adegbulugbe and Dayo, 17). This section discusses the major air polluting industries.

Steel Works. Particulate matter and sulfur dioxide levels are the steel industry's principal air emission problems, but a wide variety of additional pollutants are also generated (FEPA, 1991, 37). Other air pollutants of concern are fumes, benzene, toluene, xylene, naphthalene,

ammonia and alkaline oxide emissions from blast furnaces and byproduct coke oven operations (World Bank, 1988, 129; World Bank, 1991, 135). Steel rolling and finishing processes generate sulfur gases, and iron oxide, acidic, salt flux, and solvent fumes (World Bank, 1988, 149).While the specific furnace type used in Nigerian steel making is not known, the most common is the basic oxygen furnace. Principal waste outputs are eat, slag, CO, CO_2, and iron oxide particulates (World Bank, 1988, 164).

Air emissions from the Delta Steel facility deposit metals in downwind areas. Soil levels of cadmium, chromium, and lead 250m from the pellet plant were all about 7.5 times background levels. Nickel concentrations were measured as 140 ppm; over 30 times background levels. The mean metal concentrations of nearby cultivated crops were also found to be elevated. Epidemiological studies on the surrounding communities would have to be conducted to determine the health effects from exposure to metals from the facility. Air emissions, including metals from the delta plant, may represent a case where air pollution imposes a significant health risk on local communities (Ndiokwere and Ezihe, I 990).

Petroleum Refineries and Petrochemical Facilities. Air emissions are the most significant causes of environmental degradation from refineries. The major air pollutants emitted by refineries and petrochemical facilities are sulfur oxides, nitrogen oxides, particulates, carbon monoxide, and hydrocarbons. A study of metal concentrations near the Warri refinery found elevated level in both soils and plants. Concentrations ranged from 3 times background for chromium (44 ppm), 4 times for lead (20 ppm), 4 times for zinc (119 ppm), 6 times for copper (43 ppm), to 7 times for nickel (7 ppm) and cadmium (44 ppm). Plant levels were similarly elevated. The combination of metals and other air pollutants from the refinery complex may mean air pollution, as well as wastewater, is impacting human and ecosystem health (Ndiokwere and Ezihe, 1990).

Cement. One cement facility operates Warri and a cement packaging plant is located in Port Harcourt. Water pollution is not a major concern from cement plants, but they do create tremendous amounts of dust. In developed countries, well established control equipment is used to keep emissions to acceptable levels. It is not known how many Nigerian cement factories operate such equipment. However, the Bendel Cement Company in Delta State has been cited as emitting very high particulate levels (NEST, 1991, 126). The Rivers State cement packaging plant (Eagle Cement Factory) is located in a moderately populated area of Port Harcourt and may increase respiratory problems in neighboring communities.

In addition to very high particulate emissions, CO, SOx, NOx, and smaller quantities of hydrocarbons, aldehydes, and ketones are commonly generated. Cement plants are classified as leaching or non-leaching depending on whether the plant uses leaching systems to avoid emitting high alkali dust. However, if the systems are in place and high alkali raw materials are used, water quality is impaired more extensively. Given the high particulate emission levels from Nigerian plants, it is unlikely that they use leachate systems. Waste generation at cement plants is exacerbated by the fact that none of the cement or asbestos-cement plants reviewed in a study of the industry undertook any form of reprocessing or recycling (Achi in Math and Robinson, 1991, 483).

Other Industries. Air emissions are not a significant component of the food processing subsector's waste stream. However, noxious odors are a common problem for nearby communities. With the possible exception of carbon dioxide (a greenhouse gas), air emissions from breweries are also not of concern (Akintunde in Industrial Control Unit, 1986, 88). Except for fibers, dust, and volatized synthetic fibers, air pollution is not an important consideration for the regulation of textile mills, but, as in the case of the Asaba textile null, very high fiber levels may make working conditions difficult. (World Bank, 1988, 453). Fumes from metallurgical plants can be hazardous to workers and communities in the neighborhood of the plant (FEPA, 1991, 37). Communities near the NAFCON fertilizer plant have complained of choking gases coming from the plant, which could be nitric oxide or ammonia releases (The Rivers Chiefs, 1994). The air emissions control equipment at NAFCON is reported to have broken down (Isoun, 1994).

ANNEX I
GAS FLARING ASSESSMENT AND ALTERNATIVES[19]

Methodology. Emissions from gas flaring are difficult to evaluate as only little is known about flame temperatures. The flares are said to be operating at temperatures between 300-1400°C, which may be the case in the center of flares, but combustion is at lower temperatures in most of the flame.[20]

In the North Sea, equipment for gas flaring includes pressure injection of air and 95 percent of vented gas is burned off. In Nigeria, with uncontrolled flares, 80 percent or less of the total gas outlet is expected to be burned off. In this report, for estimation of air emissions, 20 percent of the total outlet of gas is assumed to be present as volatile organic carbon, VOC, exclusively as methane.

For estimating emissions of particulates and nitrogen oxides, gas flaring is supposed to be comparable with outlets from power plants supplied with natural gas and with combustion temperatures below 1000°C (WHO, 1989). For emission of SO_2, the estimate is based on a very low sulphur content of 0.11 percent (WHO, 1989). Comparisons with emissions from gas flaring with gas power plants will most probably mean that emission of particulates from gas flares is underestimated while emitted amounts of N-oxides are overestimated. In Table 19 estimated emissions from gas flaring are presented.

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[19] Grevy, 1995.

[20] The seven different flares inspected on this mission were clearly orange and sooting, indicating a much lower temperature and only a partial combustion of gaseous components.

Table 19: Air Emissions from Gas Flaring

Unit	Product Unit/year	Particulates kg/unit	tons/year	N-oxides kg/unit	tons/year	VOC kg/unit	tons/year	SO_2 kg/unit	tons/year	Remarks
1000 m^3	6.967 million	0.24	1,672	9.6	66,833	546[21]	3.8 million	1.82	12,679	Shell, Rivers State
1000 m^3	3.826 million	0.24	918	9.6	36,729	546	2.1 million	1.82	6,963	Shell, Delta State
Total Shell	10.250 million		2,590		103,562		5.9 million		19,642	Shell, 40% of produced oil in Nigeria
The Delta	20.500 million		5,180		207,124		11.8 million		39,284	The Delta, 80% of produced oil in Nigeria
Emission tons/km^2			0.15		5.9		337.0		1.1	35,000 km^2, area of the Delta

[21] Calculated as: 20% of 1000 m^3 methane with a density of 2.73 kg/m^3

Effects of Gas Flaring. It can be estimated that the total emission of CO_2 from gas flaring in Nigeria amounts to 35 million tons/year with methane from Delta and Rivers State expected to contribute to around 12 million tons/year. Methane, together with CO_2, is the main green-house gas responsible for global warming which has probably raised the average global temperature by around 0.5°C within the last century.

The expected amounts of N-oxides and SO_2 being emitted from gas flaring are estimated to be approximately 210,000 and 40,000 tons/year, respectively, in Rivers and Delta States (Table 2.7). N-oxides and SO_2 are some of the main components causing acidification as a consequence of both wet and dry deposition. The figures cannot be related to actual concentration levels, but the amounts indicate that acidification effects may occur.

One of the most frequent complaints concerning gas flaring is that it causes acidification which is rapidly corroding galvanised steel roofs. Corrosion is a considerable problem because most houses are covered with steel roofs. No regional surveys of air quality parameters, including monitoring of SO_2 concentrations and N-oxides are being performed in Nigeria. But concentration levels relating SO_2 concentrations to the lifetime for galvanised sheet steel roofs have been measured elsewhere in the world (Table 20). It is unlikely that concentration levels of SO_2 for heavy industrial areas are ever reached in Nigeria. If the lifetime for galvanised sheet roofs of 3-4 years is correct, it should be considered whether the coating of roof sheets or other production dependent practices have been changed or how salts originating from the sea, such as SO_4^{2-}, promote corrosion.

Site specific measurements of SO_2 and N-oxides related to gas flaring have been undertaken[22] and do not indicate that the two parameters are emitted to an extent where dry and wet depositions cause serious acidification effects. Over a wide range of distances centered from the gas flare at Bonny, SO_2 was not registered within the detection limits of the applied method. N-oxides (NO_2) were found with maximum concentrations of 27.2 $\mu g/m^3$ as an average over 3 hours at a distance of 50 m from the flare. These figures are not disturbing. Nigerian ambient air quality standards operate with permissible concentrations measured as daily average of hourly values between 75 and 115 ug NO_2/m^3 and 260 μg SO_2/m^3 (FEPA, 1991).

[22]E.g: *Environmental impact study around the gas flare of the Bonny Flow Station.* Renseigner industries Ltd. for The Shell Petroleum Development Company of Nigeria, 1993. University of Calabar Gas Flaring Study for the Shell Petroleum Development Company of Nigeria.

Table 20: Acidification and Life Time of Galvanised Sheet Steel

SO_2-concentration $\mu g/m^3$	Type of Environment	Observed Lifetime Years
13	Rural	30-35
260	Semi industrial	15-20
1,040	Heavy industrial	3-5

Partly according to: *Effects of economic materials and structures.* Yocom, T. E. et al. In Air pollution. 3rd edition. Academic Press, New York. 1977

Other assessments support the view that serious acidification effects do not arise from gas flaring.[23] Unfortunately these assessments are not based on direct measurements of air emission parameters, but on indirect emission effects registered in rainwater, surface water and groundwater. Rainwater is the main receptor for gaseous emissions from gas flaring and is responsible for distribution of the wet deposition of acidifying elements. No pH values below 5.86 in rainwater were measured close to a number of gas flares. Compared to pH values below 4.0 measured in the moderate and heavily industrialised part of the northern hemisphere, these values are in no way alarming.

Nevertheless, water quality parameters in ground water show a close correlation between distance from flares and gradient values for a number of chemical components. It could be questioned whether oil exploitation and not gas flares are the main reasons for environmental effects in ground water.

Alternatives to Gas Flaring[24]

Reinjection of Associated Gas. Generally oil and gas fields in the Niger delta are small but numerous and situated at shallow depths in the soil profile. No rock formations shield the fields. According to Shell, a technical explanation for not reinjecting associated gas into oil fields in Nigeria is the shallow position of oil fields combined with the absence of rock formations to withstand high pressures from reinjected gas. It is reported that water infiltration into cavities in oil fields arising from oil extraction is rapid. If gas is reinjected, the combined pressure of water infiltration and gas reinjection may cause uncontrolled outbursts of gas or even blow outs to the surface.

Reinjection of gas in Nigeria is used in a few low pressure oil fields in soils with a low water transmissivity causing slow water infiltration. Reinjection in such fields is used to maintain the pressure needed for extraction of oil and not for environmental reasons.

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[23] Assessment of impact of gas-flaring on the quality of rain water, surface water and groundwater in parts of the oil producing region of Nigeria.

[24] Grevy, 1995.

Utilization of Associated Gas for Power Generation. The daily oil and associated gas production in Nigeria is around 2.0 million barrels and 2,000 million cubic feet, respectively. The amount of gas to be lifted for each barrel of oil being extracted is on average around 1000 cubic feet. This figure corresponds to 187 m^3 of associated gas for 1 m^3 of oil extracted.

In 1989, around 87 percent of all lifted associated gas was flared (ESMAP, 1993). This corresponds to the fact that one cubic metre of extracted oil induces a gas flaring of approximately 160 m^3. Only 5 percent of lifted associated gas was used for commercial purposes. At the same time non-associated gas sold for commercial use in the energy sector represented 15 percent of the total gas production.

The possibility for using associated gas depends on market prices for associated and non-associated gas, and in the Niger Delta the associated gas cannot compete. The reasons are that: (i) well productivity for non-associated gas is much higher than for associated gas with crude oil; (ii) capital costs for treatment and drilling equipment to develop non-associated gas are distributed over larger reserves in specific gas fields than for associated gas with crude oil; and (iii) additional recovery costs are introduced for associated gas when it has to be compressed from atmospheric to pipeline pressure. Non-associated gas is recovered with a pressure high enough for immediate pipeline use. Accordingly, non-associated gas can be sold for much lower prices than associated gas. For 1989 it has been calculated that supplying commercial users with associated gas instead of non-associated gas would have cost around US$90 million extra even at the very low consumption rate of 1989.

The prospective for a future reduction of flared gas volumes is unlikely for environmental reasons. The major gas outlet for commercial use will, in the future, be production of liquified gas mainly for export. Shell has cleared an area at Bonny for establishment of storage facilities for liquified gas and a gas plant. Mobil is said to be preparing large scale facilities for gas extraction. These projects and several others are all, as far as it is known, expected to be based on non-associated gas extraction. An estimate of the future gas extraction based on planned, proposed and approved gas projects indicates a commercial use of non-associated gas of approximately 2,100 million cubic feet/day compared to 350 million cubic feet/day in 1989. Information from Shell indicates that only minor changes in commercial use of non associated gas has occurred between 1989 and 1994.

Gas Consumption in the Petrochemical Industry. When large scale production of liquified gas is commenced, exported gas will be used in petrochemical industries elsewhere in the world. In Nigeria, building of a petrochemical plant has commenced at Eleme, but like other users of gas, the production is expected to be based on a feedstock of non-associated gas.

There is no prospect indicating that gas flaring practices associated with oil production will be changed in the near future.

J
REGULATORY AND INSTITUTIONAL RESPONSE TO DEGRADATION

A. LEGISLATION AND REGULATIONS

Energy and Minerals

Oil companies in Nigeria are under federal jurisdiction. The federal government is both a partner in all oil activities, through NNPC, and is required by federal law to enforce environmental compliance of oil operations through the Department of Petroleum Resources. This situation has resulted in the government inadequately regulating oil pollution while at the same time, being party to much of the oil related environmental problems of the Delta. Under the regulations established in the 'Environmental Guidelines and Standards for the Petroleum Industry in Nigeria', the Department of Petroleum Resources can revoke the licenses of firms which fail to comply with regulations on operating practices, oil pollution prevention, safety standards, and acceptable petroleum containers. The regulations require that oil concession operators are required to "adopt all practical precautions" to prevent pollution, including EIAs, contingency planning, and water quality monitoring. The guidelines do not cover the environmental impacts of seismic exploration, infrastructure construction (roads and slots) or the potential impact on wildlife (Powell, 1995, 31). Unlike many oil producing countries, Nigeria does not have a separate statute for conservation of oil. Instead the Petroleum Act, 1969, and the Petroleum (Drilling and Production) Regulation, 1969, include sections designed to promote efficient use of petroleum resources.

Perhaps more important for the Niger Delta than the Land Use Act of 1978 which vests all land in the state government is the 1979 law granting all mineral rights to the federal government. Consequently, local communities and state governments have no legal rights to oil and gas reserves in their territory. The federal government sells oil mining leases to the oil companies who negotiate with the state governors over land requirements. Since riverine communities have no rights to the oil, the oil companies are not required to initiate a dialogue with villages before beginning operations, instead they can merely inform communities of impending activities.

Under the Petroleum Act, the Minister of Mines, Power and Steel has established pollution regulations for water bodies, calling for precautionary measures and proper maintenance of drilling and mining equipment. Pollution regulation is bolstered by the Oil in Navigable Water Act, 1968, which bans all oil activities from discharging oil into water courses. Very few oil pollution cases have gone to trial; most are settled out of court. As shown by the poor spill record discussed in the oil pollution section, the oil pollution legislation and its enforcement have been ineffective.

Decree No. 23 of 1992, establishing OMPADEC, states that a primary objective of the Commission will be to manage ecological problems arising from the exploration of oil minerals. However, the Commission has decided not to pursue environmental issues until its LGA infrastructure program is well developed.

To reduce gas flaring and conserve gas resources, the government promulgated the Associated Gas Reinjection Decree, 1979, which required companies to stop flaring by 1984. The geology of most Nigerian fields limited the potential for reinjection, greatly limiting the impact of the Decree. It was amended in 1985 by fixing a 2 kobo penalty for each thousand cubic feet of gas flared, but this proved to be too small an incentive to induce companies to reduce flaring (World Bank, 1994a, 7). Although gas utilization will increase, in the near term it will be based on economical non-associated gas supplies and not reduce gas flaring. The largest future outlet for Nigeria's gas, the Bonny LNG plant, will liquefy primarily non-associated gas (ESMAP, 1993, 48).

Major Constraints

- No requirement for community participation in planning and development of oil activities;
- Corruption and inadequate compensation for damage to property; and
- Lack of enforcement of environmental regulations.

Forestry, Wildlife and Fisheries

Under the Nigerian Forestry Act, 1937, State Governors are free to establish forest and game reserves. The Act also recognizes the power of local governments to demarcate their own reserves and create communal forestry areas. State legislation covers specific regulations for reserves and timber species. Within the Delta, the state governments control the forests under reservation and the rights to timber trees outside of reserves. The legal status of existing reserves needs to be reviewed and strengthened, especially after Risonpalm attempt to expand into the Upper Orashi Forest Reserve. The system of granting logging permits and concessions to companies does not work well. Loggers often ignore conditions attached to concessions or do not even bother to obtain felling permits.

Legislation concerning wildlife was first enacted in 1916 with the Wild Animals Preservation Act which protects wildlife from hunting. In conjunction with the Endangered Species (Control of Internal Trade and Traffic) Decree, the Act prohibits hunting and trafficking in threatened species. The current Endangered Species Decree updates earlier wildlife legislation and lists 90 rare and threatened fauna for protection. However, the listing are often appropriate with many common species and even species not found in Nigeria being given national protected status. Vulnerable flora are not listed. The laws focus on species protection and hunting regulations, neglecting to consider habitat conservation or ecosystem-level management. The Decree need to be reviewed to conform with CITES listings and to specify

any Schedule III species (species which are not restricted internationally, but which will require license for export from Nigeria. The Decree should be accompanied by identification aids (Powell, 1995, 32). Other legislation that include conservation or preservation provisions are the Public Lands Act, 1970, the River Basins Development Authority Act, the National Parks Decrees, and the Town and Country Planning Act.

