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The Gambia River Basin Studies (GRBS) generated three environmental reports, a sociological report and a synthesis report. Titles of the series, with their identifying acronyms, are as follows:

- Aquatic Ecology and Gambia River Basin Development (AE). A survey of river resources.
- Terrestrial Ecology and Gambia River Basin Development (TE). A survey of wildlife and vegetation.
- Water-associated Diseases and Gambia River Basin Development (WD). A survey of public health.
- Rural Development in the Gambia River Basin (RD). A survey of rural sociology and economics.
- Water Resource Management and Gambia River Basin Development (WR). A synthesis of the other four reports.

The present report deals with public health. The principal author was Curt R. Schneider, public health team leader. Substantial contributions in the form of GRBS Working Documents were made by Alice Hamer (rural health attitudes in Guinea); Morton S. Hilbert (rural water supply and sanitation); Dawooda M.B. Jagne (rural water supply and sanitation in The Gambia); Evelyne Laurin (health situation in Guinea); Emile A. Malek (schistosome snails of the Gambia River Basin); Tonia Marek (food and nutrition surveillance in the Gambia River Basin); and Sara McAndrew (health situation in Senegambia).

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LIST OF ACRONYMS AND ABBREVIATIONS

AHT	Agrar-und Hydrotechnik
CDA	Community Development Assistant
CDC	Communicable Diseases Control Department
CHN	Community Health Nurse
CHW	Community Health Worker
CRED	Center for Research on Economic Development
CRS	Catholic Relief Service
DANAS	Division de l'Alimentation et de Nutrition Appliquée au Sénégal
ENIPHARGUI	Enterprise Nationale de l'Industrie Pharmaceutique de Guinée
FAO	Food and Agriculture Organization of the United Nations
GRBS	Gambia River Basin Studies
HHL	Howard Humphrey Limited
LRD	Lower River Division
MCH	Maternal and Child Health Services
MEPID	Ministry of Economic Planning and Industrial Development (The Gambia)
MID	MacCarthy Island Division
MLGL	Ministry of Local Governments and Lands (The Gambia)
MOH	Ministry of Health
MRC	Medical Research Council
NBD	North Bank Division
OCP	Onchocerciasis Control Programme
OMVG	Gambia River Basin Development Organization
OMVS	Organisation pour la Mise en Valeur du Fleuve Sénégal
ORANA	Organisme de Recherches sur l'Alimentation et la Nutrition Africaines
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
PMI	Protection Maternelle et Infantile
PPMU	Planning, Programming and Monitoring Unit of the Ministry of Agriculture (The Gambia)
PPNS	Programme de Protection Nutritionelle et de Santé (Senegal)
RMO	Regional Medical Officer
RNA	Regional Nutrition Agent
RVH	Royal Victoria Hospital
SEN	State Enrolled Nurses
SGE	Service des Grandes Endémies
SIPOA	Société Industrielle Pharmaceutique de l'Ouest Africain
SRN	State Registered Nurse
TBA	Traditional Birth Attendant
THA	Technical Health Agent
UNEP	United Nations Environment Programme
URD	Upper River Division
USAID	United States Agency for International Development
VHW	Vilalge Health Worker
WASH	Water and Sanitation for Health Project
WD	Western Division
WFP	World Food Programme
WHO	World Health Organization

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1. SUMMARY

1. The public health section of this environmental assessment was undertaken in connection with five major dam construction projects proposed by the OMVG (Gambia River Basin Development Organization), as well as the improvement and installation of new irrigation schemes that will accompany the development.

The five projects include:

- The Balingho Barrage on the Gambia River near the estuary, to control saltwater flow upstream, eliminate tidal action in the upper river, provide a year-round water supply for agriculture, and bridge the river gap in the Trans-Gambia Highway;

- The Kekreti Dam on the Gambia River in eastern Senegal, to generate hydroelectric power and stabilize water supply in order to ensure year-round availability for downstream agriculture;

- The Kogou Foulbe Dam on the Koulountou River in middle Guinea, to generate hydroelectricity and conserve water for downstream irrigation in the Koundara area;

- The Kouya Dam on the Gambia River near its origin in the Fouta Djallon highlands, to generate hydroelectric power and with a possible irrigation potential;

- The Kankakoure Dam on the Liti River in the Fouta Djallon highlands, to generate hydroelectric power.

2. Dam construction will alter many environmental parameters, leading to increased incidence of disease. Such health changes will be seen as responsibilities requiring the active participation of the OMVG. The responsibilities fall into three categories:

- Health protection for construction personnel;
- Control of health risks for populations undergoing resettlement;
- Management of vector-borne diseases over time.

3. The public health experiences of three large, completed dams in Africa (Kainji, Kariba, and Volta) exemplify the kinds of challenges likely to be engendered by the Gambia River Basin dams.

- The Kainji Dam on the Niger River in Nigeria was closed in 1968. Flooding forced the resettlement of 44,000 people.

The consequences are discussed. Schistosomiasis became highly prevalent in certain shore areas. Malaria continued to be highly prevalent in all areas, even after local spraying campaigns aimed at adult mosquitoes. Onchocerciasis was controlled along the lakeshore but not below the dam. These three conditions, in addition to the deterioration in environmental sanitation due to crowding in new communities, represented the main health problems ascribable to dam construction.

- The Kariba Dam on the Zambezi River in Zambia/Zimbabwe was completed in 1958 and created a very large lake of 4,300 square kilometers. The aggregate of preventive and personal medical services provided by the construction authorities represented an admirable response to a difficult challenge and, in the event, proved to be relatively inexpensive (only 0.3 percent of the total cost of the Kariba Dam project). This experience has been well documented in detail and could be offered as a paradigm to potential construction authorities in the Gambia River Basin.

- The dam at Akosombo on the Black Volta River created, what is to date the largest man-made lake in Africa, Lake Volta, between 8,500 and 9,000 square kilometers in area. The 80,000 persons displaced by rising waters have now been replaced by 100,000 persons who have come to live along the shores of the new lake. This large population movement was apparently effected without imposing a great deal of central governmental control. A high rate of onchocerciasis persists among people who lived close to the former river, providing a source of infection for blackflies which still breed in tributaries of the lake. Malaria is transmitted year-round and is holoendemic; the extensive shoreline of the lake (6,400 kilometers) permits many suitable breeding sites for transmitting mosquitoes. Tsetse fly breeding sites, drowned by rising water, have for the most part, not become reestablished but it is believed that, with time, this situation will change to support larger fly populations. Schistosomiasis has become a major health problem because the ecological changes in the lake have permitted increased populations of vector snails.

It is thought that the Kekreti Lake will be a smaller version of Lake Volta and Lake Kainji. Blackflies will be eradicated from the old riverbed but will settle in seasonal tributaries and in the spillway. Malaria will continue to be holoendemic. Schistosomiasis of both urinary and intestinal types will become firmly established in new populations of settlers seeking to exploit the resources of the new lake and control will be feasible but costly.

4. A selection of nineteen water-associated diseases that occur naturally in the Gambia River Basin and that, under the conditions to be imposed by water impoundment, might become more widely transmitted, is given below. They are classified by mode of spread, according to the system of Bradley (1977).

- Water-borne diseases (fecal agents are consumed directly in contaminated water): cholera, typhoid fever, bacillary dysentery, amebiasis, and poliomyelitis.

- Water-washed diseases (deficiency in quality or quantity of water permits development and spread of the infectious agents): scabies, ringworm, trachoma, and yaws.

- Water-based diseases (an aquatic intermediate host is involved in transmission): guinea worm, urinary schistosomiasis, and intestinal schistosomiasis.

- Water-related diseases (water-breeding insect vectors are required for completion of the parasite life cycle and for transmission): malaria, yellow fever, dengue, onchocerciasis, Bancroftian filariasis, trypanosomiasis, and leishmaniasis.

- Fecal-borne disease (defective environmental sanitation permits parasite spread): hookworm disease.

The prevalence, incidence (where known), and public health importance of each of the nineteen diseases is discussed according to data derived from the literature.

5. Where water-dwelling invertebrates are concerned, health authorities want to understand their behavior, ecological requirements, and geographic distribution in order to predict changes that will accompany construction.

- Mosquitoes: *Anopheles* species (*gambiae*, *funestus*, and *melas*) transmit malaria. *Aedes aegypti* transmits urban yellow fever; four or five species of forest-dwelling *Aedes*, including *africanus*, *luteocephalus*, *vittatus*, and *furcifer/taylori* are capable of transmitting sylvatic yellow fever among wild monkeys and/or from monkeys to man.

- Tsetse flies: *Glossina palpalis* transmits human trypanosomiasis. *G. morsitans* is a livestock pest.

- Blackflies: *Simulium damnosum* (actually a complex of three cytologically distinct species) transmits river blindness (onchocerciasis) in eastern Senegal and in the Fouta Djallon of middle Guinea.

6. The access of rural peoples in the Gambia River Basin to medical services is limited (as it is throughout much of the world). The bulk of each Member State's national budget assigned to health is invariably subsumed by fixed centers in urban areas. Rural areas, typically underpopulated in the Gambia River Basin, depend for day-to-day medical services on village health units and, when the situation is grave, regional health centers. Failing this, the sick individual may choose to visit a "traditional" practitioner whose effectiveness may be less impressive than the weight of tradition behind him. The village health unit is often forced (by lack of money) to present a locked door during most of the working day, and it tends to be understaffed and understocked with medicines when it is open. The solution to this state of affairs seems to reside in the concept of primary health care, at least for the larger villages. This concept now receives almost universal support throughout the underdeveloped world.

Other rural services, many of which rely on vehicles and access roads, include immunization schedules or EPI programs, MCH services, and vector control. In the recent past these have been hindered by fuel shortages, lack of spare parts and vehicle maintenance, and bad roads. The effect has been to deny rural areas supplies of needed drugs and to interrupt the cold chain essential to vaccine maintenance.

The Member States are not considered to be unusual with regard to this state of rural health services. The important point is that the system is already stressed by lack of finance and support. Health changes to be imposed by dam construction projects will not be easy to absorb into the structured system. They will have to be recognized in advance, budgetary allowances for increased demand for health services will have to be established in time to meet the demands, and the agreement and cooperation of the established health services will be required to form an essential basis for realizing improvements. There is a clear role for the OMVG technical staff to establish liaison with the health establishments of the Member States which will require upgrading the technical staff by addition of qualified health personnel.

Once in place, a health liaison officer within OMVG will be well placed to identify anticipated problems to the three member-state

governments, with a view to obtaining a change in the level of national commitment to rural health.

7. Predictably, development projects at the Gambia River Basin construction sites will change the environment in a variety of ways, large and small. This report groups such changes according to whether they will occur during the construction phase, during the first five years after construction (short-term), or after the first five years (long-term). Construction phase changes will include in-migration of workers and satellite populations to the dam site, road construction and deforestation, interruption of river current, organic pollution, introduction of new vectors, introduction of new plants and animals, canal construction, and (in the case of the Balingho Barrage) interruption of tidal action upstream from the work site.

Short-term effects will include the elimination of the salinity gradient upstream from the Balingho site; an increased surface area of water; raised water table; inundation of forests and creation of marginal swamps; change in surface water quality; influx of people along the impoundment; associated land clearing and road-building; and introduction of livestock.

Long-term effects will include establishment of a new freshwater habitat with changed shoreline and erosion patterns; replacement of drowned plant types with permanent new types both in the water and on the shore; development of equilibrium in aquatic fauna and possibly development of a new fisheries industry to exploit new fish stocks; and development of permanent human communities at the water's edge.

8. The impacts of water management on diseases transmitted by water are discussed. Major changes are anticipated in the case of schistosomiasis, onchocerciasis and malaria at the Kekreti and Guinea dam sites. It is believed that both types of schistosomiasis will become implanted in the altered Gambia River in The Gambia, substantially increasing the incidence of the urinary type throughout the country and, in effect, introducing the intestinal type to peoples living at the water's edge. The combination of perennial water supplies, increasing concentrations of susceptible persons and indifference to environmental sanitation could result in yellow fever outbreaks. There is reason to expect a resurgence of human trypanosomiasis in sections of the river where this disease has

retreated in recent years. Leishmaniasis (not strictly water-related but dependent on the water table level and consequent microhumidity) is more problematic because less well understood.

9. Mitigating interventions available for health improvements in the initial phases of construction (after identification of the etiology and ecology of the problem) include measures aimed at immunization, improvement of the water supply, improvement in environmental sanitation, mass drug prophylaxis, vector control, and health education or animation rurale.

Cholera, typhoid fever, poliomyelitis and yellow fever can be prevented by a combination of vaccinations, improved water supplies and environmental sanitation, and health education.

The water-washed diseases can be successfully resisted by making safe water easily available to communities.

The principle approach to control of guinea worm and the schistosomiases is by way of vector control, supported by case-finding, and treatment and installation of safe water supplies.

Malaria and Bancroftian filariasis are regularly controlled by prophylaxis or case treatment, augmented on a community basis by vector control. The problems posed by mass prophylaxis of malaria in holoendemic areas such as West Africa are complicated by the nature of malarial immunity and the upsurge of drug-resistant parasite strains. It is quite possible that the availability of a safe and effective malaria vaccine will resolve both dilemmas at once. It is thought that such a vaccine will be available for field testing (in The Gambia) within two years. Dengue can only be prevented by mosquito control.

In the present state of technology, onchocerciasis control is limited to attacks on the blackfly vectors.

Trypanosomiasis has largely disappeared from the Gambia River Basin, but in the event of any significant recurrence it can be controlled by a combination of drug prophylaxis and vector control.

Leishmaniases do not now represent high priorities for public health officials because the cutaneous form is self-limiting and the visceral form is only recently identified in the Gambia River Basin. Control will have to be the subject of field research.

The upgrading of diagnostic services to permit expanded case-finding and treatment, plus improvements in environmental sanitation will reduce the incidence of hookworm infection.

10. The major diseases to be considered (malaria, schistosomiasis, and onchocerciasis) are, fortunately, controllable.

Schistosomiasis can be controlled by utilizing any or all of the following: case treatment and possibly mass treatment, snail control, improved sanitation and water supply, and education. Most approaches reported in the literature have utilized more than one of these elements.

Malaria control relies on chemotherapy and vector control. There are gradations in the commitments of different health authorities to the demands of malaria control, particularly in West Africa where the disease tends to be holoendemic and the risk of reinfection following curative treatment is very high.

Onchocerciasis control in West Africa depends on aerial spraying of blackfly breeding areas and is, accordingly, extremely costly. An international control program currently being undertaken by the World Health Organization's Onchocerciasis Control Programme (WHO/OCP) is available to be extended to the Gambia River Basin (Senegal and Guinea) if financing can be achieved.

Details of these management schemes are presented in the body of the report.

11. Satisfactory methods for putting money values on poor health have not been developed. However, the costs of measures taken to mitigate the negative health consequences of dam construction can be derived from experience elsewhere.

For the purposes of this report, a narrow view is taken in which the costs of measures taken to mitigate the health consequences of development are limited to costs imposed by population movements. In other words, it is not proposed that all new health costs be assumed by the OMVG or its contractors but only those which represent continuing expenditures for construction personnel (for example, drugs or antimosquito chemicals) or capital expenditures associated with the construction site (for example, a new hospital). Other costs, particularly long-term costs, will be borne by the preexisting official health establishment within the country.

2. BASIN DEVELOPMENT AND PUBLIC HEALTH

Environmental assessment is, in our time, a standard component of water resources development planning. Of course, it is clearly not the intent of those who build dams and irrigation schemes to tip an usually delicate health/disease balance in an underdeveloped area in the direction of increased incidence of disease, but this has frequently been the documented case.

It is increasingly realized that planners, engineers, administrators, and funding agencies want to be apprised of any and all health hazards associated with their projects. The focus of the public health segment of the present environmental assessment is multiple and includes a description of the health status of targeted areas, identification of transmission patterns that may be changed for the worse by the project in question, discussion of such mitigations as may be offered by available technology and, where possible, introduction of the subject of costs.

2.1. Objectives

It is expected that the dam construction projects and irrigation schemes contemplated by the OMVG will establish a need for altered approaches to health management in the affected areas, with the focus on three categories:

i) Health protection for construction personnel, including project staff, laborers, and possibly satellite populations at the work site;

ii) Control of health risks for resettled populations, including in-migrants (if any) as well as out-migrants;

iii) Management of vector-borne diseases over time.

Technical staff of the OMVG charged with health matters will interface with established health authorities of the Member States when tackling these problems. Health status comprises a loose composition of conditions that can be discerned at the community as well as at the individual level. Logically, the immediate interests of OMVG are defined by diseases that will be affected by water resource development. Of

additional concern is the general state of nutrition in the affected region, since this impacts directly on response to infection. A major thrust of regional development will be towards irrigated and diversified crops, increased food supplies and a hoped-for amelioration in nutritional status that should accompany this result. (Although a nutritional survey lay outside the budget framework of the present study, the subject is broached in Appendix I.)

2.2. Needs

Five major riverine development projects are planned in the Gambia River Basin: the Balingho Barrage in The Gambia and the Kekreti Dam in eastern Senegal (both on the Gambia River), as well as three dams in middle Guinea, namely, the Kogou Foulbe on the Koulountou, the Kankakoure on the Liti, and the Kouya on The Gambia. The geographic proximity of the last two permits some health assessments for them to be combined. Each of these dam projects will create its own set of health problems, although certain broad descriptions are possible. Variables affecting disease transmission include climate, year-round relative humidity, resident human population, size and depth of the impoundment, draw-down, water chemistry, plant and animal associations, and accidents involving introduction of parasite strains. Table 2.1. compares certain parameters of three African man-made lakes plus the unfinished Manantali Dam in the Senegal River drainage, with the four dams proposed on the Gambia drainage. It is seen that the Kekreti dam will create a relatively small lake of only 242 square miles, while the Guinea impoundments will be smaller still, although the Kouya and Kankakoure dams near the headwaters of the basin will make very deep lakes.

Since there is an absence of specific health impact models for West African impoundments, generalized descriptions must serve the purpose of accurate description. Certain disease entities always seem to obtrude in Africa when dams are built. Heading the list are: malaria, schistosomiasis, and onchocerciasis -- representing major diseases affected by changes in the amount, nature and permanency of surface water; by changing human populations; and by the introduction of new

TABLE 2.1.

SELECTED PARAMETERS OF FOUR AFRICAN MAN-MADE LAKES COMPARED WITH NEW IMPOUNDMENTS PROPOSED BY OMVG

Dam	River	Approx. North Latitude	Maximum Surface Area (km^2)	Maximum Depth (m)	Date of Closure	Reference
Kariba	Zambezi	17°	4,300	125	1958	12
Akosombo	Volta	7°	8,800	80	1964	12
Kainji	Niger	10°	1,250	60	1968	12
Manantali	Bafing	13° 19'	477	65	1988(?)	315
Kekreti	Gambia	12° 45'	242	14.5	--	AHT/HHL[a]
Kogou Foulbé	Kouloutou	12° 12'	38	75	--	OMVG[b]
Kankakouré	Liti	12° 00'	8.3	280	--	OMVG[b]
Kouya	Gambia	12° 03'	1[illegible]	201	--	OMVG[b]

NOTES: a) Agrar-und Hydrotechnik/Howard Humphrey Limited, 1983. Projet du Réservoir de Kekreti; Sommaire de la Réalisation et Annexe C.

b) Letter from OMVG Technical Staff dated 20 February 1984.

University of Michigan, Gambia River Basin Studies, 1985.

parasite strains into an area. In addition, several other water-related infections will be affected and therefore merit inclusion in the present report. In Bradley's classification (see Bradley, 1977) they include water-borne diseases (cholera, typhoid, bacillary dysentery, amebiasis, and poliomyelitis); water-washed diseases (scabies, ringworm, trachoma, and yaws); water-based diseases (guinea worm infection and schistosomiasis); water-related diseases (malaria, yellow fever, dengue, onchocerciasis, Bancroftian filariasis, trypanosomiasis, and leishmaniasis); and fecal-borne disease (hookworm infection).

In the Gambia River Basin these entities occur with varying degrees of intensity, depending on geographic locality. Their precise distribution and public health importance can usually be obtained by consulting the published literature or current official reports. Valid predictions about their significance under impoundment conditions can be hazarded on the basis of experience with the other dams in neighboring Africa (the Kainji Dam on the Niger, the Akosombo Dam on the Volta and, farther off but still of great historical interest, the Kariba Dam on the Zambezi). Health problems associated with the construction of these great dams are discussed below. In addition, attention is paid to the Manantali Dam on the Bafing in Mali, an enterprise of the OMVS (Organisation pour la Mise en Valeur du Fleuve Sénégal), which is not complete but which neighbors the sites in the Gambia drainage.

But a short overview of each of these constructions will not provide all the desired answers required to satisfy planners and administrators in OMVG. Accordingly, a selection was made of highly visible diseases, all characterized by their dependence somehow on water for successful transmission. These "major diseases" are the subject of research reports as well as official reports, and these sources yielded considerable information about the prevalence of the listed diseases, sometimes information regarding incidence, and insight into the importance of the disease(s) to the local medical authorities and the communities. The results are presented in section 3.1.

A discussion of ecological aspects of transmission is presented in section 3.2.

The size and condition of the medical services in the Member States is given in section 3.3.

In order to delineate the anticipated health impacts of dam construction and irrigation in the Gambia River Basin, a matrix of environmental impacts was developed, against which specific disease entities could be measured. The results are discussed in section 4.1. and section 4.2. In a further section (4.3.) consideration is given to the effects of out-migration, resettlement, and in-migration of workers on disease transmission and public health.

