WATER MANAGEMENT PLAN FOR THE

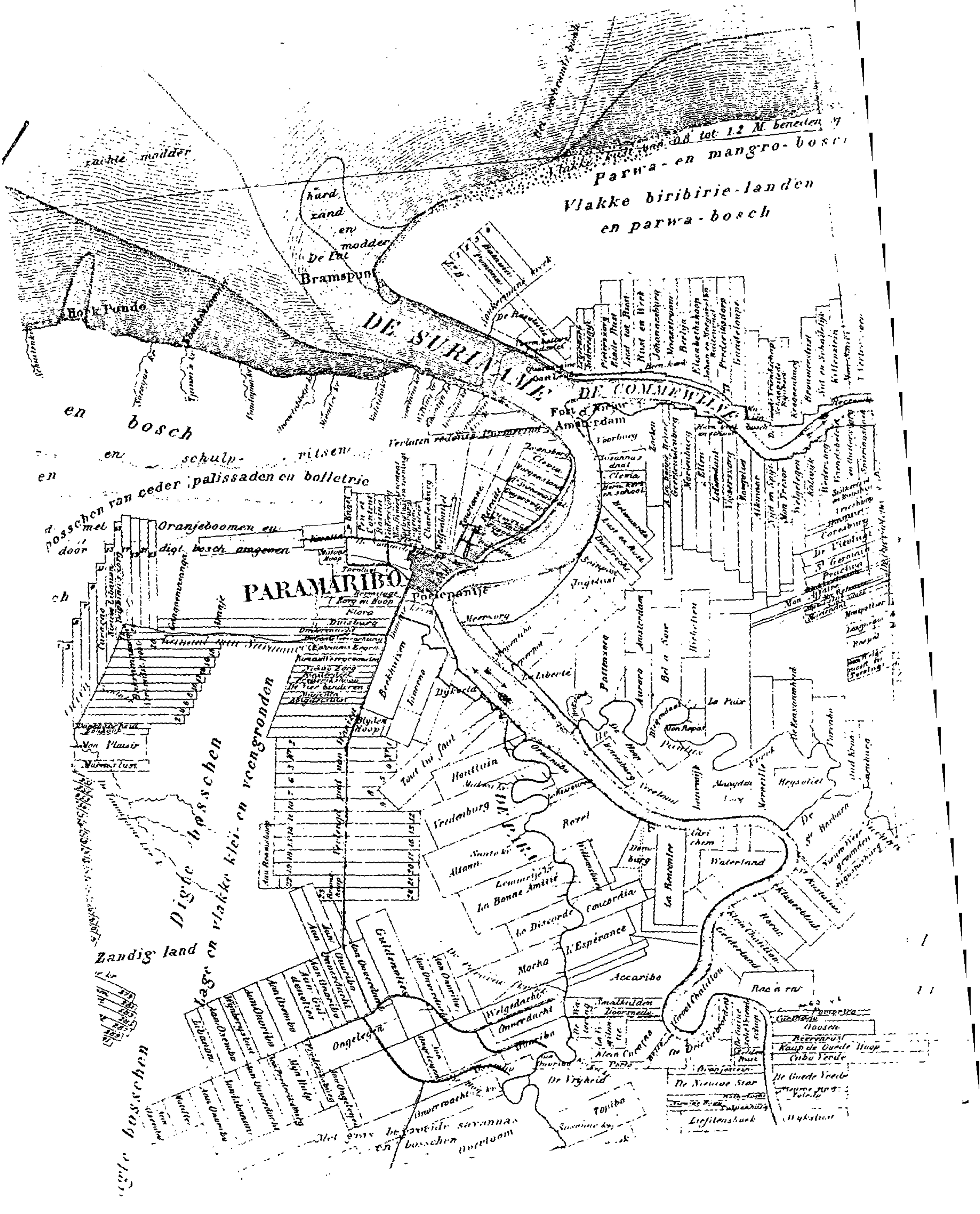
SURINAME RIVER BASIN

Plan of Operations

Hydraulic Research Division (WLA)
Water Management Commission

Organization of American States (OAS)
Department of Regional Development

Paramaribo, December 1982


zachte modder
hard zand en modder
De Pal
Bramspunt
Hoek Pando
Parwa- en mangro-bosch
Vlakke biribirie-landen en parwa-bosch
DE SURINAME
DE COMMEWYNE
Fort Amsterdam
en bosch
en schulp- ritsen
bosschen van ceder palissaden en bolletrie
met Oranjeboomen en
door digt bosch omgeven
PARAMARIBO
Poelepantje
Flora
Duisburg
Beekhuizen
Limmen
Dykveld
Tout lui faut
Houttuin
Vredenburg
Altona
La Bonne Amitié
La Discorde
Concordia
l'Espérance
Mocha
Accaribo
Welgedacht
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Guldenpoint
Rozel
Waterland
Klaverblad
Horna
Monbijou
Jagtlust
Meerzorg
La Liberté
Pattamaca
Amsterdam
Aurora
Bel a Sear
La Paix
Vreeland
Heysoliet
Nieuw Weergevonden
Groot Chatillon
Klein Chatillon
Gelderland
Rac à rac
De Drie Gebroeders
Kaap de Goede Hoop
Cabo Verde
De Goede Verwachting
Liefdensbaak
De Nieuwe Star
De Vrykeid
Topibo
Digte bosschen
Zandig land
Lage en vlakke klei- en veengronden
Met gras begroeide savannas en bosschen

Environmental Considerations in Water Resource Planning and Management in Suriname

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Introduction

This report provides a conceptual framework for the integration of a number of important considerations in water resources planning with special attention to water management in the Suriname River watershed.
In am particularly grateful to Maria Panday-Verheuvel, Pieter A. Teunissen and Joep N. Moonen, who imparted to me a wealth of information about Suriname's unique environment and culture. Richard Saunier's"Preliminary Report on Environmental considerations for the Project: Water Management Plan for the Coastal Area" provides valuable background information and a point of departure for this report.

The purposes of environmental management applied to water resources are:

- The identification and mitigation of intersectorial conflicts such as those between hydroelectric power generation and downstream fisheries production or between agricultural pest control and fisheries production.

- The identification of opportunities for sustained use of ecological processes and natural ecosystems for such purposes as waste treatement, protection of water management infrastructure and high net fishery production.

Environmental management considerations are an indespensible part of economically and technically sound actions and policies contributing to development.

The recommendations found in this report are based on observations made during the period 30 October to 19 November 1982. In addition to the interviews conducted jointly with the team leaders (listed seperately) I made jeep trips to Afobaka Dam, the Brownsberg Natural Reserve overlooking the Brokopondo reservoir, Pokigron on the Upper Suriname River and to the vicinity of Frans Creek in the savannas west of Zanderij. A team visit was made to the Commewijne agricultural development area. An overflight was made covering the Brokopondo Reservoir the Upper Tapanahoni River, the Jai Creek diversion site, the Upper Suriname River, the Kabalebo damsites, the Nickerie polders and the Northwestern coastal zone.

Water uses

Water in the Suriname River basin has a variety of uses:

- In industry as a solvent, a reagent, for cooling, steam, slurrying material for waste removal and for power generation
- As a medium for transportation and recreation
- By people for washing, drinking and waste removal
- In agriculture as an essential element in plant and animal production
- As the medium for aquatic ecosystem functioning - supporting plant and animal life - and, within limits, for processing waste inputs.

Within the context of a river basin,the above uses may be independent of one another, complementary, competitive or mutually exclusive. If water can be used for all purposes without materially affecting that use or another group's use of the resource, then there would be no need for water management. Unfortunately, in Suriname each sector's use of the water resource is more and more depriving other sectors of its full use. For instance, regulation of river flow for optimum electrical energy generation for aluminum production has adversely affected the fishery sector catch and may even have reduced the annual flushing of sediments from the river mouth, adversely affecting navigation by ships carrying aluminum and other products. Obviously there is a pressing need for comprehensive water management planning.

Quality of the water resource. Water in the context of the aquatic ecosystem requires the consideration of four interrelated parameters:

- Substrate - The type and diversity of habitants for plants and animals within the water body including riffles and pools, holes and shallows, inside and outside bends, sandy, muddy and rocky areas and streamside vegetation (elements which are virtually eliminated by channelization)
- Energy source. In-stream primary production or plants and small fauna falling or washing into the water.
- Water quality - Requisite range of conditions for the functioning of a particular ecosystem including chemical characteristics, pH, temperature range and clarity.
- Flow regime - The variation in flow and/or water level seasonally or as affected by tidal action to which organisms are adopted.