The Sea Fisheries and Inland Fisheries Decrees, 1992, control access to fisheries resources. The Decrees include wide provisions for the regulation of catch species, sizes and fishing zones. Regulations set minimum net size for both fin fish and shrimp. Each year NIOMR is supposed to publish minimum lengths for selling commercial fish species. If enforced, the regulations would provide the basis for efficient exploitation of this resource. Currently, few fishermen register their boats or adhere to fishing regulations. Similarly, international trawlers ignore Nigeria laws. Of particular concern to artisanal fishermen are trawlers flouting the five mile non-trawling coastal zone. The Decrees, as well as the Rivers State SEPA Edict prohibit employing poison or explosives to kill fish, but both of these activities continue. Fortunately, the limited availability of explosives and high cost of pesticides limits their use. The Inland Decree also requires that construction of dams, weirs or other fixed barriers ensure the free movement of fish. Road construction in the states, which frequently disrupt water courses, ignores this regulation. According to NIOMR, enforcement of the five mile artisanal fishing zone has been ineffective because the agencies charged with enforcement, the Federal Department of Fisheries, the Navy, and the Air Force, have not been able to coordinate their operations. Since the regular court system is overwhelmed with cases and special fisheries courts do not exist, trials drag on for years and few offenders are finally punished. During the implementation of the Third Multi-State Agricultural Development Project, Nigerian officials arrested only three Greek vessels for fishing within the 5 mile non-trawling zone and using undersized nets. The fines were enforced under the old 1971 Sea Fisheries Decree, amounting to just N28,000 each. Enforcement of the inland fisheries laws in the Niger Delta is virtually non-existent: the region is simply too large and remote to be covered.

Major Constraints

- Lack of enforcement and poor coordination of enforcement;
- No consideration of ecosystem management; and
- No inclusion of market based incentives (e.g., concession auctions and tradable resource quotas).

Industrial Pollution[25]

Of the different types of environmental legislation, the federal framework for controlling industrial pollution is perhaps the most comprehensive. It creates a complete monitoring,

[25] This section draws extensively from the report, *Nigeria: Strategic Options for Redressing Industrial Pollution.*

enforcement, and legal prosecution process. Current legislation began with the Federal Environmental Protection Agency Decree, 1988. Before that year, industrial regulations did not specifically target pollution, and environmental regulations were weak. The Decree establishes penalties for discharging hazardous wastes into any media and prohibits indiscriminate disposal of waste into waterbodies. The FEPA Decree also empowers the Director of the Agency to conduct public investigations for all types of pollution and install monitoring stations and networks for air emissions. The Act was followed by the 1991 National Environmental Protection Regulations, which require that every industry installs abatement equipment, restricts releases of toxic substances, and obtains permits from FEPA for storage, treatment, and transportation of toxic wastes. The guidelines and standards for effluent limitations developed by FEPA are based on a review of nine developed and developing country standards. The Regulations allow FEPA to bar a new facility from operating if it does not comply or constitutes a new point source of pollution.

In the *Guidelines and Standards for Environmental Pollution Control in Nigeria*, FEPA fulfilled its mandate to develop industry level standards for specific pollutants. A major problem with the effluent limits is that they do not consider the background water quality levels of different water bodies and even different seasons. If strictly enforced, some water bodies will be overprotected while others are degraded below the acceptable standards. Extensive solid and hazardous waste regulations are also described in the guidelines. Broadly reviewed, solid waste regulations cover landfill standards, requirements for land treatment, and incineration regulations (FEPA, 1991, 94-154). Hazardous waste ordinances include a registration and tracking system, regulations to control hazardous wastes, spill mitigation procedures, and the use of environmentally sound hazardous waste disposal techniques. The federal government responded to foreign toxic waste dumping in Koko, Bendel State in 1988 by promulgating the Harmful Wastes (Special Criminal Provisions etc.) Decree of 1988 which sentences individuals who trade, dispose, or transport toxic wastes in Nigeria or its Exclusive Economic Zone to life imprisonment.

Environmental impact assessments are now mandatory for new large industrial developments (see following section). Similarly, existing industries must conduct environmental audits of their facilities. In practice, however, only the SEPAs of Lagos and Kaduna have started making existing industries comply with regulations by requiring a plan and implementation time (Magner and Duer, 1991, 45). Although all industries in Nigeria now have to obtain discharge permits the number of firms actually holding permits is not known, but thought to be insignificant. The National Environmental Protection Regulations, 1991, briefly address zoning for industrial areas. Each state is supposed to designate industrial estates separated by buffer zones from residential areas.

The division of responsibilities between FEPA, regional federal agencies, the SEPAs, and state agencies is not yet discrete. FEPA policy is that "State governments with the appropriate infrastructure and capability approved by FEPA will implement FEPA policies, guidelines and standards in the States. Otherwise, FEPA will implement its own programs and enforce regulations in States without the necessary infrastructure and capability" (FEPA Guidelines, 1991, 22). In theory, this statement may be acceptable, but it does not correspond to the

reality that FEPA itself is grossly understaffed and poorly equipped to manage industrial pollution.

In addition to the industrial pollution and hazardous waste legislation, other media and sector specific legislation govern pollution. The Water Works Act of 1915 and the Mineral Act of 1917 prohibit pollution of water supplies and bodies. The Public Health Act, 1917, also includes penalties for water and air pollution. Under the River Basin Authorities Decree of 1987, the NDBDA is charged with the preservation of water quality in the Niger Delta. However, since the NDBDA views its mission as agricultural development, its activities, such as forest conversion, and fertilizer and pesticide distribution, increase water quality degradation. The State Ministries of Works are also mandated with controlling pollution. The Rivers State Environmental Protection Agency Edit requires the Environmental Protection Agency to control water and air pollution. Impending legislation in Delta State is anticipated to have the same requirements.

Major Constraints

- Lack of enforcement;
- National discharge regulations which many not be appropriate for the Niger Delta;
- No groundwater effluent standards;
- Overlapping responsibilities, especially between federal and state environmental protection agencies; and
- No market based incentives (pollution charges, appropriate user and input pricing, pollution abatement subsidies, etc.).

Environmental Impact Assessments

The Federal Government promulgated an Environmental Impact Assessment Decree for large-scale development projects (Decree No. 86) in 1992. It states that all public and private ventures must conduct an EIA if their activities involve the following:

- Land conversion from forest to agricultural land of 500 ha or more;
- Agriculture projects requiring the resettlement of at least 100 families;
- Agricultural projects which change agricultural uses on at least 500 ha;
- Drainage of wetlands covering 100 or more hectares; and

- Felling timber on at least 500 ha.

By requiring only the largest developments to conduct EIAs, the legislation creates an enormous loophole. Most of the developments causing significant environmental degradation are on a much smaller scale and would be exempt from performing EIAs. It is clear from Risonpalm's unwillingness to conduct EIAs that even developments falling within the criteria of the legislation do not always comply with the EIA regulations. At the end of 1994, FEPA had yet to initiate any EIAs under the Decree (Powell, 1995, 32).

Major Constraints

- Lack of enforcement.

- EIA requirement does not encompass enough activities.

Urban Development

Urban land use is governed by the Town and Country Planning Law. The state governments expand on the Planning Law with their own decrees and planning boards covering water supply, land use zoning, waste management, transportation, and sewage. The National Environmental Protection Regulations, 1991, briefly address zoning for industrial areas. Each state is supposed to designate industrial estates separated by buffer zones from residential areas. While simple, these land use regulations, if enforced, would reduce community health problems associated with housing and factories being mixed together on new industrial sites. As shown by the unmanaged development of Warri and Port Harcourt, the land use regulations and their associated boards have had little impact.

Major Constraint

- Lack of enforcement.

State Environmental Protection Legislation

The Rivers State Government promulgated the Environmental Protection Agency Edict on January 4, 1994.[26] The Edict gives the Environmental Protection Agency "the responsibility for the protection and development of the environment and biodiversity conservation and sustainable development of the State's Natural Resources". Under the Act, the agency is required to:

- develop the State's environmental policies, regulations, and legislation;

- develop environmental impact assessment procedures;

[26] The Delta State Environmental Protection Agency Decree has not yet been approved by the State Administrator and drafts are not available for review.

- establish emission standards;
- monitor and control industrial and hazardous wastes;
- conduct environmental impact assessments;
- collect effluent discharge fees;
- enforce industrial and domestic sewage treatment, and
- monitor and control erosion.

The very limited resources currently available to the SEPA makes this list of functions unrealistic. The Edict gives the SEPA strong monitoring and enforcement powers which would provide the basis for effective pollution control. The Agency can search premises, seize equipment, obtain samples, and arrest without a warrant. The SEPA's role in natural resource and conservation work is to set policy for the Forestry Department to implement, but it currently has no staff working on conservation. The lack of legal jurisdiction and institutional capacity has not prevented the Agency from creating a conservation division. Under the Act, every local government area is required to create an environmental committee to oversee environmental management in its area.

The Edict requires that waste generators obtain a permit from the SEPA and that waste discharges meet emission standards. The SEPA must also approve waste treatment processes, storage, and disposal. The State is planning to implement a pollution discharge fee fund that will include annual pollution discharge fees and non-compliance fines. This innovative program is marred by the inclusion of a clause allowing the Military Administrator to arbitrarily withdraw funds, rather than exclusively using the money for enhancing environmental protection. In addition, the discharge fee will be a flat charge which does not provide an incentive at the margin to reduce emissions. Under the Edict, the SEPA's arsenal of punishments includes fines up to N500,000, prison terms not to exceed 10 years, closure of facilities, and payment for remediation.

Major Constraint

- Lack of enforcement.

Health and Sanitation

Health and sanitation are largely state concerns. Legislation covering these issues include the Federal Government's Public Health Act and State Environmental Sanitation Decrees. In terms of environmental issues, the Public Health Act penalizes individuals for polluting water and air. The State Edicts provide a legal framework for environmental management, concentrating on domestic and small scale industrial pollution. The Edicts usually incorporate sanitation issues such as waste disposal, sewage, water supply, pest control, and pollution.

Specific state agencies, such as the Rivers State Environmental Protection Agency and the Water Board, are charged with enforcing relevant sections of the Edicts. As described in the social issues section, enforcement of regulations and provision of sanitation services is weak.

Major Constraint

- Lack of enforcement.

Flooding and Erosion

Flood and erosion control was originally mandated to the Niger Delta Basin Development Authority under the 1987 Decree establishing the Authority. Numerous other agencies include erosion and flood management as part of their mandates, including FEPA, the SEPAs, the state Ministries of Works and Transport, and the Federal Department of Flood and Erosion. However, the agencies do not actually address flooding or erosion. The high cost of control measures and the overlapping jurisdictions have limited mitigation to a small number of community level erosion projects. For example, the Federal Government has recently constructed erosion protection structures in Opobo Town, Brass, Queenstown, Abonnema, and Bonny (The Rivers Chiefs, 1992, 46). No Delta wide flood and erosion management programs exists.

Major Constraints

- Limited funds;
- Lack of enforcement;
- Absence of long term planning; and
- Overlapping jurisdictions.

B. GOVERNMENT INSTITUTIONS

Federal Government

Federal Environmental Protection Agency (FEPA). The new head of the FEPA zonal office in Port Harcourt has rejuvenated the office by relocating and beginning to properly equip it. Previously, the office had almost no capacity to improve environmental conditions in the five southeastern states it covers. The role of the zonal office is to support the work of the SEPAs and enforce environmental regulations in areas where the state institutional capacity is weak. While at least represented in Rivers State, FEPA has not been active in Delta State. Whether the improvements will be sustained with adequate long term funding is uncertain. Currently the office has a staff of 25 including 10 environmental professionals working in four thematic areas: (1) wildlife and conservation, (2) erosion control, (3) oil pollution, and (4) industrial

pollution. However, few activities are being implemented. One of FEPA's first actions has been to work closely with a World Bank consultant in the preparation of an industrial pollution inventory for Rivers State. Clearly, to be able to have a significant impact in the five states, the FEPA office must be substantially increased in terms of funding and environmental expertise.

Major Constraints

- Limited funding;
- Weak monitoring and enforcement capacity; and
- Few appropriately trained staff.

OMPADEC. Established by the federal government in 1992 to improve on the ineffective 1.5% fund to assist the development of oil producing areas, OMPADEC is designed to distribute 3% of government oil revenues back to oil producing Local Government Areas (LGAs). In 1993, the oil revenue allocation amounted to approximately N1.9 billion (US$95 million). The Commission allocates its funds strictly based on the percentage of oil produced in each LGA. For producing the largest amount of oil, Rivers and Delta State receive the biggest allocations. For instance, based on oil production levels in May 1994, Rivers State received 40.5% and Delta State received 36.7% of OMPADEC's allocations for that month (Guardian, June 28, 1994, 9).

With its substantial funding and being only responsible to the Presidency, OMPADEC is probably the strongest government institution in the region. In only 2 years, OMPADEC has achieved significant results on the ground, in the form of infrastructure projects. However, the Commission does no long term planning, preferring to develop and implement projects on an annual or even a month-to-month basis. The Commission is currently only implementing infrastructure projects, concentrating on power, water, road, and bridge projects. It hopes to do extensive canalization, but has been restricted by limited funding. It is also planning to expand into rice cultivation and aquaculture projects. The Commission anticipates subsidizing agricultural inputs to farmers in all eight states and already subsidizes fishing gear for cooperatives. The small scale loan program for fishermen, farmers, and small businessmen, could be fashioned into a suitable rural credit program, if it is well managed and transparent. OMPADEC is one of the few agencies addressing erosion and is implementing twenty-five shoreline protection and reclamation projects.

The Commission is currently deciding whether to attach service and maintenance components to its projects. As it stands, OMPADEC only provides infrastructure or equipment. For example, OMPADEC builds health centers but does not support staff for them. The obvious problem with such a development program is that the communities may not have the funds or expertise to maintain a project and watch it break down in a few years.

Consultation with local communities affected by projects and other government agencies is inconsistent. Although the Commission reported that communities decide the projects they would like to have implemented, some communities and NGOs found that projects were developed and implemented in a top-down process. Numerous line ministries in both states and the NDBDA complained that OMPADEC did not coordinate or discuss projects with them. OMPADEC officials confirmed that they limited consultations with other organizations, such as state ministries and oil companies, to informing them of an impending project. The lack of dialogue has resulted in OMPADEC and the oil companies duplicating projects in the southern Ijaw LGA (omp-2, 4). OMPADEC officials stated that they conduct environmental impact assessments of their projects, but no reports are available.

One of OMPADEC's eight directors has been assigned to cover environmental protection and pollution control. However, the Commission's ecological work is limited to assessing environmental problems in the eight oil producing states. It has commissioned a GIS and remote sensing mapping program. In conjunction with the mapping work, the commission is determining critically polluted areas for possible remediation. It is also studying the environmental and human health effects of gas flaring and exposure to petroleum (omp-3, 1994). The Commission may implement environment projects after the initial phase of infrastructure projects is well established.

Major Constraints

- No environmentally sustainable development emphasis;
- Lack of implementation of its ecological mandate;
- No long term planning;
- No provision of maintenance and services;
- Lack of environmental policies, expertise, and project assessment; and
- Poor dialogue with other institutions and communities.

Niger Delta Basin Development Authority. The Decree for the establishment of all the River Basin Development Authorities emphasizes infrastructure development for irrigation, water use management, and flood and erosion control:

> the functions of each Authority shall be:
>
> (a) to construct, operate and maintain dams, dykes, polders, wells. and other works necessary for the achievement of the Authorities functions; and

(b) to construct, operate and maintain infrastructure services such as roads and bridges linking projects sites.

Although NDBDA is supposed to manage flooding and erosion in the Delta, it has not been active in this area, preferring to concentrate on irrigated rice projects. When the Authority has periodically decided to tackle erosion issues, federal funding has not been sufficient. Officials reported that the Authority has recently begun assessing the environmental impact of its projects. In the 1980s. the Authority commissioned several pollution and erosion studies. The most important of the studies was a long term pollution monitoring program run in conjunction with the Institute of Ecology at Obafemi Awolowo University that has been terminated because of lack of funds. To complement its water quality work, the NDBDA operates one of the few functioning scientific laboratories in the delta.

Major Constraints

- No environmentally sustainable development emphasis;
- Lack of funding and implementation of its water quality, flood, and erosion mandates;
- No long term planning ; and
- Lack of environmental polices, expertise, and project assessment.

Department of Petroleum Resources. The regulatory unit of NNPC, the Department of Petroleum Resources has federal responsibility for minimizing the environmental impact of oil activities. Lacking monitoring and basic office equipment, the Department is currently not able to perform its duties and is limited to obtaining oil company spill reports (Grevy, 1994).

Federal Ministry of Health. The Federal Ministry of Health has supported some state wide health programs in the Niger Delta, particularly the guinea worm and onchocerciasis programs (Harry, 1994). They also fund the university teaching hospitals.

Federal Forestry Agencies. Other than providing oil palm seedlings to Risonpalm and other plantation developers, the Federal Department of Forestry does not appear to be active in the Niger Delta. The Mangrove Forestry Research Station in Port Harcourt, which is run by the Forestry Research Institute of Nigeria, has not contributed to mangrove research (Adegbehin and Nwaigbo, 1990, 19). FORMECU sent research teams to study the possibility of an integrated conservation and development project for the Taylor Creek reserve in 1993, but has not developed projects proposals.

Water Hyacinth Control Committee. The Federal Government has established a water hyacinth control committee. Direct intervention, primarily mechanical harvesting, is the principal option for controlling the spread of water hyacinth. In some areas, workers have installed bamboo barriers to halt its expansion. Biological control attempts in Nigeria have

been aborted because of a poorly developed and managed program. All levels of government and the oil companies, especially Shell Petroleum, have spend approximately US$1 million to control water hyacinth and other aquatic weeds since 1989 (Egborge, 1993b, 10).

***National Institute for Freshwater Fisheries Research* (NIFFR).** The institute has a field station at Oguta Lake (Imo State), but it has not operated for several years.

***National Istitute of Oceanography and Marine Research* (NIOMR).** The agency manages two field stations in Rivers State: one mangrove and one freshwater (African Regional Aquaculture Centre (ARAC)). They have training programs, supply fingerlings, and conduct oyster aquaculture research. Designed as a continental training and research institute, ARAC has not developed as expected and has lost its FAO funding.