Many of the environmental changes imposed by dam construction will be permanent and their effects will have to be accepted by the indigenous peoples of the Basin. Some changes will be quick and highly visible, such as the constellation of health problems that accompany new population concentrations. Other changes will be slow and possibly not associated in the public conscience with dam construction. The commitment of each Member State to health management is probably fixed. The need to tackle newly created problems may force health authorities to seek outside the country for resources with which to do it. Section 5.1. considers the current in-country responsibilities. The mitigative kinds of actions which will lead to disease control are considered in section 5.2. Available technology provides formal control procedures with identified components only in the case of the most widespread of the water-associated diseases (schistosomiasis, malaria, onchocerciasis) and these are considered in section 5.3.

Finally, Chapter 6 develops the economic implications, trade-offs, and costs of the different schemes and available interventions.

The substance of the present report was derived principally from library materials, supplemented by field visits to riverine impact sites, as well as discussions with health officials and informed individuals in The Gambia, Senegal and Guinea.

The following University of Michigan GRBS Working Documents were utilized in the preparation of this report:

- #1 Materials towards a Bibliography related to Gambia Basin Development. Banjul: UM GRBS, 3 March 1983. 70 p.

- #4 Gambia River Basin Studies Work Plan. Ann Arbor: UM GRBS, March 1983. 171 p. Plus three addenda of later date.

- #9 Material on Medical Establishments in OMVG Member States, by Sara McAndrew. Banjul: UM GRBS, 30 July 1983. 67 p.
- #27 Snail Intermediate Hosts of Human Schistosomiasis in The Gambia and Senegal, by Emile A. Malek. Banjul: UM GRBS, 16 February 1984. 17 p.
- #31 Costs of Mitigating Measures for Public Health in the Gambia River Basin, by Marty Makinen. Banjul: UM GRBS, 30 March 1984. 24 p.
- #34 A Food and Nutrition Surveillance System for the Gambia River Basin, by Tonia Marek. Banjul: UM GRBS, March 1984. 102 p.
- #35 Rural Water Supply and Sanitation in the Gambia River Basin, by D.M.B. Jagne. Banjul: UM GRBS, June 1984. 29 p.
- #43 Draft Materials on Analytical Methodology for Economics and Trade-offs in Public Health, by Marty Makinen. Banjul: UM GRBS, September 1984, 16 p.
- #54 Heath Situation in the Republic of Guinea, by Evelyne Laurin. Ann Arbor: UM GRBS, November 1984.
- #55 An Indigenous Perspective of Health and Disease in Guinea, by Alice Hamer. Ann Arbor: UM GRBS, February 1985. 45 p.
- #56 An Overview of Nutritonal Status in the Gambia River Basin in Guinea, by Alice Hamer. Ann Arbor: UM GRBS, February 1985. 32 p.

2.3. Experience Elsewhere in Africa

An examination of the health and ecological problems of certain geographical areas of Africa posed by the building of dams and creation of man-made lakes, must precede a consideration of potential health problems in the Gambia River Basin. Three areas (in Zimbabwe, Ghana, and Nigeria) have been the sites of fairly recent river development projects. The experiences of these projects will support predictions in The Gambia, Senegal, and Guinea.

2.3.1. Kainji

The following account is adapted from Imevbore (1975).

2.3.1.1. Geographical features of the Kainji Dam area. The Niger River arises in the Fouta Djallon highlands of Guinea, traverses 2,550

miles of semidesert, grassland, deciduous woodland, and evergreen forest, and finally empties into the Atlantic Ocean off southern Nigeria.

The dam on Kainji Island is 1,030 km from the sea. It was finished in 1968. The resulting impoundment, Kainji Lake, has an area of 1,250 km^2. The dam is 8.3 km long and 65.5 m high.

The area is generally humid with small seasonal and daily variations in temperature. The mean maximum temperatures (30-40° C) are highest in March and April, while the mean minimum temperatures (20-25° C) are lowest between December and February. The total annual rainfall (on the order of 100 cm) occurs between the months of April and October, and takes the form of localized violent rainstorms of an uneven distribution. The five months of November to March are generally dry and there is practically no rain in January.

The people of the area live by farming, fishing, cattle-raising or trading. The population density varied (in 1965) between 38 people per square mile (15 per km^2) and 9 per square mile (3.5 per km^2). The low population density may be ascribed to the prevalence of Simulium damnosum and onchocerciasis.

Before the construction of the dam, people lived in small villages consisting of mud huts. The value of these, and also the cost of the land, was negligible. As a consequence of the flooding of the lake basin, 44,000 people were resettled in 139 new villages and two towns, comprising 4,320 houses with 27,642 rooms. General services were provided in the form of wells for drinking water, markets, shops, schools, town halls, dispensaries, veterinary clinics and mosques. The cost of all this to the government was L10,700,000 -- amounting to 12.6% of the total cost of the Kainji project.

The lake has drowned many Simulium breeding sites. Every year the lake receives two floods, the first between August and October, the second between December and February. Both raise the level of the lake considerably, while the annual draw-down of 10 m reduces the volume (15 km^3) and area (1,250 km^2) of the lake to about one-third of its maximum during the peak of the dry season.

The lake water is turbid as a consequence of colloidal clay in suspension and a fairly rich growth of unicellular algae. The zooplankton includes rotifers, cladocerans and Thermocyclops sp., and

mosquito and water-mite larvae. Snails of the genus Mutela seem to thrive along the edge of the lake but their numbers are limited by the annual drying-up of the littoral zone.

2.3.1.2. Health hazards before the dam (disease vectors).

- Simulium damnosum. The blackfly was breeding in numerous sites in the area and onchocerciasis was a major health hazard. In 1959, 270 people were examined and an infection rate of 49% was found. In 1956, 5.7% of a sample of 66,000 people were determined to be blind as a result of onchocerciasis. Biting rates of 1-5 per man per hour were common. The breeding season seemed to last 10 months in many of the streams.

Because of the heavy risk of onchocerciasis, the living quarters of the workers on the Kainji Dam had to be located about 10 miles from the river. Today a town called New Bussa has developed around these camps left by the contractors.

- Snails. Both Bulinus truncatus and B. globosus (the carriers of Schistosoma haematobium) and Biomphalaria pfeifferi (the carrier of S. mansoni) were found in the area. The occurrence of these snails, in the area of the dam construction and around the camps, indicated the possibility of the spread of schistosomiasis within a short time after dam construction.

- Tsetse flies. Both vectors of human sleeping sickness, Glossina palpalis and G. tachnoides, were found in the area before dam construction. The overall prevalence of trypanosomiasis in 2,115 examined people was low (0.38%) but in certain villages it was as high as 2.86%.

- Mosquitoes. Two vectors of malaria, Anopheles gambiae and A. funestus, were present. The former was the wet-season species, breeding in pits, pools, road site, gutters and other man-made foci, while A. funestus bred throughout the year in slow-running rivers, streams, and swamps.

2.3.1.3. Health hazards during dam construction.

- Influx of population. The building of Kainji Dam involved the services of more than 20,000 workers over a 4-year period. Health was endangered mainly by crowding and by accidents. Camps were built to house people of different nationalities and their families but, in addition to this labor force, all kinds of people flocked to the area to

seek their fortunes. These rural people settled either near the camp or in the nearby village of Wawa, which was lacking in sanitation. As a consequence various infectious diseases were prevalent.

- Insect control. The high incidence of onchocerciasis and malaria among the indigenous population demanded a control program aimed at the health of the construction labor force. Control of both *Simulium* and *Anopheles* was attempted by treating breeding sites with DDT.

Simulium was attacked by dosing breeding sites in streams with DDT at concentrations from 0.33 ppm to 2 ppm for 30 minutes every 10 days. Application was manual, into streams and rivers in the neighborhood of the dam and within 10 miles downstream. The result was a reduction in breeding in treated stretches of the river, but neither larvae nor adults were ever completely eliminated, as shown by their rapid reappearance and recolonization of the breeding sites. Adult flies remained abundant in the area. Reinfestation from undiscovered foci was frequent.

Anopheline breeding sites near the construction camp were sprayed with DDT to destroy larvae. The results were difficult to assess. Mosquito density may have been reduced, but malaria continued highly prevalent in the area, and it is likely that DDT-resistance on the part of the mosquitoes may have been involved.

2.3.1.4. Health hazards after the establishment of the lake.

- *Simulium*. Above the dam, breeding of blackflies in the lake was prevented. As a consequence, where there had existed only 10 small riverine settlements in former *S. damnosum* foci, there were more than 70 permanent fishing villages and camps after construction. Blackflies are still found below the dam but not in the first 10 miles of the main river.

Schistosomiasis has become very prevalent in some areas near the lakeshore. In 1972 a survey of 4 major villages, including 1,656 people, revealed an overall infection rate of 31%. The major parasite in *S. haematobium* is carried by *Bulinus globosus*. *S. mansoni* was still a relatively minor menace in 1975.

Although *Anopheles gambiae* was found breeding at certain points on the lake shore where the drawn-down is gentle, most of the shoreline of Kainji Lake is flat and unstable, rendering it unfavorable for breeding of this species.

No cases of trypanosomiasis were found among 85,482 people examined in the area in 1972.

When cholera broke out in Nigeria in 1971-72 only a few sporadic cases were reported from near the lake.

Immediately after the dam was closed and when the lake was filling (August-October 1968) there were several reports of snake bites among fishermen. The rising lake level dislodged the snakes which then clung to fishing nets or sought refuge in boats or canoes anchored near shore.

2.3.2. Kariba

This account is based on the reports of Webster (1960, 1975).

The Zambezi River begins its 2,000-mile course in Zambia, flows through Angola and the Caprivi Strip, becomes the boundary between Zambia and Zimbabwe, then flows east to Mozambique and the Indian Ocean. Prior to 1955, Kariba was represented by a deep gorge east of the Zambezi's confluence with the Sanyati and Naodsa Rivers. The gorge was flanked by hills that rose 1,600 feet above the river.

The dam across the gorge that was to create Kariba Lake behind it was begun in 1956 and was virtually complete by the end of 1959. Although this dam was approximately 1,300 feet above sea level, the housing site for workers was positioned, for health and comfort, further up the slope of the gorge at 2,700 feet above sea level.

The project called for construction of a concrete dam 130 meters high, some 600 meters long at the crest and consisting of about 1.3 million cubic meters of concrete. In the event, this dam created a vast lake, Kariba Lake, flooding over 5,000 square kilometers of Zambia and Zimbabwe (or Northern and Southern Rhodesia, as they then were).

At the start of work in mid 1955 there were 10 Europeans and 320 Africans working at Kariba. By the end of 1959, nearly 13,000 men had worked there, including 11,000 Africans and 2,000 Europeans.

The population displaced on both north and south shores of the river, the Batonka, were pastoralists and herders who had been driven into the Zambezi Valley by more warlike people ages before. The then Southern Rhodesian government undertook to relocate some 22,000 Batonka, together with a small group of another tribe, the Kore-Kore, who inhabited the area closest to the damsite. The move was made over a period of three

years. It was facilitated by the fact that the Batonka were being moved back to lands which their ancestors had once occupied.

2.3.2.1. Health program. The main features of the program of preventive and personal medical care services provided for the workers on the Kariba Dam project were as follows:

- Preemployment medical examination, treatment and acclimatization. All work recruits underwent a medical examination on arrival at the work site. Parasitic infections were treated. Antimalarial drugs were started prophylactically.

- Antimalaria measures. Living quarters at the Kariba camp were treated three times each year with a residual insecticide. The standard prophylactic drug, pyrimethamine, was given weekly (25 mg/week).

- Antitrypanosme measures. A program of intensive air spraying of insecticide was undertaken. It covered a period of about 4 months during the cool season of the first year and effectively eliminated the fly from the construction site for the whole of the construction period. Reinvasion was discouraged by site control teams patrolling main routes and spraying vehicles.

- Living conditions. An early decision was to provide Kariba workers with above-standard housing, and sanitation and water supplies.

- Nutrition. Rations were provided uncooked for married men but single men had their meals cooked for them.

- Prophylactic inoculations. Upon arrival all personnel were vaccinated against smallpox, and all adults received a course of immunization against enteric fevers and tetanus. For children, BCG vaccination and diphtheria, whooping cough and tetanus prophylaxis were available. Early in the project a program of poliomyelitis immunization was undertaken.

- Medical services. A clinic and dressing station was established in each housing area early in the construction phase. This facility dealt with minor disabilities, and served as a base for mother and child welfare clinics and inoculation stations.

- Hospital. A fully equipped 100 bed hospital was built and staffed by three medical officers.

2.3.2.2. Costs. By June 1957, there were 6,197 Africans and 1,168 Europeans employed at the construction site.

Over a period of four years, adequate and comprehensive health service was provided at a cost of less than 250,000 pounds, including the capital cost of the hospital.

Related to the total cost of the Kariba Dam project, the cost of medical services amounted to 0.3%.

2.3.3. Volta

This account is drawn largely from the reports of the Smithsonian Institution (1974) and Obeng (1975).

Construction on the Akosombo dam commenced in 1962 and was completed in 1968, when the lake began to form. The dam created the largest man-made lake in the world, Volta Lake. Some 700 kilometers of the Volta River became a vast, dendritic-shaped lake with approximately 6,400 kilometers of new shoreline and a surface area of 8,500 square kilometers. The maximal controlled elevation of the surface was 90.5 meters above sea level behind the dam (Smithsonian Institution, 1974).

Approximately 80,000 persons were displaced from their homes as the waters rose. This occasioned a major relocation effort and a major cost. By 1971, the total cost of resettlement amounted to some $34 million (in 1969 dollars). Of the 80,000 affected individuals in the Volta basin, 67,000 agreed to be resettled and 13,000 opted for cash compensation (Smithsonian Institution, 1974).

The water-oriented communities on Lake Volta now consist of established towns and villages which existed before the formation of the lake ("host" communities), the 52 resettlement villages constructed to house families displaced by the lake, plus numerous spontaneous and short-lived villages of fisherfolk, located at the shoreline itself. It has been estimated that about 100,000 persons now live in up to 1,000 communities located on or near the shore of the lake (Smithsonian Institution, 1974).

2.3.3.1. River blindness. Before dam construction the blackfly (*S. damnosum*) bred extensively in the rapids of the Volta River and its several tributaries. The rising waters of Volta Lake flooded out the breeding sites by submerging the rapids. In 1965, soon after the lake formed, 42 streams near the lake were examined for blackflies. It was found that many species of blackfly continued to breed in the Volta River

and its tributaries below the dam, as well as in most of the rivers flowing into the lake above the dam, although the species damnosum was poorly represented in the collections (Obeng, 1975). No larvae have been found in the Pru or the Afram Rivers where they flow into the lake, but other smaller tributaries do support S. damnosum, whose long range flight permits them to bite long distances away from their breeding sites. The ecological requirements of the flies have not been altered by the lake since flies breeding below the dam and in tributaries of the lake, still find their blood meals, evidenced by the persistent high rate of infection among people who used to live close to the Volta River.

2.3.3.2. Malaria. The extensive shoreline of 6,400 kilometers provides many suitable places for the breeding of malarial mosquitoes. A. gambiae, the principal vector, has a wide range of breeding habitats, including isolated pools and puddles near shore as well as shallows of the littoral zone of the lake. Between 1964 and 1972, larval and adult stages of this mosquito have been collected in numerous areas around the lake (Obeng, 1975). A. funestus is associated with weedy areas near shore and particularly with the water lettuce, Pistia stratiotes. Other species which transmit malaria are now found in tributaries of the Volta Lake, including A. pharaoensis. Since malaria is transmitted on a year-round basis and is holoendemic in Ghana, the disease is found to be particularly prevalent wherever human settlements are in proximity to mosquito-breeding sites.

2.3.3.3. Sleeping sickness. Tsetse flies used to breed heavily along the shore of the Volta River and many of its tributaries. Although the preadult stages of Glossina are independent of water, the fly requires cool shady areas where humidity is high both for normal habitat and for breeding purposes. Ten species of Glossina occur in Ghana including those involved in transmission of human trypanosomiasis or sleeping sickness, G. palpalis and G. tachinoides. Fly populations recorded on the edge of the inundated area have been smaller than previously recorded, and few flies have been found to be infected. This could change as suitable habitat becomes reestablished at the lake's edge.

2.3.3.4. Schistosomiasis. Creation of the Volta Lake did not introduce schistosomiasis into Ghana. However, populations of the vector mollusks have increased due to ecological changes created by the lake.

Chief among these is the increased flourishing of submerged aquatic plants such as hornwort (Ceratophyllum demersum), which provides protection to Bulinus snails and their eggs. Indeed, breakup of mats of submerged plants and their dispersal to other parts of the lake is a chief method for distributing the mollusks to new sites, including areas frequented by man. Although Bulinus snails are found near shore as well as in Ceratophyllum growths further away from shore, there tends to be an abundance of snails infected with schistosomes near the shore. This is because of heightened human activity in the shallower part of the water, and also because the shoreline creates a "rebounding" barrier to miracidial spread, ensuring that shore-ward snails have a higher chance of becoming infected.

It is now known that transmission of urinary schistosomiasis in Lake Volta is a focal phenomenon that can be interrupted by focal mollusciciding and weed clearance. Until quite recently, S. haematobium had been the only form of schistosomiasis associated with the lake. Now, however, Biomphalaria pfeifferi, a snail which transmits intestinal schistosomiasis, has been found in certain tributaries.

Discussion. The creation of an immense lake with a complicated shoreline liberally sprinkled with hundreds of small communities taking advantage of the newly developed fish resource should represent an economic benefit, all the more valuable for being unanticipated (Volta Lake was created primarily to provide energy for a commercial aluminum industry in Ghana).

However, the health problems inherent in these communities has gotten out of hand. Intestinal schistosomiasis, for example, has become a universal plague that defies efforts at control. Although intestinal schistosomiasis was known to exist in the Volta Basin, rates were relatively low. The disease was transmitted by a snail, Bulinus globosus, and it was confidently predicted that this snail would be spread far and wide by the new lake. But in the event, globosus did not spread (even today this species is limited geographically to one small tributary of the present lake) and instead a new snail, not previously suspected, became the prime vector.

The possible parallels with the proposed Kekreti Lake are remarkable. They include a dendritic lake with a very long shoreline

replacing about 150 km of river; the possible in-migration of large numbers of settlers to live at the edge of the new lake in order to profit from the newly created fisheries resource; the possibility that water plants and the shape of the shore of Kekreti will resemble that of Volta; the probability that schistosome snails, already present in the area, will increase in numbers, especially in the vicinity of human settlements, thus starting another round of disease transmission; the creation of hundreds of thousands of new, predator-free habitats for malaria mosquitoes to breed in; the retrenchment of blackfly breeding to the spillway and areas below the dam plus numerous tributaries to the new lake during the rainy season, thus reducing considerably the expected health benefit to be derived from destruction of blackfly breeding sites in the impounded river bed; the drowning of tsetse fly areas, eventually to be reestablished at the edge of the new lake as suitable plantings are reestablished.

In this connection it is sobering to reflect on the difficulties that have faced health authorities in Ghana since the creation of Volta Lake. The difficulties have been barely, if at all, manageable, although they have stimulated a large amount of field research. It is confidently predicted that the experience will be repeated in the Kekreti Lake, in the absence of a concentrated effort at mitigation in advance of and during construction.

2.3.4. Unfinished Projects of the OMVS

The Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) is currently engaged in the construction of two dams in the Senegal River Basin. The geographic proximity of the locations suggests the possibility of parallels with OMVG projects. Specificially, the Diama Dam resembles the proposed Balingho Barrage in certain important aspects and the Manantali Dam can be compared with the proposed Kekreti Dam. As the following discussion shows, however, there are distinctions between the OMVS and OMVG projects that are as significant as the similarities.

2.3.4.1. Manantali. The Manantali dam is not finished, thus this discussion of health impacts stands apart from the preceding sections which describe and utilize faits accomplis elsewhere in Africa for their predictive value. Although construction at Manantali has only recently

begun and a definitive overview of associated health impacts is still in the stage of formulation, mention is of interest in the present discussion because of the dam's geographic proximity to the proposed Gambia River construction sites and because the major health responsiblities of the responsible guiding group, OMVS, parallel in most respects those of the sister organization, the OMVG.

The Manantali site, in Mali, is 1,200 kilometers from the mouth of the Senegal River. It is on the Bafing River (which unites with the Bakoye River at Bafulabe to form the Senegal). The dam will regulate flow and impound annual flood waters for release as required by agriculture during the lengthy dry season. It will also provide hydroelectric power.

Construction began in 1981 and is scheduled for completion in 1988. The regulated water flow will permit development of extensive irrigation schemes that will provide double or triple harvests, in contrast with the present flood-dependent recession agriculture currently being practiced along the banks of the river.

The dam will create a reservoir 146 kilometers long. The maximum height of the impoundment will be 65 meters above foundation rock. The area to be submerged is 477 square kilometers (Platon, 1981).

- Anticipated water-related health hazards. In the Manantali area the usual triad of malaria, schistosomiasis, and onchocerciasis has attracted the attention of planners. Other diseases to be anticipated include trypanosomiasis and arthropod-borne viroses. The role of malnutrition in potentiating the severity of infectious diseases is addressed (Gannett Fleming, 1982). Onchocerciasis seems to pose the biggest problem.
- Malaria. Malaria is hyperendemic in the valley above Manantali, transmitted only in the rain season. Although the creation of a new lake ought to provide many new suitable breeding sites for both *Anopheles gambiae* and *A. funestus* (the principal mosquito vectors), it has been speculated that atmospheric humidity would be so low even in the vicinity of the lake that adult mosquito activity will be restricted in the dry season, as it is now, and thus the impact of the lake on the incidence of clinical malaria will not be a major one (Gannet Fleming, 1982).