These quality parameters are particularly relevant in the management of water for energy generation, agriculture and fisheries in the Suriname River basin.

National context of the Suriname River

From east to west, Suriname exhibits similar geographical characteristics along any given latitude.
Similar basement rock complexes, elevations and rainfall patterns result in similar ecosystems and hydrology across the southern three quarters of the country. The savanna belt (Coesewijne Formation), old coastal plain (Coropina Formation) and the young coastal plain (Demerara Formation) all stretch in bands of varying width across the country. Likewise coasts, mangrove communities, lagoons, mudflats and occasional sand beaches from a repeating pattern. Major rivers flowing north join smaller westward flowing streams to break through to the sea.

The Suriname River basin encompasses a south to north sample of all condition of the major geomorphic, vegetational, land and water bodies existing in Suriname. The water management issues related to hydroelectric power generation, aluminium production and urban development are presently unique to the Suriname River basin, but are of future concern in other basins.

The Suriname River System

Figure 1 illustrates the major components of the Suriname River watershed. Some of the water related issues and concerned institutions are listed in Table 1. For convenience of discussion, issues have been addressed under the headings A. through G. below. Each component is illustrated by a simple diagram which provides a descriptive water balance relevant to water management. Quantification of these models is recommended as an early step in management planning.
With the exception of solar energy, wind, rain, tidal action, evapotranspiration and commercial exchanges, each component output represents an input affecting another component or sector.
For reference, a conceptual system model has been developed showing the regional system with its component interactions (Figure 2a-c).
The Suriname River basin has been divided into the upper and lower watershed at the Afobaka dam because of the distinctive management requirements of the two portions of the basin. For illustration, the lower watershed is further divided into two parts corresponding to the area with problems related predominately to fresh water management (Figure 2b) and the estuarine portion of the river affected directly by the mixing of fresh and salt water (Figure 2c).

A. Upper watershed. The upper watershed is made up of a geologically ancient basement complex, predominately granitic. Soils are shallow and highly weathered; slopes are short with an abrupt to rolling character and there is virtually no alluvial accumulation. Rainfall ranges from near 2000 mm per year to over 3000 mm in the Wilhelminagebergte area. The dominant ecosystem is Tropical Moist Forest with areas of transition to Tropical Wet Forest, often somewhat impoverished by the poor and shallow soils (Holderidge Life Zone System).
Mineral cycles in the virtually undisturbed forest are extremely tight which, combined with the leached soil and resistent bedrock, results in clear water poor in plant life except for the Podostemaceae family which clings tenaciously to the rocks. Food chains are largely dependent on plant material and small fauna falling into the water from the overhanging forest.

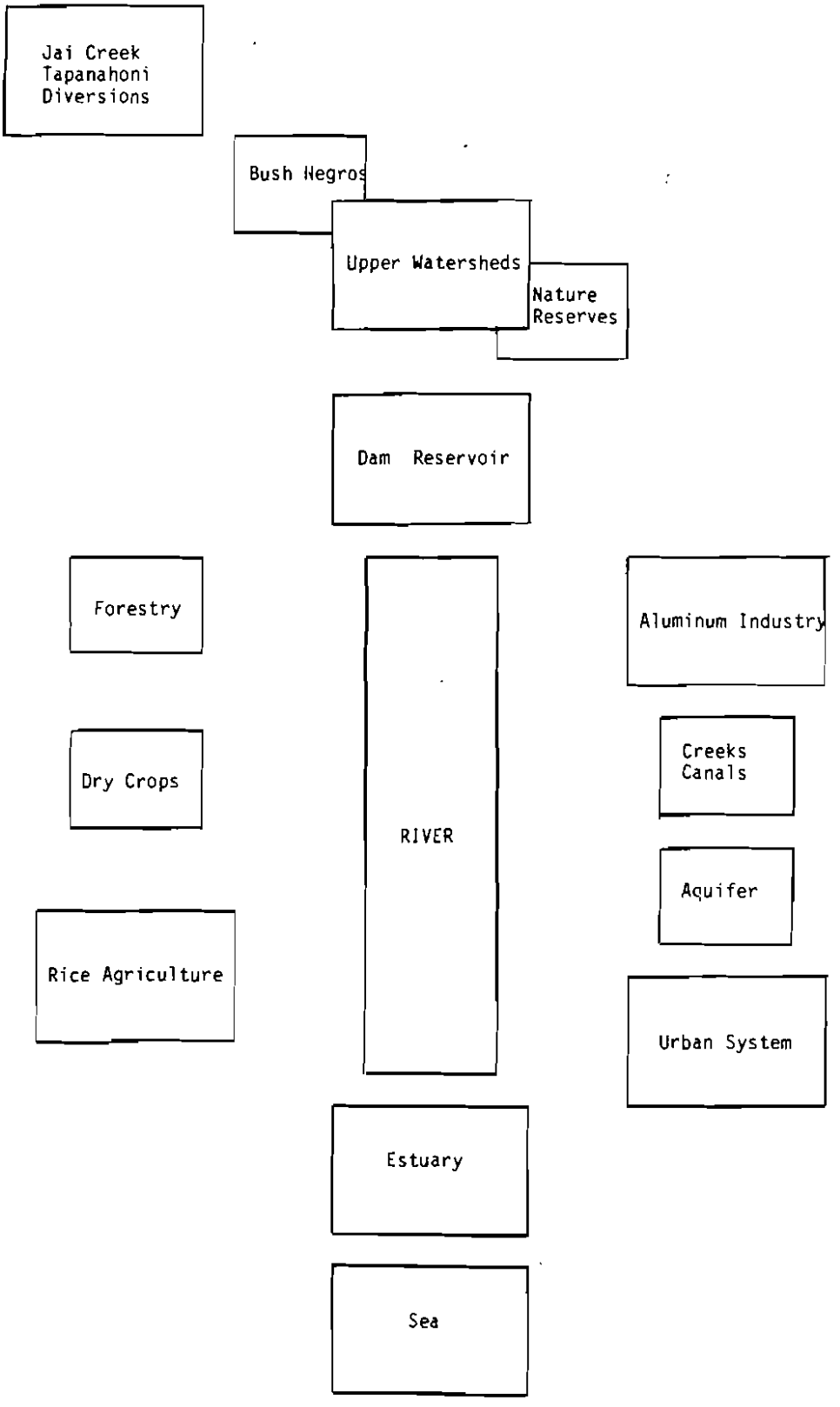
Component	Elements	Instituut	Institution
	drinking water supply	Surinaamse Waterleiding Maatschappij Afd. Watervoorziening (Ministerie van Binnenlandse Zaken)	Surinam watersupply Company (ministry o Internal affairs;Watersupply Division
	recreation	Bureau voor het toerisme	Office for Tourism
	Irrigation	Stichting Landbouw Ontwikkeling Commewijne	Foundation for Agricultural development Commewijne
Main River (brackish water)	Hydrology + salt intrusion	Waterloopkundige Afdeling	Hydraulic Research Division
	Waterquality	Waterloopkundige Afdeling	Hydraulic Research Division
	dredging	Waterloopkundige Afdeling; Dienst Scheepsvaart	Hydraulic Research Division
	Navigation	Dienst Scheepsvaart	
	recreation	Ministerie van Cultuur Jeugd en Sport	Ministry of Culture, Y and S.
	urban and Industrial waste water	Zie boven	See former Component
Fresh water swamps	Water reservoir for irrigation	Stichting Landbouw Ontwikkeling Commewijne	Foundation for Agricultural Development Commewijne
	Fisheries	Visserij Dienst	Fisheries Service
	Waste water discharge	Suralco	Suralco
Brakish water swamps	Hydrology and Waterquality	Waterloopkundige Afdeling	Hydraulic Research Division
	olie winning	Staats Olie Maatschappij	Lands Oil Company
	aquaculture fisheries	Dynamic Agencies Visserij Dienst	Dynamic Agencies Fisheries Service
	Recreation	-	-
Creeks and canals	hydrology	Waterloopkundige Afdeling	Hydraulic Research Division
	Waterquality	Waterloopkundige Afdeling	Hydraulic Research Division
	Navigation	Ministerie van Openbare Werken Dienst voor de Scheepvaart	Ministry of Public Works Navigation Service
	health	Waterloopkundige Afdeling, Centraal Laboratorium	Hydraulic Research Division, Central Laburatory
	urban and industrial waste discharge	Waterloopkundige Afdeling	Hydraulic Research Division
	fisheries	-	-
	recreation	Dienst voor de Toerisme	Office for Tourism
	drinking water supply	Dienst Watervoorziening	Watersupply Service
Aquifer	recharge: . natural . agriculture . urban, industr. . mining	Dienst Watervoorziening (ministerie van Binnenlandse Zaken)	Watersupply Service (Ministry of Internal Affairs)