***Directorate for Roads and Rural Infrastructure* (DFFRI).** DFFRI has constructed major roads through the region, including the Biseni-Asambiri road through the proposed Taylor Creek reserve.

State Government

State Environmental Protection Agencies (SEPAs). Delta State is in the process of creating a SEPA which will be operational early in 1995. A former FEPA official and current Commissioner of Agriculture for the state, Dr. Ivbijaro, is the coordinator for establishing the SEPA. It is expected to be a policy making body in the Governor's office, leaving implementation to the line ministries. In addition to a director, the SEPA will include about eight assistant directors and a technical committee comprised of two scientists, NGO representatives, and officials from eight line ministries. The initial work of the SEPA will focus on creating an inventory of degraded areas in the state and other baseline data gathering. It will also dialogue with the LGA leaders to induce them to manage their solid wastes effectively. When fully established, the Agency plans to concentrate on mangrove and coastal management. The Commissioner is establishing a Coastal Zone Coordinating Committee to provide leadership in assessing and addressing the priority coastal zone concerns. The state government is establishing a committee to control water hyacinth to cooperate with the Federal committee, in which the SEPA will play a major role (Ministry of Works, Delta State, 1994). The SEPA will use the FEPA industrial pollution standards until it is able to develop its own standards. The edict establishing the SEPA will require that public and private activities conduct environmental impact assessments (Ivbijaro, 1994). Since the SEPA will only be a policy making institution and the line ministries are underfunded and have other, often contradictory, priorities, it is not anticipated that environmental problems will be adequately managed in Delta State.

The Rivers State Environmental Protection Agency has a staff of 24 in six divisions, 10 of which are environmental specialists. The divisions are (1) planning, research, and statistics, (2) inspection and enforcement, (3) conservation, (4) coastal management and beautification, (5) pollution control, and (6) claims, compensation, and relief. The SEPAs budget allocation for 1994 was N1.4 million, far too small to implement its broad responsibilities (paragraph 6.10).

However, if the Agency is strengthened, it could become an effective policy development and coordination body which leaves most implementation to line ministries. The SEPA's policy and regulatory work is presently concerned with developing industrial emission guidelines, writing EIA procedures, and assisting LGAs to improve solid waste management. The SEPA is the lead agency for the Coastal Zone Coordinating Committee which comprised of high level officers from relevant state agencies, FEPA, industries, and NGOs. The Committee is initiating an integrated development strategy for the state. Collaboration between the Protection Agency and the Ministry of Health is enhanced by having a Ministry official as part of the Agency's advisory committee.

The SEPA has only one vehicle and does not have a boat which is a necessity for movement in the riverine areas. Lacking a laboratory, the Agency is unable to monitor water or air quality. The Agency has commissioned a study on the environmental effects of gas flaring, but ran out of funds to complete it. It has created a water hyacinth committee to examine methods for slowing the plant's spread.

Given the limited resources, the Agency has not been able to prevent environmental degradation. Instead, it reacts to acute, visible problems as they occur by documenting them; lacking the resources to deal with even these immediate concerns. Much of its energy is directed to responding to oil spills by visiting sites and certifying that clean ups are completed. Since its jurisdiction over oil related activities has not been defined and it does not have the expertise or equipment to assess pollution levels, it ability to assess and manage oil pollution is very limited.

Major Constraints

- Limited funding;
- Weak monitoring and enforcement capacity;
- Few appropriately trained staff; and
- Lack of environmental information

State Ministries of Agriculture and Natural Resources: Forestry Departments. The Rivers State Forestry Department is in charge of forest management, forest reserves, wildlife conservation, nurseries, and selected plantations for the state. In addition to the Port Harcourt office, the Rivers State Department has four other offices in the state. It has a total staff of 175, including 13 professionals. The Director of Forestry stated that the number of upper level staff has been growing disproportionately and more junior officers are needed to work as forest assistants, guards, and nursery attendants. The Department also has a problem of its administrative unit being overstaffed with unqualified staff from the Personnel Department. In 1993, revenue from timber, non-timber forest products, and seedlings was just N72,238 in 1993, but even in the highest recent revenue year, 1989, the Department only generated N113,689. With illegal felling and transport of logs, the Department receives only a small

fraction of the potential timber revenue. Moreover, the forest guards and managers have very limited capacity to enforce laws or collect revenue.

The Department aims to reserve 20% of the total land area of the state, however, as the biodiversity section discusses, the total stands at 7.5% and the 20% goal is not likely to be realized. Limited funding has brought work at the Department's nurseries and plantations to a halt (Department of Forestry, Rivers State, 1994, 3). However, it still manages to distribute seedlings for school and road side planting programs. The State manages a mangrove regeneration study begun in 1987 that has been successfully regenerating a 4.1 ha site (Department of Forestry, Delta State, 1994). In conservation, Forestry officials have worked closely with the Biodiversity Unit of the Rivers State University of Science and Technology to document species in forest and game reserves, but are unable to adequately protect the reserves from illegal poaching or felling. The Department attempts to regulate harvesting practices and reduce illegal felling from 4 field offices, However, it does not have a presence in the mangrove forests and much of the freshwater swamp zone because it does not own a vessel. The only Department vehicle is an old truck.

The Delta State Forestry Department is a more robust institution than the Rivers State department. However, its total budget was the lowest of the four agricultural departments, N6.5 million (11% of the agricultural budget). The agricultural ministry itself only receives 3.2% of the state budget. It has a total staff of 181, of which 21 are higher level forestry technicians.[27] Revenues from its activities generated N1.3 million in 1993, over 10 times revenue generation by the Rivers State Department. The Department is well organized with a clear goal of sustainable forest management, emphasizing timber production, but has only limited means for attaining its objective. The Department has prepared a draft Tropical Forestry Action Plan with innovative watershed management, biodiversity, medicinal products project, and community forestry programs which, if implemented, could form the basis for environmentally sustainable forest management (Delta State Forestry Department, 16). It operates several plantations in the state (3900 ha) and tree crop seedling programs.

Though it is charged with conservation, this aspect of its work is not given as high a priority as in Rivers State. Approximately 4.6% of Delta State is in reserve (87,676 ha). While part of the reason for this lack of conservation emphasis relates to the smaller area of primary forest in the state than in Rivers State, it is also a function of the Department's traditional focus on rubber plantations. Even today, 15% of agricultural land in the state is planted with rubber trees. The Department spent N1,249,960 (US$5,700) on forest reserve protection and log control in 1993. In other West African countries, it has been determined that about US$5/ha/yr needs to be spent for effective forest reserve management, which is over three times the Delta State figure (US$1.50/ha/yr).

The Department does operate a vigorous tree crop seedling program for farmers, principally rubber and oil palm trees. Taungya agroforestry programs have generally not been successful. The timber tree seedling program, which produces mainly exotics, such as pine, *Tectona*

[27] The total budget of the Agriculture Ministry is about 15% of the state budget.

grandis (teak), and *Gmelina arborea*, distributed 230,000 seedlings in 1992 and 1993 (Department of Forestry, Delta State, 1994). The Department attempted a ogbono tree planting program in the late 1980s, but it was not well received by farmers (Oyo, 1994).

Major Constraints

- Limited funding;
- Weak monitoring and enforcement capacity;
- Lack of personnel skilled in forest management and conservation; and
- Lack of forest resource information.

State Ministries of Agriculture and Natural Resources: Fisheries Departments. The Rivers State Fisheries Department has a total staff of 94, with 26 senior staff. Like its forestry counterpart, the Fisheries Department is an administrative body without a significant field presence. The Department has not been able to collect any fisheries statistical data over the years. Funding constraints cut short a government fish farm and grounded the state trawlers several years ago (Ivangunima, 1994). The Delta State Fisheries Department is at a comparably weak level of institutional development as its Rivers State counterpart. The state conducts no fisheries monitoring, enforcement, or data collection. The tangible activities of the Department are limited to providing a small number of loans to individual fishermen to purchase fishing equipment. In both states, the Agricultural Development Projects (ADPs) have taken over fisheries data collection, but it remains unreliable.

Major Constraints

- Limited funding;
- Negligible monitoring and enforcement capacity;
- Few appropriately trained staff; and
- Lack of fisheries information.

State Ministries of Works, Housing, and Transport. The Ministries of Works are charged with a broad range of infrastructure development activities and even environmental management. These opposing mandates frequently conflict with infrastructure development given greater emphasis. For example, although the Delta State Ministry of Works, Housing, and Transport is mandated with overseeing EIAs for all major projects, it does not perform EIAs on its own projects. Its other environmental responsibilities, including (1) flood and erosion control, (2) monitoring and abatement of pollution, (3) water hyacinth control, (4) domestic waste (liquid and solid) disposal outside of major urban areas, are not met. Approximately 40% of the Delta State budget is allocated to the Ministry of Works. A large

proportion of the Rivers State budget is also allocated to Works, particularly for its rural road construction program which is viewed as the most important development priority (Egberipou, personal communication, 1994).

Major Constraints

- Lack of implementation of its environmental responsibilities;
- Lack of environmental expertise; and
- Absence of environmental impact assessments.

State Health Ministries. Health services are comparably developed in the two states, but neither of them focus on preventative environmental health. They concentrate on controlling epidemics and immunizing children. Approximately 8% of the Delta State budget is allocated to health. Of the two health ministries, the Delta State Ministry places greater emphasis on environmental health issues that the Rivers State Ministry. The two health issues that Delta State considers of greatest priority, water-borne diseases and sanitation, clearly fall under this rubric. The Commissioner of Health in Delta State is advocating two main programs for improving the health status of the population: (1) mass education to get basic health and sanitation information disseminated to rural communities and (2) improving access to safe drinking water, particularly through low cost water supply options.

The Delta State Ministry of Health operates 28 hospitals in the 19 LGAs, of which 5 are central hospitals. Seventy-six health clinics provide rural health services in the LGAs (mini, table 1). In addition, approximately 400 private health clinics supply medical services and increase health coverage in the state. The total number of health care providers for Delta State is estimated to have dropped from 4,000 in 1992 to 3,500 in 1994. The Rivers State Ministry of Health manages 34 hospitals and 326 health centres, in this more populated state, but had only 1,900 health care workers in 1992 (Harry, 1994).

Programs to operate community health clinics in the LGAs to provide health care and teach basic sanitation have been unsuccessful, especially in the riverine areas. Even though the Rivers State Ministry trained two dozen community health workers in each of the LGAs a few years ago, only 5 or 6 typically remain active today (Joe, 1994). An equivalent number (150) of village health workers cover health issues in Delta State's LGAs. They require increased training, incentives for remaining in the villages, and basic infrastructure, medical equipment and supplies. Turnover of health workers is reported to be high because of the poor working conditions and limited supplies. Delta State also has a program to help train the 200 traditional birth attendants who live in rural communities (1994). Efforts to get rural households to boil their drinking water have been generally fruitless because of the high cost of fuel and cultural aversion to the taste (Joe, 1994). In the old Bendel State, the Ministry of Health ran a pit latrine construction program that was moderately successful until funding ended in 1991.
Both State Health Ministries concede that riverine communities suffer from much more limited access to health services. Rivers State used to operate river ambulances and health

clinics, but these have not run for several years. Funding constraints also terminated a helicopter ambulance pilot program run by the Ministry and an oil company (phminister, 1994).

Major Constraints

- Limited funding;
- Lack of emphasis on preventative environmental health and sanitation;
- Few appropriately trained staff; and
- Inability to consistently provide health care in riverine areas.

C. OTHER ORGANIZATIONS

Communities

The emergence of the Movement for the Survival of the Ogoni People (MOSOP) is a community response to social and environmental degradation. The community coalesced to improve their situation by calling attention to their plight with protests and a bill of rights. They also demanded substantial benefits from oil extraction. As their requests have been unmet, the Ogoni have disrupted oil production in their area. In addition to gaining national attention, MOSOP has been successful in getting international NGOs to take up the Ogoni cause.

Some development agencies are beginning to realize that local participation must be incorporated into the project cycle from its conception. It is not sufficient to get the approval of accommodating community members before moving the dredgers in. Formal mechanisms such as advisory councils, community meetings, and socio-economic assessments, are important steps for better local participation. Informal regulation in both rural and urban areas can be very effective in reducing environmental degradation. Citizens can play a vital role in monitoring nearby industries and developments. Coasian bargaining between communities and point sources of pollution have been found to be surprisingly common and effective in reducing emissions (Hug and Wheeler, 1993), but requires well informed communities. Considering the low levels of education, Delta communities may have difficulty establishing such negotiations.

NGOs

The Rivers Chiefs and Peoples Conference. A institution with substantial influence at the community level, the Rivers Chiefs and Peoples Conference, is the oldest NGO in the state. Its primary purpose is to advocate for the interests of rural communities at the state and national level. Representatives from the Conference discussed the environmental and social issues of

the Niger Delta at the Indigenous Peoples Conference associated with UNCED in Rio de Janerio in 1992. For the Rio meeting, the NGO prepared the first regional assessment of the principal environmental and social issues in the Delta.

Niger Delta Wetlands Centre. The Niger Delta Wetlands Centre is the only environmental NGO based in Rivers State. The Centre includes some of the most experienced and knowledgeable experts in areas of biodiversity, pollution, and flood and erosion. Its goal is to further conservation and sustainable development in the rural areas of the state through research, information management, education, and environmental management. In addition to its Port Harcourt headquarters, the NGO has a field office near the proposed Taylor Creek Forest Reserve. Lacking adequate funding, the Centre is not yet in a position to implement its proposed research or integrated conservation and development projects or programs.

Pro Natura. An international environmental and social development NGO, Pro Natura, has exclusively focused on the Niger Delta in Nigeria because it believes that the delta is an area of great environmental value associated with social unrest that has been neglected by more established NGOs. Pro Natura has conducted a delta-wide participatory rural appraisal study to ascertain local perceptions of environmental and social issues. It is beginning a similar study in Port Harcourt to obtain information on conditions in urban communities.

Wetlands Environmental Protection Association. This NGO was established in 1971 to provide legal assistance to communities which take oil companies to court to gain compensation for damages from oil spills. It is the only environmental NGO operating in Delta State. The Association has created a small environmental education/monitoring program in which village youths document oil spills and report them to the companies, authorities, and the NGO. The Association also runs village environmental education seminars.

Nigerian Conservation Foundation. The Nigerian Conservation Foundation and World Wildlife Fund (WWF-UK), with ODA financial assistance, have created environmental education curriculum development units at the Universities of Benin and Calabar, as part of one of the largest WWF environmental education programs in Africa. The Foundation began a survey of the major social and environmental problems of Niger Delta communities which will also assess the effectiveness of community development programs. The survey is supported by World Bank funding.

International Organizations

Niger Basin Authority. Established in 1964 by the nine countries in the Niger basin watershed, including Nigeria, the Niger Basin Authority's (NBA) goals are to study and implement projects and run Hydroniger, a hydrological data collection system. However, the Authority has not been very effective and is currently not operating (Rangeley et al, 1994, 9).

The World Bank. The World Bank has not been very active in the Niger Delta. Most of the Bank's work has been to improve the agriculture sector, including fisheries. No infrastructure or social sector (health, education, nutrition, and population) projects are being implemented

or proposed for Rivers and Delta States. For information on the **Escravos - Flared Gas Reduction Project**, refer to Chapter 2.

Third Multi-State Agricultural Development Project. The Third Multi-State Agricultural Development Project (MSADP III) includes a large number of programs for Rivers State, as well as Lagos, Ondo, and Oyo States, designed to improve agricultural and fisheries productivity. Specific components of the project involve:

- extension services emphasizing women farmers;
- improved smallholder farming technology for food and tree crops;
- soil and water conservation programs;
- enhanced food and tree crop seed production;
- alternative agroforestry systems;
- irrigated vegetable plots;
- pilot agroprocessing projects; and
- improved commercial farm services.

The direct agriculture components are complemented by road and waterway rehabilitation and maintenance. The construction and repair of about 2,400 wells, as well as maintenance training, will improve the water supply for communities in the four southern states.

As part of the fisheries segment of MSADP III, the Bank is supporting NIOMR and the Monitoring, Control and Surveillance Unit of the Federal Department of Fisheries to survey fisheries resources and utilization in Rivers, Ondo, and Lagos States. The project also supports private fish hatcheries and conducts adaptive research for freshwater and marine shrimp cultivation. Villages are benefiting from enhanced capture and processing technologies, especially engines, fishing gear, and repair facilities (1989). It is also planning to organize the distribution of fuel to inshore marine fishermen through a fuel distribution company. For selected areas, this program should greatly reduce both the time require to obtain fuel and its cost. The fuel distribution and fisheries research programs are planned to continue under the proposed Second National Agricultural Technology Project.

The United Nations Agencies. As well as the programs discussed in detail below the UN agencies fund family planning, onchocerciasis control, small industry development, and women in development projects.

NIR/C3 - Environment and Natural Resources Management. The UNDP recently approved a US$2.2 million grant for supporting environment and natural resource management in Nigeria. FEPA will be the executing agency and will implement the program along with relevant federal line ministries. Rivers and Delta State are expected to benefit from environmental management and environmental impact assessment training, as well as environmental education and public awareness initiatives.

RAF/92/G34 Water Pollution Control and Biodiversity Conservation in the Gulf of Guinea Large Marine Ecosystem. The United Nations, through UNIDO and the US NOAA, is preparing to implement a GEF project to control water pollution and conserve biodiversity along the West African coast from Guinea-Bissau to Gabon. Emphasizing the evaluation of regional pollution, the US$7.5 million coastal zone project will: (1) assess the health of the coastal region and improve the understanding of relevant ecosystems; (2) evaluate land-based sources of pollution and develop case studies to control them; and (3) integrate the work into national and regional environmental management strategies and policies. The outputs from the project will be national and regional in scope focusing on institutional strengthening, information gathering and management, and policy options, rather than the provision of equipment and infrastructure. The project will examine some of the issues discussed in this report, but with a much broader perspective.

NIR/88/011 Artisanal Fisheries Development Project. This UNDP project (US$534,000) attempts to improve the economic and living conditions in fishing communities in Rivers and Akwa Ibom States. In addition to preparing socio-economic studies of fishing villages, the project involves (1) strengthening institutions, (2) introducing improved processing methods, (3) establishing cage culture fishing, and (4) funding a credit line for artisanal fishermen. Performance evaluation reports noted that the project has been well implemented in its initial phases.