The speculation is guesswork and it may be necessary to experience conditions following completion of the dam in order to determine if the guess is correct. Alternatively, it might be speculated that the creation of many thousands of microhabitats by the extension of the shore length could permit some heightened mosquito activity since humidity in microhabitats could rise in the vicinity of perennial water.

A more dependable control effect will be exerted on aquatic mosquito larvae in the wake of sudden draw-down, a well-established method for reducing mosquito density in the vicinity of an impoundment.

- Schistosomiasis. The presence of Bulinus globosus snails near the impoundment area virtually insures that the impoundment will be colonized by them. The increased length of shoreline will offer numerous niches. Colonization will be controlled by the availability of food and support plants such as underwater Ceratophyllum or floating Pistia (B. senegalensis is also to be found in the area but is a resident of shallow ponds, able to survive months of desiccation, and is not a riverine dweller). The threat of increased incidence of urinary schistosomiasis depends on perennial supplies of snails living in the vicinity of human habitations, and the human hosts regularly coming into contact with the waters which harbor the snails, such as coves and inlets in the neighborhood of riverine settlements. Levels of increased incidence, and particularly the intensity of schistosome infections, can only be conjectured, but increased numbers of any of the three elements of transmission (i.e., susceptible humans, susceptible snails, or parasites) will lead to increased incidence. Urinary schistosome infections have been demonstrated in the area. Suitable snails exist there. It would seem that it remains only for the development of suitable human habitations on the edge of the new lake to provide the impulse for heightened transfer of infection. Fortunately, the prediction is that in-migration following completion of construction will be minimal.

The intestinal type of schistosomiasis is transmitted by Biomphalaria pfeifferi, snails which are rare in the area. The parasites have not been recorded. Under future conditions they could, of course, be imported.

- Onchocerciasis. The environmental assessment of Gannett Fleming (1982) assigned a low probability of increase to this infection, noting

that the effect of impoundment would be to obliterate the riverine breeding sites of the transmitting blackfly for a distance of more than 125 kilometers upstream from the dam. Nothing was said about the persistence of blackfly breeding sites in the more than 12 major tributaries of the river (and of the eventual lake), of the blackflies noted ability to fly distances greater than the proposed length of the lake in search of a blood meal, or of the extent of new breeding downstream. The assessment stated, without further explanation, that the spillway for the Manantali Dam would not provide a suitable environment for blackfly larvae.

After two years of construction, a small WHO-funded blackfly control project is in operation in Manantali. The area, not heavily infested with Simulium damnosum, is at the northernmost edge of the geographic range of this insect.

- Trypanosomiasis. The local tsetse fly is Glossina morsitans, not a significant vector of human sleeping sickness although an efficient transmitter of diseases of veterinary interest. Sleeping sickness is seldom diagnosed along the Bafing River. The rising waters of the lake may inundate some breeding sites, but morsitans is not primarily riverine and will probably be unaffected by the flood. The trypanosome stress on local horses and cattle will probably continue unabated.
- Arthropod-borne Viroses. Although the increased shoreline will offer new habitats to the mosquitoes that transmit arboviruses (Culex, Anopheles, Aedes, Mansonia), their activity may be curtailed by low atmospheric humidity if this prevails even in the vicinity of the lake. Additionally, lake breeding will be damaged by draw-down. The Gannett Fleming (1982) assessment predicted no change in arboviral diseases as a result of the Manantali impoundment.

2.3.4.2. Diama. In connection with the dam under construction at Manantali, the OMVS plans a dam for Diama, near the estuary and 23 kilometers from Saint-Louis by river. Its purpose is threefold: to prevent saltwater from flowing up the estuary during low water periods; to retain a certain mass of water for irrigation; and to assure that depressions and lakes along the river's edge are filled (Platon, 1981). A symbolic cornerstone of the Diama Barrage was laid on December 12, 1979; construction began in 1981 and completion is expected in 1986.

Health concerns associated with the Diama Barrage were addressed in the environmental assessment of Gannett Fleming (1982). The two main problem factors were resettlement and impounded waters.

Resettlement was thought to be a minor problem (involving at the most 3,500 persons) dispersed thinly in the area upstream from the dam. Many villages are protected by dikes but leaks may occur and drainage problems may ensue.

Impounding waters may lead to an increase in mosquito breeding, thus an upsurge in such diseases as malaria and arboviroses. The Gannett Fleming report (1982) thought that the impoundment would not provide a good breeding site for Anopheles species. No mention was made of A. funestus which can breed in lakes if the shoreline vegetation is sufficiently dense. it was noted that the saltwater breeding A. melas would be replaced by the freshwater breeding species (although A. gambiae was offered as the substitute instead of A. funestus). On the whole, it was believed that the Diama Barrage would not affect the incidence of malaria or arboviruses.

Low human density, water chemistry constraints, and incompatibility of parasites and snails were used to explain the very low level of urinary schistosomiasis and the lack of intestinal schistosomiasis in the delta region. No prediction was made about the effect of impoundment on this status quo except to note that, for reasons of snail host physiology it seems unlikely that transmission of intestinal schistosomiasis will ever become established so close to sea level.

Discussion. It is interesting to compare the projects of the OMVS on the Senegal River with those proposed by the OMVG on the Gambia River.

Both propose saltwater extrusion barrages near the estuaries of the rivers and both propose hydroelectric, deep-water impoundments well inland.

The Diama Dam resembles the proposed Balingho Barrage in some environmental respects, principally with regard to increased incidence of mosquito-borne diseases. In both areas the saltwater breeding A. melas may be replaced by freshwater breeding species, probably A. funestus (although the Gannett Fleming report mentions A. gambiae in this regard). Schistosomiasis is thought to represent only a small threat in the Senegal River delta, whereas in back of the Balingho Barrage (with

the increase in population of Bulinus globosus and B. truncatus snails) the problem may become serious, particularly if the economic development of the Balingho "Lake" entails many new communities along its edge. Sleeping sickness is not recorded in the delta but was at one time a major problem along the Gambia River and could become so again with stabilization of the water supply and an increase in human population. River blindness is not recorded in either the Senegal River delta or in The Gambia.

The Manantali Dam will create a lake smaller than that proposed by the Kekreti reservoir, but will share some of the health hazards with it. The critical factor may be the ultimate settlement of new populations along the edge of the impoundment. The availability of a new source of diet protein (assuming that the fisheries are developed and that the food is equitably distributed), plus foodgrains from irrigation schemes will do much to alleviate the poor state of nutrition, especially in the very young. Yet, increasing riparian populations will create o- of the essential elements in heightened disease transmission. River blindness may be controlled wherever impoundment drowns the vectors' breeding sites but new sites may come into existence, especially in connection with the spillways, and the long flight capacity of the blackflies will permit them to find and colonize such sites. Urinary schistosomiasis will have an increased incidence, and intestinal schistosomiasis may become a new problem for local people if in-migration introduces the appropriate strains of parasites.

3. CURRENT PUBLIC HEALTH SITUATION

> The distribution, form, biotic associations and human treatment of water underlie the epidemiology of most human parasitic diseases. [Water's] role is crucial in understanding the onset, extension or control of parasitism in populations in developing areas (from Heyneman, 1984).

It has been said that significant social and health sacrifices are unavoidable once the decision has been made to replace a habitat, to dam, to flood, to clear-cut, or to recreate an environment (Heyneman, 1984).

This section of the report focuses on the major water-related diseases of the Gambia River Basin that may be affected by development. Available baseline data are used to project impacts by zones and to speculate on disease control strategies.

3.1. Major Diseases Associated with Water

Bradley's (1977) classification separates water-associated diseases into four categories. They are summarized as follows:

- Water-borne diseases, in which fecal agents are consumed directly resulting in conditions such as cholera, typhoid, bacillary dysentery, amebiasis, poliomyelitis, and hepatitis;
- Water-washed diseases, in which water quality or quantity is deficient permitting development and spread of ectoparasitic or fungal infections (scabies, hookworm), spirochaetal infections (yaws), or viral infections (trachoma);
- Water-based diseases, in which an aquatic intermediate host is involved, such as schistosomiasis (snails) or guinea worm infection (copepods);
- Water-related diseases, which depend for transmission on water-breeding insect vectors, such as malaria, yellow fever, dengue and filariasis (mosquitoes), onchocerciasis (blackflies), or vectors that breed near water, such as riverine sleeping sickness (tsetse flies) and leishmaniasis (sandflies).

It is noted that the categories may not be mutually exclusive. Moreover, the water requirement may be merely tangential in the case of tsetses or sandflies, needing as they do an elevated humidity in the breeding sites.

The second category may also be conceived to embrace helminth agents such as hookworm and Ascaris, where defecation patterns may be influenced by water availability.

3.1.1. Water-borne Diseases

These are infections whose causative agents are transferred by mouth from drinking contaminated water. Examples selected include viruses (poliomyelitis), bacteria (bacillary dysentery, typhoid, cholera), and protozoa (amebae). All have their origin in human feces.

3.1.1.1. Cholera. Elements of transmission:

- The cholera vibrio, Vibrio cholerae, classical and El Tor biotypes.
- Fecal contamination of drinking water.

Cholera is a disease of poverty and insanitation. It is transmitted from man to man by direct fecal contamination of water and food. No animal reservoir is known. Classical cholera is endemic to India. El Tor cholera, caused by a tougher organism, infects more people with a milder disease and has a higher carrier rate than the classical form. El Tor cholera is now endemic in West Africa but not in the Gambia River Basin. (An endemic area is defined as one in which the total number of months with absence of cholera does not exceed 30 in 32 years, or one in which a break of five or more months in cholera incidence does not take place.) Cholera is always a notifiable disease.

- Senegal

No cases of cholera were reported in Senegal in 1979. Senegal does not require cholera vaccination of international travelers.

- The Gambia

No cases of cholera have been reported in The Gambia in recent years (1979-81). Cholera immunization is still required of international air travelers to The Gambia, in excess of the International Health Regulations established by the World Health Organization.

- Guinea

Cholera has not been reported in recent years in Guinea. Vaccination is no longer required of international travelers.

Transmission. Freshwater is an important vehicle of cholera. The classical vibrios can live in reservoir water for two weeks. The El Tor vibrio is tougher and can survive in saline conditions; it can also

multiply in sweat and contamination of a localized environment by the sweat of healthy carriers can cause outbreaks of cholera.

Although there is currently no cholera in the Gambia River Basin, the El Tor organism is thought to abide elsewhere in West Africa and could be introduced by transmigrant workers. Its present absence is not a reason to omit considering it.

3.1.1.2. Typhoid and paratyphoid fevers. Elements of transmission:

- The enteric bacilli, *Salmonella typhi*, *S. paratyphi* A or B.
- A typhoid patient or carrier-excreting bacilli.
- Contamination of drinking water.

In Africa the type of enteric fever most commonly encountered is typhoid fever caused by *S. typhi*. There is no animal reservoir of infection, the sources being human patients, who excrete bacilli in feces and urine, and carriers.

Carriers can be (i) convalescent, (ii) chronic fecal carriers, and (iii) chronic urinary carriers.

Chronic fecal carriers harbor organisms in the gall bladder. Chronic urinary carriers harbor the organisms in the renal pelvis.

In persons infected with *Schistosoma mansoni* and *S. haematobium* there is a high rate of carrier *Salmonella* transmission, the bacilli being harbored by the adult schistosomes. In *S. haematobium* infections urinary carriers are found while in *S. mansoni* infections the carriers are fecal.

- Senegal

Typhoid and paratyphoid fevers are grouped together and reported as a single entity. In 1979, the following numbers of cases were notified:

Region	Number of Cases	Percent
Cap-Vert	19	7.0
Casamance	8	3.0
Diourbel	0	0
Fleuve	66	24.5
Senegal Oriental	72	26.8
Sine-Saloum	44	16.4
Thiès	60	22.3
Louga	0	0
Total	269	100

University of Michigan, Gambia River Basin Studies, 1985.

- The Gambia

There were no separate figures for typhoid fever in The Gambia.

- Guinea

In 1981, enteritis and other diarrheal diseases were listed third among principal causes of morbidity in the Republic of Guinea, or 6.5 percent of all reported infectious diseases. The proportion referrable to typhoid fever was not given.

3.1.1.3. Bacillary dysentery. Elements of transmission:

- The enteric bacilli, *Shigella dysenteriae*, *S. flexneri*, *S. boydii*, and *S. sonnei*.
- Indiscriminate defecation in exposed places.
- Houseflies (*Musca domestica*).
- Contamination of drinking water.

Bacillary dysentery, a diarrheal disease, is associated with overcrowding and poor sanitation. It is prevalent in developing countries, particularly the tropics. Infection occurs when bacilli are ingested by mouth. Some protection is conferred by gastric acidity and large numbers of infecting organisms are required to establish an infection in a new host. Water can be the source of infection, particularly when the sanitary control of the water supply breaks down. Convalescent patients may become carriers, important in the epidemiology of the disease.

- Senegal

Dysentery, without etiology, is a regular rubric in health post reporting in Senegal. In 1979 the distribution of cases in health facilities under a physician's care was as follows:

Region	Number of Cases	Percent
Cap-Vert	10,122	10.1
Casamance	2,959	5.6
Diourbel	645	1.2
Fleuve	3,677	6.9
Senegal Oriental	16,661	31.4
Sine-Saloum	11,983	22.6
Thiès	2,729	5.2
Louga	4,241	8.0
Total	53,017	100

University of Michigan, Gambia River Basin Studies, 1985.

It is evident that not all of these cases could be ascribed to Shigella dysentery without further evidence. It may be of interest that the greatest proportion of cases, almost a third of the total, were recorded from Senegal Oriental province.

- The Gambia

Cases are subsumed under the rubric "dysentery and diarrhoea" which must include much disease unrelated to bacillary dysentery and, indeed, much that is not water-borne. The figures reproduced below are for the entire country:

	1979	1980	1981
Cases of dysentery and diarrhoea	34,961	39,883	31,511

- Guinea

Bacillary dysentery was not signalled out for separate treatment in official notification in 1981.

3.1.1.4. Amebiasis. Elements of transmission:

- The parasitic ameba, Entamoeba histolytica, in cystic form.
- Fecal contamination of food and water.

Amebiasis exists in the rural population of the Gambia River Basin largely as a widespread infection causing little disease. Peaks of infection occur soon after the start of the rains and approximately two months after the last rain. These peaks are due to a combination of climate factors and host self-cure. Severity of symptoms is greatest where diet is deficient in protein. Severity may also be associated with type of concomitant bacterial gut flora.

Unprotected water holes or wells may be sources of infection although amebiasis is usually considered only marginally water-borne.

- Senegal

In general, rates for amebic infection in Senegal agree with areas of population, as seen below (figures for 1979):

Region	Number of Cases	Percent
Cap-Vert	107	12.1
Casamance	142	16.1
Diourbel	77	8.7
Fleuve	148	16.8
Senegal Oriental	72	8.2
Sine-Saloum	99	11.2
Thiès	151	17.1
Louga	86	9.8
Total	882	100

University of Michigan, Gambia River Basin Studies, 1985.

- The Gambia

A country-wide stool survey of The Gambia in 1977 showed the prevalence of Entamoeba histolytica cysts to range from 13.7 percent up-country in the dry season to 52.3 percent near the coast. A longitudinal survey (Bray and Harris, 1977) showed a near 100 percent infection rate over one year and a sharp rise in prevalence as the rains commenced with an equally sharp fall as the rains progressed.

Attempts to discover the presence of cysts in the environment of villages by cultivation of specimens of water, soil, food, flies and washings from clothes and hands were generally unsuccessful although E. histolytica was recovered once from a well.

- Guinea

Amebiasis figured in eleventh place on a list of infectious diseases diagnosed in health facilities throughout the Republic of Guinea in 1981, with 6,987 cases out of 301,613 examined, or 2.3 percent.

Discussion. Clinical amebiasis, with blood in the stools, is rare in the Gambia River Basin. Transmission person-to-person or self-reinfection may be infrequent due to the relatively low population density. Rapid fecal transmission occurs during the rains; at other times the environment does not support the survival of cysts except in water (deep ponds, wells).

3.1.1.5. Poliomyelitis. Elements of transmission:

- Poliomyelitis virus (types 1, 2 and 3).
- Fecal contamination of the water supply.

The poliomyelitis virus is widespread in developing countries and is now recognized as extensively present in the tropics.

Most infections are subclinical, the virus apparently constituting a portion of the normal gut flora. Under conditions of crowding children tend to become infected early. Where sanitation is poor virus is most widespread and paralytic poliomyelitis is less often seen.

The clinical disease, with nervous system involvement, does not differ from that observed in nontropical areas. The clinical disease is probably underreported, often limited to cases requiring hospitalization, in the Gambia River Basin.

- Senegal

In 1979 little clinical poliomyelitis was reported in health posts manned by a physician. There were no epidemics. The disease is notifiable and the following numbers were officially recorded:

Region	Number of Cases	Percent
Cap-Vert	76	52.8
Casamance	0	0
Diourbel	3	2.0
Fleuve	4	2.8
Senegal Oriental	2	1.4
Sine-Saloum	35	24.3
Thiès	20	13.9
Louga	4	2.8
Total	144	100

University of Michigan, Gambia River Basin Studies, 1985.

Between 1970 and 1979 there were 1,666 cases of acute anterior poliomyelitis notified in Senegal. In two of those years (1974 and 1978) the number of cases appeared to increase suddenly, suggesting epidemics (see Table 3.1.).

TABLE 3.1.

CASES AND DEATHS FROM ACUTE ANTERIOR POLIOMYELITIS IN SENEGAL DURING THE DECADE 1970 TO 1979

Year	Cases	Deaths	Lethality (%)
1970	39	4	10.3
1971	119	8	6.7
1972	145	-	-
1973	73	5	6.8
1974	312	31	9.9
1975	144	3	2.1
1976	161	4	2.5
1977	175	-	1.7
1978	354	43	12.1
1979	144	14	9.7
Total	1,656	115	6.9

University of Michigan, Gambia River Basin Studies, 1985.

- The Gambia

Little clinical poliomyelitis is notified in The Gambia. The trend is given below:

	1977	1978	1979	1980	1981	
Poliomyelitis cases	3	21	5	1*	1	(* = death)

The increased numbers recorded in 1978 suggest an epidemic.

- Guinea

No data on clinical poliomyelitis were available from Guinea.

3.1.2. Water-washed Diseases

These are diseases which are transmitted as a result of poor general hygiene and insufficient water for washing. They are indicators of the level of social development as well as personal lifestyle. They tend to diminish and even disappear spontaneously with improvements in environmental and personal sanitation and in general education.

3.1.2.1. Scabies. Elements of transmission:

- Scabies mite, *Sarcoptes scabiei*.
- Susceptible hosts, usually children who:
  - (i) have close contact and;
  - (ii) seldom wash.

- Senegal

Senegal Oriental province in 1979 accounted for more than 12 percent of reported cases (in contrast with having 6 percent of Senegal's population). Notified cases reported at outpatient health posts are given in Table 3.2.

- The Gambia

A total of 10,722 cases of scabies were reported in 1981, a prevalence for the entire country of 1.74 percent and an increase of 2.2 percent over the previous year. More than half the country's cases were reported from MacCarthy Island Division (which includes the Bansang Hospital). The figures are as follows:

Division	Number of Cases	Percent
Western	2,100	19.6
Lower River	353	3.3
North Bank	1,137	10.6
MacCarthy Island	5,638	52.6
Upper River	1,494	13.9
Total	10,722	100

University of Michigan, Gambia River Basin Studies, 1985.

- Guinea

In a health report of 1983, scabies is listed as the fourth or fifth most commonly complained of condition in middle Guinea. Country-wide figures list it in third place, with a morbidity ratio of 5.3 percent.

Transmission. Lack of washing facilities aids in the dissemination of scabies, accounting for its prevalence in hot, dry conditions where water is scarce. Scabies tends to be most common in children but affects all age groups where washing is systematically ignored. The complaint is one of itching, bleeding due to scratching, and possibly secondary bacterial infection.

TABLE 3.2.

CASES OF SARCOPTIC INFESTATION (SCABIES) REPORTED IN OUTPATIENT HEALTH POSTS IN SENEGAL, 1979

Region	Age										Total	%
	-1		1-4		5-14		15-54		55			
	M	F	M	F	M	F	M	F	M	F		
Cap-Vert	507	622	647	133	824	601	678	606	683	958	6,259	49.00
Casamance	3	11	28	39	48	33	53	66	46	68	395	3.09
Diourbel	-	-	-	1	2	1	1	-	-	-	5	0.04
Fleuve	147	190	253	247	242	265	198	165	146	142	1,995	15.62
Senegal Oriental	-	-	132	138	615	195	167	196	247	313	1,553	12.16
Sine-Saloum	11	30	110	218	363	307	208	54	41	22	1,364	10.68
Thiès	38	29	54	56	48	122	124	128	106	94	799	6.25
Louga	34	52	48	81	30	39	43	31	26	20	404	3.16
											12,774	100.00

SOURCE: Adapted from: République de Sénégal, Ministère de la Santé Publique, Statistiques Sanitaires et Démographiques du Sénégal, Année 1979.

University of Michigan, Gambia River Basin Studies, 1985.

Transfer of mites to new hosts occurs wherever body contact permits. Bed-sharing is a critical factor.

Individual cases are treated with salves containing gammexane (HCH) or DDT to kill the mites.

Prevention is linked to personal hygiene and improvements in life style.

3.1.2.2. Other infectious skin diseases. Elements of transmission:

- Superficial skin parasites (bacterial and fungal).
- Susceptible human hosts, principally children, who:
  - (i) have intimate body contact with each other or with fomites such as shared clothes, bedclothes, etc., and
  - (ii) wash infrequently.