Component	Elements	Institute	Institution
	Withdrawal: . agriculture . Urban industrial . mining	Surinaamse Waterleiding Maatschappij; Dienst Watervoorziening.	Surinam Water Supply Company; Watersupply Service;
	Saltintrusion	Surinaamse Waterleiding Maatschappij; Geologische Mijnbouwkundige Dienst;	Surinam Water supply Company Geological and Mining Service
	exchange with surface water	-	-
	health	Centraal Laboratorium	Central Laboratory
Urban system	Water Supply	Surinaamse Waterleiding Maatschappij	Surinam Watersupply Company
	Waste water discharge	Waterbouwkundige Afdeling (Ministerie van Openbare Werken); Waterloopkundige Afdeling.	Division for Construction of water wo (Ministry of Public Works) Hydraulic Research Division
	Waste water treatment	Waterbouwkundige Afdeling (Ministerie van Openbare Werken,) Bureau Openbare gezondheidszorg	Division for Construction of water wo (Ministry of Public Works) Public Health office
	recreation	Ministerie van Cultuur Jeugd en Sport;Stichting Natuurbehoud Suriname.	Ministry of Culture J. and S. Foundation of Nature preservation
	Fishing	Dienst Milieubeheer (Ministerie Volksgezondheid)	Service for milieu management (Ministr of Public Health)
Mining and processing (bauxite stone)	Wateruse for cooling and processing	Suralco	Suralco
	Wateruse in in mining	Suralco, Billiton	
	Navigation	Alcoa Dienst Scheepvaart	Alcoa Navigation service
	Waste water discharge and pollution	Suralco, Sohansingh	Suralco, Sohansingh
	groundwater use and saltintrusion	Dienst Watervoorziening; Geologisch Mijnbouwkundige Dienst.	Watersupply Service Geological and Mining Service
Forestry and tree-crops	research (production)	Landsbosbeheer; Centrum voor Landbouwkundig onderzoek.	Forest Service Centre for Agricultural Research
	harvesting	Particulieren; Bruynzeel, Ghanda	Timbercompanies: Bruynzeel, Ghanda
	Aquifer recharge	-	-
	runoff	Dienst watervoorziening; Centrum voor Landbouwkundig Onderzoek	Watersupply Service; Centre for Agricultural Research.
	transportation	Landsbosbeheer	Forest Service
Small Scale agriculture	drainage needs	Ministerie van Openbare Werken; Ministerie van Landbouw, Veeteelt en Visserij.	Ministry of Public Works Ministry of Agriculture, Animal Husbandry and Fisheries
	Pestcontrol	Ministerie van Landbouw, Veeteelt en Visserij.	" " "
	transportation	-	-

[illegible]	[illegible]	[illegible]	[illegible]
	runoff	Ministerie van Landbouw Veeteelt en Visserij	Ministry of Agriculture Animal Husbandry and Fisheries.
	aquifer recharge	-	-
Large scale agriculture (banana's, sugarcane oilpalm, rice, citrus)	irrigation	Waterloopkundige Dienst, Ministerie van Openbare Werken, Ministerie van Landbouw, Veeteelt en Visserij; Betrokken Plantages, Ministerie van Binnenlandse Zaken,	Hydraulic Research Division; Ministry of public works; Ministry of Agriculture, Animal Husbandry and Fisheries Plantations involved Ministry of Internal Affairs
	drainage		
	runoff	-	-
	subsurface drainage	Landbouwproefstation	Agricultural Research station
	transportation	Ministerie van Openbare Werken Ministerie van Landbouw V. en V.	Ministry of Public Works Ministry of Agriculture A.H and F.
	saltwater intrusion	Waterloopkundige Afdeling	Hydraulic Research Division
	pestcontrol	Ministerie van Landbouw Veeteelt en Visserij Betrokken Plantages	Ministry of Agriculture Animal, Husbandry and Fisheries. Plantations involved