The European Union. The European Union has nearly completed a study of the Niger Delta called Flood Plain Lake Management of the Lower Niger Delta in Nigeria: Ecology, Stock Assessment, and Improvement of Exploitation (TS2-A-287-B). The aim of the project is to increase the understanding of aquatic ecology in the delta, but all activities are occuring on the northern fringe of the region. The study also assesses fisheries exploitation and production to develop a model for increased resource production (European Community, 1993). The project leader, Prof. Nwadiaro of the University of Port Harcourt, is conducting a socio-economic study of local communities. The European Union is funding the expansion of RISONPALM oil plantations into freshwater swamp forests. The EU has reduced its funding to RISONPALM because of community and NGO protests of the project. Four universities (Rivers State University of Science and Technology, the University of Port Harcourt, Edo State University, and the University of Lagos) are conducting coastal erosion research with EU support. The University of Calabar has an EU grant to study aquaculture and oil palm development.

International Fund for Agricultural Development (IFAD). IFAD is assisting the artisanal fisheries sector through providing fishing equipment, processing equipment, and credit. It also supports rural infrastructure development (Otobo, 1994).

***International Institute for Tropical Agriculture* (IITA).** IITA operates a research station at Onne for plantain and agroforestry development.

Bilateral Aid. NOAA and the Rivers State University of Science and Technology have a cooperative agreement on establishing a Seal Level Monitoring/Cooperative International GPS Network (CIGNET) Station in Port Harcourt as part of NOAA's global sea level rise monitoring program. USAID is implementing a small scale community development project in the Ogoni region (Hall, 1994).

The Dutch Ministry of Transport and Public Works and the Rivers State University of Science and Technology prepared a management plan proposal for the Niger Delta in 1990, but their work did not go beyond the initial document. The University of Science and Technology has close ties and training programs with the Delft University of Technology in the Netherlands.

ANNEX K
EDUCATION

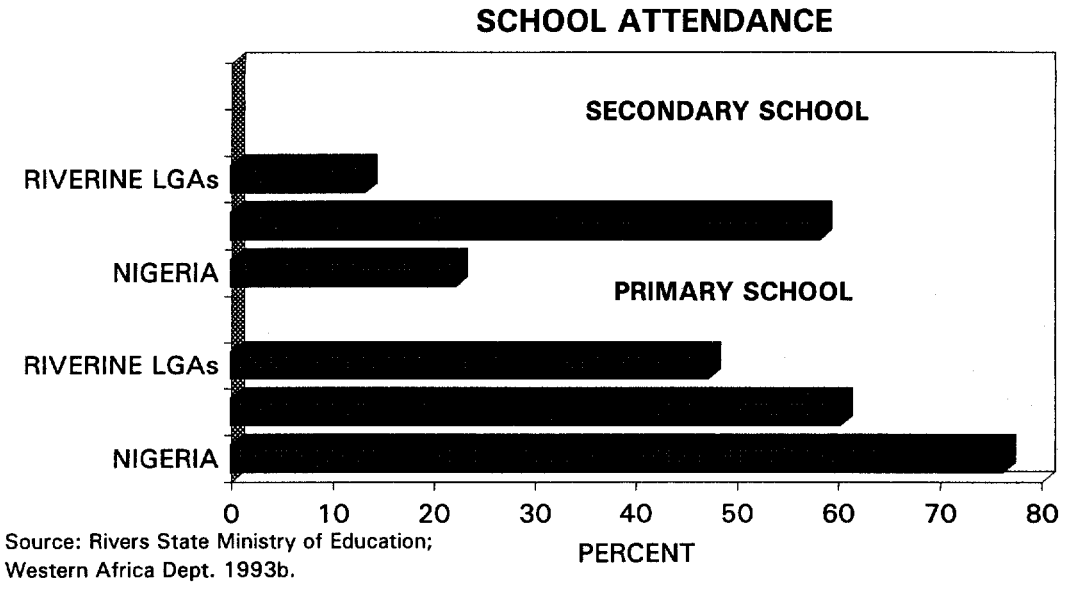
Education is critical for environmentally sustainable development in three different areas: (a) general environmental awareness, (b) basic education, and (c) specialized environmental training. As traditional resource management and knowledge bases are eroded, environmental awareness programs become increasingly important to ensure that communities recognize and attempt to practice activities that manage resources for long term use. Essential for personal and societal development, attaining basic education levels is also critical to be able to communicate environmental information. The final component of environmental education, specialized environmental training, is necessary to assess environmental issues and propose interventions to redress them.

General Environmental Awareness

General environmental awareness is low in most riverine communities. Traditional indigenous systems of knowledge and resource management have broken down in face of increased land pressure, poorly defined property rights, and outmigration of young adults to urban centers. Communication of more modern environmental concepts is not developed enough to support or replace the traditional knowledge. While policies exist for the Ministries of Health to teach basic sanitation practices, limited resources mean that actual work in the field is sporadic and relies on the individual initiative of local health care providers (Ministry of Health, Rivers State, 1994b). Neither the Rivers State Environment and Pollution Bureau or the Forestry Department allocate staff or resources to environmental education programs. Lack of funding also hampers the Bureau's plans to develop its proposed environmental awareness campaign, including a newsletter, radio and television programs, and workshops (Rivers SEPA, 1993, 33). Environmental education is not part of the public education curriculum (Esendu, 1994).

Basic Education

Basic education levels are low for both states, with particularly poor levels in Niger Delta LGAs (Figure 2). In the eight riverine LGAs of Rivers State, only 47 percent of school age children attended primary school compared with 60 percent for the entire state and 76 percent for the nation. The situation is even worse for secondary school, with an average of 13 percent of riverine children actually attending secondary school compared with 58 percent for the State as a whole and 22 percent for Nigeria (Ministry of Education, Rivers State, 1994, Table 1; Western Africa Department, 1993b, xx). In both Rivers and former Bendel states, education of women has lagged greatly behind that of men, but the gap is much smaller among current school children (Federal Office of Statistics, 1992).



Source: Rivers State Ministry of Education; Western Africa Dept. 1993b.

Figure 2

The Social Sectors Strategy Review noted that for southern Nigeria, only in the remote areas of the southeast (i.e., the riverine areas) did qualified teachers appear to be in short supply (1993, 88). Riverine communities also suffer because many of them are too small to support the minimum number of students necessary to establish a public school and transportation to schools in larger communities is either too slow or too expensive (Esendu, 1994). Obtaining an education is a major problem for children of migrant fishermen who move seasonally to different fishing grounds. This migratory lifestyle does not permit them to attend conventional schools. Estimated to number 200,000 in Rivers State, the State's population of children in school would jump by nearly 30 percent, if education programs could be tailored for them. However, nomadic education programs available in northern Nigeria have not been developed for these communities (Esendu, 1994).

Educational facilities have deteriorated in both States, mirroring declines in the rest of the country (Western Africa Department, 1993b, 83). For instance, while offering basic science courses, public secondary schools are not equipped with science laboratories. Library books are virtually non-existent (Esendu, 1994). The situation is equally poor in many primary schools. For example, some primary schools have doubled the number of teaching sessions per day while others cram as many as 90 students into classrooms designed for 35 (Osujih, 238).

As well as the lack of educational equipment and overcrowding, many schools are simply an unhealthy environment for children. One study found that of 108 schools surveyed in Rivers State, only 5 had adequate drainage and only 15 practiced satisfactory environmental sanitation. Thus, students are required to try to learn in not only a difficult, but also an unsanitary environment (Osujih, 239).

The low education levels reduce the efficacy of communicating environmental concerns and interventions. Widespread poverty and poor education make a dangerous mix, as people are forced to cast aside sustainable resource practices to ensure daily survival. Environmental awareness will only be possible if it is coordinated with basic education and poverty alleviation social sector programs.

Specialized Environmental Training

Rivers State has relatively strong environmental specialist programs at both the University of Science and Technology and the University of Port Harcourt. In addition to teaching and research, the faculty conduct extensive environmental impact assessment consulting primarily for the oil companies. Although environmental studies are still at an early stage in Delta State, the University of Benin in neighboring Edo State operates an environmental unit comparable to those in the Rivers State universities. At the universities, training is concentrated in environmental variations of traditional curriculums, such as biology, chemistry, and engineering, but has yet to be integrated into the social sciences. For example, environmental economics, natural resource policy, and industrial environmental management training are not yet available.

The combination of a decade of inadequate funding, expanding student populations, and faculty concentration on consulting work has greatly degraded the quality of training available to environmental specialists. Laboratory equipment goes unrepaired, subscriptions to scientific journals have lapsed, and faculty salaries are extremely low. As a result, graduating students are in general poorly prepared to become environmental professionals. These conditions also impair the quality of the environmental research and impact assessment studies conducted by the university environmental consulting units. Much of the research is theoretical, rather than applied to the priority environmental and social problems of the delta.

Private consulting firms typically composed of university based environmental experts compete with the university consulting units for oil company contracts. Experienced environmental professionals also work at the regional NGOs. Looking outside of the Niger Delta, Nigeria is fortunate to be relatively well endowed with environmental specialists in comparison with other West African countries.

ANNEX L
ESTIMATING THE HEALTH COSTS OF ENVIRONMENTAL DEGRADATION[29]

MORTALITY (PRODUCTIVITY LOSS)

The economic losses associated with premature deaths are assessed using a human capital approach. The human capital is estimated by the present value of future income, i.e., labor earnings or subsistence production that may have been generated had the individual not died prematurely. The high unemployment rate in Port Harcourt (30 percent) makes a human capital approach based only on wage earnings less meaningful.

The life expectancy in the delta is assumed to be 55 years.[30] It is assumed that income is generated between age 15 and 55. There are no statistics on income distribution to age class and gender. It is supposed that the average annual income is ₦30,000. This is based on the monthly wage rates listed in Table 21 and an additional supplement income (e.g., cultivation of crops for the market) that doubles or triples the labor earnings.

Table 21: Monthly Average Earnings in Port Harcourt[31]

Domestic help	500 - 1,000 ₦/month
Teacher	700 - 1,000 ₦/month
Driver	1,000 - 2,000 ₦/month
Typist	1,500 ₦/month
Full university professor (plus free accommodation)	6,000 ₦/month

The present value of lost income because of a premature death at age T, PV(T), is the discounted income flow (₦30,000/annually) from the T'th to the 55th year. The interest rate is a social discount rate (SDR) of 5 percent.

$$PV(T) = (1-e^{-r(55-T)})*r^{-1}*₦30.000 \qquad (T \geq 15)$$
$$PV(T) = PV(15)*e^{-r(15-T)} \qquad (T < 15)$$

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[29] Linddal, 1995.

[30] The World Development Report (1994) reports the average life expectancy in Nigeria to be 52 years. Eurostat (1989) reports the life expectancy at birth in Nigeria to be 52 for women and 48 for men in 1985. Local health authorities estimate the life expectancy to be 60 years in Rivers state and 53 years in Delta state. WDR, 1994: *Infrastructure for development - world development indicators*. World Development Report, Oxford University Press, 254 pp. Eurostat, 1989: Reports on ACP countries - Nigeria. *Eurostat*, Luxembourg, 101 pp.

[31] Prof. M. Isoun (pers.comm.)

The cost of a premature death is largest at age 15 (₦519,000) while it is four times lower at age 50 (₦132,600). If the premature death happens randomly at any age, the average cost is ₦358,200. This would reflect a higher rate of mortality in the older age-classes due to a larger proportion of younger age-classes.[32] The economic loss of an average premature death using a human capital approach is estimated to be ₦400,000.

The objectivity of the human capital approach for the valuation of a premature death is subject to extensive critique. A main reason for its use is that data requirements are substantially less than for willingness-to-pay assessments. The data input to the human capital approach makes the estimate a lower bound value. The costs of pain and suffering for the victim or family members are not included.

With a crude death rate of 14 per 1,000 and an estimated population in Rivers and Delta State of 7 million, it is assumed that there are 98,000 deaths annually in the two states. The health statistics from Delta State include 659 deaths in government hospitals in 1991, i.e., about 1.3 percent of the expected deaths in the state. The crude death rate in Nigeria dropped from 21 to 14 per 1,000 from 1970 to 1992. It is probably the result of the population trap with improvements in medical care that prolong life expectancy and lower infant mortality. Health education is also a cause for these improvements. With a birth rate of 43 per 1,000 and an infant mortality rate of 180 (under-5 mortality) per 1,000[33], about 54,000 of the deaths (or 55 percent of total no of deaths) are children under 5 years.[34] The high mortality rate among children could be a result of poor environmental standards.

Tuberculosis, bronchitis, asthma and hypertension accounted for 56 deaths (10 percent), etensis, typhoid and other diarrhoeal diseases account for 47 (7 percent), and malaria for 34 (5 percent). Major causes of reported deaths in Rivers state are diarrhoeal diseases (dysentery, cholera and typhoid) with 181 incidence. There are no figures for malaria or the total number of registered deaths. There is no evidence of the extent of pre-mature deaths, and how many of those are a result of environmental degradation.

Investments in sewerage systems and waste management is relevant in urban areas, i.e., Port Harcourt. Assume an investment in these facilities will result in a reduction of the diarrhoeal causes of death by 100 annually. Valued at ₦400,000, that is ₦40 million per year. Capitalized at 10 percent, it is a benefit totaling N4 billion. It is an absolute **minimum** value of the potential gain from saving 100 premature deaths.

The mortality in Mexico due to water contamination was estimated to be 32.8 per 100,000.[35] That equals about 300 deaths in Port Harcourt, or an estimated value of ₦120 million annually. Another gain is the reduced risk of epidemic diseases. An outbreak every decade

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[32]About 48 percent of the population in Nigeria was younger than 15 years in 1985 (Eurostat, 1989, op.cit.).

[33]The under-5 mortality rate is about 11 in high-income economies (WDR, 1994, op.cit..).

[34]The mortality rates and birth rate are specific for the whole of Nigeria (WDR, 1994, op.cit.).

[35]Margulis, 1992: *Back-of-the-envelope estimates of environmental damage costs in Mexico.* World Bank, Policy Research Working Papers, 29 pp.

causing 1,000 premature deaths is another ₦400 million each time. It is estimated that the gain from a reduction in premature mortality from a reduced water contamination is about ₦120 million annually. The concern for premature mortality induced by environmental pollution is not an attempt to assess the total costs of health damage, but only the cost that eventually can be avoided.

MORBIDITY

The cost of morbidity occurs from: (i) productivity loss, (ii) treatment costs, and (iii) pain and suffering. The productivity loss of morbidity can be assessed by the value of lost working days. With the figures from the human capital approach, the yearly income is ₦30,000 or about ₦100/day. Pain and other suffering are additional costs.

In addition to productivity loss of morbidity, there are costs from:

- Treatment costs and hospital facilities as a result from increased morbidity.
- Expenditures from avoiding risk of diseases, e.g., the use of bottled water and relocation cost.

An environmental impact with considerable health damages is traffic emissions. Health impacts from traffic emissions is mainly an issue in Port Harcourt. There has been **no** data retrieved on traffic loads, ambient pollution levels or consumption and composition (e.g., lead) of the fuel. If data had been available they would only have revealed what was going on before October (1994) when the recent increase in fuel prices occurred. Traffic in Port Harcourt is dense but the increase in the price of gasoline from ₦3 to ₦11 per liter has reduced traffic loads. Presumably the ambient pollution levels have dropped accordingly..[36]

[36]SEPA wish to initiate a monitoring programme to inventor ambient levels of air pollutants. An inventory of ambient pollution levels could be transformed into health impacts with dose-response models assessed locally.

An approach for assessing the impact of traffic emissions:

1. Assessment of car emissions (baseline):[37]

Number of vehicles	* average driving distance		=	vehicle km
1000 Vehicle km	*	0.07	=	kg particles (TSP)
-"-	*	0.042	=	kg SO_2
-"-	*	2.1	=	kg NO_X
-"-	*	0.11	=	kg lead/(gr. lead/liter)

Comparing the baseline case with projects having other levels of vehicle km yields the total change in emissions.

2. Conversion of the emissions to ambient pollution levels. This depends on the physical extent and size of the urban area and climatic conditions. No model was found applicable for the specific area.

3. Conversion of ambient pollution levels to health effects:[38]

Impacts from a change in the concentration of 10 mg/m^3:

	PM10	SO_2	Lead
premature mortality (% change)	0.96	0.48	-
premature mortality/100,000[39]	13.4	6.72	35.0
RRAD/person[40]	0.58	-	-
Respiratory symptom/adult	-	0.27	-
Hypertension/1,000 adults	-	-	7.3

4. The economic assessment of changes in health impacts.

There is no specific data for Port Harcourt, and an assessment of the economic gain from improving the air quality is not possible to estimate. Assume it was a target to reduce the ambient level of PM10 by 10 mg/m^3; [41] it is only the health improvement of reduced particle matter that is taken into account. It is a lower bound on the health benefits but double

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[37]According to: WHO, 1989: *Management and control of the environment.* 153 pp.

[38]From a survey of several studies by: Ostro, B., 1994: *Estimating health effects of air pollution - a methodology with an application to Jakarta.* 60 pp.

[39]Assuming a crude mortality rate of 0.014, i.e. (0.0096 * 0.014 * 100,000 = 13.4).

[40]RRAD: Respiratory related Restricted Activity Days.

[41]PM10 is converted to TSP by a factor of 1.82 (Ostro, op.cit.). The space for the ambient pollution in Port Harcourt is assumed to be 75 mio. m^3, i.e. the urban area is estimated at 5 km * 5 km and the urban pollution is up to 3 m above ground. The concentration of 1 mg/m^3 is thus equal to 1.37 kg TSP, or equivalent to the emission of 1,900 vehicle km. If the TSP contribute to the ambient pollution for one week the daily reduction in vehicle km must be 270.

counting from including other pollutants is avoided. The health effect is 134 avoided premature deaths (₦400,000 each, i.e., a total of ₦53.6 million) and 580,000 saved working days[42] (₦100 each, i.e., a total of ₦58 million), and the total benefit is ₦111.6 million annually. The estimation, although crude, reveals the magnitude of the potential health benefits. The method described here will enable an assessment of the benefits from various environmental control policies. An improvement in quality and coverage of data is essential.