Bacterial skin conditions (pyoderma) and the constellation of fungal skin infections (including tinea and ringworm) are prevalent in West Africa, including Senegal, The Gambia, and Guinea, but are notified in official reports by "groups" (i.e., infectious skin diseases) rather than by entity.

These conditions constitute another of the "indicators" of poor hygiene associated with a lack of water.

Occurrence is seasonal. The study by Porter (1979) may serve as a paradigm of the situation throughout the Gambia River Basin. Porter encountered almost twice as much clinical skin disease in the wet season as compared with the dry season. His study, effected at the village of Keneba, 50 miles east of Banjul in The Gambia, revealed that infectious skin diseases of all kinds comprised 83 percent of the total skin disease present in a population approaching 1,000 villagers. The point prevalence for all skin disease was 28.2 percent in the rainy season, dropping to 22 percent in the dry period.

3.1.2.3. Trachoma. Elements of transmission:

- TRIC virus (trachoma-inclusion conjunctivitis).
- Inadequate water supply, dust, dirt, and flies.
- Direct and indirect (fly) contact with sources of infection.

The most widespread eye disease in the world, trachoma, afflicts 500 million people according to WHO estimates. It is endemic in developing countries where protein food is in short supply, malnutrition is common, domestic sanitation is poor and where there is inadequate water for

domestic use. Contagion is by contact, either direct or by the visits of flies. Dust and sand in the air seem to assist transmission. The incidence of trachoma usually declines with the introduction of higher standards of living and good health education.

- Senegal

Trachoma is reported from all of Senegal's regions, the point prevalence probably reflecting population density as much as the availability of good diagnosis. In one special study done in 1979 very few cases were encountered in Senegal Oriental province (0.2 percent of total cases reported); however, in the previous year 11.8 percent of all notified cases of trachoma were reported from Senegal Oriental (see Table 3.3.).

- The Gambia

Since trachoma is not singled out for individual notification in The Gambia, no data on prevalence were available. There is little doubt that the condition exists, particularly in MID (MacCarthy Island Division) and URD (Upper River Division), but the disease seems to be grouped with other ocular conditions under the rubric "diseases of the eye." Interestingly, eye diseases tended toward a reduction in incidence between 1980 and 1981 (from 25,233 to 14,680 reported cases, or a reduction of 41.8 percent). However, between 1979 and 1980 similar rates increased, from 13,607 to 25,233, or an increase of 85.4 percent. Since it seems unlikely that the incidence of eye diseases would vary so markedly in this short time it is suspected that the figures reflect a change in diagnostic method.

- Guinea

No data on trachoma were available from Guinea.

3.1.2.4. Yaws. Elements of transmission:

- The spirochaete, *Treponema pertenue*.
- Hot, humid conditions and direct skin contact.
- Failure to stress bodily cleanliness.

TABLE 3.3.

CASES OF TRACHOMA IN SENEGAL, 1979, REPORTED DURING EPIDEMIOLOGICAL SURVEILLANCE

Region	Number of Cases	Percent
Cap-Vert	620	31.0
Casamance	495	24.7
Diourbel	60	3.0
Fleuve	144	7.2
Senegal Oriental	3	0.2
Sine-Saloum	400	20.1
Thiès	152	7.6
Louga	125	6.3
Total	1,999	100.0

SOURCE: Statistiques Sanitaires et Démographiques du Sénégal, Année 1979.

University of Michigan, Gambia River Basin Studies, 1985.

Yaws is essentially a disease of rural areas in hot climates. It is transmitted most readily where few clothes are worn. It is not venereal. There are three stages: (i) The primary lesion is an elevated papilloma on the skin, usually covered with a scab; (ii) The secondary lesion is a thickening of the epidermis, usually on the palms and soles of the feet; (iii) The tertiary lesion is a destruction of skin, subcutaneous tissues and bones. The stages may be separated by latent periods. A degree of immunity may be conferred during infection, to be lost gradually with cure.

Yaws responds quickly to penicillin. Since penicillin is useful in so many other infectious conditions, its wide use may explain the retreat of yaws in the area under study.

- Senegal

The following shows how the 307 cases of yaws detected during special surveillance in 1979 were distributed within the country.

Region	Number of Cases	Percent
Cap-Vert	33	10.7
Casamance	29	9.5
Diourbel	-	-
Fleuve	48	15.6
Senegal Oriental	86	28.0
Sine-Saloum	3	1.0
Thiès	14	4.6
Louga	94	30.6
Total	307	100

University of Michigan, Gambia River Basin Studies, 1985.

- The Gambia

Yaws was reported to account for 3.16 percent of all outpatients and admitted patients in all regions of The Gambia in 1981. The distribution was as follows:

Division	Number of Cases	Percent
Western	35	11.0
Lower River	33	10.3
North Bank	28	8.8
MacCarthy Island	170	53.3
Upper River	53	16.6
Total	319	100

University of Michigan, Gambia River Basin Studies, 1985.

- Guinea

There are no data on the prevalence of yaws in Guinea. In the area of Koubia (within the Gambia River Basin) where recourse to traditional health practitioners is common, yaws was included in a list of the most common complaints.

3.1.3. Water-based Diseases

3.1.3.1. Guinea worm infection (Dracontiasis). Elements of transmission:

- Freshwater copepod.[1]
- Giant tissue-dwelling nematode worm, Dracunculus medinensis.
- Susceptible human hosts who:
  - (a) wade in shallow ponds or wells;
  - (b) drink unfiltered water containing infected copepods.

The disease is usually recorded, if at all, as of low intensity in the human population. In Senegal Oriental during 1979, health posts recorded only 24 cases of guinea worm, of 205,961 examined (0.01 percent). There were no data from The Gambia or Guinea but the disease is presumed to exist in those countries. In the absence of environmental changes there is no reason to anticipate any changes in incidence of infection and, indeed, the trend over the last 10 years of increasing drought conditions may be considered as inhibiting the spread of guinea worm.

3.1.3.2. Urinary Schistosomiasis. Elements of transmission:

- Freshwater bulinid snails.[2]
- Trematode worms of the species Schistosoma haematobium.
- Susceptible human hosts who:
  - (a) urinate in infested waters; and
  - (b) come into physical contact with infested waters.

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[1]A microscopic crustacean or water flea. In much of West Africa the transmitting species is Thermocyclops nigerianus.

[2]In The Gambia the principal transmitter is the pond-dwelling snail, Bulinus senegalensis; some infections are undoubtedly conveyed also by B. globosus (= B. jousseaumei). In Senegal the principal transmitting snail is reported to be B. truncatus guernei. In Middle Guinea the main transmitting snail is unknown but is probably B. globosu.

TABLE 3.4.

RESULTS OF A 1979 SURVEY FOR SCHISTOSOMIASIS HAEMATOBIA AMONG SCHOOL CHILDREN IN SENEGAL ORIENTAL PROVINCE, SENEGAL

School	Age											
	5-9			10-14			15+			Total		
	Exam.	+	%	Exam.	+	%	Exam.	+	%	Exam.	+	%
Missira	131	56	42.7	46	27	58.7	0	0	0	177	83	46.9
Dialakoto	37	1	2.7	77	6	7.8	4	0	0	118	7	5.9
Goudiry	122	81	66.4	108	75	69.4	3	2	66.6	233	158	67.8
Kédougou:												
Ecole Régionale	325	214	65.8	231	194	83.9	7	4	57	563	412	73.2
Ecole Municipale	311	253	81.3	208	178	85.6	7	7	100	526	438	83.2
Mission Catholique	149	83	55.7	106	75	70.7	7	6	85.7	262	164	62.5
TOTALS	1,075	688	64	776	555	71.5	28	19	67.8	1,829	1,262	67.1

SOURCE: Bigard, A.; Bodian, M.; Bassène, A.; and Badji, A. La bilharziose urogénitale au Sénégal-Oriental. Tambacounda, 1979, Grandes Endémies, Bilh No. 1/79.

University of Michigan, Gambia River Basin Studies, 1985.

The disease schistosomiasis is not necessarily coterminous with the geographic distribution of the snail hosts. Yet when S. haematobium is endemic a very high proportion of the population is usually affected. Thus, in endemic regions foci of nearly 100 percent infection can be found within a mile or two of trouble-free areas.

- Senegal

Prevalence. A survey performed by the Service des Grandes Endémies in 1969 discovered that more than a third of school children in Tambacounda schools were passing eggs of S. haematobium in the urine (912 of 2,612 examined, or 34.9 percent). Intensity of infection as measured by egg counts was not determined.

Schistosomiasis haematobia has a focal transmission. This was confirmed in a subsequent survey of school children in six schools in Senegal Oriental province, all within the Gambia River Basin (see Table 3.4.). A total of 1,879 school children were checked, eliciting positives in 1,262 (67.1 percent). Rates varied, however, from Dialakoto, where a relatively low rate of 5.9 percent was discovered, to an extreme of 83.3 percent, discovered in the Municipal School of Kedougou.

It should be noted that these children were not clinically ill. In the absence of a specific study, the fact of their infections would not have been noticed.

Morbidity. In 1979 only 1,355 cases of schistosomiasis came to the attention of physicians in government health installations. The officially reported distribution of cases around the country, by age and sex, was as follows:

Age	Males	Females	Total
1	0	0	0
1-4	26	22	48
5-14	482	271	753
15-54	231	204	435
55+	63	56	119
TOTAL	802	553	1,355

University of Michigan, Gambia River Basin Studies, 1985.

It is presumed that these were primarily cases of schistosomiasis haematobia, the predominant form of the disease in West Africa. Most of the cases were reported from health posts supervised by a nurse. The figures convey certain relationships which seem to hold true in most transmission foci.

- The infection rate in males is higher than in females. It is known that this represents greater exposure opportunities on the part of the males, not a sex-linked resistance on the part of females.

- There is a reduction in prevalence in the older age groups. The older worms may cease to deposit eggs as they age. In any event, the fact that transmission is maintained in the community by the younger members is widely accepted by the scientific community.

Transmission patterns. In Senegal Oriental there is evidence to connect transmission with permanent pools of water. The transmitting snails are not found in swamps, bas fonds, marigots, or bolons. Such permanent bodies of water are vulnerable to desiccation during severe dry seasons, halting transmission. In addition, once identified, they are open to use of molluscicides. It appears that transmission of schistosomiasis is fragile, although apparently inevitable under prevailing conditions of life style and attitudes to public health in Senegal Oriental.

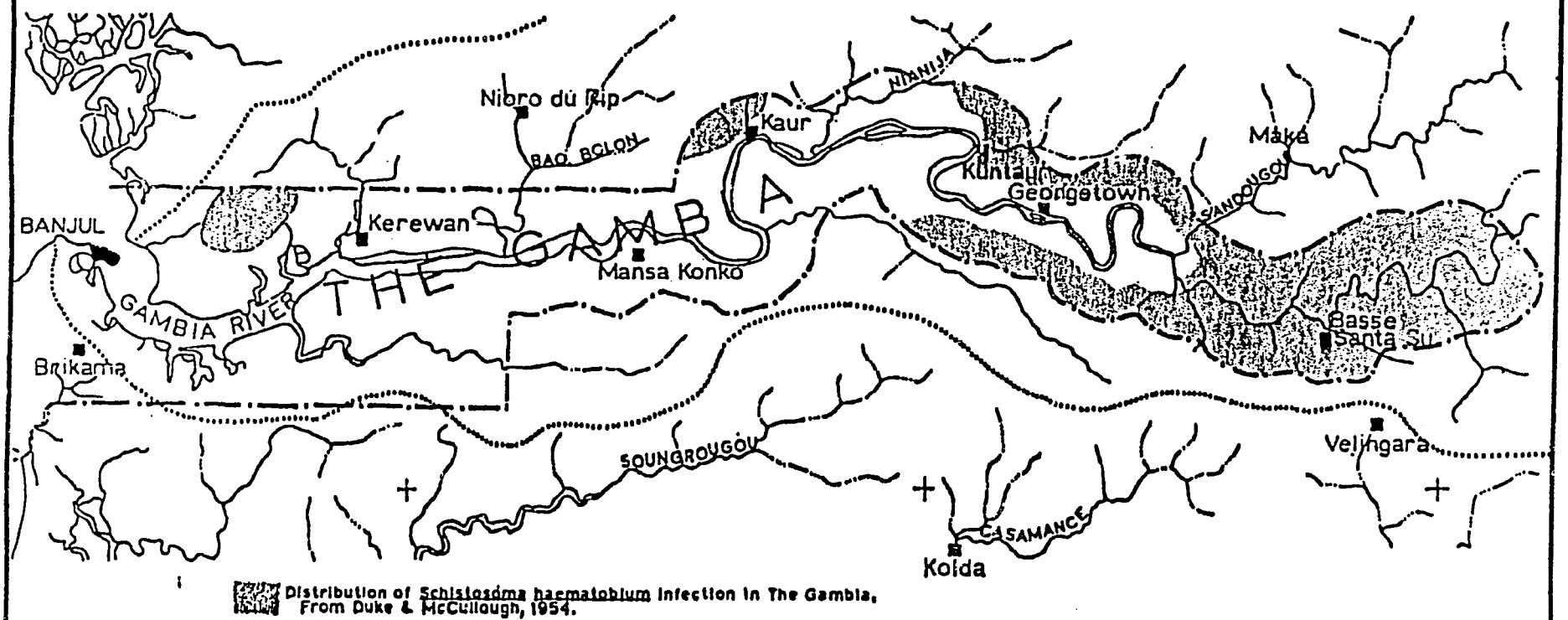
It must be assumed that foci of transmission in Senegal Oriental are associated with certain of the rice-growing schemes (perimètres) in the Kedougou area as well as along the northern frontier of The Gambia.

- The Gambia

Prevalence. While there are no good figures for prevalence of urinary schistosomiasis in The Gambia, several statements can be made that are amply supported by established facts: (i) The disease is very focal in areas where it occurs. One village may have an 80 percent prevalence and be separated by less than a mile from a village that shows little or no infection; (ii) The prevalence is highest in Upper River Division (URD) and MacCarthy Island Division (MID). Transmission does not occur in the river proper, thus a map (Figure 3.1.) will show the distribution set back from the river. A focus of infection discovered in

FIGURE 3.1.

Distribution of Schistosoma haematobium infection in The Gambia



University of Michigan, Gambia River Basin Studies, 1985.

North Bank Division (NBD) by Thomas in 1947 has not been reconfirmed; (iii) Transmission occurs primarily in laterite pools on the plateau away from the river. Since the pools are shallow and seasonal, transmission is also highly seasonal.

An early survey of 37 villages of MacCarthy Island Division (Duke, Lewis and Moore, 1966) indicated that infection was prevalent throughout the inhabited region but that the point prevalence increased according to the distance from the river and the proximity to the laterite plateau (see Table 3.5.). Thus, 16 villages located near swamps close to the river revealed a prevalence of only 11.6 percent, whereas 14 villages located on the plateau had a prevalence of 52.6 percent. Seven villages located at the heads of bolons but still close to the swamp villages had a total prevalence of 21.9 percent.

It is doubtful if anything has happened in the interval between the date of this work and the present that would produce a shift in these figures were the work to be repeated. Indeed, recent work in several small villages on the plateau south of Bansang measured prevalence rates that reached 100 percent by the age of 10 years plus extremely high egg counts in the urine (more than 1,000 eggs in 10 ml of noon urine; Wilkins, 1977). It is noted, too, that during the second and third decade of life prevalence and intensity of infection declined.

Transmission. In The Gambia the transmission of urinary schistosomiasis occurs primarily in seasonal or temporary shallow ponds on the laterite plateau and the principal transmitting snail is *Bulinus senegalensis* which is peculiarly adapted to survive the dry season in such habitats by estivation under the mud and to repopulate the ponds quickly as they refill when the rains arrive.

Some transmission appears to be mediated through *B. globosus* particularly in connection with rice agriculture schemes supported by pump irrigation. Some transmission occurs naturally but at relatively low levels in villages close to swamps near the river.

It is emphasized that at the present time there is no evidence for transmission of any form of schistosomiasis in the Gambia River or any of its larger tributaries (bolons).

TABLE 3.5.

RESULTS OF 37 VILLAGES IN MACCARTHY ISLAND DIVISION, THE GAMBIA, SURVEYED FOR THE PROPORTION OF PERSONS PASSING OVA OF S. HAEMATOBIUM

	Age								
	3-15			16+			Total		
	Exam.	+	%	Exam.	+	%	Exam.	+	%
Swamp villages (16)	276	28	10.1	233	31	13.3	509	59	11.6
Laterite plateau villages (14)	276	194	70.3	332	126	38.0	608	320	52.6
Lower bolon villages (7)	94	17	18.1	57	16	28.1	151	33	21.9
TOTAL (37)	646	239	37.0	662	173	27.8	1,268	412	32.7

SOURCE: Figures adapted from Duke & McCullough, 1954.

University of Michigan, Gambia River Basin Studies, 1985.

3.1.3.3. Intestinal schistosomiasis. Elements of transmission:

- Freshwater planorbid snails of the species *Biomphalaria pfeifferi*.
- Trematode worms of the species *Schistosoma mansoni*.
- Susceptible human hosts who:

  (a) defecate in or near infested waters; and
  (b) come into physical contact with infested waters.

Intestinal schistosomiasis occurs in the Gambia River Basin but at present detected cases are rare and the disease is not a major problem (see Figure 3.2.).

- Senegal

Foci of *S. mansoni* infection in Senegal have been identified in Casamance, in Sine-Saloum, and in Thiès. Cases have also been encountered in school children in Senegal Oriental in the vicinity of Kedougou.

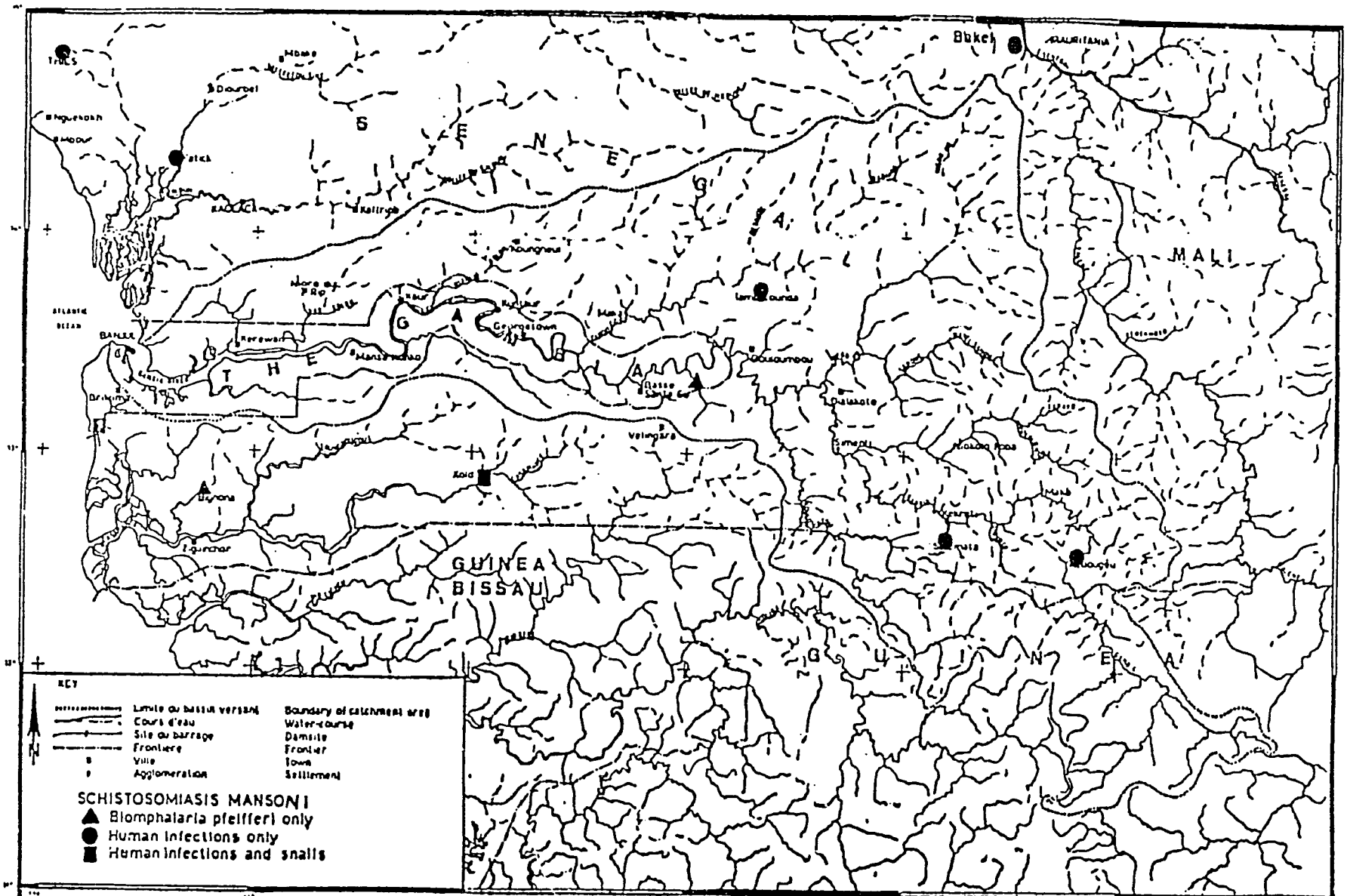
The transmitting snails, *B. pfeifferi*, have on occasion been found, some shedding schistosome cercariae, in these regions. This snail is particularly susceptible to elevated temperatures and drying conditions, both conditions which probably contribute to its relative scarcity in the West African region.

- The Gambia

Intestinal schistosomiasis has been reported from only two foci in The Gambia, one east of Basse and the other at the westernmost part of the country near Kartung. At present it seems as if the Kartung focus has disappeared with advancing drought. In the east, however, *B. pfeifferi* can still be found in the dry season remnant of the Simoto bolon.