SURINAM RIVER BASIN

Figure 1



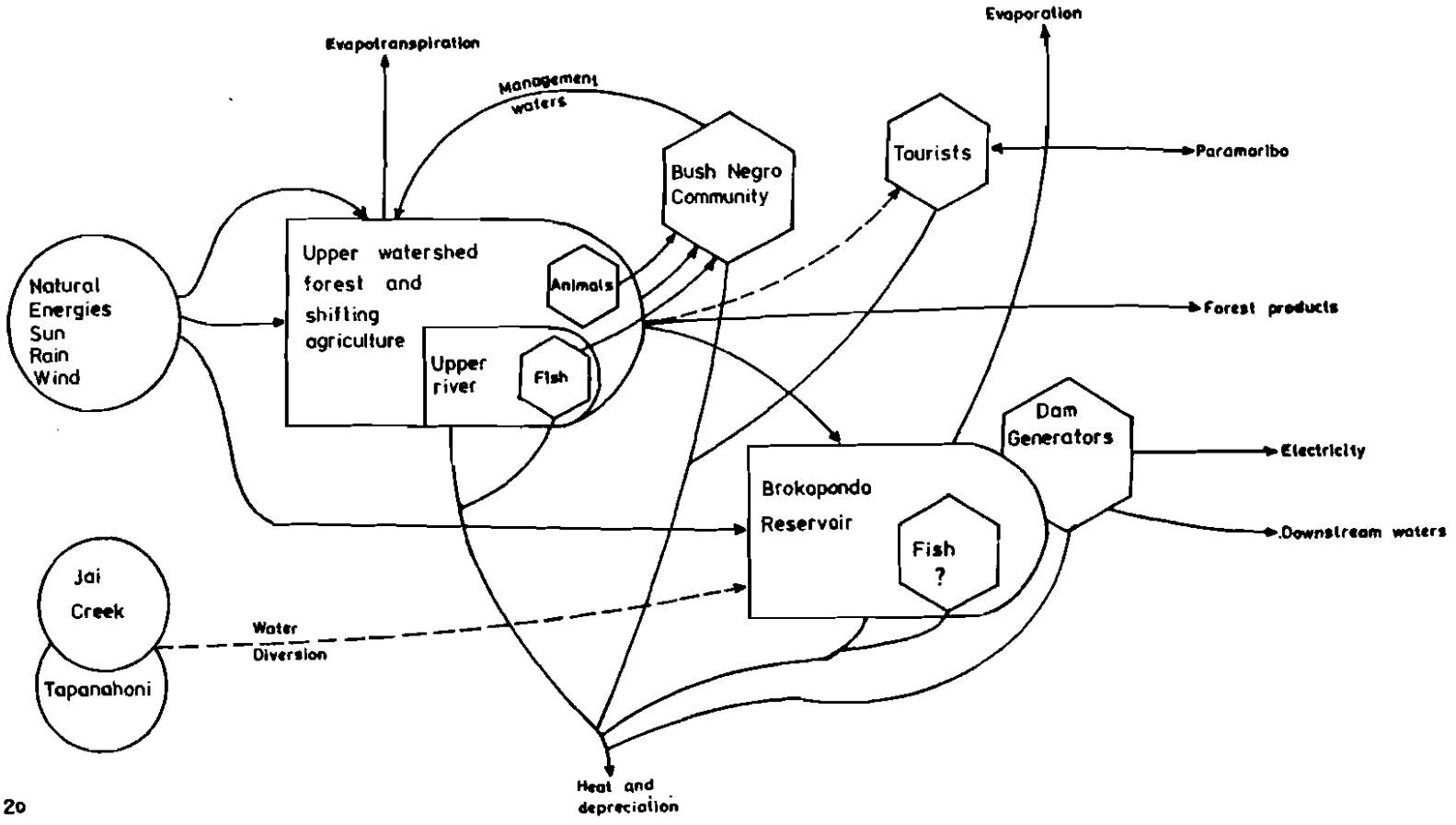


Figure 2o

Conceptual System Model of the Suriname River Basin
UPPER WATERSHED

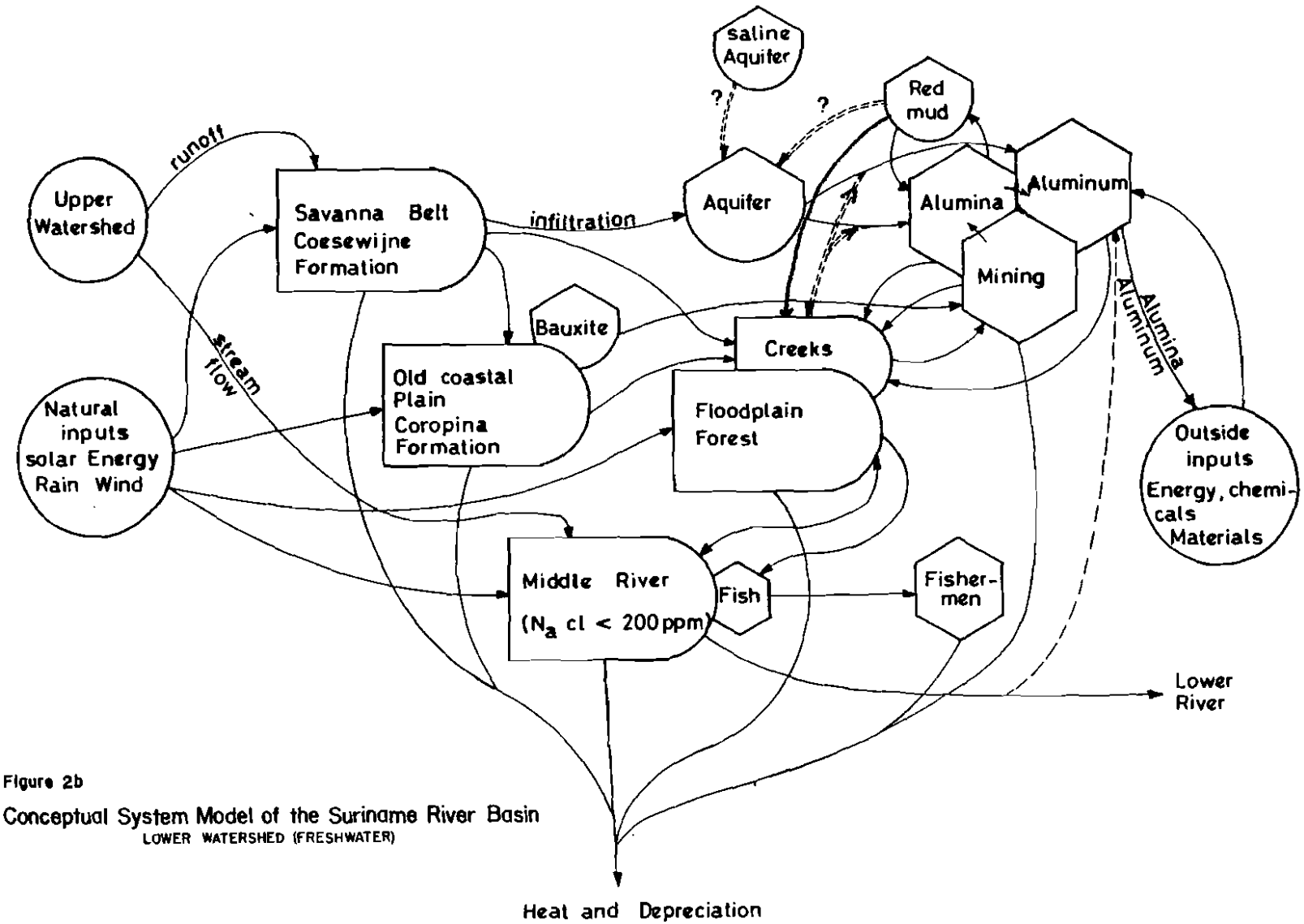


Figure 2b

Conceptual System Model of the Suriname River Basin

LOWER WATERSHED (FRESHWATER)

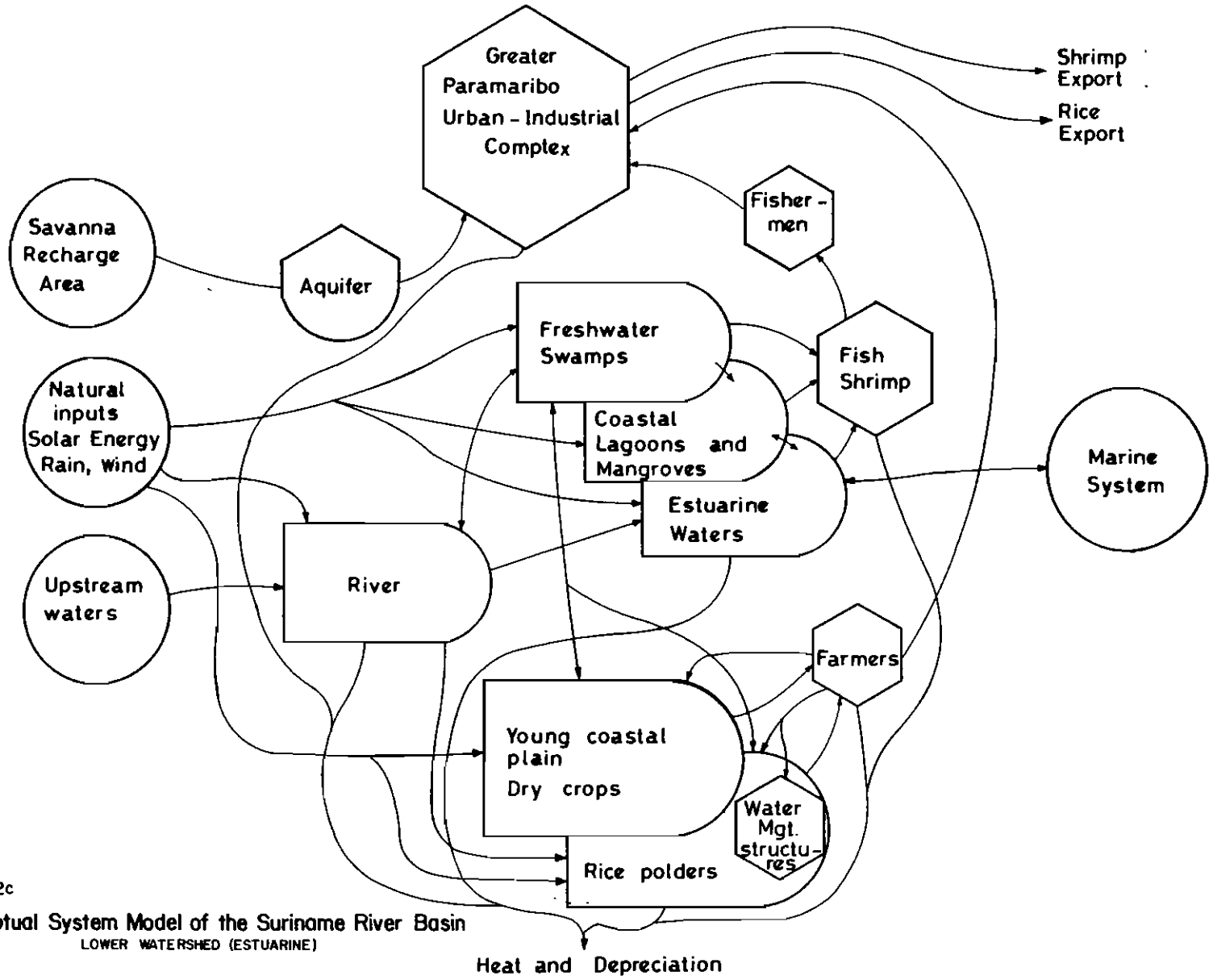


Figure 2c

Conceptual System Model of the Suriname River Basin

LOWER WATERSHED (ESTUARINE)

The Bush Negro population scattered along the main rivers live in dynamic equilibrium with the forest and waters practicing shifting agriculture and hunting and fishing to meet their subsistence needs. They and their agriculture result in a small organic enrichment of the river. The quality of the water resource (as defined above) remains extremely high.

The major potentially important change in the upper watershed is the proposed diversion and interbasin transfer of Jai Creek and perhaps even the Upper Tapanahoni River to the Brokopondo reservoir. (See figure 3). Issues could arise from this action include:

1. Some increase in sedimentation resulting from access road construction and subsequent economically marginal logging. The problem can be mitigated by appropriate road design and construction. Isolation and lack of economic attractiveness will limit forest exploitation or agriculture along access roads.
2. Diversion, particularly if both streams are included, would have international implications and would result in impacts on the well-being and natural integrity of any downstream Bush Negro communities.
3. Diversion would reduce future options for large power development on the lower Tapanahoni.