[42]Two RRAD are assumed to cause the loss of one working day.

ANNEX M
OIL INFRASTRUCTURE SABOTAGE AND COMPENSATION PROGRAMS

Sabotage. Sabotage of oil company property is believed to be widespread, but it is often difficult to discern sabotage from equipment failure. One oil industry official estimated that sabotage accounted for 40 percent of spills. There are three major reasons for sabotage: (1) compensation for damage was inadequate, not paid, or did not reach the community; (2) individuals cut flow lines on their property to obtain compensation in excess of the cost of actual damage; (3) individuals disrupt production to force companies to provide amenities to their community (Ideagwuani, 1994).

In Table 22, oil spillage from Shell has been specified with respect to causes. It should be noted that even if sabotage is given much attention in discussions of spillage, it only accounts for approximately 14 percent of all incidents of spillage by number and 35 percent by volume. If these figures from Shell in Delta State are representative of all oil production in the Delta and Rivers State, generally speaking the causes for spillage are mainly due to the oil companies (Grevy, 1995).

Table 22: Oil Spillage. Causes and Volumes for Shell in Delta State, 1991-1994

	1994		1993		1992		1991	
	No.	Volume Barrels	No.	Volume Barrels	No.	Volume Barrels	No.	Volume Barrels
Corrosion of oil equipment	25	124	26	131	24	183	17	266
Failure with equipment	15	89	17	275	20	126	22	178
Sabotage	13	235	13	161	9	642	7	26
Other	20	65	16	50	19	269	23	233
Total	73	515	72	617	72	1220	69	705

Source: Shell Petroleum Development Company.

Under the current compensation system, communities are rewarded for sabotage. Since compensation is one of the few ways of directly benefiting from oil activities, communities have an incentive to cause spills. The federal government has attempted to reduce this incentive by increasing penalties for damaging oil equipment, including life sentences for sabotage, but they have not reduced the incidences of sabotage.

One solution to sabotage would be to give communities an incentive to keep the pipelines intact. The oil companies could allocate a fund paying a cash premium to villagers if a pipeline through their area is not sabotaged in a given period. The communities would benefit because the usual compensation does not cover the value of the destroyed crop. It should be possible to compete with the low compensation and income from employment when the avoided cost of a spillage to the oil company is included (Linddal, 1995, 69).

Compensation for Oil Activities. Under the federal constitution, energy companies must pay compensation for damaging buildings, crops, fish, and economic trees. However, compensation may not be paid to the affected community or individuals. Instead, other communities, disbursement agents, or powerful individuals may keep the compensation funds (Powell, 1995, 27). Examples of compensation rates for exploration activities are included in Table 23. Oil companies report that they typically pay considerably more than the official compensation rates (Achebe, 1994). Considering the market prices for these crops, the official compensation rates are very low. For example, yams grown in the delta produce yields between 1500-3000 kg/ha valued at ₦6,000 to ₦15,000 annually, compared with total compensation of ₦2,831 per ha (Ogbe, Egharevba, Bamidele, n.d., III, 31). The rates for the economic trees are equally unrealistic. A single ogbono tree annually produces fruit worth over double (₦30-₦50) the N18.50 compensation rate and is able to so for decades . The differential between the value of a mango tree and the compensation offered is large: ₦200-₦300 worth of fruit per tree annually compared with a compensation rate of ₦25 (Ogbe, Egharevba, Bamidele, n.d., III, 31). Compensation for lost fishing runs form ₦2 per m^2 for fin fish to ₦20 per m^2 for prawns (Gberesu in NEST, 73). Valuation studies from other areas of the world have consistently found mangroves to be worth considerably more than the ₦62 per ha (US$3) figure used for compensation (Table 24). An initial estimate of the value of mangrove products from the Niger Delta found that they are worth ₦3,200 or 50 times the compensation rate. Damage to freshwater and upland forests is paid at ₦1000 per ha, which does not reflect the real value of sustainable forestry or the ecological and social values of the forests (see Box 3). The compensation rates create a market failure because the opportunity cost of lost indigenous production is not included in the operational costs, such that oil companies consume excessive land and cause excessive environmental damage.

Box 3
Compensation Rates and the Value of Forest Land

The oil producers pay about ₦1,000/ha in compensation for damaging forest land in Delta State. Using an estimated annual land rent of forest land of ₦5,000/ha from a sustainable forest management and production of NTFP (Chapter 2), the price should at least be ₦50,000 (land value at 10 percent) or 50 times larger. A larger price could result in more efficient use of forest land and reduce the environmental impact of oil activities, but more importantly compensate local communities for the loss of forest products.

Linddal, 1995.

The compensation rates do not include long term, non-market goods, or off-site effects. For example, only crops from a single year are considered for compensation. Similarly, long term ecological changes including vegetation changes from dredging and mangrove destruction are not covered. The program also neglects to include indirect economic impacts, like the disruption of breeding grounds for marine fish. Compounding dissatisfaction with the low rates are numerous village level problems. Reports of incomplete damage assessments and compensation not being paid to the damaged parties are widespread (Isoun,M., 1994).

The current compensation programs aggravate community relations and reinforce the perception that oil activities cause most of the problems of the delta. Riverine people feel that the oil companies do not consider themselves accountable to the local people. Resentment of their marginalization in contrast to the value of the oil reserves has resulted in clashes with oil company personnel and federal police/military forces.

Table 23: Compensation Rates In Oil Exploration Areas

Common Crops	Rate Per Ha (₦)	Common Trees	Rate Per Tree (₦)
Rice	1375	Mango	25
Beans	290	Banana	2.50
Yams	835	Plantain	2.50
Cocoyams	625	Oil palm	12.50
Cassava	000	Ogbono	18.75
Most vegetables	625	Timber hardwoods	50
Bitter Leaf	63	Mangroves	62/ha

Source: Gberesu in NEST

Table 24: Mangrove Valuation Studies

Resources Valued	Location	Value (US$/ha/year)
Complete Mangrove Ecosystem		
	Tanzania (1991)	300-600
	Trinidad (1974)	500
	Fiji (1976)	950-1,250
	Fiji (1990)	3,000
	Puerto Rico (1973)	1,550
Traditional Hunting, Gathering and Fishing		
	Indonesia (1992)	33
Forestry Products		
	Trinidad (1974)	70
	Indonesia (1978) - charcoal and chips	10-20
	Malaysia (1980)	25
	Thailand (1982)	30-400
	Indonesia (1992)	67
Fisheries		
	Thailand (1982)	230-2,100
	Indonesia (1978)	50
	Fiji (1976)	640
Nigeria		
Compensation Rates for Mangrove Damage from Oil Activities	Niger Delta	2.80 (₦62)
Mangrove Fisheries and NTFPs Estimate	Niger Delta	150 (₦3,200)

Sources: Dixon and Lal, 1993; Lal, 1990; MTNRE in Western Africa Department 1994a , 1994; adapted from Ruitenbeek, 1992; Linddal, 1995. See mangrove section for basis of Niger Delta mangrove value estimate.

ANNEX N
INTRODUCTION TO INTEGRATED COASTAL ZONE MANAGEMENT

The principal concerns of an integrated coastal zone management (ICZM) strategy are: (1) developing sound institutional and legal frameworks, (2) focusing on environmental planning and management, (3) coordinating the activities of the major institutions in the region such that they work together towards the common objective of long term development, (4) stressing stakeholder participation and ownership. Sectoral planning and management remains essential, but should operate within the general framework of ICZM. The complexity of coastal activities requires an understanding of the concerns and aspirations of all major stakeholders gained through their involvement throughout the planning and implementation of the coastal management program.

An important motive for improving the management of coastal resources throughout the world is the realization that it is becoming increasingly difficult to manage any one particular coastal natural resource or enhance one economic sector in the absence of a comprehensive, integrated, framework for policy planning and management. In many countries, ICZM has proved to be an effective framework for dealing with conflicts from interactions of the various uses of coastal areas.

The Niger Delta could greatly benefit from an integrated management plan which addresses its priority environmental problems - problems that ICZM plans have mitigated in other regions of the world (Table 25).

Table 25: Benefits of ICZM for Environmental Problems in the Niger Delta

Environmental Problem	Benefit of ICZM
• Fisheries Depletion • Deforestation • Agricultural Land Degradation	⇒ Facilitating sustainable economic growth based on natural resources
• Biodiversity Loss • Deforestation • Expansion of Water Hyacinth	⇒ Conserving natural habitats and species
• Water Contamination by Sewage • Vehicular Emissions • Municipal Solid Wastes • Industrial Pollution (including toxic and hazardous substances)	⇒ Controlling pollution and shoreland alterations
• Flooding • Erosion	⇒ Controlling watershed activities which adversely affect coastal zones
• Oil pollution • Deforestation	⇒ Managing excavation, mining, and other alteration of the environment and important habitats

Governments worldwide are recognizing the critical role integrated coastal management can play in their national development. In addition to developed country ICZM programs, many developing countries, particularly in Asia and Latin America, have initiated or implemented ICZM or conceptually similar river basin management programs (ICZM: Malaysia, the Philippines, Sri Lanka, Costa Rica, Brazil, South Africa, Tanzania, and Kenya; River Basin Management: Mekong, Ganges, Indus, and Nile Rivers) and many more are preparing to do so. The initiation of ICZM is usually in response to a crisis, a perceived use conflict, a severe decline of a resource, or increasing destruction from natural phenomena. In the Niger Delta, conflicts over resource rights and use, particularly associated with oil activities, as well as fisheries productivity declines and pollution, have led to calls for improved management of coastal resources - a primary objective of ICZM. Worldwide, fisheries and aquaculture productivity, increased tourism revenues, reduced coastal pollution, sustainable mangrove forestry, and security from natural hazard devastation are some of the most common arguments for implementing a ICZM strategy.

Key Principles of Integrated Coastal Zone Management

Generally accepted ICZM principles which have formed the conceptual basis for successful programs throughout the world include (Environment Department, 1993, 7):

- ICZM employs a holistic, multisectoral perspective which recognizes the interconnections between coastal systems and uses.

- ICZM harmonizes policies and legislation across sectors so that the overall objectives of coastal development and management are advanced across sectors.

- ICZM maintains a balance between protection of valuable ecosystems and development of coast-dependent economies. It determines priorities for uses, taking into account the need to minimize the impact on the environment.

- ICZM is proactive (stressing planning and impact assessment) rather than reactive.

- ICZM is an analytical process which advises governments on priorities, trade-offs, problems, and solutions.

- ICZM is a dynamic and continuous process which responds to changing values and new information.

- ICZM emphasizes participation and ownership of the process and strategy by all relevant stakeholders.

- ICZM provides mechanisms for reducing and resolving resource conflicts and equitably distributing benefits to stakeholders.

- ICZM promotes awareness at all levels of government and community about the concepts of sustainable development and the importance of environmental protection.
-
- ICZM also follows several general principles important to sustainable development:

    - the precautionary approach;
    - the polluter pays principle;
    - full cost resource accounting;
    - the trans-boundary responsibility principle; and
    - the principle of intergenerational equity;

ANNEX O
LAND USE ZONING

Land use zoning is discussed as a strategic option for addressing many of the environmental problems in the Region because it is a strong tool for directing human activities to appropriate locations. To be effective, land use zoning must take a holistic view of the region's the enclave approach which has characterized land use zoning and planning in Africa (Mabogunje, 1992, 34). It requires cross-sectoral coordination, extensive community participation, and enforcement. Land use zoning is particularly well suited to the limited information base available for the delta because it can include a precautionary approach that reduces the risk of unintended problems from development. Zoning has the potential to be very effective in decreasing the economic and social costs of developing hazardous areas prone to flooding and erosion. In urban areas, it is also an excellent tool for concentrating industrial growth and associated pollution away from residential areas. Land use zoning regulations for the delta should build on the existing Town and Country Planning laws and environmental regulations. The land use zoning process must include environmental and sociological surveys to ensure that zoning decisions make the best use of land resources and account for local uses, aspirations, and concerns. Land use zoning should make extensive use of spatial information analysis and utilize geographic information systems. It should be implemented in a proactive, rather than reactive fashion which focuses on directing future development to suitable areas. Land use zoning should also be coupled with an incentive structure to promote decision making that explicitly or implicitly considers the environmental and social impacts of development. Clearly, land use and environmental information systems are absolutely critical for understanding the implications of different types of zoning on private development, communities, and ecosystems.

ANNEX TABLES AND BOXES

Table A.1: Land Use in Rivers State

Land Classification	Area (ha)	% of State
Forest, swamp	589,060	33.3
Forest, riparian	13,593	0.8
Forest, oil palm	96,406	5.5
Forest, raffia palm	4,688	0.3
Forest, mosaic - oil palm/swamp	104,209	5.9
Mangroves	43,596	30.7
Farmland, over 60% intensity	232,030	13.1
Farmland, mosaic - farmland/oil palm forest	46,875	2.7
Plantations, crops	9,064	0.5
Surface Water	124,376	7.1
Built up areas	4,688	0.3
Total	**1,768,751**	**100**
Total forest reserve area within state	135,949	7.7

Source: Rivers State Department of Forestry.

Box A.1
Water Supply Issues

Water availability is a concern in many African countries as growing populations increase demand for water and watershed degradation decreases its supply. While both of these conditions are affecting water supply in the Niger Delta, water availability problems are not currently significant enough on a regional level to warrant short or medium term interventions. However, in coastal and urban areas, the issue is becoming more important. The environmental impacts of reduced water supplies will probably be minimal given the abundance of water in the area and the wetland characteristics of the region. The major concern is habitat modification and resulting biodiversity and fresh water forest losses. Examples of salt water intrusion causing mangrove encroachment into fresh water forest systems are evident in small areas of the delta. The human health impacts are more significant because reduced water supply is a major cause of disease in developing countries. From an economic perspective, reduced water availability increases provision costs for domestic consumption and can reduce rural income. For example, a public hand pump program upstream in Imo State reduced the median time for water collection from 6 hours to less than 45 minutes per day (wdr, 1993, 93). The loss of fresh water forest to mangrove encroachment is reported to have reduced community income levels in Okoroba, Rivers State.

Currently, the direct causes of surface water reductions are over-use, salt water intrusion, and seasonal variation. With increasing rice production, over-use will become a more important issue in the future. Seasonal variation is exacerbated by Kainji dam which has greatly modified the natural hydrological regime of the delta. In addition to upstream dams, several other indirect causes of surface water supply reductions, such as population pressure, open access, and lack of water pricing, may lead to future surface water supply problems. Over-abstraction and salt water intrusion are the direct causes of ground water depletion. While not currently a large scale issue, ground water depletion is expected to impact urban and coastal communities as domestic and industrial extraction increases. The principal indirect causes of groundwater depletion are open access and lack of water pricing.

Table A.2: Cost and Benefits of Increased Frequency of Flooding

Benefits:	
Direct benefits:	- Increased productivity (fish ponds and farming).
Indirect benefits:	- Potentially less erosion impact.
	- Reduced salt water intrusion.
Costs:	
Direct costs:	- Flooding of communities, including destruction of houses, polluted water sources (defensive expenditures).
Indirect costs:	- Waterborne diseases.
Opportunity cost:	- Seasonal opening of the dams.
	- Sediment by-pass at the reservoirs.

The direct cost from the loss of houses due to flooding can be estimated. The reconstruction of a mud house will cost about 50,000 N and a new house of better quality costs on average 250,000 N.[1] Even if a mud house is lost, it would be worthwhile compensating for that loss with a better quality home. This would improve the quality of life for the community as a whole. More flooding resulting in, for example, an increase in the fishery in the delta of 1 percent (10,000 tons) valued at 50 N/kg, could finance the relocation of about 2,000 new houses annually to outside of the flood zone.

Source: Linddal, 1995.

[1] Dr. Ayayi, Zonal head, FEPA (pers.comm.).

Box A.2
Intensification and Plantations - Issues for Forest Conservation

Agricultural intensification is often strongly endorsed as a method for reducing conversion pressure on unmanaged forests. However, this assumption is not always correct. In the case of agricultural products with highly elastic demand (e.g., export crops) and intensification benefits available to all land types, intensification increases the profitability of farming on all land. As a result, agriculture would expand into forested areas. Only if demand for the agricultural product is inelastic (e.g., subsistence farming) will agricultural improvements lead to reduced pressure on forests since the same farming area will produce more food. However, increased subsistence productivity could lead producers to switch to cash crop agriculture, with its higher demand elasticity and incentives to expand into forested areas.

This concept holds for the introduction of timber and tree crop plantations. If demand is extremely elastic, plantations will reduce the area of natural forest because they increase the number of competing land uses. Alternatively, if the plantation products are used for subsistence (fuelwood, canoe construction, etc.), such that demand is inelastic, increased supply of plantation products will reduce the pressure on unmanaged forests.

In actual agriculture and plantation situations, demand will not be completely elastic or inelastic, so must be assessed for each case. However, it is dangerous to assume that either option will axiomatically reduce conversion pressures on forests.

von Amsberg, 1994.

Table A.3: Catch and Catch Per Effort of Inshore Fish and Shrimp Trawlers
(1980 to 1990)

Year	Catch (MT)	Number of Trawlers	Catch/Effort (MT)
1980	13,631	80	170.38
1981	9,611	81	118.65
1982	18,861	86	219.31
1983	19,245	120	160.33
1984	25,650	133	192.85
1985	26,142	163	160.38
1986	25,042	250	11.16
1987	24,910	252	98.80
1988	35,608	372	95.72
1989	33,645	440	76.46
1990	25,539	317	80.56

Source: Federal Department of Fisheries, 1990.

Table A.4: The Potential Maximum Sustainable Yield (MSY) in Metric Tons

Marine and brackish water fisheries	190,000
Inshore demersal stocks	16,620
Prawns	3,500
Tuna (offshore fisheries)	10,000
Other offshore fisheries	21,000
TOTAL	**241,120**

Source: Tobor, 1991.