Transmission. Cases of *schistosomiasis mansoni* in Senegal and The Gambia are few and isolated. Intestinal schistosomiasis is not, presently, an important disease; however, it is of interest that the infection seems to hang on, year after year, in this region. Somewhere, at some time of the year, conditions are right for a limited transmission. The right snails, the parasites, the susceptible human hosts, all are present and manage to come together.

FIGURE 3.2. Schistosomiasis mansoni in the Gambia River Basin



University of Michigan, Gambia River Basin Studies, 1985.

Given the intensity of the drought in recent years plus the uncertainty of rains during the rainy season, the fact that transmission occurs at all is remarkable. Clearly, lack of surface water in the environment restricts transmission. The obvious corollary is that any change in environmental conditions that eventuated in more permanence for surface water will potentiate transmission. It seems clear that the impoundment of waters in the region will accomplish this. Models of the likely consequences are provided by Lake Volta, Lake Kariba and Lake Kainji.

3.1.4. Water-related Diseases

These diseases are characterized by having insect intermediate hosts which are true vectors, i.e., which actively bring the infecting parasites to the human host. Typically, these vectors breed in or very near to water.

3.1.4.1. Malaria. Elements of transmission:

- Mosquitoes of the genus Anopheles.[3]
- Protozoan intracellular parasites, genus Plasmodium.[4]
- Susceptible human hosts.

In most of West Africa malaria is hyperendemic: transmission is intense but seasonal and immunity is insufficient to prevent the effects of malaria on all age groups.

All three Member States identify malaria as the leading health problem of rural communities.

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[3]In West Africa the most important vectors are Anopheles gambiae and A. funestus.

[4]The most frequent form in West Africa is Plasmodium falciparum, accounting for upwards of 90 percent of all cases of malaria. Next in importance is P. malariae. Last in importance is P. ovale. P. vivax which is common elsewhere in the tropics is not normally encountered in West Africa.

- Senegal

In 1979 the number of patients treated for malaria was 508,010, compared with 413,961 in 1978, representing an increase of 18.5 percent. The incidence (frequency of illnesses commencing during the year) was 92 per 1,000 in 1979 as contrasted with 77 per 1,000 in 1978.

It is noted in Table 3.6. that the ratios seem elevated for the Casamance region. This may be due to the climatological conditions there which are more favorable on a year-round basis for malaria transmission.

TABLE 3.6.

PROPORTIONAL DISTRIBUTION OF SENEGAL'S 1979 POPULATION AND THE DISTRIBUTION OF MALARIA CASES TREATED

Region	Percentage of Population	Percentage of Treated Malaria Cases
Cap-Vert	20.3	17.3
Casamance	14.2	23.5
Diourbel	8.2	3.5
Fleuve	10.4	9.1
Louga	8.1	5.1
Senegal Oriental	5.4	5.6
Sine-Saloum	19.7	20.3
Thiès	13.7	15.2

SOURCE: Adapted from figures in Statistiques Sanitaires et Démographiques du Sénégal, Année 1979.

University of Michigan, Gambia River Basin Studies, 1985.

Table 3.7. presents data on the number of treated cases and recorded deaths blamed on malaria for the decade 1970-1979 in Senegal. Monthly morbidity for the three-year period 1977-1979 is shown in Table 3.8.

TABLE 3.7.

NUMBER OF TREATED CASES OF MALARIA AND RECORDED DEATHS FOR 1970-1979 IN SENEGAL

Year	Number of Treated Cases	Deaths	Mortality (per 1,000)
1970	472,461	574	1.2
1971	499,130	447	0.9
1972	472,048	355	0.8
1973	521,181	416	0.8
1974	555,925	826	1.5
1975	483,773	563	1.2
1976	443,741	640	1.4
1977	366,967	726	2.0
1978	414,031	685	1.7
1979	508,010	1,274	2.5
Total	4,737,267	6,506	1.4

SOURCE: Statistiques Sanitaires et Démographiques du Sénégal, Année 1979.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 3.8.

TREATED MALARIA CASES BY MONTH IN SENEGAL
FOR THE YEARS 1977, 1978 and 1979

Month	1977	1978	1979
January	31,350	23,381	35,732
February	31,928	21,221	27,463
March	33,167	20,119	26,851
April	23,132	19,379	39,397
May	23,666	20,229	32,854
June	24,130	23,972	37,783
July	28,311	33,406	50,333
August	36,812	46,076	59,717
September	36,839	57,218	58,312
October	32,248	55,278	64,360
November	39,833	59,443	38,991
December	25,551	34,229	36,217
Total	366,967	413,961	508,010
% Increase Over Previous Year		12.8	18.5

SOURCE: Adapted from Statistiques Sanitaires et Démographiques du Sénégal, Année 1979.

University of Michigan, Gambia River Basin Studies, 1985.

- The Gambia

In 1981 there were 71,545 clinical cases of malaria officially notified and duly recorded from all regions of the country except Banjul and the Kombos. The numbers recorded in the three-year period were as follows:

	1979	1980	1981
Total Cases	51,993	60,900	71,545
Percent increase from previous year		17.1	17.5

University of Michigan, Gambia River Basin Studies, 1985.

The distribution of malaria cases within the country is compared with the proportional distribution of population in Table 3.9. It is noted that the population ratio and the case ratio do not agree for Western

TABLE 3.9.

THE NUMBER OF MALARIA CASES REPORTED BY REGION IN 1981 AS COMPARED WITH THE REGIONAL POPULATION IN THE GAMBIA

Division	Population	Percent	Number of Malaria Cases Diagnosed	Percent
Western	119,509	18.8	24,025	33.6
Lower River	49,023	7.7	3,709	5.2
North Bank	117,662	18.5	9,036	12.6
MacCarthy Island	131,618	20.7	21,461	30.0
Upper River	108,665	17.1	13,314	18.6
Total	635,913	100	71,545	100

SOURCE: Adapted from: Gambia Government Medical & Health Department Annual Report, 1981.

University of Michigan, Gambia River Basin Studies, 1985.

Division (WD) or MacCarthy Island Division (MID), where the number of cases seem high, or in North Bank Division (NBD), where the cases seem low. (In the case of WD and MID easier access to health facilities may have affected the totals. In the case of NBD, the opposite may have been true.)

Typically, it is seen that more than half the year's cases (52.7 percent) were acquired or became evident in the four-month period August-November, two months after the rains began and two months after they ended.

Monthly prevalence figures for 1981 were as follows:

Month	Number of Cases	Percent
January	4,149	5.8
February	4,141	5.8
March	4,402	6.1
April	3,475	4.9
May	6,048	8.4
June	4,002	5.6
July	4,585	6.4
August	6,856	9.6
September	10,511	14.7
October	11,306	15.8
November	9,056	12.7
December	3,014	4.2
Total	71,545	100

University of Michigan, Gambia River Basin Studies, 1985.

- Guinea

Malaria is listed first among principal causes of morbidity according to statistics released in 1983 from the Ministry of Health (MOH), and accounted for 126,754 cases among a total of 301,613 cases of infectious and parasitic disease, or 42.03 percent. An extensive malariometric survey carried out by the Ministry of Health in 1979 is reported elsewhere in this paper (see section 3.2.2.) and the data will not be repeated here. The disease appears to be mesoendemic throughout most of Guinea, i.e., found typically among small rural communities with varying intensity of transmission depending on local circumstances.

3.1.4.2. Yellow Fever. Elements of transmission:

- Yellow fever virus (Group B arbovirus).
- Mosquitoes of the genus Aedes.[5]
- Reservoir host monkeys.[6]
- Susceptible human hosts.

Yellow fever is an enzootic infection of wild monkeys that can, under certain circumstances, become transferred to human populations in town. It is profoundly affected by the ecological conditions that man creates for himself. In forest areas sporadic human cases occur and at forest edges there may be small outbreaks. But in towns and cities where the domestic Ae. aegypti occurs, sporadic yellow fever can be converted into epidemic yellow fever. Immunity is high following clinical attack or immunization; yellow fever is unlikely to spread widely among such a population until a new supply of nonimmunes has either been born or immigrated from other territories.

- Senegal

In 1965 yellow fever appeared in epidemic form in Diourbel, 140 km east of Dakar. The country is dry guinea savanna, the population almost entirely rural living in villages of 500-1,000 persons. There were 100 deaths suspected of being due to yellow fever. The diagnosis was confirmed in a further 50 fatal and 26 nonfatal cases. Nearly 90 percent of the fatalities were among children aged less than 10 years. Mass campaigns of vaccination against yellow fever had been practiced in Senegal from 1942 to 1960 after which they ceased. However, during the last campaigns the infants had not been vaccinated owing to the risk of reactions. Thus, by 1965 very few of those below the age of 10 years had any protection. The total morbidity for this outbreak was estimated to be at least 2,000. The sole vector for the outbreak was Aedes aegypti.

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[5]In Africa, the urban mosquito Aedes aegypti is responsible for transmission in towns, while the monkey-mosquito-monkey cycle is maintained by Ae. africanus. Mosquitoes able to effect transfer from monkeys to man include Ae. luteocephalus, Ae. vittatus and Ae. furcifer/taylori.

[6]Reservoir monkeys include red patas monkeys (Erythrocebus patas) and Western baboons (Papio papio).

No cases of yellow fever were detected in Senegal between this outbreak (1965) and the annual statistical report of 1979. But in October 1979 two French tourists spent 24 hours in tourist accommodations in the village of Toubacouta, about 50 km north of the Gambian border. After 3 or 4 days they became ill and died shortly thereafter of yellow fever in two different hospitals in Paris.

- The Gambia

A yellow fever outbreak was reported in The Gambia from June 1978 to January 1979. The epidemic peaked in October. The outbreak was largely confined to the eastern half of the country (MID and URD). In nine survey villages in this area (total population 1,531) the attack rate was 2.6-4.4 percent, with a mortality rate of 0.8 percent and a case-fatality rate of 19.4 percent. Extrapolating from this survey it is estimated that there were as many as 8,400 cases and 1,600 deaths during the outbreak. The disease incidence was highest in the 0 to 9-year age group (6.7 percent) and decreased with advancing age to 1.7 percent in persons over 40 years.

On December 12 the Ministry of Health requested emergency assistance from the United States. Subsequently, both USAID and WHO assisted the Gambian government in obtaining 500,000 doses of yellow fever vaccine and the CDC (Communicable Diseases Control Department) provided equipment and technical assistance for vaccine administration.

- Guinea

Yellow fever has not been reported as a separate clinical entity in Guinea in recent years. However, coastal Guinea and Guinea-Bissau are recognized endemic foci.

3.1.4.3. Dengue. Elements of transmission:

- Dengue type 1 and type 2 viruses (Group B arboviruses).
- *Aedes aegypti* mosquitoes, in urban surroundings; and *Ae. vittatus*, *Ae. luteocephalus* and *Ae. furcifer/taylori* in rural areas.
- Susceptible human hosts.

This disease has caused more deaths in recent years in the tropical world than any other arbovirus disease with the exception of yellow fever. Its presence in West Africa has only recently been noted (Brès, 1970).

It is associated with urban conditions and abundant Ae. aegypti populations but can be transmitted in rural areas. The disease produces fever, cellular damage and hemorrhage, and may progress to dehydration and shock.

Field studies have indicated the presence of antibodies to dengue 1 in Guinea-Bissau (prevalence of 0.2 percent) and Cameroon (5 percent). Antibodies to dengue 2 have been reported in a survey in Nigeria (0.3 percent; Brès, 1970). In 1983 two cases of dengue 2 were reported from Senegal Oriental, according to a verbal report from the Pasteur Institute in Dakar.

The diagnosis of dengue fever is complicated by frequent serological cross-reactions with other viruses in Group B, notably yellow fever. Nevertheless it appears that dengue fever, possibly imported from neighboring regions of West Africa, could assume increased importance at newly established construction camps on the Gambia River.

3.1.4.4. Onchocerciasis. Elements of transmission:

- Filarial worms, Onchocerca volvulus.
- Blackflies, Simulium damnosum.[7]
- Susceptible human hosts.

In West Africa the differences between severity of onchocerciasis in the arid northern savannah and in the humid southern forest have been remarked. In the former area, which includes Senegal Oriental and central (Moyenne) Guinea, eye lesions are severe and blindness is frequent, whereas in the latter area they are rare.

In describing levels of endemicity of onchocerciasis, the terms hyperendemic mesoendemic, and hypoendemic have been used. Exact definitions of these terms may vary somewhat according to the user but the World Health Organization (1981) has suggested adoption of the following rates:

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[7] S. damnosum is a complex of forms which can be identified by cytological methods. In Senegal Oriental and Central Guinea the complex includes S. damnosum s.s., S. sirbanum and S. soubrense. The first two are responsible for transmission of the severe form of the disease encountered in the northern savannah, including the territories of the Gambia River Basin.

	Infections	Blindness
Hyperendemic	65%	2.3%
Mesoendemic	35% to 64%	1.2%
Hypoendemic	34%	0.6%

University of Michigan, Gambia River Basin Studies, 1985.

- Senegal

In Senegal Oriental the main foci of onchocerciasis are situated along the paths of the two largest rivers, the Gambia and the Falémé. A hyperendemic zone extends about 10 km either side of these rivers, in which transmission is very active during the rainy season but drops to almost nil in the dry season. A third important focus exists on the Koulountou River near the Guinea frontier. There are numerous blackfly breeding sites within the borders of the Niokolo-Koba National Park, but with few exceptions people are excluded from the Park as permanent residents. The arondissement of Salémata includes both mesoendemic and hyperendemic villages. The remainder of the département of Kedougou is mesoendemic or hypoendemic.

Table 3.10. shows the distribution of known breeding sites of Simulium in the Gambia River Basin, and outlines zones known to be mesoendemic (or hypoendemic) and hyperendemic for onchocerciasis. Hyperendemicity is seen to coincide with areas of heavier population (see Figure 3.3.).

- The Gambia

Onchocerciasis is not endemic to The Gambia and blackfly breeding has never been demonstrated within its borders.

- Guinea

The Republic of Guinea comprises four ecological zones: lower (maritime) Guinea is characterized by the alluvial coastal plain; middle (central) Guinea consists of the highlands of the Fouta Djallon; upper Guinea is primarily an extensive Sudanian plain; and forest Guinea supports rain forest. The Gambia River Basin drains a portion of middle Guinea. Although political divisions do not exactly correspond to ecological divisions, it is convenient to include the administrative

TABLE 3.10.

POPULATION OF SENEGAL ORIENTAL AND EASTERN CASAMANCE PROBABLY EXPOSED TO ONCHOCERCIASIS IN 1980

Department	Region	Total Population	Hyper-endemic	Meso-endemic	Hypo-endemic	Non-exposed
Kedougou	Senegal Oriental	69,000	22,000	31,500	15,500	0
Bakel	Senegal Oriental	97,000	1,000	5,000	27,500	63,500
Tambacounda	Senegal Oriental	147,000	-	4,500	22,000	120,000
Vélingara	Casamance	105,000	-	-	70,000	35,000
Total		418,000	23,000	41,000	135,000	219,000
Percent			5.5	9.8	32.3	52.4
				47.6		

SOURCE: World Health Organization. Projet Sénégambie. Lutte contre l'onchocercose en Guinée, Guinée-Bissau, Mali, Sénégal et Sierra Léone. 1981.

University of Michigan, Gambia River Basin Studies, 1985.

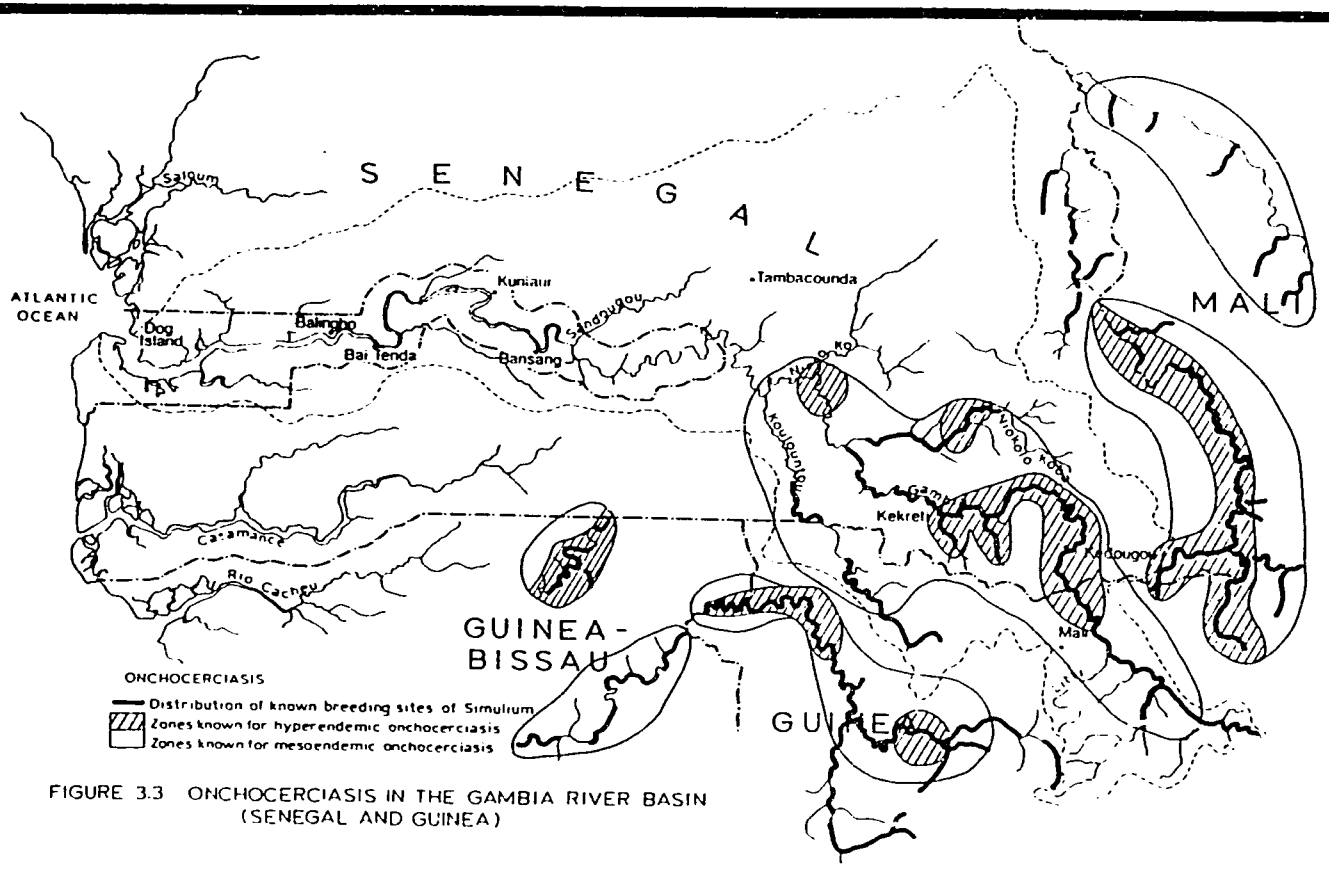

FIGURE 3.3 ONCHOCERCIASIS IN THE GAMBIA RIVER BASIN (SENEGAL AND GUINEA)

University of Michigan, Gambia River Basin Studies, 1985.

regions of Gaoual, Koubia, Koundara, Labé, and Mali in the Guinean portion of the Gambia River Basin. Koubia and Labé are elevated; Goual, Koundara share altitudes with the portions of Senegal just across the border. Mali includes low regions and elevated regions. Table 3.11. shows the prevalence of onchocerciasis in middle Guinean sectors belonging to the Gambia River Basin. It is noted that higher rates are seen in the low-lying areas whereas the elevated parts (Labé and Koubia) display lower rates. Hyperendemic villages were encountered only along the Koulountou River (Gaoual and Koundara).

3.1.4.5. Bancroftian filariasis. Elements of transmission:

- Filarial worms, *Wuchereria bancrofti*.
- Anopheline mosquitoes, *Anopheles gambiae* and *A. funestus*.
- Susceptible humans.

Man is the only known host. Many people with microfilaremia show no clinical or pathological signs of filarial infection. When damage does occur it is because of interference with normal lymph flow that is caused by worms in various stages of development. It is of interest that elephantiasis and hydrocele, associated with filariasis in most of its range, is uncommon in West Africa.

There are two biologically different forms of *W. bancrofti*: one periodic with nocturnal periodicity of the microfilariae, transmitted by night-biting mosquitoes, and the other subperiodic with diurnal periodicity of the microfilariae, transmitted by day-biting mosquitoes.

- Senegal

This filaria exists in most regions of Senegal but infection is heaviest in Senegal Oriental and in Casamance (see Table 3.12.). The reported figures are based on blood work effected during the day. However, in one village in which periodicity was studied in the Casamance, the microfilariae proved to have a nocturnal periodicity (Hocquet; Larivière, Camerlynck and Diallo, 1964). It is thus likely that official figures, in the absence of general studies directed at periodicity, should be viewed conservatively. As a further caution, it seems very likely that some of the cases reported from Senegal Oriental might represent other filariae and even, in rare instances, onchocerciasis.

TABLE 3.11.

DATA ON PREVALENCE OF ONCHOCERCIASIS IN SECTIONS OF MIDDLE GUINEA INCLUDED IN THE GAMBIA RIVER BASIN, BASED ON FIELD STUDIES OF 1980

Region	Villages Visited	Census Population	Number Examined	Positive for Onchocerciasis	Prevalence	Number of Blind	Prevalence of Blindness	Number of Villages		
								Hypo	Meso	Hyper
Gaoual	13	1,602	1,215	509	41.9	61	3.8	5	6	2
Koubia	8	1,227	1,096	143	13.0	9	0.7	6	2	-
Koundara	9	1,522	1,078	362	33.5	37	2.4	5	3	1
Labé	8	891	825	26	3.1	3	0.3	8	-	-
Mali	7	1,193	766	398	52.0	21	1.8	2	5	-
Total	45	6,435	4,980	1,438	28.9	131	2.0	26	16	3

SOURCE: World Health Organization. Projet Sénégambie. Lutte contre l'onchocercose en Guinée, Guinée-Bissau, Mali, Sénégal et Sierra Léone. 1981.