Management opportunities in the basement rock watersheds include:

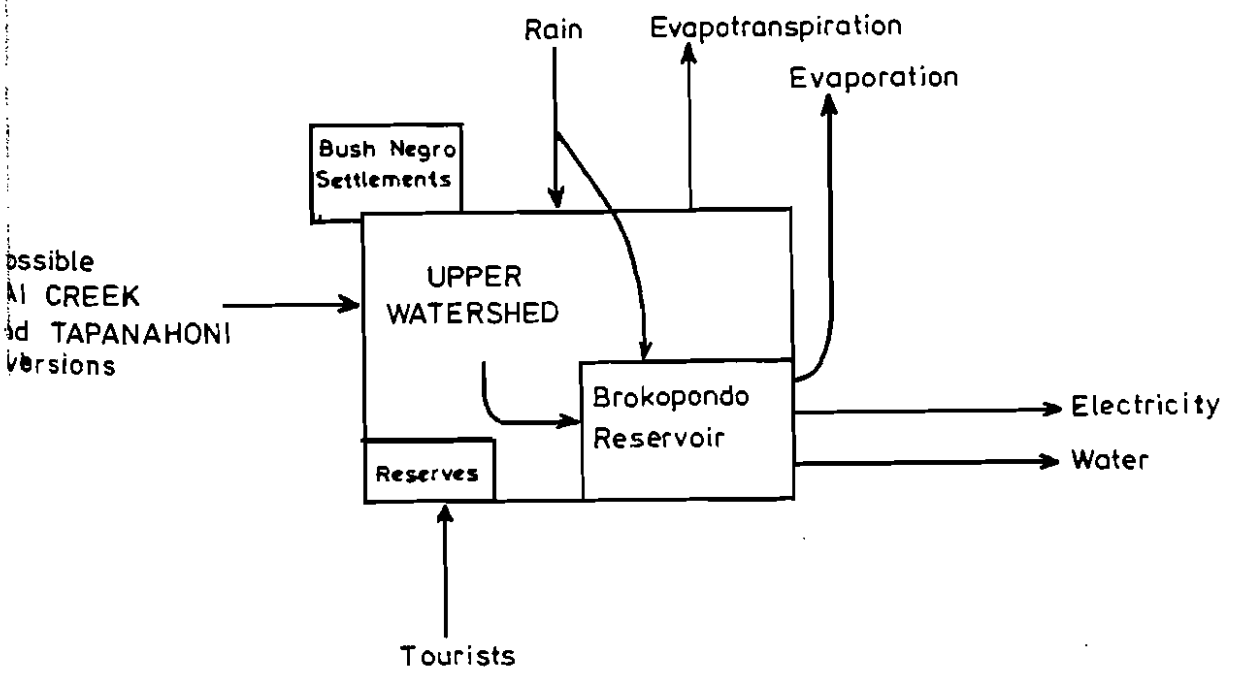
1. Protection of the upper areas from ill - conceived economic activities so that these watersheds can continue to provide large quantities of high quality water for multiple downstream uses.
2. Expansion of the size and use of Nature Reserves and National Parks managed by STINASU. Through national and international tourism the forests and waters can make a high sustained contribution to the economy.

   It is probable that nature oriented tourism would have a higher net value per hectare than would forest exploitation over most of the area without affecting water resources.

3. Small scale hydropower development on the streams of the lower portion of the basement complex. This could be important to small scale forest products industries where there is road accessibility. A program of this sort could specifically benefit any displaced Bush Negro groups who have a natural affinity for forest related activities.

Figure 3

Water and material balance



B. Dam and Reservoir. The Brokopondo reservoir covers an estimated area of 180.000 ha when filled to a depth of 46,9 meters at the dam. Average depth is 11,9 meters. The area covered is relatively level with small hills which emerge as islands. No vegetation was felled or removed before the reservoir was filled; consequently many thousands of tree trunks protrade out of the water. Filling of the reservoir resulted in a tremendous release of nutrients and a massive growth of water hyacinths. Efforts to control the hyacinth were greatly helped by the return of the water to their nutrient poor state as described in the upper watershed section. An overflight in November 1982 revealed no floating vegetation and virtually no vegetation on the shoreline exposed by low water; occasional patches of botton anchored vegetation were noted in the upper, shallow area.Only one wading bird was seen. (See Figure 4)

The problems for other sectors which resulted from the construction and operation of Brokopondo that would likely occur with implementation of other proposed inpoundments are the following:

1. Flow regulation - Whereas seasonal flows previous to dam closure ranged for 50 to 700 m^3/s, flows now average between 200 and 300 m^3/s without significant peaks. The persistant effect is a marked reduction in the flooding of forest adjacent to the rivers and along tributary creeks. Fish are prevented from feeding and reproducing in the rich forest environment. Consequently the freshwater fish population has been drastically reduced. In addition, the pulse of organic material entering the estuarine and marine environment has been reduced with undocumented effects on fish production. The role of pulses of clear freshwater with high erosive potential in maintaining a scoured channel through the mud of Amazonian origin at the river mouth should be investigated.

2. Flow elimination and O_2 depletion. The total elimination of river flow during reservoir filling combined with the sudden release of oxygen depleted water caused considerable fish mortality downstream. Continuing withdrawal of water for the turbines from the oxygen depleted layer in the lake chronically affects downstream water quality although oxygen content of the water is generally improving as a result of gradual oxidation of organic matters in the reservoir.

3. Reservoir fishing. The concentrated river fishery described in the upper watershed section has been replaced by a dispersed fish population more difficult to harvest.

4. Displacement of people. The total disruption of the life style and resource base of the displaced Bush Negro population can occur in other projects unless authorities are sensitive to the physical and sociocultural needs of the people.

Opportunities to be considered in future dam and reservoir development planning:

1. Location in the basement rock area of reservoirs assures an extremely long useful life of the works with minimal investments in watershed protection.

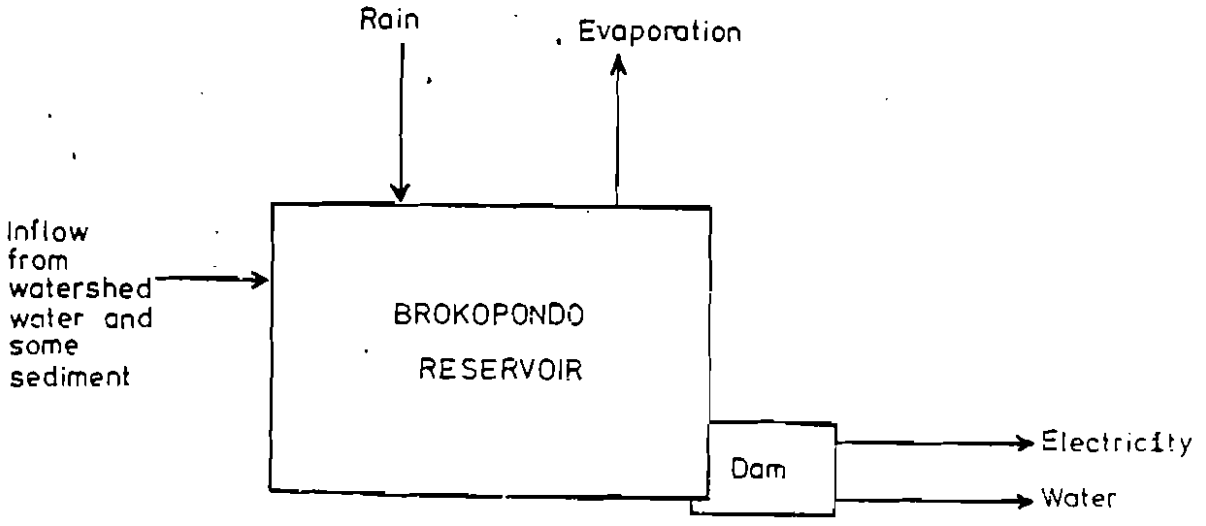
2. The benefits from maintaining a minimal base flow during reservoir filling and the use of multiple intakes to tap more oxygen rich water should be evaluated.

3. Expenditures for forest removal and aquatic weed control do not appear to be justified. After the large amount of biomass covered with water oxidizes, the weed problem tends to disappear as naturally nutrient poor conditions in the reservoir area are restored.