Table A.5: Official Catch Statistics and an Index of Fishing Effort for the Niger Delta

Year	Nigeria - Harvest (Industrial & Artisanal)	Rivers State Harvest (Artisanal)	Rivers State Fishers	Rivers State Index	Bendel State Harvest (Artisanal)	Bendel State Fishers	Bendel State Index
1980	476,189	86,521			53,769		
1981	491,394	90,322			76,420		
1982	516,071	107,469	61,584	1.75	87,010	49,859	1.75
1983	542,496	90,890	46,446	1.88	75,677	40,337	1.88
1984	384,653	40,850	18,040	1.69	70,045	41,513	1.69
1985	227,525	27,206	27,900	0.98	40,177	41,202	0.98
1986	292,178	18,565	55,828	0.33	55,382	40,034	1.38
1987	273,887	16,469	58,081	0.28	43,287	41,012	1.06
1988	334,173	39,449	58,371	0.58	52,887	41,061	1.29
1989	337,099	42,334	60,706	0.70	53,686	42,703	1.26
1990	309,032						
1991	327,482						
1992	323,272						
1993	169,247						

Note: Fishers is the number of 1:1 full-time and 4:1 part-time fishers. The index does not account for an increased use of engines or more efficient fishing equipment.
Source: Federal Department of Fisheries, 1994.

Table A.6: The Price in Port Harcourt and the Capture in Rivers State for Eight Species

Species:	Price N/kg	Capture tons
Croaker (*Pseudotolithus spp.*)	100	227
Catfish (*Arius spp.*)	150	253
Grunt (*Pomadasuys spp.*)	100	182
Ray (*Raja spp.*)	100	-
Sole (*Cynoglossus spp.*)	100	-
Mullet (*Mugli spp.*)	90	233
Tilapia (*Sarotherodon spp.*)	70	272
Bonga (*Ethmalosa spp.*)	70	324

Note: Price and capture as at September 1994. These species account for about 25 percent of the total catch in Rivers State according to ADP statistics, and the weighted price is 95 N/kg. This price is seasonal and at the highest seasonal level now (October). The prices for fish have increased about 5 times compared with the same seasonal price last year in both Port Harcourt and Asaba.
Source: ADP in Port Harcourt.

Table A.7: Constituted and Proposed Forest Reserves

Name of Reserve	Status	Area (ha)
Upper Orashi	Constituted	9,696
Nun River	Constituted	9,848
Lower Orashi	Constituted	4,375
Apoi Creek	Surveyed/Proposed	6,094
Egbedi Creek	Proposed	6,094
Sombreiro	Proposed	13,756
Ikebiri Creek	Proposed	19,531
Otamiri	Proposed	16,719
Okoroda	Proposed	9,531
Taylor Creek	Proposed	21,863
Lower Imo	Proposed	4,036
Upper Imo	Proposed	10,782
Total Forest Reserves		**132,645**
Andoni Game Reserve	Proposed	12,400
Total Game Reserves		**12,400**
Sombreiro Mangrove Reserve	Proposed	52,000
Brass River Mangrove Reserve	Proposed	42,000
Pennington River Mangrove Reserve	Proposed	37,925
Total Mangrove Reserves		**131,925**
Rivers State:		
Total Proposed Reserve System		**276,970**
Delta State:		
Total Proposed Reserve System		**87,676**

Sources: Rivers State Department of Forestry; Delta State Ministry of Agriculture.

Table A.8: Rivers State Area Measurement of Land Use within Forest Reserves

Classification	Area (ha)	%
Forest, swamp	78,447	57.7
Forest, riparian	15,001	11.0
Forest, oil palm	12,344	9.1
Forest, rafia palm	2,188	1.6
Forest, mosaic	3,750	2.8
Mangroves	9,062	6.8
Farmland, over 60% intensity	11,875	8.7
Crop Plantations	3,282	2.4
TOTAL	**135,949**	**100**

Source: Rivers State Forestry Department

Table A.9: Conservation Status of Selected Fauna in the Niger Delta

Species	Status			Suspected Distribution or Location
	World	Nigeria	Niger Delta	
Angwantibo	V	?	C/V	Rivers State, forest
Red-capped Mangabey	V	-	V	Swamp forests & mangrove.
White-throated Guenon	E	E	C	Central & West Delta forests.
Sclater's Guenon	E	?	V	Eastern Delta forests.
Delta Red Colobus	E/V	Ex	E	South-central Delta forests.
Olive Colobus	V	?	V	Swamp forest, northern sector.
Chimpanzee	V/E	E	E	Ogibia; Kpakiama; Barrier Islands?
Long-tailed Pangolin	-	-	V	Flood forest.
Brushtailed Porcupine	-	I	C	Forest.
Cape Clawless Otter	-	I	C	Remote swamps & waterways, mangrove.
Spotted-necked Otter	-	I	C	Remote swamps & waterways, mangrove.
Crested Genet	E	-	?	Swamp forest,?mangrove.
Long-nosed Mongoose	-	-	?	Forest.
Serval	-	I	Ex?	<Sapele: Happold, 1987>
Leopard	-	I	E	Marsh & coastal forests.
Manatee	V	I	V	Brackish & freshwater channels.
African Elephant	V	I	E	Andoni; Odoni-Odi area.
Heslop's Pygmy Hippo	Ex	-	E/Ex	?Upper Orashi FR; ?Orua-Tongbo sector.
Hippopotamus	-	-	E	Andoni Island, Finima (Bonny).
Water Chevrotain	-	I	V/E	Freshwater swamp forest.
Sitatunga	-	E	C	Freshwater swamp forest, mangrove.
Maxwell's Duiker	-	V/I	A	Forest generally (excl. mangrove).
Black Duiker	-	V	?	?Kwale area (Anadu & Oates, 1982).
Yellow-backed Duiker	-	E	?	Lowland forest.
Black-fronted Duiker	-	-	C	Freshwater marsh forest.
Ogilby's Duiker	V	I	E	East-of-Niger lowland forest.
Bates' Dwarf Antelope	-	E	V or E	East-of-Niger lowland forest.
Dwarf Crocodile	-	I	C	Swamp forests.
Slender-snout Croc.	V	?	?	Creeks & lakes.
Nile Croc.	-	I	V	Rivers & lakes.
Royal Python	-	I	?	
Rock Python	-	I	?	

A = abundant; C = common; V = vulnerable; E = endangered; Ex = extinct; I = indeterminate.

Source: World Status from IUCN 1994 Red List of Threatened Animals; Nigerian Status from WCMC (1988), Nigeria. Conservation of Biological Diversity. Niger Delta Status from Powell (1993) and Niger Delta Watlands Centre (1995).

Table A.10.a: Oil, Water and Gas Production by The Shell Petroleum Development Company of Nigeria (East), Port Harcourt, Rivers State

Year	Oil production[2] million m^3/year	Water production million m^3/year	Water content % of oil production	Flared gas[3] million m^3/year	Utilised gas million m^3/year	Oil produced/water/flared gas $m^3/m^3/m^3$
1991	33.7	8.6	25.5	7,072	1,248	1 / 0.34 / 282
1992	35.6	8.9	25.0	7,439	1,014	1 / 0.33 / 279
1993	36.1	8.9	24.6	7,139	1,417	1 / 0.33 / 262
1994	31.2[4]	7.8	25.0	6,217	1,012	1 / 0.33 / 266
Average	34,2	8.6	25.0	6,967	1,172	1 / 0.33 / 272

Table A.10.b: Oil, Water and Gas Production by The Shell Petroleum Development Company of Nigeria (West), Warri, Delta State

Year	Oil production million m^3/year	Water production million m^3/year	Water content % of oil production	Flared gas million m^3/year	Utilised gas million m^3/year	Oil produced/water/flared gas $m^3/m^3/m^3$
1991	47.1	20.9	44.3	-	-	-
1992	44.6	18.6	41.7	-	-	-
1993	42.8	17.5	40.9	3,728	463	1 / 0.69 / 147
1994	40.5	16.9	41.7	3,925	257	1 / 0.71 / 166
Average	43.8	18.5	42.2	3,826	360	1 / 0.70 / 156

Source: Shell Petroleum Development Company.

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2 Includes both oil and water.

3 Flared gas is not the same as associated gas. Some associated gas is utilised by consumers. A minor part of associated gas is reinjected.

4 Calculated from production figures representing the period January - October.

Table A.11: Average Concentrations and Total Amounts of Oil in Discharged Production Water

	Bonny Terminal, Rivers State		Forcados Terminal, Delta State		Ughelli separation station	
Year	Outlet concentrations ppm	Oil discharged tons/year	Outlet concentrations ppm	Oil discharged tons/year	Outlet concentrations ppm	Oil discharged tons/year
1991	8.6	74	17.8	372	32.9	-
1992	8.1	72	17.1	318	83.6	-
1993	5.7	51	16.0	280	25.3	-
1994	8.7	68	11.1	187	16.1	-
Average	7.8	66	15.5	289	39.5	-
Total amount of oil discharged by Shell in Rivers and Delta State: 355 tons/year						
Total amount of oil discharged by all companies in Rivers and Delta State: 710 tons/year						

Source: Shell Petroleum Development Company.

Box A.3
Experiments to Study the Effects of Oil Pollution in Mangrove Vegetation

La & Feng (1984) reported on field experiments that showed that relatively large concentrations of fresh crude oil were needed to cause significant mortality in mangroves. Young mangroves, shorter than 180 cm, were more susceptible while larger plants could survive long exposures to high concentrations. Most of the seedlings survived the impact of oil as long as their leaf surfaces were not 100% oiled.

Getter et al. (1989) reported on experiments with different oils and oil dispersant combinations and their effects on different species of mangroves. The study shows that lighter oils (diesel and oil, light crude) are relatively more toxic to seedlings of mangroves. Bunker oil and heavy crude were relatively non-toxic. The studies showed that red mangroves (*Rhizophora*) was less sensitive to oil contamination than white mangroves (*Avicennia*). The study also showed that certain stocks of mangroves are less sensitive to oil contamination than others.

McGuinness (1990) studied short- and long-term effects of oil spills on molluscs and crustaceans in mangrove forests. Mortality of some species was noted but densities reached control levels within a few weeks. Sampling of areas previously affected by spills also provided little, if any, evidence of long-term effects. There were few residual effects of the oil; recolonization occurred rapidly, depending on size of the patch affected and the rate of recruitment from plankton.

Grant et al. (1993) studied the effects of weathered Baee Strait (Australia) crude oil (2 l/m2) on mangrove seedling survival. 96.4% of the seedlings died within 14 days.

Table A.12: Oil Spillage in Delta and Rivers State, 1991-1994

DELTA STATE				
	All Companies[5]		Shell[6]	
	No. of Spills	Quantity Spilled Barrels	No. of Spills	Quantity Spilled Barrels
1991	78	950	50	705
1992	129	12,232	55	1,220
1993	116	909	58	617
1994	-	-	59	515
Total	323	14,091	222	3,057
Average/year	107	4,697	56	764
Average m^3/year		746		
RIVERS STATE				
	All Companies		Shell[7]	
	No. of Spills	Quantity Spilled Barrels	No. of Spills	Quantity Spilled Barrels
1991	98	5,103	86	4,214
1992	223	21,480	143	1,390
1993	232	8,101	248	3,251
1994	-	-	203	18,527
Total	552	29,679	680	27,382
Average/year	184	9,893	170	6,845
Average m^3/year		1,571		

[5] According to NNPC

[6] According to Shell (West)

[7] According to Shell (East)

Table A.13: Impact of Oil in Mangroves

Site of Spill & Date	Quantity & Type of Oil	Impact on Mangroves	Source
Tarut Bay, Saudi Arabia, pipeline break, 1970	100,000 barrels Arabian crude	Defoliation but many survived	Spooner (1970)
Pacific coast of Colombia (S.A) near Tumaco, spill from tanker *Saint Peter*, 1976	243,000 barrels, crude oil	Partial defoliation but recovery in one year. Barnacles and bivalves affected during the acute phase but recolonized within one year.	Jernelov & Linden (1976)
Cabo Rojo, Puerto Rico, spill from tanker *Zoe Colocotroni*, 1973.	37,000 barrels, Venezuelan crude.	Death of adult trees (red and black) over 1.0-2.7 ha within 3 years.	Nadeua & Bergquist 1977, Lewis 1979.
Florida Keys, USA, spill from ship *Grabis*, 1975	1,500-3,000 barrels, crude oil and water emulsion	Death of young red mangrove and some dwarf black mangroves.	Chan (1977)
Indonesia, spill from tanker *Showa Maru*, 1975.	54,000 barrels, Arabian crude.	Some dead trees (both species), unquantified; areas of greatest impact in sheltered bays; low numbers of crabs and snails in oiled sediments.	Baker (1981), Baker et al. (1981).
Corpus Christi, Texas, pipeline rupture, 1976.	377 barrels, crude oil.	Mangrove burned to remove oil. Uncleaned mangroves recovered after minor defoliation.	Holt et al. (1978).
Guayanilla Bay, Puerto Rico, spill from unknown vessel, 1977.	1,000 barrels, Venezuelan crude.	Damage to the root and trunk community, trees survived.	Lopez (1978).
St. Croix, US Virgin Islands, spill from tanker *Santa Agusta*, 1971.	12,500 tons crude oil.	5 ha completely destroyed, little or no recolonization after 7 years.	Lewis (1979 a), Lewis & Haines (1980).
Puerto Rico, spill from barge *Peck Slip*, 1978.	440-466,000 gallons, Bunker C.	Significantly affected mangroves, crab, snail and epiphyte populations.	Gundlach et al. (1979), Getter et al. (1981).
Tampa, Fla. spill from tanker *Howard Star*, 1978	40,000 gallons, 20% diesel, 80% Bunker C.	Mortality in three species of mangroves, death of mollusks and polychaetes, root abnormalities.	Lewis (1980a,b), Grundlach et al (1979), Getter et al. (1980.1981).

Site of Spill & Date	Quantity & Type of Oil	Impact on Mangroves	Source
Bahia de Campeche, Mexican Gulf, blow-out from offshore platform *Ixtoc 1*, 1979-1980.	475,000-1,600,000 tons crude oil.	No long-term impact on mangroves or the associated fauna and flora exposed to weathered crude.	Jernelov & Linden (1981).
Makupa Creek, Mombasa, Kenya, spill from ruptured tank on land, 1989.	1,000-1,500 tons of fuel oil	Some defoliation and death to mangroves over 10ha. No recovery after 3 years.	Hedrenius & Linden (1989).
Persian Gulf, Kuwait & Saudi Arabia, spills from tankers and ruptured pipelines, 1991.	Very large, but unknown quantities, mostly crude oil.	Heavily oiled during the acute phase, but most of the trees survived.	Linden & Jernelov (1991).
Northern Red Sea, spills from oil fields and tankers, 1982 and 1983.	Repeated spills, mostly crude oil	Moderate effects. Some defoliation from acute oiling. Trees normally survive.	Dicks (1986).

Source: Modified from Baker (1981) and Lewis (1983).

Table A.14: Manufacturing Industries in Port Harcourt Area

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
1	0000	Eastern Enamel Factory Ltd.	Enamelware	82	86 tons	Produced enamel 5 tons[8]
2	2200	The Shell Petroleum Development Company of Nigeria (East)	Crude petroleum and natural gas. Headquarters, East	8,000	-	Production in the delta. See oil production
3	2200	Ashland	Crude petroleum and natural gas. Headquarters	32	-	Production in the delta. See oil production
4	2200	Agip Oil and other companies	Crude petroleum and natural gas. Headquarters		-	Production in the delta. See oil production
5	3114	Coastline Fishing Company	Shrimp processing	32	400 tons	
6	3114	Frozen Foods Nig. Ltd.	Fish and chicken processing	14	700 tons	
7	3114	Ibru Sea Foods Nig. Ltd.	Shrimps and fish processing	72	7,000 tons	
8	3114	M/S Globe Fishing Ltd.	Fish processing	32	5,000 tons	
9	3114	S.K.S. Foods Nig. Ltd.	Fish processing	30	4,120 tons	
10	3115	Rivers State Vegetable Oil Company	Palm kernel oil, palm kernel extractions/pell	400	24,300 tons	[8]

[8] Indicates Member of: Manufacturers Association of Nigeria, Rivers State Branch.

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
		(Rivoc) Ltd.	ets, soya beans oil, soap			
11	3115	Everlast Ind. Nig. Ltd.	Palm kernel oil, cake and allied products	-	12,000 tons	[8]
12	3115	General Agro Oil Industry, Ltd	Edible vegetable oil, palm kernel pellets	161	7,000 tons	[8]
13	3115	Nalin Industry Nig. Plc.	Edible oil and fats	-	-	[8]
14	3116	Port Harcourt Flour Mills Ltd	Flour, semolina, palletized wheat bran	197	120,000 tons	[8]
15	3117	Rivers State Biscuit Company Ltd.	Biscuits	49	5,000 tons	
16	3121	Nigerian Caterers and Supermarkets	Food processing	389	-	Prepared dinners assumed 5,000 tons
17	3133	Pabod Breweries	Beer	100	39,600 m^3	Old plant
18	3134	Nigeria Bottling Company Plc.	Coca cola soft drinks	310	80,000 m^3	[9]
19	3210	Major Gloves production Co. Ltd.	Industrial cotton gloves	-	-	[9]
20	3210	Horizon Fibres Nig. Plc.	Yarn, texturized and twisted	-	-	[9]
21		Technoshoes	Shoe soles and	-	-	[9]

[9] Indicates Member of: Manufacturers' Association of Nigeria, Rivers State Branch.