University of Michigan, Gambia River Basin Studies, 1985.

- The Gambia

Bancroftian filariasis is prevalent in The Gambia but morbidity is low. Rates are highest near the coast. Because of the rarity of symptoms, people have little or no consciousness or fear of the disease. The following infection rates have been reported in eastern Gambia:

Village	Number Examined	Number Positive	Percent	Year	Source
Kololi	158	77	48.4	1954	158
Jiboroh	199	48	25.1	1954	158
Mandinari	194	70	36.1	1954	158
Keneba	603	230	36.5	1951	162

University of Michigan, Gambia River Basin Studies, 1985.

There have been no recent (within the last 10 years) assessments of filariasis in The Gambia, and the relation of the above figures to current reality is unknown.

- Guinea

No data on bancroftian filariasis in Guinea were encountered. It is likely that it is to be found in the coastal areas.

Discussion. A nonpathogenic filaria, *Dipetalonema perstans*, is commonly diagnosed along with *W. bancrofti*. The microfilariae resemble each other superficially but can be distinguished with proper training. Transmission is by the midge, *Culicoides austeni*. *D. perstans* is considered a zoonosis in many areas, being found commonly in chimpanzees and gorillas, but in the area of the Gambia River Basin, it is probably principally a human infection.

Failure to distinguish between these two parasites might explain high prevalence rates reported from some areas.

3.1.4.6. African sleeping sickness. Elements of transmission:

- The blood flagellate, *Trypanosoma brucei gambiense*.
- The riverine tsetse fly, *Glossina palpalis*.
- Susceptible human hosts.

Gambiense trypanosomiasis is an infection of riverine and lake areas of West Africa, found wherever riverine tsetse flies and man come into

TABLE 3.12.

CASES OF FILARIASIS NOTIFIED IN SENEGAL, 1979

Region	Number of Cases	Percent
Cap-Vert	24[a]	1.1
Casamance	941[b]	42.6
Diourbel	-	-
Fleuve	53[a]	2.4
Senegal Oriental	1,180[c]	53.4
Sine-Saloum	2	0.1
Thiès	9[d]	0.4
Total	2,209	100

NOTES: a) Cases seen only in a nurse-directed health post.
b) 716 cases seen in a physician-directed health center; 225 cases seen in a nurse-directed health post.
c) May include filariae other than *W. bancrofti*.
d) Cases seen in physician-directed health center; two cases seen in nurse-directed health post.

University of Michigan, Gambia River Basin Studies, 1985.

close contact, such as river crossings, lakeside villages and waterholes frequented by man and a few infected flies. Fishermen may be especially affected.

- Senegal

Trypanosomiasis has been retreating in recent years but remains a constant preoccupation of health authorities because apparently foci of infection still persist. In 1979, 15 cases (both old and new) were diagnosed. This compares with 19 diagnosed in 1978.

- The Gambia

The trend of incidence of human trypanosomiasis in The Gambia may be summarized for the years 1979-1981 as follows:

	1979	1980	1981
Number of Cases	153	239	15
Percentage Change		+56.2%	-93.7%

In 1983 the author was unofficially informed that only a single case of trypanosomiasis had been reported in The Gambia (at Bansang). Clearly, there has been a great reduction in incidence since the decade of 1925-1935 when thousands of cases and many deaths were reported (see Figure 3.4.).

- Guinea

In 1979 there were 2,084 old and new cases of sleeping sickness reported by the Communicable Diseases Control Department (CDC) in 1979. The distribution by region was as follows:

Region	Existing Cases	New Cases	Total	Percent
Kindia	286	8	294	16.4
N'Zérékoré	53	114	167	9.3
Kankan	620	30	650	36.3
Faranah	339	20	359	20.1
Labé	263	8	271	15.1
Boké	37	12	49	2.7
Total	1,598	192	1,790	99.9

University of Michigan, Gambia River Basin Studies, 1985.

3.1.4.7. Leishmaniasis. Elements of transmission:

- Intracellular amastigote protozoan parasites, genus Leishmania.[8]
- Psychodid sandflies, Phlebotomus dubosqui (for CL).
- Burrows of certain rodents, as breeding areas.[9]
- Susceptible human hosts.

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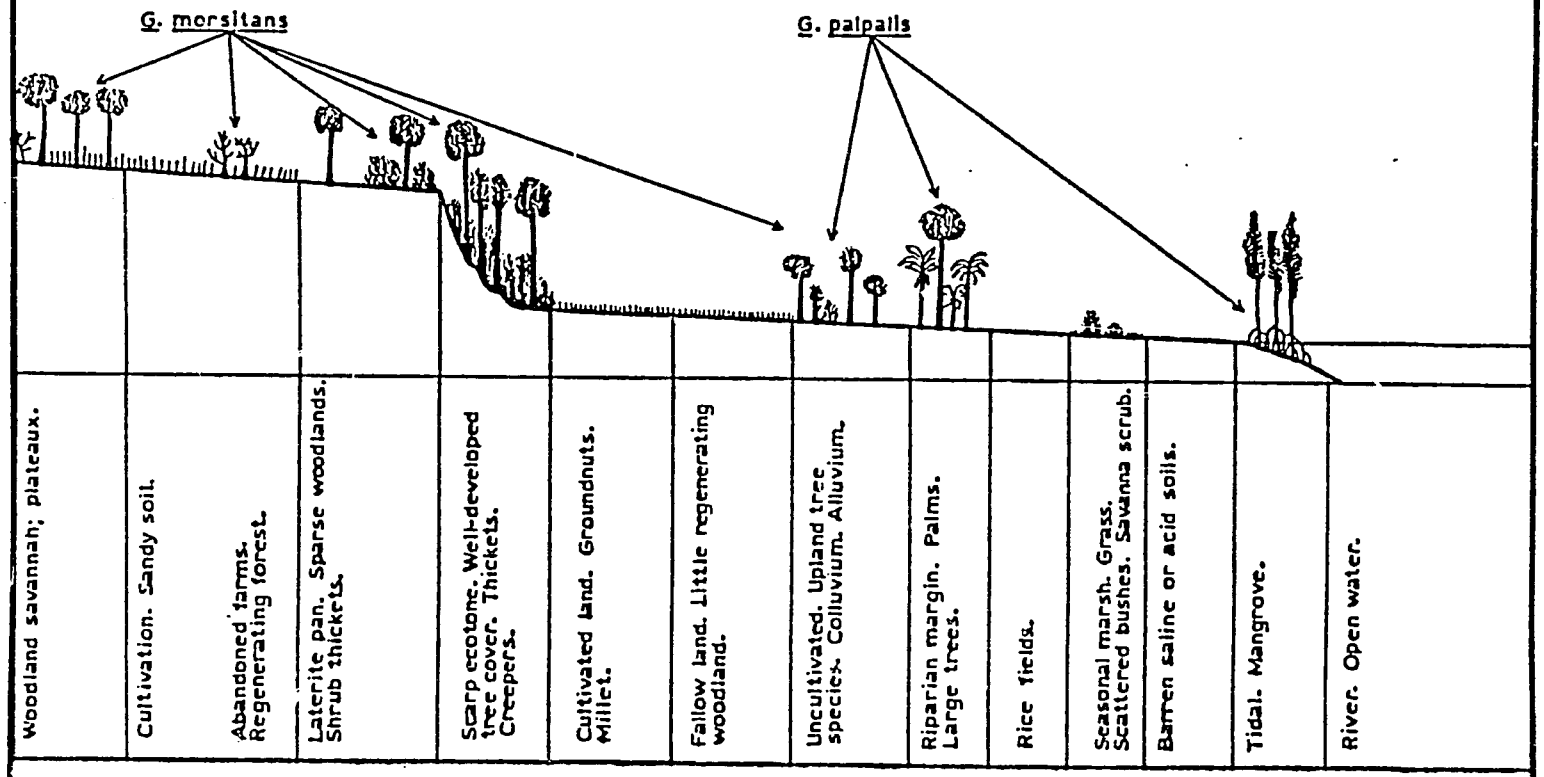
[8]Leishmania major is the cause of rural (wet sore) cutaneous leishmaniasis (CL) in West Africa. Very recently, visceral leishmaniasis (VL) or kala-azar has been reported (in The Gambia); the agent is unknown but may derive from dogs which are known to be infected with L. donovani infantum (canine VL).

[9]P. dubosqui breeds in burrows of the Nile Grass Rat (Arvicanthus niloticus), the Multimammate Rate (Mastomys erythroleucus), and the Large Naked-soled Gerbil (Tatera gambiana).

FIGURE 3.4. Ecological distribution of riverine tsetse flies (Glossina palpalis) and game tsetse flies (G. morsitans) in The Gambia



University of Michigan, Gambia River Basin Studies, 1985.

Leishmaniasis is caused by parasites of the genus Leishmania, originally parasites of rodents, transmitted by sandflies (Phlebotomus) and have become adapted to dogs and man. They are classified by the types of disease that they cause. In West Africa, two forms exist: visceral leishmaniasis (VL) and cutaneous leishmaniasis (CL). Infection with the VL is extremely rare in humans. Infection with CL is sporadic and concentrated geographically in areas near the coast. The conditions are cited here because of uncertainty about their behavior under future conditions of ecological disruption.

- Senegal

VL has not been reported from humans in Senegal but the causative parasite (L. donovani infantum) occurs in dogs. It is not known if the dog parasite can be transferred to humans.

CL is not uncommon in Senegal. Most cases are diagnosed in Dakar, regardless of point of orign. More than half of the cases originate in three regions, namely, Thiès, Fleuve, and Sine-Saloum. Very few cases have been reported from Senegal Oriental; accordingly, it is not possible to determine whether this region is truly endemic.

- The Gambia

Both VL and CL occur in The Gambia but are extremely rare. Apart from a single case reported in 1949 (Walters, 1949), no VL was encountered until 1980 when a fatal case was reported from Mandinari (Cornet, Robin, Chateau, et al., 1979). The same report listed a new case of CL. Since CL is widely recognized to be self-limiting and not life-threatening, it may be that people do not feel the need to solicit medical help. If this is the case, epidemiological data on CL will only be forthcoming from a longitudinal survey.

- Guinea

VL has never been seen in Guinea. With regard to CL, skin-testing performed on workers originating from all regions of Guinea (coastal, central, upper, and forest) resulted in inconclusive figures, thus it is not yet possible to verify that CL occurs in Guinea.

3.1.5. Fecal-borne Diseases (Hookworm Disease)

Elements of transmission:

- Infection with human hookworms.[10]
- Habit of indiscriminate defecation in frequented places.

Hookworms exist throughout the inhabited tropical world as indicator organisms for poor diet and inadequate sanitation on contaminated soil. The worms inhabit the small intestine where they attach to the intestinal wall by means of their chitinous teeth and suck blood. When worms are present in very large numbers the blood loss from the intestine may result in severe anemia.

Although in many tropical countries transmission is perennial, in the dry sub-Sahelian climate characteristic of the Gambia River Basin transmission is heaviest during the rainy season.

Man is the only source of infection. The life histories of the two species are almost identical. The soil in the vicinity of living quarters is contaminated with human feces out of which infective larvae develop. If they come in contact with human skin the larvae bore their way through the skin and, by a circuitous route through the lymphatics, blood vessels, lungs, bronchi and trachea, come to pass through the esophagus and stomach and so reach the small intestine.

- Senegal

Hookworm disease is probably underreported in Senegal. The great majority of clinically diagnosed cases are from Casamance. The reported cases in 1979 were as follows:

Region	Number of Cases	Percent
Cap-Vert	253	6.6
Casamance	3,330	86.3
Diourbel	0	0
Fleuve	0	0
Senegal Oriental	0	0
Sine-Saloum	16	0.4
Thiès	257	6.7
Louga	0	0
Total	3,856	100

University of Michigan, Gambia River Basin Studies, 1985.

[10] Of the two species of human hookworms, Ancylostoma duodenale is essentially a parasite of the north coast of Africa, while Necator americanus is predominant in central and southern Africa. Both species may be encountered in West Africa.

- The Gambia

In one study (Knight and Merrett, 1981) of two Gambian villages in 1981, Necator americanus egg counts began to rise 2 months after the short rainy season and reached a maximum after 7 months. Egg counts in adults tended to return to their previous value after 12 months but children below 10 years of age showed net increments.

The two villages were Mandinari (on the Gambia River, about 7 km south of Banjul) and Marakissa (about 5 km from the southern border with Senegal). The prevalence in each village for boys and girls aged 1 to 4 and also 5 or more is given below:

Village	Ages 1-4		Ages 5+	
	M	F	M	F
Marakissa	87	80	94	93
Mandinari	39	56	92	80

University of Michigan, Gambia River Basin Studies, 1985.

The total mean egg counts in Marakissa were more than twice those in Mandinari. Below the age of 10 years both sexes in each village had similar counts but over this age males had significantly higher counts than females.

- Guinea

In 1981 there were 15,597 cases of ancylostomiasis and necatoriasis reported among a total of 301,613 infectious and parasitic disease cases in outpatients at all health facilities, or 5.2 percent. Hookworm disease ranked fifth among these disease problems, after influenza but before gonorrhea.

3.2. Vectors and Transmitting Agents of Water-borne Diseases In The Gambia River Basin

Many tropical parasites require the intervention of invertebrate intermediate hosts for the completion of the transmission cycle. These invertebrate hosts are vectors if they actively transport the parasite to

man, e.g., Anopheles mosquitoes, or transmitting agents -- if their role is passive, e.g., freshwater snails.

The behavior, ecological requirements and geographic distribution of some of the most significant of these, are listed below. All are characteristic of the Member States. They include the mosquitoes of malaria, yellow fever, dengue, and the filariases, the tsetse flies of sleeping sickness, the blackflies of river blindness, the sandflies of cutaneous leishmaniasis, the water fleas of guinea-worm infection, and the snails of schistosomiasis. The diseases with which they are identified are listed in Table 3.13.

3.2.1. Mosquitoes (Diptera: Culicidae)

All mosquitoes undergo a cycle of hatching from an egg into water, a larval or wriggler stage of variable duration, an active pupal stage of usually short duration, and an adult.

Female adult mosquitoes need vertebrate blood to produce eggs. Their mouth parts are accordingly modified to suck blood. Their biting habit has been exploited by many protozoan and metazoan parasites, including those which cause disease.

The efficiency of a mosquito species as a transmitter of disease depends on the size of the population (population density), the degree of anthropophily (human blood index), and whether the parasite in question can complete its development in that species. Behavioral factors include house haunting, flight distances, and breeding near human habitation.

3.2.1.1. Anopheles species. Human malaria is always transmitted by mosquitoes of the genus Anopheles. Parasites are ingested with a blood meal, enter the mosquito's gut, undergo a series of developmental stages, and eventually invade the salivary glands in an infective stage capable of reestablishing the infection in a new host.

In West Africa the principal vectors of human malaria include Anopheles gambiae (and the very closely related A. arabiensis), A. funestus, and in areas affected by high salinity, A. melas.

- Anopheles gambiae s.s. and A. arabiensis: The six "subspecies" of the Anopheles gambiae complex have now been given names. Those of the Gambia River Basin are now termed A. gambiae s.s. and A. arabiensis. They cannot be easily separated in the field and are best assigned to gambiae s.l.

TABLE 3.13.

LIST OF WATER-BORNE DISEASE VECTORS OF THE GAMBIA RIVER BASIN, THE PRINCIPAL DISEASES WITH WHICH THEY ARE IDENTIFIED, AND THEIR MEMBER STATE DISTRIBUTION.

Vector/Transmitter	Disease	Area		
		Gambia	Senegal	Guinea
Mosquitoes				
Anopheles melas	Malaria	+	-	-
A. gambiae/A. arabiensis	Malaria; Bancroft's Filariasis; Chikungunya virus	+	+	+
A. funestus	Malaria; Bancroft's Filariasis	+	+	+
Aedes aegypti	Yellow Fever (urban); Dengue	+	+	+
Ae. africanus	Yellow Fever (sylvatic)	+	+	+
Ae. luteocephalus	Yellow Fever (sylvatic)	+	+	+
Ae. vittatus	Yellow Fever (sylvatic)	+	+	+
Ae. furcifer/taylori	Yellow Fever (urban & sylvatic)	+	+	+
Tsetse Flies				
Glossina palpalis	Human Sleeping Sickness	+	+	+
G. morsitans	Animal Trypanosomiasis	+	+	+
Blackflies				
Simulium damnosum s.l.	River Blindness (Onchocerciasis)	-	+	+
Sandflies				
Phlebotomus dubosqui	Cutaneous Leishmaniasis	+	+	
Water Fleas				
Cyclops sp.	Guinea Worm (Dracontiasis)	+	+	+
Mollusks				
Biomphalaria pfeifferi	Intestinal Schistosomiasis	+	+	+
Bulinus senegalensis	Urinary Schistosomiasis	+		
B. globosus/B. jousseaumei	Urinary Schistosomiasis	+		+
B. truncatus guernei	Urinary Schistosomiasis		+	

University of Michigan, Gambia River Basin Studies, 1985.

They breed in small water containers, ground depressions such as footprints of cattle, tree holes, discarded tin cans, old tires, coconut husks, and the like. They are closely associated with human habitation. The species constitutes one of the most efficient vectors of human malaria, always associated with high parasite rates wherever abundant. They are responsible for most of the malaria in urban and rural West Afric

Peak populations are recorded in the rainy season (June-August). These mosquitoes tend to vanish at the height of the dry season (February-March).

- Anopheles funestus: These are characteristically associated with large bodies of water and is especially found along river courses. They have been collected within the cities of Dakar and Banjul.

  They transmit malaria most efficiently during the beginning of the dry season, "taking over" transmission of malaria as populations of A. gambiae decline. Thus, they help to carry year-round malaria along the edges of rivers.

- Anopheles melas: This is a brackish-water breeder with particular preference for white mangrove (Avicennia) swamps. The lower Gambia River possesses an abundance of such swamps, flooded bimonthly by high spring tides, which are important breeding places because of the salt content and the flat, peaty soil. Larvae of A. melas can withstand sudden changes in salinity but must have salt in order to breed. As vectors they are almost as efficient as A. gambiae (see above) in terms of house-haunting, preference for human blood and the level of sporozoite indices in wild-caught females. A. melas maintains transmission of most of the highly endemic coastal malaria in rural West Africa (Foote and Cook, 1959).

3.2.1.2. Aedes species. Many Aedes are vectors of arboviruses, some of which (yellow fever, dengue II, chikungunya, and Zika) are now known to cause important human diseases in West Africa. Aedes eggs are especially capable of withstanding desiccation. Many arboviruses can be passed transovarially in Aedes, i.e., from mother to progeny via the egg.

- Aedes aegypti: This is the most widespread and dangerous species of this genus in West Africa. It breeds close to human habitations in containers (flower bowls, discarded cans, old tires, rock holes, tree holes, etc.) It is the only urban vector of classical yellow fever. It is also associated with transmission of dengue II, certain of the encephalitis-causing viruses, and bancroftian filariasis (elephantiasis) (Cordellier, Germain, Henry and Mouchet, 1977; Foote and Cook, 1959).

- Aedes africanus: This species transmits sylvatic or "rural" yellow fever, and is a canopy breeder of the sudan and guinea savannas. The seasonal distribution closely parallels the rainfall, large numbers of adults appearing before, during, and just after the period of maximum rainfall (July-August). It bites either monkey or man indifferently. Although the species prefers to bite in the canopy, it will bite readily at ground level when trees are disturbed by felling and clearing. The principal carriers of sylvatic yellow fever virus in MacCarthy Island Division, Upper River Division and Senegal Oriental are probably red patas monkeys (Erythrocebus patas) and Western baboons (Papio papio), both of which will raid farms and thus enter the living space of humans. A. africanus will bite man but never enters villages to do so. Its transmission role has been proved experimentally and yellow fever virus has been isolated from wild-caught specimens (Cordellier, 1978).

- Aedes luteocephalus: Its requirements and habits are similar to those of A. africanus (see above). It may replace the latter in Galery Forest in the southern part of the sub-Sudan savanna. Yellow fever virus has been isolated from wild-caught adults in Senegal. A. luteocephalus may have been involved in the Gambian epidemic of 1978-79 (Cordellier, 1978; Germain, Francy, Monath, et al., 1980).

- Aedes vittatus: This species inhabits open savanna country, and breeds under full sunlight in rock pools, margins of streams, tree holes, pirogues filled with rainwater, filled cattle hoofprints, barrels, buckets, and wells. The larvae mature very rapidly (in 3 days) and this species can thus utilize temporary water collections which may dry up quickly. It transmits sylvatic yellow fever among the natural (monkey) reservoir hosts (Cordellier, Germain, Herny and Mouchet, 1977; Foote and Cook, 1959).

- Aedes furcifer/A. taylori group: It is abundant in villages of the West African savanna, and breeds in tree holes in forested areas outside of villages. Noted for its tendency to fly farther than other mosquito species in order to bite, it is one of the mosquitoes that can effect an exchange of yellow fever virus between monkeys and man. A nocturnal biter, it is thought to have been involved in yellow fever transmission in The Gambia during the early stages of the 1978 outbreak (Cordellier, 1978; Monath, Craven, Adjukiewicz, et. al., 1980).