4. Runoff from the basement complex rocks represent a yet undeveloped source of high quality water for urban and industrial use.

Figure 4

Water and material balance



Bauxite mining and processing of Alumina and Aluminum

The presence of yet unexploited bauxite resources in Suriname make evalution of potential conflicts and opportunities of major importance. The dominant place of aluminum/ alumina exports in the economy makes it possible at times to forget the need to maintain the productivity of other sectors - urban, agricultural and fisheries - which have important long term functions in the economy and society. The relatively high level of wellbeing of the Surinamese population in general derives from productive management of equitably distributed natural resources in addition to earnings from the aluminum industry. (See Figure 5)

Problems which should be considered in water management include the following:

1. Mining may go deeper than 30 meters. Mine dewatering can result in local aquifer depletion if water bearing strata are cut. The use of surface water for overburden slurrying does not constitute a major issue. If excess water discharge is not filtered through swamps, undesirable sediment input to surface waters could occur.

2. The red mud, byproduct of alumina, is potentially hazardous to surface and ground water quality. The present pond system appears to provide adequate containment.

3. The single most important effect of the aluminum industry is the large quantity of high quality groundwater used for all purposes, from vehicle washing to steam processing of alumina. The volume and quality requirements of the industry should be evaluated.

4. It is not known what quality or quantity water enters the surface water from the alumina and aluminum processing operations. This should be investigated.

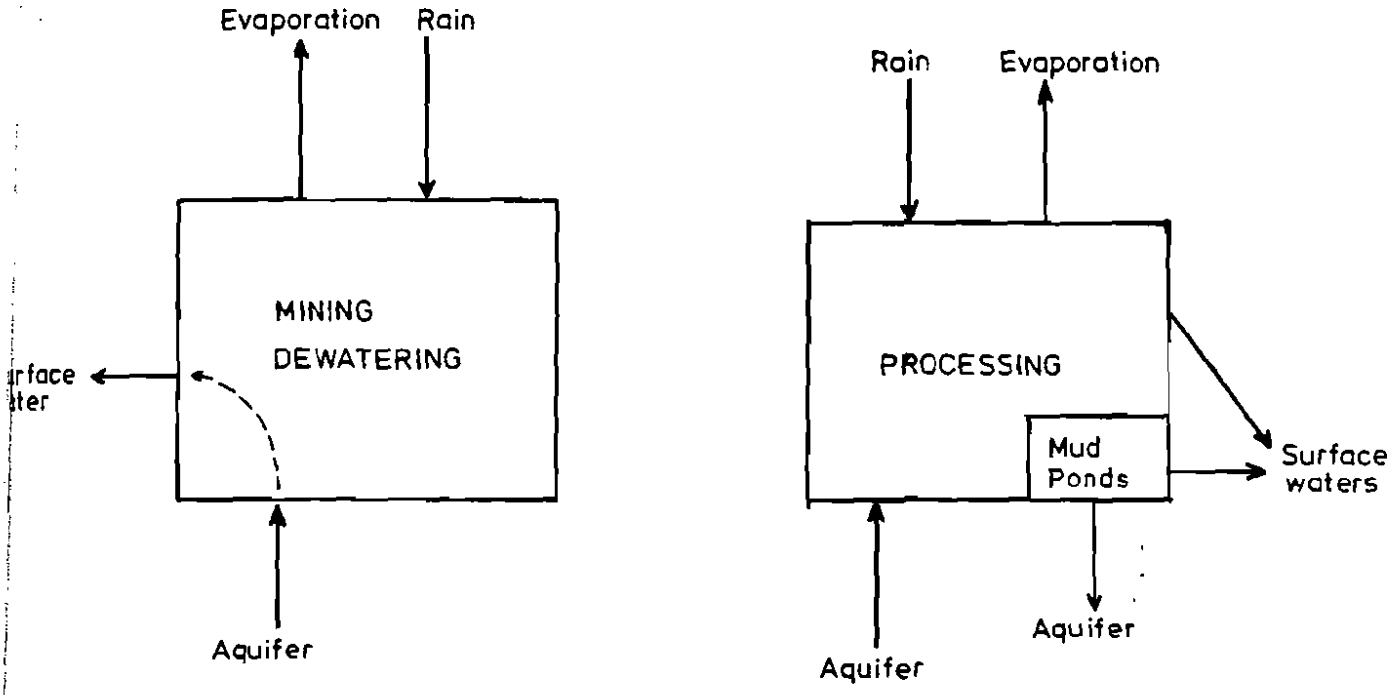
Opportunities for consideration relative to the aluminum industry:

1. Cooperative strategies between industry and other water users to provide for water needs without causing salt water intrusion into the aquifer. Development of surface water resources appears to be indicated.

2. Reclamation of mined areas through breaking down of steep slopes of spoil piles and pit edges for safety and to permit natural succession for restoration of terrestrial and aquatic vegetation.

Figure 5

Water and material balance for Aluminum industry

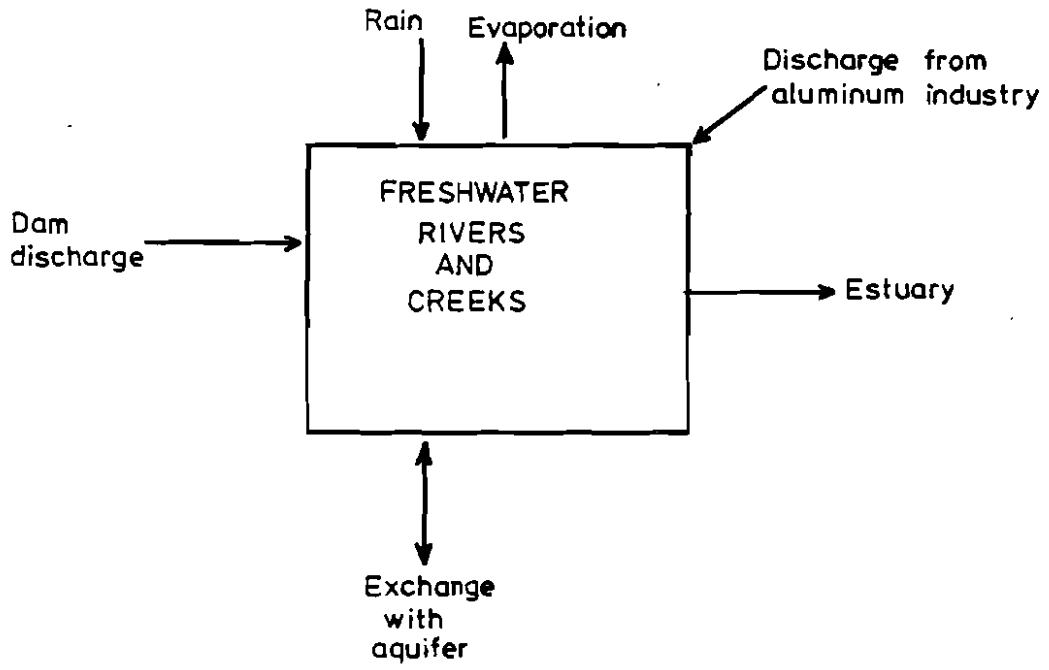


D. Freshwater rivers and creeks

The problems of water fluctuation and fisheries has been discussed as have questions relative to the quality of water discharged by mining and processing. (See Figure 6)

Figure 6

Water and material balance for freshwater rivers and creeks



E. Greater Paramaribo urban-industrial area

Paramaribo is located in the young coastal plain upstream from the mouth of the Suriname River. The low-lying landscape is made up of alternating sand and shell ridges and intervening poorly drained low areas. Originally settlements and roads were located along the east-west tending sand ridges. Now, high and low ground is settled with an impermeability approaching 90% in the built up areas. Except for one small packing plant, the entire city uses septic tanks for waste water disposal. Water supply comes from wells. (See Figure 7)

Major water related problems include:

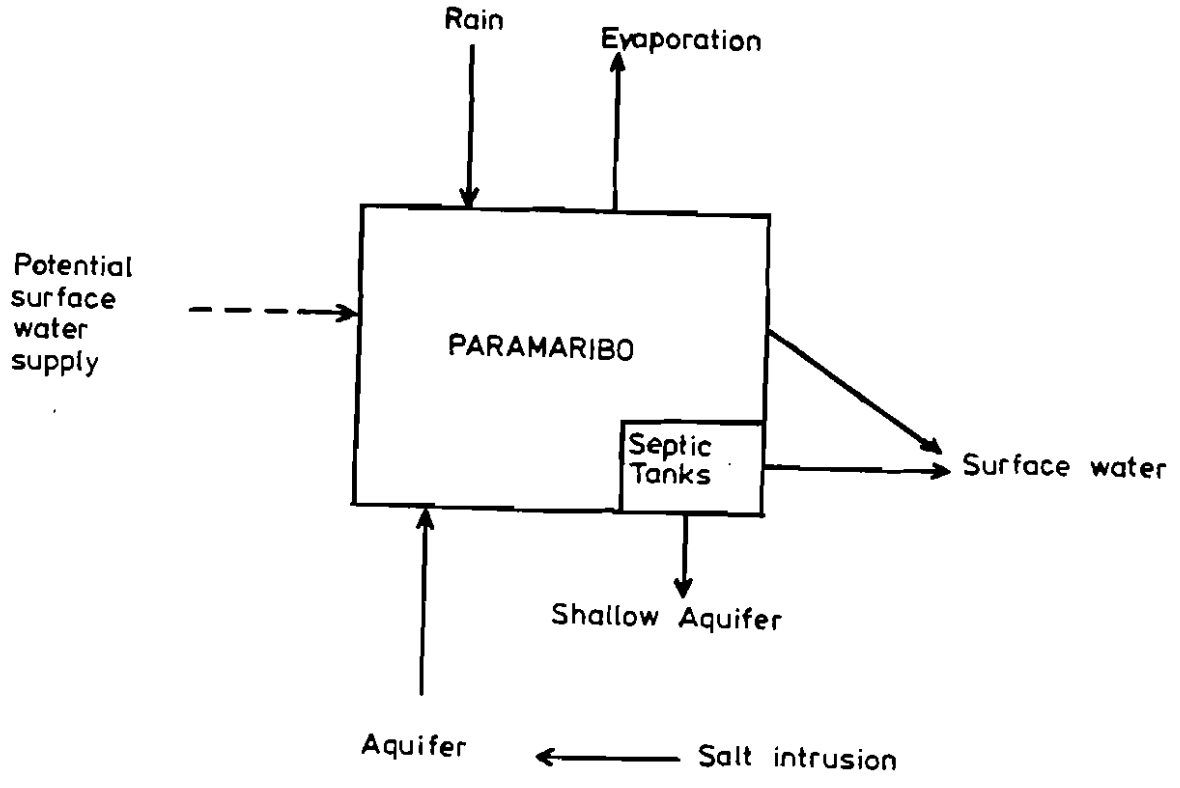
1. Salt water intrusion in aquifers near the city and limited future prospects of expanding water production in the shallow aquifers of the savanna belt.
2. Waste water generation approaching the capacity of the river to assimilate oxygen demanding material.
3. Poor soil conditions for use of septic tanks except on sand ridges. Increasing impermeability of built up area results in increasing problems of flooding by rainwater when high tide blocks drainage of streams and rivers. Flood water contains contaminants from septic tank overflows. Pumping stations being built will transfer contaminated water more rapidly to the rivers and will forgo the use of wet lands for natural treatment of the waste waters.

Opportunities in water management include:

1. Major investigation into the use of surface water for future needs of both the aluminum industry and Paramaribo. The proposed Phedra dam on the Suriname River below the Afobaka dam represents one possibility.
2. Design of a waste treatment system for Paramaribo which makes maximum use of connected settling ponds and swamps/marshes for processing of affluents which meets or exceeds quality requirements for agriculture, fish culture or aquifer recharge purposes.

Water balance for PARAMARIBO

Figure 7



F. Drainage zone - "dry" crop cultivation

Early colonial agriculture was developed to use the low tide period for drainage by means of sluices and to use the rivers for transportation Subsequently road oriented settlement and agriculture developed followed the sand ridges. The ridges are cultivated and cropping extended into lower areas by the use of raised beds. This strategy of raising the land rather than lowering the water was practiced by Indians in the Galibi area in Pre-Colombian times. (See Figure 8)

The major problems of the zone are:

Frequently crop losses due to flooding or high water table currently limits the productive capacity of thousands of full-and part-time small scale farmers.

Opportunities for contributing to agricultural productivity and development through water management include:

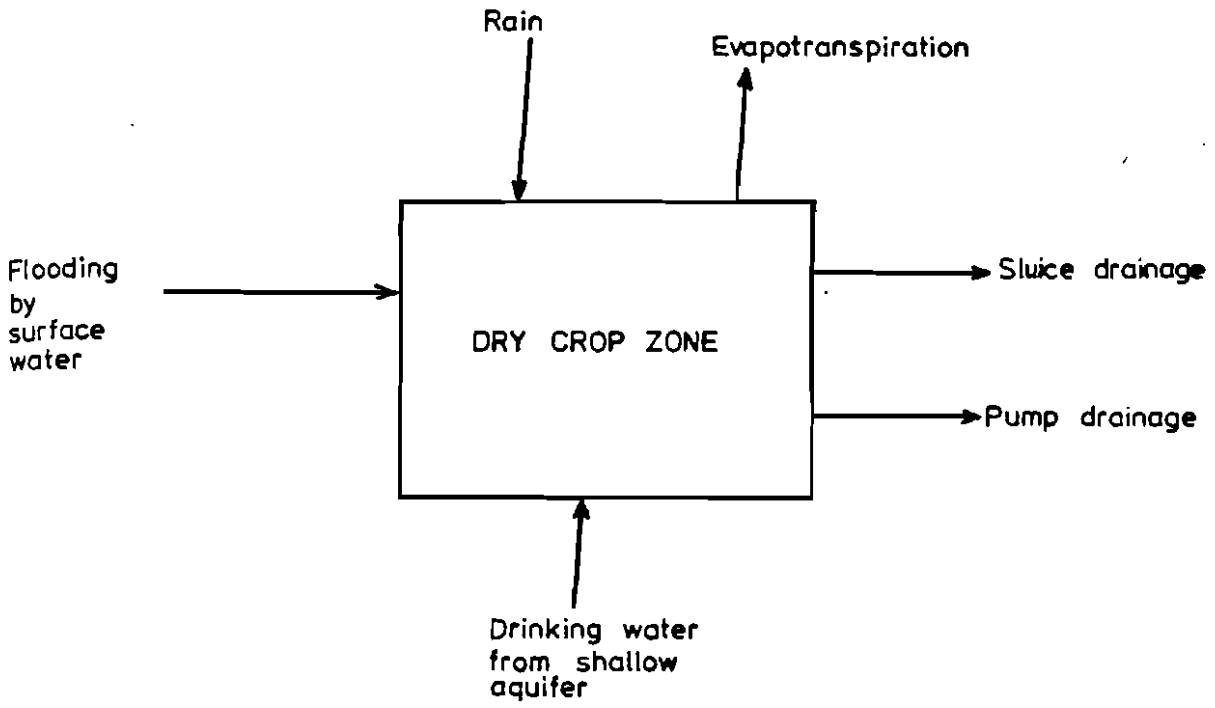
1. Lowest capital and energy costs would be incurred in (a) rehabilitating plantation era sluice drainage systems and medium sized farms growing tree crops and long cycle annual crops on raised beds; (b) providing road access to under-developed sand ridge areas combined with use of raised field technology, requiring minimal drainage works to remove excess water.

2. Intermediate capital and energy cost would be involved in integrated drainage district development with use of sluices augmented by pumping.

3. Either of the above alternatives should be accompanied by imaginative and aggressive efforts in experimentation and extension in water management and cropping system producing locally or internationally marketable crops or animal products. As an example, combined production of fish from ponds, cassava roots and leaves, fruit (the palm Guilielma gasipaes as ingredients for feed concentrate for poultry, hogs or cattle.

Figure 8

Waterbalance Dry Crop Zone



G. Rice production zone

Rice is produced on the heavy clay soils of the young coastal plain using irrigation water from streams and swamps upstream of the polders and drainage via sluices to downstream waters.