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
		Co. Nig. Ltd.	all foot wear components			
22	3320	Metal and Wood Furniture Ltd.	Furniture	150	4,800 tons	Processing
23	3320	CFC Furniture Coy Est. Ltd.	Furniture			Processing9
24	3320	Scano (Nig) Ent. Ltd.	Furniture	-	-	Processing9
25	3411	Femina Hygienical Products Nig. Ltd	Paper toiletries, Sanitary napkin/ baby diapers, toilet rolls	141	145 tons	Kraft coarse paper9
26	3411	Cicopacks Limited	Industrial paper cartons			9
27	3420	Sunray Publications Limited	Daily and weekly newspapers, books, calendars	-	-	9
28	3420	Apex Mills (EN) Ltd.	Note books	42	48 tons	4,800 cartons, estimated 10 kg/carton9
29	3512	National Fertilizer Company of Nigeria (NAFCON)	Fertilizer production	2,500	Urea: 493,000 Ammonia: 342,000 NPK: 277,000	Outside Port Harcourt9
30	3513	Solor Manufactors Ltd	Plastic film, polymers	-	-	
31	3513	Metal &	Plastic wares,	-	-	9

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
		Plastic Production Ltd.	polybags			
32	3513	Polo Packaging Ltd.	Polypropylene bags, packaging material	-	120,000 tons	9
33	3513	Nikko Industries Nig. Ltd.	Nylon fishnets and trawl nets	-	-	9
34	3513	Stretch Fibers Nigeria Ltd.	Nylon, fishing nets, trawler nets	45	1,000 tons	9
35	3513	Bellhope Plastics Industry Ltd.	Polypropylene, plastic socks, jerricans, slippers	81	70,000 tons	3.5 million sacks/y, estimated 20 g/sack, Also polyethylene and PVC9
36	3513	Zenith Plastics Industry Ltd.	Plastic and rubber slippers	70	2,000 tons	10
37	3513	Zenith Containers Company Ltd.	Plastic containers	41	1,160 tons	10
38	3513	General Plastics Nig. Ltd.	Various plastic wares	50	1,300 tons	10
39	3513	Metalloplastic a Nig. Plc.	Plastic wares	-	-	10
40	3513	Patkun Industries Ltd.	Foot wear and plastic moulded footwear	-	-	10
41	3513	United Plastics Ind. Nig. Ltd.	Plastic slippers	-	-	10

[10]Indicates Member of: Manufacturers' Association of Nigeria, Rivers State Branch.

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
42	3513	Sunflower Manufac. Co. Ltd.	Plastic slippers	-	-	10
43	3520	Crude oil Refinery	High-cracking of crude oil		3.8 million m^3	Scarce information[11]
44	3521	Sloak Paints Nig. Ltd.	Paints, wood finishes and allied products	-		10
45	3521	Berger Paints Nig. Plc.	Paints and chemical products	-	-	10
46	3521	Fareast Paint Ink Lustre	Paints, polish, dyes, pigments, varnishes, resins, lustre	-	3600 tons	10
47	3523	Multi purpose Ventures Ltd.	MP. 90 Industrial liquid detergents	-	120 tons	10
48	3551	Michelin Nigeria Ltd.	Automotive tires and tubes	1,800	18,000 tons	10
49	3620	West African Glass Industry		266	1,700 tons	
50	3692	Ph Chalk & Crayon Co. Ltd	School chalk and crayon	-	-	10
51	3692	Eastern Bulkcem Cement Company	Cement packaging, Eagle Cement Brand	700	600,000 tons	Only packaging10
52	3710	Crocodile Matchets Nig.	Machetes and knives	115	1,000 tons	The production capacity

[11]The yearly production has been calculated from a daily capacity of 120,000 barrels/day and anticipating a working period of 200 days/year.

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
		Ltd.				uncertain 1,000,000 pcs. Assumed 1 kg/pc.10
53	3710	Trident Steelworks Nigeria Ltd.	Weld mesh, barbed wire, reinforcement bars	230	6,000 tons	10
54	3710	Quality Radiators Ltd.	Radiators for Peugeot	-	-	10
55	3720	First Aluminium Products.	Aluminium Products	-		12
56	3720	Alfay Nigeria Ltd.	Aluminium products fabrication	-	-	12
57	3720	First Aluminum, Nigeria Plc.	Aluminum strap sheet circles, collapsible tubes	300	4,000 tons	12
58	3720	ACME Alumwear, Mfg.	Aluminium household products	-	-	12
59	3819	General Metal Products Ltd.	Steel products	60	1,300 tons	
60	3819	Alusteel Construction Ltd.	Steel products	-	-	12
61	3831	Nulec Ind. Ltd.	Cassettes, radio, TV sets	-	-	12
62	3831	Nigerian Engineering Works Ltd.	Air conditioners, Freezers, fans	350	Air conditioners 5,0 Freezers 2,500 Transformers 60 Ceiling fans 3,600	Complicated12

[12]Indicates Member of: Manufacturers' Association of Nigeria, Rivers State Branch.

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
63	3831	Sunlight Electromechanics Ltd.	Electrical utilities	7		
64	3831	Koycee Nigeria Ltd.	Video, TV, Radio amplifier decks	31		12
65	3841	Modant Marine Ltd.	Boat repair	-	-	12
66	3841	Almarine Limited	Ship repair, plastic moulding	-	-	12
67	7121	Murphy Shipping and commercial services Ltd.	Shipping and transport	30		10 m^3 oil and lubricants
68	8324	Schlumberger, Dannell	Oil Services	46		10 m^3 oil and lubricants, acids, drilling fluids
69	8324	Halliburtan Nig. Ltd.	Oil Services	80		10 m^3 oil and lubricants
70	8324	American oil field divers, Nigeria Ltd.	Oil services	18		10 m^3 oil and lubricants
71	8324	Western Geophysics	Oil Services	42		10 m^3 oil and lubricants
72	8324	Amasco Atlantic Mediterranean Ltd.	Oil services	23		10 m^3 oil and lubricants
73	8324	Oil and Industrial Services Ltd.	Oil services, gears shafts, bolts, flanges	-		10 m^3 oil and lubricants12
74	8324	Galba Limited	Service for Fiat, trucks, trailers, diesel and gas	-		10 m^3 oil and lubricants[13]

[13]Indicates Member of: Manufacturers' Association of Nigeria, Rivers State Branch.

	ICIS No.	Name of establishment	Products manufactured	Number of employees	Production capacity per year	Remarks
			turbines			
75	8324	Tractor and equipment Ltd.	Service and repair	150		2,000 vehicles of 5 l 10 m^3 oil
76	8324	Aero Contractors Ltd.	Aviation services	96		30 m^3 oil and lubricants
77		Totatex	Film processing, printing	20		
78	-	Magcobar Manufacturing Nig. ltd.	Bentonite and barite	63	18 tons	
79	-	Air liquid (Nig. Ltd.)	Gas products	>350	-	
80	-	Port Harcourt Sack Ltd. Eastern Bulkcem Prem.	Cement sacks from imported paper			

Table A.15a: Estimated Air Emissions from Traffic in Nigeria[14]

ICIS No.	Unit	Product Unit/year	Particulates kg/unit	Particulates tons/year	N-oxides kg/unit	N-oxides tons/year	NM VOC kg/unit	NM VOC tons/year	Lead kg/unit	Lead tons/year	Remarks
7112	1,000 km	52.2 million	0.07	3,654.0	0.042	2,192.4	2.1	109,620.0	0.11	5,742	Gasoline
7112	1,000 km	29.0 million	1.0	29,000.0	1.2	34,800.0	1.1	31,900.0			Diesel
			Total Particulates	tons/year 32,654.0	Total N-oxides	tons/year 36,992.0	Total NM VOC	tons/year 141,520.0	Total lead	tons/year 5,742	
Area	923,770 km^2			35,3 kg/year/km^2		4.3 kg/year/km^2		153.2 kg/year/km^2		6.2 kg/year/m^2	

Table A.15b: Estimated Air Emissions from Traffic in Rivers State

ICIS No.	Unit	Product Unit/year	Particulates kg/unit	Particulates tons/year	N-oxides kg/unit	N-oxides tons/year	NM VOC kg/unit	NM VOC tons/year	Lead kg/unit	Lead tons/year	Remarks
7112	1,000 km	2.3 million	0.07	161.0	0.042	96.0	2.1	4,830.0	0.11	253.0	Gasoline
7112	1,000 km	1.3 million	1.0	1,300.0	1.2	1,560.0	1.1	1,430.0			Diesel
			Total Particulates	tons/year 1,461.0	Total N-oxides	tons/year 1656.0	Total NM VOC	tons/year 6,260.0	Total lead	tons/year 253.0	
Area[15]	18,754 km^2			77.8 kg/year/km^2		8.8 kg/year/km^2		333.4 kg/year/km^2		13.5 kg/year/m^2	

[14]The estimates are consided to be lower bound figures because the analysis does not consider the poor condition of the vehicle fleet or the impact of traffic jams.

[15]According to: Population. 5th edition. Rivers State of Nigeria, Ministry of Finance and Economic Planning, 1993.

Table A.15c: Estimated Air Emissions from Traffic in Port Harcourt

ICIS No.	Unit	Product Unit/year	Particulates kg/unit	Particulates tons/year	N-oxides kg/unit	N-oxides tons/year	NM VOC kg/unit	NM VOC tons/year	Lead kg/unit	Lead tons/year	Remarks
7112	1,000 km	0.49 million	0.07	34.0	0.042	20.6	2.1	1,029.0	0.11	53.9	Gasoline
7112	1,000 km	0.27	1.0	270.0	1.2	324.0	1.1	297.0			Diesel
			Total Particulates	tons/year 304.0	Total N-oxides	tons/year 344.6	Total NM VOC	tons/year 1,326.0	Total lead	tons/year 53.9	
Area[16]	272 km^2		1,117.0 kg/year/km^2		1,264.7 kg/year/km^2		4,875.0 kg/year/km^2		198 kg/year/km^2		

[16]Refers to Port Harcourt local governmental area. Port Harcourt City area is estimated to 18 km^2.

Box A. 4
Existing and Potential Uses of Water Hyacinth

Water hyacinth is considered to be among the worst weeds in the world. Control programs can be expensive, and therefore it is worth considering potential uses (Quinones and Bravo, 1992), including.

- Water hyacinth has a high ash content of 14.3 percent and important nutrients which could make it a valuable compost fertilizer.
- The fibers can be utilized for pulp and paper, clothes, fiber boards.
- The dried stem can be used for straps of shoes and clogs for baskets and chairs.
- The fresh petioles are base stalks for the cutflower industry (one bundle composed of 10 water hyacinth clusters costs 1.5 - 5.0 pesos in Metro Manila outlets).
- It is a potential source of activated carbon for batteries, of carbon black for paint, and for cement boards.
- Water hyacinths have been used for decades in Japan and Indonesia for biogas production. From one ton of water hyacinth, a biodigester can produce 373 m^3 of methane gas (5,700 kcal.).
- Water hyacinth is used as a low-cost waste water treatment in which the plant absorbs nutrient and toxic residues.

None of the options are immediate solutions for the Niger delta. Obstacles include limited technical abilities, and the fact that local communities have not traditionally used it. It should be noted that water hyacinths can be towed out of the water beds and down-stream relatively easily, e.g., to a fiber treatment site or a biogas production facility.

Linddal, 1995.

Table A.16: Estimated Air Emissions from Industries in the Port Harcourt Area

No.	Unit	Product unit/year	Particulates kg/unit	Particulates tons/year	Nitrogen oxides kg/unit	Nitrogen oxides tons/year	NM VOC kg/unit	NM VOC tons/year	Other	Remarks
1	tons	5					420	2.1		Based on enamel consumed
5	tons	400	3.25	1.3					H_2S	
6	tons	700	3.25	2.3					H_2S	
7	tons	7,000	3.25	22.7					H_2S	
8	tons	5,000	3.25	16.2					H_2S	
9	tons	4,120	3.25	13.4					H_2S	
14	tons	120,000	38	4,560						Uncontrolled
16	tons	(5,000)	-	-						Meat processing
17	m^3	39,600	0.8	31.6			0.25	9.9		
25	tons	145	100	14.5			15	2.2	H_2S	
26	tons	(1,000)	100	100.0			15	15.0	H_2S	
27	Capita	(100)					0.4	0.04		
28	tons	48								
29	tons	Urea 325,400	0.3	97.0					NH_3	Urea, controlled
		Ammo 463,000	0.7	324.0					NH_3, HNO_3	Ammonia controlled
		NPK 277,000	0.15	41.0					F_2,NH_3	NPK controlled
32	tons	120,000	1.5	180.0			0.35	42.0		Polypropylene uncontrolled
33	tons	(1,000)	7.5	7.5						Polyanide
34	tons	1,000	7.5	7.5						Polyanide
35	tons	70,000	1.5	105.0			0.35	24		Polypropylene uncontrolled
36	tons	2,000	1.5	3.0			0.35	0.7		Polypropylene uncontrolled
37	tons	1,160	1.5	1.7			0.35	0.4		Polypropylene

No.	Unit	Product unit/year	Particulates kg/unit	Particulates tons/year	Nitrogen oxides kg/unit	Nitrogen oxides tons/year	NM VOC kg/unit	NM VOC tons/year	Other	Remarks
										uncontrolled
38	tons	1,300	1.5	1.9			0.35	0.5		Polypropylene uncontrolled
39	tons	(1,000)	1.5	1.5			0.35	0.4		Polypropylene uncontrolled
40	tons	(1,000)	1.5	1.5			0.35	0.4		Polypropylene uncontrolled
41	tons	(1,000)	1.5	1.5			0.35	0.4		Polypropylene uncontrolled
42	tons	(1,000)	1.5	1.5			0.35	0.4		Polypropylene uncontrolled
43	m^3	3,800,000	0.695	2,641	0.204	775				CO-boiler assumed[17]
44	tons	(3,000)	10	30			15	15.0		Paint uncontrolled
45	tons	(3,000)	10	30			15	15.0		Paint uncontrolled
46	tons	(3,600)	10	30			15	15,0		Paint uncontrolled
47	tons	120	45	5.4						
49	tons	1,700	8.7	14.7	2.2	3.7	4.7	7.9		Pressed blown glass
51	tons	600,000	3.5	2,100.0						Conveying
52	tons	1,000	5.65	5.65						Alloy steel uncontrolled
53	tons	6,000	8.5	51.0						Carbon steel uncontrolled
54	tons	(3,000)	8.5	25.0						Carbon steel uncontrolled
55	tons	(2,000)	2.15	4.3						Secondary melting
56	tons	(2,000)	2.15	4.3						
57	tons	4,000	2.15	8.6						
58	tons	(4,000)	2.15	8.6						

[17] Calculations have been undertaken from production numbers and not from amount of feed-stock With CO-boiler no NM VOC.

No.	Unit	Product unit/year	Particulates kg/unit	Particulates tons/year	Nitrogen oxides kg/unit	Nitrogen oxides tons/year	NM VOC kg/unit	NM VOC tons/year	Other	Remarks
62	tons	5,000[18]					16.2	0.4		Evaporation from painted sheets
Total no			Total particulates		Nitrogen oxides		Total NM VOC			
41			10,496 tons/year		779 tons/year		152 tons/year			

[18] Evaporation of paints used is about 29 kg/ton of iron sheets, 10% of production anticipated to be iron sheets

Table A.17: Estimated Water Effluents from Industries in the Port Harcourt Area

No.	Unit	Product unit/year	BOD_5 kg/unit	BOD_5 tons/year	SS kg/unit	SS tons/year	Oil kg/unit	Oil tons/year	N kg/unit	N tons/year	P kg/unit	P tons/year	Other	Remarks
5	tons	400	84	33.6	93	37.2	20	8.0	5.9	0.4				Shrimps breeded
6	tons	700	13.4	9.3	10.4	73.0	7.4	5.0	2.1	0.7				Tuna
7	tons	7,000	84	588.0	93	651.0	20	140.0	5.9	41.3				Shrimps breeded
8	tons	5,000	13.4	67.0	10.4	52.0	7.4	37.0	2.1	10.5				Tuna
9	tons	4,120	13.4	55.0	10.4	42.8	7.4	30.0	2.1	8.6				Tuna
10	tons	24,300	24.9	605.0	24.6	597.0	28.1	682.0						General
11	tons	12,000	24.9	299.0	24.6	295.0	28.1	337.0						General
12	tons	7,000	24.9	174.0	24.6	172.0	28.1	196.0						General
13	tons	(7,000)	24.9	174.0	24.6	172.0	28.1	196.0						
14	tons	120,000	0.11	13.0	0.1	12.0								Wheat bulger
15	tons	5,000	0.7	3.5					0.005	0.02				Dry pastry
16	tons	(5,000)	17	85.0	14	70.0	15	75.0	0.44	2.0	0.19	0.95		
17	m^3	39,600	18.8	744.0	7.3	289.0								
18	m^3	80,000	3.1	248.0	4.3	344.0								Major plant syrup prep.
19	tons	200	115	23.0	70	14.0								Cotton
20	tons	5,000	30	150.0	55	275.0								Rayon processing
25	tons	145	5.5	0.8	10.5	1.5								Kraft coarse paper
26	tons	(1,000)	5.5	5.5	10.5	10.0								Kraft coarse paper
29	tons	493,000							0.1	49	1.0	493	F	Urea, treated
	tons	342,000							0.1	34	1.0	342.0	F	Ammonia, treated
	tons	272,000			0.4	108.0			0.4	108			F	NPK, treated

No.	Unit	Product unit/year	BOD_5 kg/unit	BOD_5 tons/year	SS kg/unit	SS tons/year	Oil kg/unit	Oil tons/year	N kg/unit	N tons/year	P kg/unit	P tons/year	Other	Remarks
32	tons	120,000	5.0	600.0	1.16	139.2	3.0	360.0						Polypropylene uncontrolled
33	tons	(1,000)	68	68.0	4	4.0								Polyanide
34	tons	1,000	68	68.0	4	4.0								Polyanide
35	tons	70,000	5.0	350.0	1.16	81.0	3.0	210.0						Polypropylene uncontrolled
36	tons	2,000	5.0	10	1.16	2.32	3.0	6.0						Polypropylene uncontrolled
37	tons	1,160	5.0	5.8	1.16	1.4	3.0	3.4						Polypropylene uncontrolled
38	tons	1,300	5.0	5.0	1.16	1.5	3.0	3.9						Polypropylene uncontrolled
39	tons	(1,000)	5.0	5.0	1.16	1.16	3.0	3.0						Polypropylene uncontrolled
40	tons	(1,000)	5.0	5.0	1.16	1.16	3.0	3.0						Polypropylene uncontrolled
41	tons	(1,000)	5.0	5.0	1.16	1.16	3.0	3.0						Polypropylene uncontrolled
42	tons	(1,000)	5.0	5.0	1.16	1.16	3.0	3.0						Polypropylene uncontrolled
43	1000 m^3	3,800	72.9	277.0	18.2	69.2	31.2	118.6	28.3	107.5				Assumed trickling filter
47	tons	120	3.0	0.4	0.3	0.04	0.5	0.6						
48	tons	18,000	0.4	7.2	1.0	18	0.12	2.1						
49	tons	1,700												Only cooling water
52	tons	1,000												
53	tons	6,000											Fe, Cl	Carbon steel uncontrolled
54	tons	(3,000)											Fe, Cl	Carbon steel
55	tons	(2,000)					0.65	1.3						