3.2.2. Tsetse Flies (Diptera: Glossinidae)

This species are large, narrow-bodied flies, 6-15 mm long, with a stout proboscis projecting forward well in front of the head. Both male

and female flies feed exclusively on the blood of vertebrates. In humans the bite is extremely painful and can quickly become edematous. Flies reproduce viviparously, a single mature larva being extruded onto the ground where there is shade and suitably porous soil texture. Larva actively burrows a few millimeters below the surface and pupates. After emergence from the puparium and reaching the soil surface the fly rests a short period before seeking its first blood meal.

- Glossina palpalis gambiensis: The major vector in West Africa of human trypanosomiasis (African sleeping sickness). The causative agent is a flagellated protozoan parasite, Trypanosoma brucei gambiense. Flies are generally considered to breed on the shores of lakes and rivers but definitely require forested or formerly forested areas. Occur the length of the Gambia River from the coast to middle Guinea. In the absence of humans and domestic animals, G. palpalis feeds about half the time on reptiles (crocodiles and monitor lizards), a quarter of the time on bushbuck (Tragelaphus scriptus) while other animals take the remainder of the bites. Humans and their livestock become a major source of blood meals at river crossings and water holes, where outbreaks of sleeping sickness traditionally occur (Laird, 1967; Laveissière and Toure, 1982; Manson-Bahr and Apted, 1982).

- Glossina morsitans submorsitans: The "game" tsetse fly, it breeds in shaded savanna and open forest, biting wild or domestic bovids (including antelopes), as well as pigs and warthogs. It is considered a livestock pest, and occurs throughout The Gambia with the exception of western parts of Western Division, and in Senegal Oriental and middle Guinea. Breeding may overlap that of G. palpalis in some savanna woodlands.

3.2.3. Blackflies (Diptera: Simuliidae)

These are small, robust, hump-backed flies (1-5 mm long), that breed in moving, well-oxygenated waters (large or small rivers, freshets, spillways). They are widespread in The Gambia, eastern Senegal, Niokolo-Koba, Koulountou, Niori-Ko, and Falemé Rivers, but do not extend west of Gouloumbou or into The Gambia. Females attach eggs at the moisture's edge to half-submerged stones, floating plant stems, etc. Eggs hatch in 1-2 days. Emerging larvae require: solid surface support for attachment; well oxygenated, moving water; and suspended organic particulate matter (food). Larval stage lasts 1-2 weeks, followed by construction of tent-like cocoons and pupation. Pupal period is 2-10

days. Emerging adults can feed on plant juices but females require a blood meal for successful oviposition. Blackflies bite domestic (dog, goat, sheep, ass, cow, rabbit, chicken) and wild (antelope, wild fowl) animals as well as humans. In forested sub-Sahelian sections of West Africa there are reports that blackflies prefer animals to humans, thus, the presence of domestic animals may deflect human attacks. Female blackflies are capable of long flights; reinvasion of controlled areas in West Africa was detected over distances of 200-400 km.

- Simulium damnosum s.l.: The vector of the filarial nematode, Onchocerca volvulus, is the agent of river blindness in West Africa. The species is not homogeneous but is composed of 7 or 8 cytotypes (chromosomal variants) which are morphologically indistinguishable in the field. The complex in eastern Senegal and middle Guinea includes S. damnosum ss., S. sirbanum, and S. soubrense. S. damnosum and S. soubrense in this area transmit the savanna form of onchocerciasis, thought to be more pathogenic than the forest type encountered further south.

3.2.4. Sandflies (Diptera: Psychodidae)

These are small (1.5-2.5 mm), hairy flies with long legs. Vectors of human and canine leishmaniasis, they are slow, weak fliers and crepuscular, inactive in daylight hours when they rest in dark, humid places such as rodent burrows and termite hills. Only the females take blood meals.

- Phlebotomus dubosqui: Thought to be the vector of Sahelian zoonotic cutaneous leishmaniasis (oriental sore), the ethiologic agent of which is a flagellate protozoan intracellular parasite, Leishmania major. P. dubosqui is closely associated with burrows of certain rodents, including the Nile grass rat (Arvicanthus niloticus), the multimammate rat (Mastomys erythroleucus) and the large naked-soled gerbil (Tatera gambiana), all of which are proposed as reservoir hosts of the parasite. Found in the more arid sections of the Senegambian region, they are sometimes found resting in houses.

3.2.5. Water fleas (Copepoda: Cyclopidae)

These are small (1 to several millimeters long) fresh-water crustaceans found actively swimming in shallow wells and small bodies of surface water in warm countries. They are the intermediate hosts of the guinea worm, Dracunculus medinensis.

- Cyclops sp.: Many of the species in the following list have a more or less worldwide distribution, while others are geographically more limited: Cyclops quandricornis, C. strenuus, C. viridis, C. coronatus, C. bicuspidatus, Mesocyclops leuckarti (occurs in the Gambia River, see Aquatic Ecology and Gambia River Basin Development), M. hyalinus, Tropocyclops multicolor, Thermocyclops nigerianus. These species are reported to be efficient intermediate hosts of Dracunculus.

  Released into the water, the worm embryos move actively and convulsively, attracting the attention of water fleas which ingest them. Usually one water flea harbors no more than 4 developing larvae at a time. Development includes 2-3 months and requires 4-6 weeks. When about 1 mm long the larva becomes infective; when the water flea host is swallowed by man the larva emerges in the stomach, migrates to the subcutaneous tissues by way of the lymphatic system. The adult stage is reached after 1 year. The adult worms, which may be 60 cm in length, do not harm their host until they are ready to produce young. Then the female worms migrate typically down to the legs and feet, approaching the skin from beneath. Their presence irritates the dermis, producing blisters. On contact with water the blister breaks, releasing the active embryos into the surrounding water to be picked up by other water fleas.

3.2.6. Freshwater snails (Glastropoda: Planorbidae)

They are small to medium-sized mollusks with long tentacles and red blood. Transmitters of trematode worms of the genus Schistosoma, in West Africa they occur in diverse aquatic habitats. Some are more resistant to drying than others. They are hermaphroditic, thus a single mature specimen theoretically will suffice to populate an entire pond. However, cross-fertilization occurs regularly in normal populations. Eggs are laid in gelatinous capsules on solid surfaces (stones, twigs, leaves, bottles). Growth of hatchling snails are affected by food supply, temperature, crowding and concurrent trematode infections. Life span probably does not exceed 30-80 days in the wild; there may be as many as 3 generations in a year.

3.2.6.1. Biomphalaria species. Only one species of Biomphalaria is known to transmit schistosomiasis to humans in West Africa, B. pfeifferi.

- Biomphalaria pfeifferi: They inhabit clear-flowing streams, seepage areas, and a variety of man-made bodies of water including irrigation channels and dammed lakes, where

there is plenty of vegetation. Not found in seasonal ponds or swamps, they are usually detected crawling on stems and leaves of water lilies, often in association with Bulinus globosus (see below). In The Gambia and eastern Senegal, this is a rare snail under present conditions. It seems to be more widespread in the Fouta Djallon of Guinea.

3.2.6.2. Bulinus species. These are small to medium-sized sinistrally-coiled snails with a spire. Different species may have widely differing ecological requirements which in turn have an important bearing on their role as intermediate hosts of Schistosoma haematobium, the causative agent of urinary schistosomiasis or bilharziasis.

- Bulinus senegalensis: Now known to occur in a wide variety of habitats in The Gambia, Senegal, and Guinea, including seasonal laterite pools (in The Gambia), alluvial pools, irrigated rice fields, and overflow swamps, it is the principal transmitter of S. haemotobium in The Gambia, where it is found mostly in seasonal shallow pools on the laterite plateaux of MacCarthy Island Division and Upper River Division. It is able to withstand 6 or 7 months of severe drought each year by aestivating in the dry mud, and has also adapted to the high temperatures which are reached during the afternoons.

- B. forskalii: It resembles B. senegalensis, from which it must be differentiated. They are never found in laterite pools, but are common in alluvial pools, swamp drainages, and often in cultivated rice fields. Although not a carrier of human schistosomes, it is an intermediate host of bovine schistosomiasis and in certain West African countries it is a transmitter of the human parasite, Schistosoma intercalatum (not known to occur in any of the Member States). It can withstand drought, like its relative, B. senegalensis.

- B. globosus: This species is found in the clear, flowing waters of permanent steep-sided bolons of Upper River Division (i.e., Simoto and Prufu bolons). At intervals these bolons wides to form small pools where the rate of flow is slower and aquatic vegetation, especially water lily, is more abundant. It is also found in association with the rice schemes between Pacharr and Jahaly in MID. The literature refers to B. jousseaumei which seems to be a synonym of B. globosus.

- Bulinus truncatus guernei: These are not found in temporary habitats such as rain-fed laterite pools. Commonly found in irrigation canals and their accompanying seepage pools, in The Gambia it was found during field

reconnaissance in the old Colonial Development Corporation canal bringing Gambia River water to the Chinese rice scheme near Saruja (MID). Its presence is a threat as it is hardly wide-spread at present but is well-adapted to lakes and impounded reservoirs. In Senegal it has been credited with the greatest part of bilharzial transmission in Senegal Oriental.

3.3. Medical Establishments and Services

The health service systems of Senegal and Guinea are based on a French model while that of The Gambia is based on a British model. Thus, item for item, services, facilities, titles of personnel, etc., are not strictly comparable. When identical terms are shared by the two systems these are not necessarily indicative of identical forms and functions. In considering the term "doctor," it must be admitted that the training of physicians differs between the Member States with the result that medical practitioners may have quantitatively, if not qualitatively, varying degrees of knowledge. It is not clear that standards among the Member States are commensurate. On the other hand, the term "health center" does seem to be employed with a similar meaning in Senegal, Guinea and The Gambia, describing a facility that offers certain services.

3.3.1. Administration

- Senegal

Administratively, health services in Senegal are organized on the pattern of other public services, to be provided at all political levels from the national level down to that of the village level.

At the national level are the (national) hospitals, the offices of health education, and the infectious disease control service. At the same level, the hygiene service and the maternal and child health service (MCH) are encountered. The same services are offered at the regional level in association with the regional hospitals. At the present time, Senegal Oriental Province is the only region without a functioning hospital: the newly constructed complex in Tambacounda is scheduled to commence service by 1987.

At the departmental level the main health centers with MCH and hygiene services are found. The health centers of the arrondissements are attached to the departmental health centers.

At the rural community level, rural health posts are attached to either health or medical centers; some have dispensaries and rural maternities.

Senegal Oriental Province. Of the 440 health posts in Senegal, only 46 (10.5 percent) are located in Senegal Oriental Province, which occupies 30.3 percent of the area of the country and contains 6 percent of the population. Such figures indicate a serious problem of accessibility to health services. It is noted, for example, that on occasion the people of Bakel prefer to visit the hospital in Selibabi (Mauritania) which is staffed by Chinese doctors, rather than face the trip to Dakar.

New facilities are under construction. The region's first hospital, in Tambacounda, is slated to commence services in 1987. Two additional health centers and 37 health posts are also to be completed by this date. In an effort to improve primary health care, the government plans to construct 502 health huts (cases de santé) by 1987 and a total of 1,435 by 1997. USAID is supporting this project with $462,000 (see section 3.3.7. on the Bakel Health Project).

Sine-Saloum Province. Sine-Saloum is the second largest region in terms of population and receives the third largest allocation of the national health budget. It is noted that almost 40 percent of this allocation is consumed by the regional hospital in Kaolack. The remaining funds are shared by the regional administration and its services, plus nine medical centers and their corresponding health posts and services.

Seven health centers and 832 health huts (cases de santé) are scheduled for construction by 1987 and a total of 19 health centers and 2,377 health huts by 1997. USAID is supportive of the primary health care program in Sine-Saloum, particularly with regard to training.

- The Gambia

The country is divided into three medical regions for administrative purposes:

- Western region - comprised of the Western Division, Banjul, the Kombos, Cape St. Mary, and the western part of the North Bank Division;
- Central region - comprised of the Lower River Division and the eastern part of the North Bank Division;
- Eastern region - comprised of MacCarthy Island Division and Upper River Division.

Each regional headquarters is staffed by a regional medical officer (RMO). A regional public health nurse, a regional health superintendent (supervisor of health inspectors), and village health worker trainers. A regional store is located at each regional headquarters, found in Banjul (western region), Mansa Konko (central region), and Bansang (eastern region).

Health services are available at the national, regional and local levels. The two hospitals serve as referral centers. The Royal Victoria Hospital (RVH) is the highest referral center in The Gambia, providing specialists in general and orthopedic surgery, obstetrics/gynecology, pediatrics, radiology, pharmacy, and dentistry. There is also an outpatient clinic and a laboratory. Under the auspices of RVH are the mental hospital at Campama, the TB sanitorium, the home for the infirm, and the Leman Street and New Street clinics (MCH clinics).

The following facilities and services function below the hospital level: (i) the polyclinic, which offers a number of services in the Banjul-Kombo-St. Mary area, between the level of hospital and health center; (ii) health centers are the principal health facility in rural areas, providing curative outpatient care, environmental health protection and promotion, maternal and child health services. They are staffed by a dresser/dispenser, a nurse/midwife, a community health nurse, a public health officer, and auxiliary nurses; (iii) dispensaries provide outpatient care in rural areas and are sometimes visited by mobile MCH teams; they are staffed by a dresser/dispenser and sometimes by a public health officer; (iv) subdispensary facilities provide periodic outpatient care for a group of villages by either a dresser/dispenser or a team from a health center or a dispensary, but the subdispensary has no resident staff.

The people have input to the health system by means of development committees organized at village, district and divisional levels.

- Guinea

The health planning process in Guinea involves reviewing the existing situation and determining necessary actions. Health facilities are erected according to administrative boundaries i.e., in a regional capital there is supposed to be a regional hospital, etc. The health facilities are designed according to standard plans. Accessibility, epidemiology of diseases, population density, patterns of utilization are not taken into consideration.

The MOH does not have details on the physical status of the hospitals and health centers and does not know exactly how many health centers are fully functional. There is no complete inventory of the equipment in health units around the country. Many donor-funded projects have been providing equipment to health centers. On a recent inspection tour, officials found that some health centers have received two refrigerators or bicycles, for example, while others have received none.

To remedy this situation and to assess the actual sanitary state the Service de Prevention organized a comprehensive survey of the health system in Guinea. The goals of this evaluation which started in January 1984 are:

- to measure the quality and quantity of the resources of the health system and their distribution;
- to evaluate the health activities and their impact on the population.

This survey which is being applied in all health facilities in the country will analyze the health infrastructure, the equipment and material, the existing services and their utilization, and the number of health personnel. The results of the study were not available in time for this report.

3.3.2. Vital Statistics

A comparison of vital statistics figures for Senegal and The Gambia is presented in Tables 3.14, 3.15 and 3.16. It is seen that although Senegal possesses almost 6 million inhabitants (compared with The Gambia's population of 635,000), the population density in The Gambia (47

TABLE 3.14.

VITAL STATISTICS IN SENEGAL AND THE GAMBIA

	Senegal[a]	The Gambia
Population	5,703,017	635,913
Crude Birth Rate (CBR) (live births per 1,000)	48	49-50
Crude Mortality Rate (CMR) (deaths per 1,000)	20	-
Crude Infant Mortality Rate (IMR) (deaths per 1,000 live births)	93	217[b]
Natural Growth Rate	2.8	2.8[c]
Fertility Rate	7.2	6.4
Life Expectancy at Birth	44	41[d]
Population Density (persons per km^2)	27	47[e]

SOURCES: République de Sénégal, Ministère de la Santé Publique, Programmation Sanitaire du Sénégal. 1982. p. 33.

Gambia Government, Medical and Health Department. Annual Report. 1981. p. 2, 3 and 8.

NOTES: a) 1978 data, except mortality rate and life expectancy, which date from 1970.

b) From 1973 data.

c) From 1970 census.

d) 1980 data.

e) 1975 data.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 3.15.

POPULATION DISTRIBUTION IN SENEGAL, 1980

Regions	Population	Percentage
Cap-Vert	1,197,635	21
Casamance	804,125	14
Diourbel	473,350	8
Fleuve	264,599	10
Louga	456,241	8
Senegal Oriental	325,072	6
Sine-Saloum	1,140,603	20
Thiès	741,392	13
TOTAL	5,703,017	100

SOURCE: Programmation Sanitaire du Sénégal. 1982. p. 29.

University of Michigan, Gambia River Basin Studies, 1985.

persons/km^2) is almost twice that of Senegal (27 persons/km^2). There is also an outstanding difference between the two countries with regard to crude infant mortality rates (IMR): 217 per 1,000 live births in The Gambia compared with 93 per 1,000 in Senegal.

Differences between other values do not appear to be remarkable.

A demographic sample survey was conducted in Guinea in 1955. Since then 3 censuses have been held, however the results have not been published. Furthermore, there is no regular system for reporting births and deaths. Therefore all population figures are projections from the 1955 survey. These projections differ considerably especially when the assumptions on out-migration are so diverse. Consequently it is not possible to attach any relative value to these estimates. Any interpretation of these projections should be considered with reservation.

TABLE 3.16.

POPULATION DISTRIBUTION IN THE GAMBIA, 1981

Division	Population	Percent
Banjul	48,275	7.6
Cape St. Mary	61,161	9.6
Western	119,509	18.8
Lower River	49,023	7.7
North Bank	117,662	18.5
MacCarthy Island	131,618	20.7
Upper River	108,665	17.1
TOTAL	635,913	100.0

SOURCE: Gambia Government, Medical and Health Department. Annual Report. 1981. p. 102.

University of Michigan, Gambia River Basin Studies, 1985.

On the basis of the 1977 census, the MOH reported, in the first trimester of 1983, the health status measurements as follows:

> IMR (crude infant mortality rate) of 156, CBR (crude birth rate) 47, CMR (crude mortality rate) 27, rate of growth 2.0, life expectancy 47 for men and 50 for women. The high IMR of 156 has decreased to 126 according to an official of the Direction of Statistique Sanitaire. In summary the government recognizes that the health status of the population constitutes an area of high priority.

3.3.3. Health Budgets

Health budget figures were available from Senegal for the year 1979. Table 3.17 contrasts budgets in Senegal Oriental and Sine-Saloum provinces with the national total. Table 3.18 shows a breakdown of expenditures in Senegal Oriental and Sine-Saloum provinces by health facility.

It is noted that in Senegal Oriental almost 75 percent of the health budget was subsumed by the région médicale in 1979, leaving the four

TABLE 3.17.

SENEGAL ORIENTAL AND SINE-SALOUM PROVINCES;
Health Budgets by Facility, 1979

1. Senegal Oriental	Amount in CFA
Centre Médical Tambacounda	8,150,000
Centre Médical Pekel	5,991,000
Centre Médical Kedougou	6,605,000
Centre Médical Goudiry	8,025,000
Région Médicale	147,549,000
Other Services	22,983,000
TOTAL	199,303,000

2. Sine-Saloum	Amount in CFA
Hospital Kaolack	212,257,000
Centre Médical Kaolack	8,894,000
Centre Médical Fatick	6,597,000
Centre Médical Gossas	6,200,000
Centre Médical Foundiougne	4,650,000
Centre Médical Koungheul	4,946,000
Centre Médical Guineguineo	3,750,000
Centre Médical Sokone	4,920,000
Centre Médical Nioro	6,850,000
Centre Médical Kaffrine	7,219,000
Region Médicale	267,997,000
Other Services	31,469,000
TOTAL	567,105,000

SOURCE: République du Sénégal, Ministère de la Santé Publique. Statistiques Sanitaires et Démographiques du Sénégal, Annee 1979. 1981.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 3.18.

COMPARISON OF HEALTH BUDGETS FOR SENEGAL ORIENTAL AND SINE-SALOUM PROVINCES WITH THE NATIONAL HEALTH BUDGET, 1979-80

	Senegal	Senegal Oriental	Sine-Saloum
Provincial Health Budget, in Million FCFA	6,572,014	199,303	567,105
Percentage of National Health Budget	100	3	8.5
Health Expenditure Per Capita, in FCFA	1,174	613	497

SOURCE: Statistiques Sanitaires et Démographiques du Sénégal, Année 1979.

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health centers and their subsidiary health posts to divide the remaining 25 percent.

In Sine-Saloum, 38 percent of the budget was consumed by the regional hospital in Kaolack, 47 percent was allocated to the région médicale, and all other facilities shared the remaining 15 percent.

In Senegal Oriental, 3 percent of the national health budget was allocated to the 6 percent of the population residing in the region. Sine-Saloum received 8.5 percent of the national health budget for its 20 percent of Senegal's population.

Per capita expenditures in 1979 were 613 F.CFA in Senegal Oriental and 497 F.CFA in Sine-Saloum, both considerably less than the national average of 1,174 F.CFA.

The percentage of the national health budget allocated to health has dropped steadily in the last ten years (see Table 3.19). In 1970-71 it was 9.3 percent; in 1980-81 it had dropped to 5.8 percent.

In The Gambia the ratio of health expenditures to total budgeted expenditures has dropped from 9 or 10 percent (during the decades of the 60s and 70s) to a current figure in the vicinity of 7 percent. Table

TABLE 3.19.

EVOLUTION OF THE BUDGET OF THE MINISTRY OF HEALTH AS A RATIO OF THE NATIONAL BUDGET IN SENEGAL BETWEEN 1970-71 AND 1980-81 (in FCFA)

Year	National Budget	Ministry of Health Budget	Percentage
1970-71	39,000,000,000	3,555,750,000	9.3
1971-72	41,440,000,000	3,727,000,000	9.0
1972-73	44,000,000,000	3,793,874,000	8.6
1973-74	47,000,000,000	3,656,818,000	7.8
1974-75	55,000,000,000	4,102,882,000	7.5
1975-76	71,000,000,000	5,067,186,000	7.1
1976-77	86,000,000,000	5,247,326,000	6.1
1977-78	89,000,000,000	5,369,908,000	6.0
1978-79	101,470,000,000	6,133,801,000	6.0
1979-80	106,000,000,000	6,572,014,000	6.2
1980-81	115,644,220,000	6,698,202,000	5.8

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TABLE 3.20.