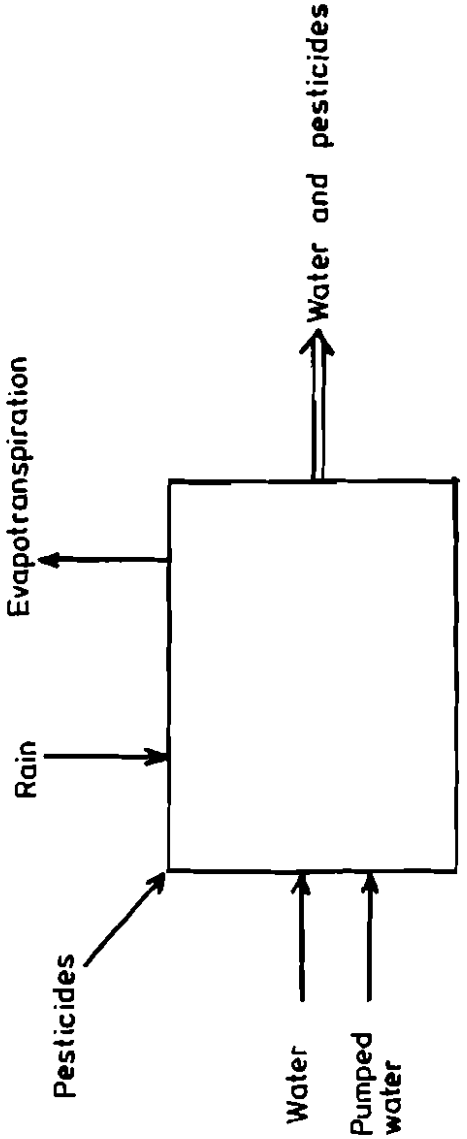
To an increasing degree, pumps are used for irrigation and drainage. Emphasis now is on systems of farms averaging 20 hectares in size. Farms are heavily mechanized with seeding, fertilization and pesticide application being done by aircraft. Development in Nort-West Suriname has exceeded availability of water locally . As a result, a canal is being built from the Corantijn river to the Nickerie area to bring 30 to 50 m^3/s of pumped water to permit expansion of rice production. (See Figure-9)

The production of rice on an export oriented scale has resulted in the following problems:

1. The building to extensive systems of roads, ditches and canals, associated with rice production has caused major disruptions in the flow of fresh water into the coastal system of lagoons and mangroves.

Figure 9

Water balance for the Rice Zone



Such systems linked to the sea serve as major nursery areas for economically valuable fish and shellfish. Productivity can be greatly reduced by the elimination of the upstream input of freshwater, nutrients and organic matter. In addition, polders have been extended up to the coast in the Coronie area completely eliminating the lagoon and mangrove communities.

2. The use of the pesticides with no controls over type, and the use of aerial application, has had a negative effect on fisheries. This effect has not been quantified. The application technique and the types of chemicals used should be determined.

3. Investment in large scale, mechanized rice cultivation represents a use of scarce development capital and a future commitment of costly resources. The opportunity cost of this investment is the net benefits which could have derived from investment in drainage in support of dry crops.

Opportunities in water management in the rice production areas:

1. Encouraging a shift to more economical hand spraying of pesticides in response to actual pest outbreaks rather than scheduled aerial spraying would significantly reduce the rate of pesticide use.

2. Introduction of techniques of integrated pest management would further reduce the amount of pesticides entering the aquatic environment. Pesticide regulation and training in their application, would entrance the complementarity of rice cultivation with fisheries.

3. With the advent of fully integrated pest management options are the production fish in conjuction with rice as practiced in Asia or in the U.S. (Louisiana with crawfish) if economically attractive.

4. In areas where dry season water is scarce and expensive, rice should be rotated with a broadleaf crops to facilitate control of grasses. Rice, rotated with soy bean, is a common example. Grass - specific herbicides may also be used.

WATER LAW - ENVIRONMENTAL CONSIDERATIONS

Concepts

Maintenance of the quality of the water resources should be the guiding principle of regulations. In this way the maximum number of options for the productive use of water downstream are preserved.

The design of a body of laws and regulations governing the management of water is not the task of a lawyer, hydrologist or ecologist working alone, rather it is an interdisciplinary task involving all interests affecting or affected by the water resource.

Specific areas of concern

Upper watershed. The integrity of the water supply function is paramount, whether infrastructure exists or not. When the capacity to back sophisticated studies with strict enforcement exists, then standards can be used. For example, a road must be designed to cause no more than a given increase in sediment generation and only certain types of development along the road will be permitted. In the case of most countries, prohibitions of certain activities is more certain to provide protection. Prohibitions should be based on realistic assessment of the land's capability to support specific activities without degradation of water production functions

The designation of hydrologic reserves as a legally defined national use of the land can help protect infrastructural developments. Additional designation of areas as national parks, reserves and recreation areas lends credibility and prestige to the protection function.

In addition, users of such resources become advocates and allies when powerful interests threaten the integrity of the water resource protection function.

Dams and reservoirs. The right to just compensation for people displaced by a reservoir should be guaranteed. Such guaranties should take into consideration the real needs of the affected group whether it be money, land with particular environmental characteristics or assistance in adaptation to new environments.

Compensation should extend to those deprived of water and those whose water supply has been degraded. For example, those living dowstream of the Afobaka dam have had the flow regime and water quality affected. Ideally such determinations should be made as part of initial benefit/cost and feasibility studies. World Bank and the Inter American Development Bank (IDB) will provide this assistance if specifically requested. IDB has specific "Guideline for preparation of loan applications in environmental management" which is designed to provide loan or grand funds for such purposes.

It may be of value to establish guaranted minimum flow and quality requirements as a means of assuring that downstream productivity is maintained during construction and operation of a water control structure.

Industrial water use. The most important considerations in regulating industrial or any other water discharge are not absolute quality parameters. Rather, the effect in the receiving system should guide regulations. For example, above 40 degrees latitude a temperature rise of 10°C for power-plant cooling water may be no problem, and may even have beneficial effects. However, in the tropics where ambient water temperature may already be near the absolute upper limit, such a temperature rise would be disasterous. All regulations should be based on analysis of the receiving ecosystem's tolerance to the discharge. Human considerations enter as well. If downstream fisherman depend on the ecosystem for survial, concern is different than if a sport fishermen's recreation is affected.

Industries may produce toxic substances such as cadmium or mercury. Such substances are damaging at a wide range of concentrations regardless of the receiving ecosystem. Rigid standards are applicable, in contrast to such discharges as organic matter, sediment, or nutrients.

Agricultural water use. Regulation of pesticide use should be guided by its behaviour in the receiving ecosystem, the effects thereof on uses of that system and its presence as resistence on the product. In the absence of specific local research, extrapolation should be based on the best available scientific judgement. Training to help farmers use pesticides economically - that is, just enough to achieve control, will go a long way toward reducing downstream problem and contamination of products.

Training requirements.

Training in environmental management takes various forms.

1. Decision makers - The goal is to convince them that development is served by intersectorial cooperation to mitigate effects of one sector's activities on another.

2. Technical level professionals - They must understand the concepts and principles of ecology and environmental management well enough to know what specialist help they need and be able to judge the validity of specialist's reports. They must than be able to translate concepts and reports into concrete actions.

3. Extension agents and field technicians - They must understand why they are taking actions and have skills to take samples or teach a farmer by example how to recognize a specific type of pest damage in rice.

The OAS project should focus on the professional level in water resource management. The terms of reference of the personnel in the following section provide an outline of professional training requirements.

Professional requirements:

1. Fisheries biologist: 4 weeks
   Tasks:

   a. Assess the relative merits of managing natural fisheries as compared with or complementary to aquaculture.

   b. Advise on the water management considerations for different aquacultural systems

   c. Outline field level training requirements for fisheries development.

2. Systems ecologist 6 week
   Tasks:

   a. Provide an ecological input to water management planning related to watershed management, industrial water use, agricultural drainage and irrigation, and water resource quality for fisheries.

   b. Coordinate an interdisciplinary field course in environmental management for water management professionals

3. Waste management ecologist 6 weeks
   Tasks:

   a. Assess the existing septic tank system and the effects on human health and aquatic ecosystems.

   b. Provide a conceptual design for waste water management in the Paramaribo area utilizing to the maximum natural ecosystems

   c. Conduct a training course for technical personnel that would be involved in executing a treatment system. Consultants should be included.

4. Estuarine ecologist 5 weeks
   Tasks:

   a. Provide a detailed assessment of the effects of present rice production at the interface of freshwater and coastal ecosystems.

   b. Recommend comprehensive water management strategies to accomodate agricultural and fisheries production.

   c. Conduct a training course for professionals in the management of development activities in the estuarine environment (urban, industrial, fisheries + agriculture).

5. Environmental law specialist: 3 weeks
   Tasks:

   Work with an interdisciplinary committe in producing a coherent legal framework for water management (environmental aspects).