No.	Unit	Product unit/year	BOD_5 kg/unit	BOD_5 tons/year	SS kg/unit	SS tons/year	Oil kg/unit	Oil tons/year	N kg/unit	N tons/year	P kg/unit	P tons/year	Other	Remarks
56	tons	(2,000)					0.65	1.3						
57	tons	4,000					0.65	2.6						
58	tons	(4,000)					0.65	2.6						
67-76	-	-						120.0					Heavy metals	Spill oil and lubricants
Total number of enterprises			Total BOD tons/year		Total SS tons/year		Total Oil tons/year		Total N tons/year		Total P tons/year			
50			4,374		3,533		2,543		362		836			

Table A.18: Estimated Waste Generation from Industries in the Port Harcourt Area

No.	Unit	Product unit/year	Putrescible waste kg/unit	Putrescible waste tons/year	Non-hazardous solid waste kg/unit	Non-hazardous solid waste tons/year	Hazardous waste kg/unit	Hazardous waste tons/year	Non-hazardous sludge kg/unit	Non-hazardous sludge tons/year	Hazardous sludge kg/unit	Hazardous sludge tons/year	Remarks
5	tons	400	570	228									Inedible fish parts
6	tons	700	280	196									
7	tons	7,000	280	1,960									
8	tons	5,000	280	1,400									
9	tons	4,120	280	1,154									
10	tons	24,300			4.7	114							Purification mud and oil
11	tons	12,000			4.7	56							
12	tons	7,000			4.7	33							
13	tons	(7,000)			4.7	33							
16	tons	(5,000)	300	1,500									Packaging and inedible food parts
25	tons	145	50	7									Cellulose liquids
26	tons	(1,000)	50	50									
43	1000 m^3	3,800									3303	12,551	[19]
44	tons	(3,000)									8.3	25	
45	tons	(3,000)									8.3	25	
46	tons	3,600									8.3	30	
48	tons	18,000							55	990			
52	tons	1,000			120	120	12.8	12.8			8.7	8.7	Electrical arc, heavy metal
53	tons	6,000			120	720	12.8	77			8.7	52	Electrical arc, heavy metal
54	tons	(3,000)			120	360	12.8	38			8.7	26	

[19] Calculated from production number and not feedstock

No.	Unit	Product unit/year	Putrescible waste kg/unit	tons/year	Non-hazardous solid waste kg/unit	tons/year	Hazardous waste kg/unit	tons/year	Non-hazardous sludge kg/unit	tons/year	Hazardous sludge kg/unit	tons/year	Remarks
55	tons	(2,000)									75	150	
56	tons	(2,000)									75	150	
u57	tons	4,000									75	300	
58	tons	(4,000)									75	300	
67-76	tons				Scrap metal	360					Drilling sludges		Heavy metals
Total number of enterprises			Total putrescible waste tons/year		Total non-hazardous waste tons/year		Total hazardous waste tons/year		Total non-hazardous sludge tons/year		Total hazardous sludge tons/year		
33			6,495		1,796		127		990		13,617		

Table A.19: Manufacturing Industries in Delta State, 1987[20]

	Town	Products manufactured	Engagement size group (transformed into no. of employees)	Production capacity (Comments)
2200 - CRUDE PETROLEUM AND NATURAL GAS PRODUCTION				
N.N.P.C. Refinery	Warri	Petrol, diesel, kerosene	-	-
Total Industries Ltd.	Koko	Lubricants and bitumen	150	15,000 t/y
3115 - MANUFACTURE OF VEGETABLE AND ANIMAL OILS AND FATS				
Agbarho Coop. Oil Mill Limited	Orho-Agbarho	Palm oil, vegetable oil	3	5,000 tins/y[21]
Edewor Vegetable Oil Company Limited	Effurun	Vegetable Oil	250	60,000 tons/y
Emoha Olomu F.M.P.C.S. Limited	Ovior-Olomu	Palm oil	3	100 tons/y[21]
Oil Palm Co. Ltd.	Ajagbodudu	Palm oil	150	-
Oil Palm Co. Ltd.	Nsukwa	Palm oil	-	-
3116 - GRAIN MILL PRODUCTS				
Life Flour Mill Ltd.	Sapele	Flour	350	60,000 t/y[21]
Mix & Brace Flour Mill Industry Ltd.	Warri	Flour	250	60,000 t/y[21]
3117 - MANUFACTURE OF BAKERY PRODUCTS				
A. Aka Bakery	Uremi	Bread	-	-
Blessing Bakery	Agbor	Bread	-	-
Bodatum Feeds Ltd.	Warri	Bread	35	1,2 million loaves/y[21]
City Bakery	Ughelli	Bread	-	-
Crest Products	Agbor	Biscuits	250	6,000 tons/y
Dova Biscuits Ltd.	Effurun	Biscuits	-	-
Ebeman Nig. Ltd.	Agbor	Bread	-	-
Edinburgh Bread Factory	Agbor	Bread	35	800,000 loaves/y[21]
E.E. Egwu & Son	Agbor	Bread	63	-
International Bakery	Oleh	Bread	15	500,000 loaves/y[21]
J.K. Otakoro Enterprises	Ughelli	Bread	-	-
Jorpas Bakery	Ughelli	Bread	-	-
Juvico Oxford Bakery	Agbor	Bread	-	-
Marantha Bakery	Effurun	Bread	-	-
Obaka Bakery	Oleh	Bread	-	-
Ofuafor & Sons Industrial Company	Ughelli	Bread	3	-
O. & G. Bakery Ltd.	Benin City	Bread	-	-
Original Kate Bakery	Ughelli	Bread	15	-
Our Bread Bakery	Oleh	Bread	-	-
Paro Mechanized Bakery	Oleh	Bread	-	-

[20] Ministry of Commerce and Industry. Bendel State Industrial Directory. 1989 Edition. Published before the establishment of Delta State. Only industries located in the present Delta State are shown.

[21] Transformed to yearly production anticipating 200 production days/y

	Town	Products manufactured	Engagement size group (transformed into no. of employees)	Production capacity (Comments)
Progress Bakery	Agbor	Bread	-	-
Sino Bakery	Effurun	Bread	-	-
3122 - MANUFACTURE OF ANIMAL FEEDS				
Lexy Nig. Ltd.	Sapele	Animal feeds	63	11,200 tons/y[22]
Top Feed Ltd.	Sapele	Animal feeds	150	262,800 tons/y
3133 - MALT LIQUORS AND MALT				
Superbru Limited	Agbarha-Otor	Lager beer	550	77,000 m^3/y
Sparkling Breweries Limited	Ughelli	Lager beer	550	30,000 m^3/y
3134 - SOFT DRINKS				
Olo Cold Drinks Nig. Limited	Ughelli	Soft drinks	-	-
Rainbow Ltd.	Mosogar	Soft drinks	-	3 million m^3/y[23]
Warri Bottling Co. Ltd.	Warri/Effurun	Soft drinks	150	62,900 m^3/y
3212 - MANUFACTURE OF MADE-UP TEXTILE GOODS (EXCEPT WEARING APPAREL)				
Beckers Lay-Tech Nig. Limited	Agbor	Imitation leather tatalin	-	-
3211 - SPINNING, WEAVING AND FINISHING TEXTILES				
Ecndel Textile Mill Ltd.	Asaba	Textiles	-	-
3240 - MANUFACTURE & REPAIR OF FOOTWEAR				
Tony-Anthony (Nig.) Ltd.	Asaba	Footwear	45	250 t/y[24]
3311 - SAWMILLS				
Anigboro Sawmill	Sapele	Sawn timber	-	-
Boye Sawmill & Sons Ltd.	Agbor	Sawn timber	-	-
Damwood Ltd.	Sapele	Sawn timber	63	-
Eboman Nig. Ltd.	Agbor	Sawn timber	25	-
F.T.C.C. Sawmill	Sapele	Sawn timber	-	-
Olori Sawmill	Ughelli	Sawn timber	-	-
Wata Timber Co. Ltd.	Oghareki	Sawn timber	150	-
3319 - MANUFACTURE OF WOOD & CORK PRODUCTS N.E.C.				
African Timber & Plywood	Sapele	Flush doors, plywood	-	-
Damwood Ltd.	Sapele	Doors, door and window frames	-	-
Delta Timber Industries Limited	Burutu	Flush doors	-	-
Oghenovo Wood Ind. Ltd.	Effurun	Doors, door and window frames	35	9,000 t/y[25]
3320 - CARPENTRY AND WOODWORK				
Coment Industries Ltd.	Sapele	Furniture	88	-
International Furniture	Aladja	Furniture	-	-
Jefe Furniture	Warri	Furniture	-	-

[22]Calculated from hourly production anticipating 8 hours/day and 200 days/y.

[23]Calculated from number of bottles anticipating the content of a bottle to be equal 0.33 l.

[24]Calculated from pairs of shoes anticipating 0,5 kg/pair of shoes.

[25]Calculated from number of pieces anticipating 30 kg/piece.

	Town	Products manufactured	Engagement size group (transformed into no. of employees)	Production capacity (Comments)
Jubi & Lee (Nig.) Enterprises	Warri	Furniture	-	-
Meek Industries Ltd.	Warri	Furniture	-	-
3419 - MANUFACTURE OF PULP PAPER AND PAPER BOARD				
Central Bookshop Nig. Limited	Agbor	Toilet rolls	-	-
Eggs Pack Ltd.	Effurun	Eggstray, toilet rolls	-	-
Lexi Enterprises Ltd.	Sapele	Toilet rolls	15	450 t/y[26]
Tamoflex Industries Ltd.	Effurun	Toilet rolls	83	-
Ustade & Sons Ltd.	Owa	Stationary	3	400 reams daily (Conversion unknown)
3420 - PRINTING, PUBLISHING AND ALLIED INDUSTRIES				
Central Books Ltd.	Agbor	Printers	-	200 books (Conversion unknown)
Edward Yekovie & Co. Ltd.	Warri	Printers	-	-
Evueta & Co. Ltd.	Ughelli	Printers	8	44 t/y[27]
Gong Printing & Publishers	Asaba	Publishers	-	-
Ighagbemi Graphic Arts Co.	Ughelli	Printers	15	-
3521 - MANUFACTURE OF PAINTS, VARNISHES AND LACQUERS				
Sha Eka Chemicals & Industri Nigeria Limited	Owa	Paints	35	2,270 m^3/y[28]
Sunny Paint Ltd.	Sapele	Adhesive, wood finish paints	15	2,500 m^3/y
3522 - MANUFACTURE OF DRUGS AND MEDICINES				
Volmed Nigeria Ltd.	Abasa	Drugs	35	750 m^3/y
3523 - MANUFACTURE OF SOAP AND CLEANING PREPARATIONS				
Akwuzie Industries Ltd.	Aniocha	Body cream	25	-
3559 - MANUFACTURE OF RUBBER PRODUCTS N.E.C.				
Apaco Foam and Chemical Ind. Ltd.	Owa	Rubber foam	15	60 blocks daily (Conversion unknown)
New Independence Rubber Company Limited	Sapele	Rubber crumbs and crepe	-	-
Okpe Trading Co. Ltd.	Sapele	Rubber crumbs and crepe	16	20,000 tons/y
Pamol Nig. Ltd.	Oghara Junction	Rubber latex	-	-
Rodco Nig. Ltd.	Oghara	-	-	-
Vita Foam	Sapele	Rubber foam	-	-
Zanord Wilson Nig. Ltd.	Sapele	Rubber crepe and crumbs	-	-
3560 - MANUFACTURE OF PLASTIC PRODUCTS				
Celest Industries Ltd.	Ibusa	Plastic crafts	-	-

[26]Calculated from number of rolls anticipating 0,3 kg/roll.

[27]Calculated from number of sheets anticipating 5 g/sheet.

[28]Calculated from gallons/d anticipating gallons (UK) and a conversion factor to litre of 4,54 and a year of 200 days.

	Town	Products manufactured	Engagement size group (transformed into no. of employees)	Production capacity (Comments)
Diamond Plastics	Koko	Plastic oil can	-	-
Delta Packaging Co. Ltd.	Sapele	Polypropylene bags	150	960,000 t/y[29]
Ebeman Nig. Ltd.	Agbor	Polypropylene bags	-	-
Mod Nigeria Ltd.	Agbor	Polythene bags	25	1,440,000 t/y
Olo Plastic Ind. Nig. Ltd.	Ughelli	Plastic wares		300,000 t/y
Phionic Ind. Ltd.	Asaba	Plastic wares	-	-
S.I.O. Industries Ltd.	Asaba	Polypropylene sacks	45	-
Unity Plastic Ind. Co. Ltd.	Owa	Plastic wares	-	-
3620 - MANUFACTURE OF GLASS AND GLASS PRODUCTS				
Delta Glass Co. Ltd.	Ughelli	Glass wares	850	124,000 t/y.
3699 - MANUFACTURE OF NON-METALLIC MINERAL PRODUCTS NOT ELSEWHERE CLASSIFIED				
A.O. Okwuogori and Sons Clock Ind.	Agbor	Cement blocks	-	173,200 blocks P.A. (Conversion unknown)
Diata Blocks Ind.	Ughelli	Cement blocks	-	-
Ero Block Industry	Agbor	Cement blocks	-	-
Eternit Ltd.	Sapele	Fibre cement roofing and ceiling sheets	250	90,000 t/y
Nnaemeka Concrete Ind.	Asaba	Cement blocks	8	800 blocks daily (Conversion unknown)
Okeehukwu Block Ind.	Asaba	Cement blocks	-	-
Quiligotti Ind. Ltd.	Sapele	Terazzo and marble tiles	8	100,000 t/y[9]
3710 - IRON AND STEEL BASIC INDUSTRIES				
Cemmico Ltd.	Sapele	Processed wire	25	2,000 tons/y
Delta Steel Co. Ltd.	Aladja	Steel billets	-	-
General Steel Mills Ltd.	Asaba	Steel rods	88	80,000 t/y
3812 - MANUFACTURE OF METAL FURNITURE				
Comet Industries Co. Ltd.	Sapele	Metal furniture	8	-
3819 - FABRICATED METAL PRODUCTS				
Abavo Metal Ind. Ltd.	Abavo	-	35	-
Akpotor Foundry	Ughelli	-	25	100 t/y[9]
Aranla Ind. (Nig.) Ltd.	Effurun	Fabricated spare parts	8	-
Asaba Aluminium Co. Ltd.	Asaba	Roofing sheets Kitchen wares	8	2,880 tons/y 120 tons/y
Bendel Steel Structures Limited	Effurun	Steel structures	150	12,000 tons/y
Christota Enterprises	Agbor	Nails	-	-
General Pipe Ind. Ltd.	Asaba	Black & galvanised steel pipes, angle irons	45	20,000 tons/y
Globe Steel (W.A.) Ltd.	Asaba	Steel structure	-	-
Glorylux Associates Ltd.	Warri/Effurun	Venetian blinds	-	-
Gochimor Steel Construction Company	Asaba	Steel structure	-	-

[29] Calculated from number of bags anticipating 30 g/bags.

	Town	Products manufactured	Engagement size group (transformed into no. of employees)	Production capacity (Comments)
Imasco Ltd.	Sapele	Fabricated spare parts	15	-
Intercity Steel Pipe Ind (Nig) Limited	Agbarho	Oil field tools	63	-
L. C. Okeke Ent. Ltd.	Asaba	Steel structure	63	-
METALOCK (NIG) LTD.	Sapele	Steel structure	-	-
Newtex Wires Ltd.	Adeje	Fencing wire	15	1,050 tons/y
Kes Corner Stone Int. Ltd.	Warri/Effurun	Metal wares	-	-
Pitajose Industries Ltd.	Ughelli/ Effurun	Metal beds, steel doors, doors & windows	15	6,000 tons/y
Subaya Metalwares (Nig.) Ltd.	Warri	Metal plates and basin	-	-
Thermosteel Nig. Ltd.	Effurun	N.A.	63	500 tons/y
Vanleer Containers (Nig.) Limited	Koko	Steel drums	-	-
Philco Steel Const. Co.	Asaba	Steel structure	-	-
3822 - MANUFACTURE OF AGRICULTURAL MACHINERY & EQUIPMENT				
Fabrication Eng. and Production Co. Ltd.	Issele-Uku	Garri processing	63	72 units P.A. (Conversion unknown)
3831 - MANUFACTURE OF ELECTRICAL MACHINERY & APPARATUS				
Asiafrica Electric Cable Company Nig. ltd.	Owa-Nta	Electric cables	3	1000 tons/y
Hopes Engineering Ltd.	Effurun	Voltage transformers	-	-
3841 - SHIPBUILDING AND REPAIRING				
Delta Boat Yard	Warri	Boat repairing	-	-
7121 - WATER TRANSPORT				
Delta Boat Yard	Warri	Boat hire services	-	-
Oboli Nigeria Ltd.	Warri	Shipping	45	-
Sea Trucks (Nig.) Ltd.	Warri	Shipping	-	-
8324 - ENGINEERING, ARCHITECTURAL AND TECHNICAL SERVICES				
Laila Mech. Eng. Services and Construction Co. Ltd.	Warri	Services	25	-
Patmaco Technical Work and Company	Ughelli	Services	15	-
Richdrill Nigeria Ltd.	Ughelli	Borehole drillers	-	-
Saka & Christie Ind. Eng. Limited	Warri/Effurun	Services	-	-
Waratem Eng. Services	Warri	Services	-	-
9514 - WATCH, CLOCK AND JEWELLERY REPAIRS				
Swiss Watchshop Ltd.	Asaba	Watches & clocks	15	-

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