COMPARISON OF NATIONAL BUDGETS AND HEALTH BUDGETS IN THE GAMBIA FOR THE YEARS 1980/81 TO 1982/83 (in thousands of dalasi)

Year	1980/81	1981/82	1982/83
Total Country Budget	89,300	118,900	102,500
Health Budget	7,299	7,591	7,895
Percent of Total	8.2	6.4	7.7

SOURCE: Shipp, 1982; World Bank, 1981; Second Five Year Plan.

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3.20. shows the ratios of health to total expenditures during the years 1980/81, 1981/82, and 1982/83.

Table 3.21. indicates that the health budget in Guinea has increased steadily between 1979-82. Health expenditures per capita are in the range of 100 sylis per year. As in many developing countries a large percentage of the budget is allocated to the medical facilities in the capital. Conakry received an allocation of almost 30 percent of the appropriation.

TABLE 3.21.

GUINEA, THE NATIONAL BUDGET AND THE HEALTH BUDGET, 1979-1982
(in thousands of sylis)

	1979	1980	1981	1982
NATIONAL BUDGET	11,252,000	12,992,575	18,067,072	14,086,747
Operations and Maintenance	4,460,000	5,000,000	9,643,311	10,806,747
Investment	6,792,000	7,992,575	8,423,761	3,280,000
HEALTH BUDGET	407,672	477,835	379,834	530,485
Personnel	240,194	238,290	294,224	301,940
Supplies and Medications	127,478	189,545	20,610[a]	178,545
Investment	40,000	50,000	65,000	50,000
Percent of National Budget	3.62	3.68	2.10	3.71

SOURCE: Guinea Ministry of Health: "Situation Sanitaire: Projets en Cours ou Prévus: Projets pour Lesquels un Financement est Recherché." Conakry, March 1983.

NOTE: a) The total appropriated for the purchase of medications and supplies was reduced in 1981 by comparison with the previous year.

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As can be seen by Table 3.22. the line items vary from one region to another. Uniform data could not be obtained for all regions. It is interesting to note that the region of Labé has a national budget (not the personnel) which is less than that of Koubia, and Mali. There is no

TABLE 3.22.

GUINEA HEALTH BUDGET FOR LABE, MALI, KOUBIA, AND KOUNDARA
1983

Région de Labé	
Budget national[a]	116.650 sylis
Planning budget or regional infrastructure	750.000 sylis
Budget régional[b] (personnel)	191.685 sylis
Budget national (personnel hôpital Labé et Direction Régionale Santé)	13.251.470 sylis
Medications	1.325.936 sylis
Hôpital Labé	
Hospital-régional Budget	1.000.250 sylis
Medications	2.600.000 sylis
Mali	
Budget national (personnel)	3.633.654 sylis
Budget régional (from the Region to the Hospital)	384.344 sylis
Budget national	126.560 sylis
Koubia	
Budget national	160.448 sylis
Budget régional	322.265 sylis
Regional infrastructure	281.600 sylis
Medication	1.200.000 sylis
Budget national personnel (physicians, RNs)	683.226 sylis
Koundara	
Budget national	116.560 sylis
Budget régional	547.806 sylis
Regional infrastructure	500.000 sylis
Medication	1.475.936 sylis
Budget national (personnel)	3.037.360 sylis

SOURCE: These data were furnished by Dr. Seydou Barry and the medical personnel of the regions visited.

NOTES: Budget national: Maintenance, operation of vehicles, cost of fuel, etc.

Budget régional (personnel): to pay every health workers except physicians and nurses.

Planning budget or regional: special projects including construction of health facilities.

a) allocation from the national budget.

b) allocation from the region.

University of Michigan, Gambia River Basin Studies, 1985.

breakdown on how much is spent for operations and maintenance, cost of fuel, supplies, construction, etc., so it is difficult to evaluate the proportion of an appropriation spent on a line item.

3.3.4. Health Personnel

The available figures (see Tables 3.23, 3.24, and 3.25) indicate that the number of trained health personnel is probably low in Senegal and The Gambia. WHO standards for adequate medical coverage is 5 doctors for every 10,000 persons, 1 nurse for every 300 persons and 1 midwife for every 300 women of childbearing age. A glance at the figures in Table 3.23. indicates that medical coverage is low in both countries. Shortages of medical personnel may be due to different reasons. In Senegal, the services of a number of doctors are not available to the general public because they are sequestered by administration, the Armed Forces, penal institutions, or the principal hospital or the medical school. In The Gambia, part of the problem is due to the lack of a local medical school with the consequence that candidates for medical school must go abroad to acquire their training; and many do not return. In

TABLE 3.23.

SELECTED HEALTH SERVICE INFORMATION FOR SENEGAL AND THE GAMBIA

	Senegal (1980-81)	The Gambia (1981)
Population	5,703,107	635,913
Population per Physician	57,606	15,898
Population per Nurse	7,614	5,344
Population per Midwife	4,310	9,936
Number of Hospital Beds	6,945	592
Beds per Population	1,821	101,074

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 3.24.

HEALTH PERSONNEL IN SENEGAL AND THE GAMBIA

	Senegal (1982)		The Gambia (1981)	
	Public[a]	Private	Public	Private
Doctors	99	126	28[b]	12[b]
Dentists	15	53	3	0
Pharmacists	23	78	-	-
Nurses, State	749	*	119[c]	0
Nurses, Other	-	-	143[d]	25[d]
Midwives	313	*	64	15
Health Agents[f]	2174	*	51	-
Auxiliary, Health	328	*	14	-

SOURCE: République de Sénégal, Ministère de la Santé Publique. Programmation Sanitaire du Sénégal. 1982, p. 67 and 72.

Gambia Government Medical and Health Department. Annual Report 1981. p. 6.

NOTES: *No date available.

a) Figures do not include personnel at the administrative offices of the Public Health Ministry in Dakar, at L'Hôpital Principal, in the armed forces or those assigned to penal institutions and the medical school faculty.

b) Figures obtained from conversation with Dr. Abdoulie Jack, Head of Epidemiology Unit Medical and Health Department, Banjul, June 15, 1983.

c) Includes state registered nurses (SRNs) and dresser/dispensers.

d) Includes public health nurses, enrolled nurses, auxiliary nurses and community health nurses.

e) Nurses/midwives.

f) In Senegal, agents sanitaires; in The Gambia, health inspectors, and in Guinea, public health technicians (techniciens de santé publique) and technical health agents (agents techniciens sanitaires).

University of Michigan, Gambia River Basin Studies, 1985.

both countries the shortage is stressed by the reluctance of available doctors to serve in rural areas. Of all doctors in public service in Senegal, 67 percent are to be found in Dakar. In The Gambia, 82 percent of the doctors are located in Banjul or its immediate environs; of these, more than half are in the Royal Victoria Hospital in Banjul. Only five doctors work in the rural areas of The Gambia; four of these are expatriates.

TABLE 3.25.

NUMBER OF DOCTORS IN RELATION TO POPULATION IN SENEGAL, 1982

Regions	Population	Percent	Number of Doctors	Percent
Cap-Vert	1,197,635	21	40	41
Casamance	804,125	14	7	7
Diourbel	473,350	8	9	9
Fleuve	564,599	10	10	10
Louga	456,241	8	3	3
Senegal Oriental	325,072	6	3	3
Sine-Saloum	1,140,603	20	14	14
Thiès	741,392	13	13	13

SOURCE: Programmation Sanitaire du Sénégal, 1982. p. 29 and 67.

University of Michigan, Gambia River Basin Studies, 1985.

The number of medical and paramedical health personnel in Guinea and their distribution in Labé, Mali, Koubia, and Koundara, are given in Tables 3.26., 3.27., and 3.28.

TABLE 3.26.

HEALTH PERSONNEL IN GUINEA: MEDICAL AND PARAMEDICAL, 1982[a]

Physicians	662
Dentists	20
Pharmacists	97
Biochemists	11
Laboratory Technicians	141
Health Aides	1,482
Midwives	388
Public Health Technicians	188
Technical Health Agents	1,006
Ordinary Nurses	305
Total	4,300

NOTE: a) Division of Planning and Statistics, Ministry of Health, Conakry.

University of Michigan, Gambia River Basin Studies, 1985.

3.3.5. Training of Health Personnel

- Senegal

Doctors, dentists and pharmacists receive their training at the University of Dakar and serve an internship in the Dakar hospitals. Doctors complete seven years of training; dentists and pharmacists complete five years of training. Upon completion of training all are required to devote three years to the public health sector.

There are six national training schools in Senegal that teach nurses and other health personnel: five are in Dakar and one is in Saint-Louis. Nurses and midwives complete three years of training. Health technicians must have a nurse's or a midwife's diploma and complete two additional years of training. Health agents complete one to three years of training.

TABLE 3.27.

DISTRIBUTION OF MEDICAL PERSONNEL IN GUINEA BY CGR, 1982
(Compared with percent of population by CGR)

	Physicians	Pharmacists	State[a] Nurses	Midwives	Nurses	Technical Health Agents	Total	As % of Total Health Personnel	Pop. as % of Total Pop.
Conakry	283	44	764	222	116	262	1,691	(40.3)	(19.6)
Boké	47	6	151	25	15	69	313	(7.5)	(9.6)
Kindia	68	3	200	26	31	110	438	(10.4)	(11.6)
Labé	64	6	136	19	57	140	422	(10.1)	(17.8)
Faranah	54	6	193	28	32	119	432	(10.3)	(13.5)
Kankan	64	4	140	27	30	163	428	(10.2)	(13.0)
N'Zérékoré	54	8	204	41	24	143	474	(11.3)	(14.5)
Total	634[b]	77	1,788	388	305	1,006	4,198		

SOURCE: Ministry of Health: "Situation Sanitaire: Projets en Cours ou Prévus: Projects pour Lesquels un Financement est Recherché." Conakry, March 1983.

NOTES: a) Includes laboratory technicians and health aides.

b) In Table 3.26. the total number of physicians (662) includes those working in the central administration.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 3.28.

DISTRIBUTION OF HEALTH PERSONNEL
IN LABE, MALI, KOUBIA, AND KOUNDARA, 1983

Category	Labé		Mali	Koubia	Koundara
	Medical Region	Hospital			
Physicians	0	18	8	5	7
Pharmacists	0	3	1	1	2
Midwives	7	3	2	0	1
Health Aides	0	30	9	4	11
Technical Health Agents	27	0	19	13	12
Public Health Technicians	7	0	1	4	3
Ordinary Nurses	4	17	4	1	1
Traditional Birth Attendants	0	0	0	0	4
Laboratory Aides	0	0	0	0	3
Health Administrators	0	2	0	0	0
Miscellaneous Personnel[a]	41	45	21	13	28

NOTE: a) This category includes cleaners, drivers, laborers, etc.

University of Michigan, Gambia River Basin Studies, 1985.

- The Gambia

Doctors. The Gambia has no medical school. In the past, Gambian doctors received training in Europe, the USA or the USSR. More recently, candidates have been sent to Dar es Salaam, Cairo, or Ibadan. Because of the small number of medical scholarships available to Gambians, there is a current shortage. Of individuals who leave the country for training, some never return. Others may receive a defective education and must be retrained. Staffing health facilities outside of Banjul poses another difficulty. Most doctors do not want to practice in rural areas. More than 80 percent of the country's doctors are currently located within a ten-mile radius of Banjul, leaving the remaining doctors (less than 20 percent) to care for 80 percent of the population. Under current regulations, doctors in the public health service are assigned to one of the hospitals, where they are required to serve for at least two years. However, some tours of duty are shortened as the doctors are moved from post to post in response to staff shortages, resignations, or the need for additional training.

Nurses and Other Health Personnel. The School of Nursing and Midwifery in Banjul trains state registered nurses (SRNs) in a three-year program: dresser/dispensers and nurse/midwives are SRNs who have completed a year of specialty. The School for State Enrolled Nurses (SENs) at Royal Victoria Hospital trains SENs in an 18-month program. Public health nurses are nurse/midwives who have received additional training, usually in England, in maternal and child health. Auxiliary nurses receive on-the-job training with some eventually being encouraged to enter the SEN program. Community health nurses are trained at Mansa Konko. Health inspectors undergo a three-year training course at the School of Public Health in Banjul.

The attrition rate among nurses and health inspectors is high, for a number of reasons, and has created a manpower shortage in the health field. Many persons who have trained in the health field eventually leave it because of reluctance to accept positions in the rural areas or because of the availability of more lucrative opportunities in the private sector.

This stressful situation draws attention to the important role of the primary health care worker, to be discussed below.

- Guinea

The government has made a conscious effort to increase the number of trained health personnel. In 1980, 36 physicians were trained in Cuba. All health personnel with a baccalaureate diploma follow a common curriculum. After 2 years of study they take an exam. Those who succeed continue on the track to become physicians after 3 years of study, and pharmacists at the end of 2 years. The rest receive one additional year of training to qualify as state nurses, technical health agents, health technicians, and laboratory technicians.

To increase the level of paramedical training the government created two secondary schools of health opened in N'Zerekore in 1982; three more are planned for Kindia, Boke, and Faranha. These THAs (technical health agents) receive 3 years of practical training by the hospital staff. The training orientation is mainly in basic personal health and community health services. They are expected to work in health centers and dispensaries.

It is projected that by end of the academic year 1983-84 the total of graduates will reach 254. The School of Medicine is graduating about 50 physicians a year. The midwives are health aides who receive training for 2-3 years in a maternity ward.

Salaries of public employees in Africa are generally low. The health personnel in Guinea is no exception. Public employees often are not paid on a regular basis and they usually "moonlight."

3.3.6. Health Facilities

The Gambia River Basin, with the exception of the Banjul area, is comprised of rural areas. Health facilities are few. Accessibility is poor most of the time and very poor during the rainy season. In general existing facilities are not equipped with the necessary vehicle support to carry out medical evacuations. Location of hospitals and major health centers in The Gambia, Senegal and the Gambia River Basin of middle Guinea are illustrated in Figure 3.5.

Construction of the new hospital in Tambacounda is virtually complete but service is not promised before 1987. The hospital in Kaolack, although technically outside the Gambia River Basin, is frequently utilized by people from the basin area.

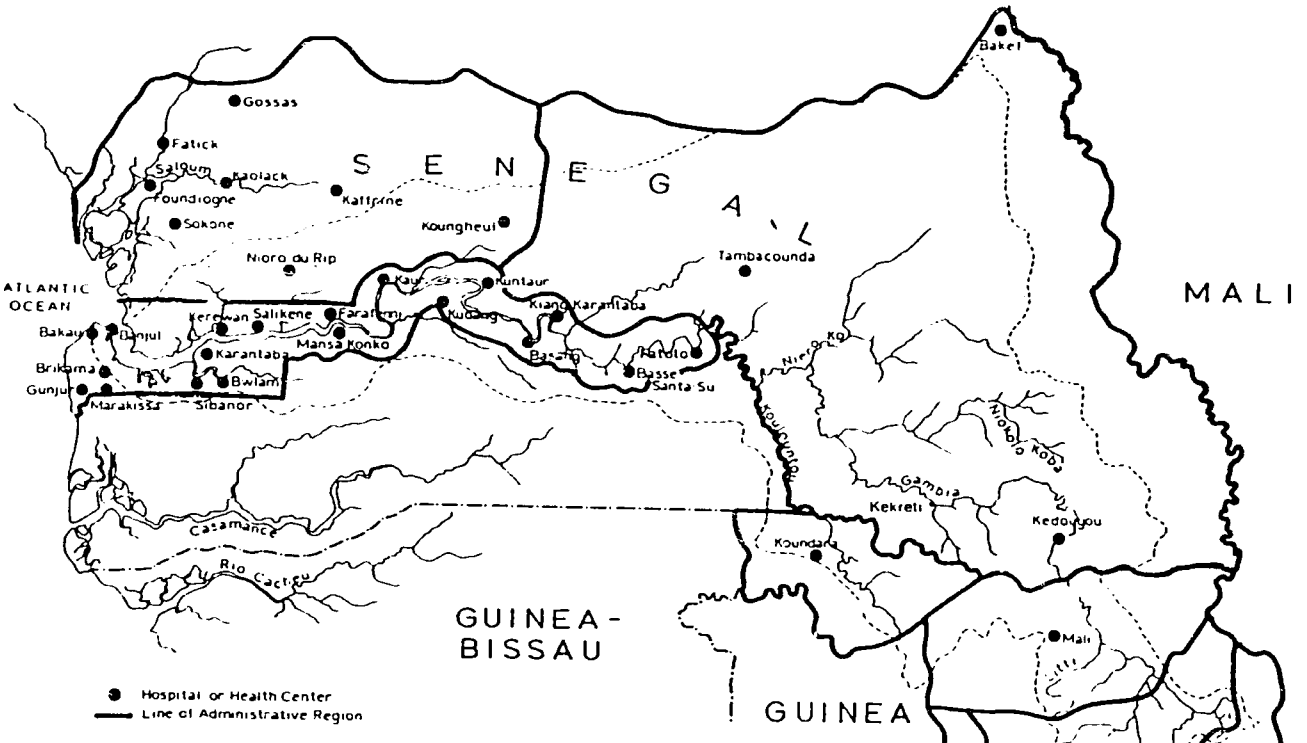


FIGURE 3.5 LOCALITIES OF HOSPITALS AND MAJOR HEALTH CENTERS IN THE GAMBIA, SENEGAL AND GUINEA (GAMBIA RIVER BASIN)

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 3.29.

GUINEA DISTRIBUTION OF HEALTH FACILITIES BY PROVINCE, 1982

	C. G. R. (Commissariat Général de la Révolution)							
Type of Facility	Conakry	Kindia	Boké	Labé	Faranah	Kankan	N'Zérékoré	Total
University Hospital	2							2
CGR Hospital		1	1	1	1	1	1	6
Regional Hospital	3	3	3	5	4	4	4	26
Private Company Hospital	1		1					2
District Health Center	31	46	27	54	54	59	44	315
PRL Dispensary	13	37	14	9	58	52	29	212
Total	50	87	46	69	117	116	78	563

SOURCE: Ministry of Health: "Situation Sanitaire: projets en Cours ou Prévus: projets pour Lesquels un Financement est Recherché." Conakry, March 1983.

University of Michigan, Gambia River Basin Studies, 1985.

In The Gambia, access to the hospitals in Banjul and Bansang is now facilitated by improved bus service on the main highway.

The distribution of health facilities by province in Guinea is shown in Table 3.29. The nature and number of regional health facilities in Labé, Mali, Koubia and Koundara are given in Table 3.30.

The number of hospital beds available to the population is often taken as an indication of the extent of medical services, although obviously not of their quality. In the Gambia River Basin the number of beds available to those who need hospitalization is small. In Senegal Oriental there is one bed for every 2,843 persons, and in Sine-Saloum there is one bed for every 909 persons, if maternity beds are included. In The Gambia, the figure is one bed for every 1,026 persons. In the four administrative regions of middle Guinea contiguous with the Gambia River Basin (Labé, Koubia, Mali, and Koundara), a similar calculation gave a figure of one bed per 1,589 persons, or 0.63 beds per 1,000 population.

TABLE 3.30.

GUINEA REGIONAL HEALTH FACILITIES

	Labé	Mali	Koubia	Koundara
Health centers	14	13	5	7
Hospital	1	1	(under construction)	1
Pharmacies	3	1	2	2
Neighborhood dispensaries	2	7	3	2
Prevention center		1		
Central dispensary			1	
Leprosy center	1			1
Health immigration center				1
Dispensaire regional	1			

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 3.31.

RATIO OF HOSPITAL AND CLINIC BEDS TO POPULATION IN SENEGAL AND THE GAMBIA

	Population	Number of beds	Ratio of beds per 1,000 population
Sénégal[a]	5,996,975	4,311	0.72
Cap-Vert	1,295,520	2,174	1.68
Senegal Oriental	326,977	115[b]	0.35
Sine-Saloum	1,180,453	1,299[c]	1.1
The Gambia[d]	685,886	678	0.98

SOURCES: Gambia, Medical & Health Department. Statistiques Sanitaires et Démographiques du Sénégal, 1979, and Annual Report. 1981.

NOTES: a) Figures for 1982.

b) If beds in maternities excluded, = 78 beds, or 0.02 per 1,000 population.

c) If beds in maternities excluded, = 371 beds, or 0.3 per 1,000 population.

d) Figures for 1983.

University of Michigan, Gambia River Basin Studies, 1985.

These data are given in Tables 3.31. and 3.32. in a slightly altered form, reducing the ratio to beds per 1,000 population for quick comparison.

It is clear that rural areas are deprived of established medical services in the Gambia River Basin, and that facilities and professional people tend to concentrate in the urban areas. A person needing hospitalization in rural Gambia River Basin is unlikely to get it. Under these conditions that person will seek the help available to him, whether in the form of a traditional health practitioner or today, a village health worker.

TABLE 3.32.

RATIO OF HOSPITAL AND CLINIC BEDS TO POPULATION IN ADMINISTRATIVE REGIONS OF MIDDLE GUINEA, 1984

Administrative Region	Population[a]	Number of beds[a]	Ratio of beds per 1,000 population
Labé	253,214	211	0.87
Koundara	94,216	105[b]	1.12
Koubia	98,053	12	0.12
Mali	210,889	74	0.35
Totals	656,372	413	0.63

NOTES: a) Data from official records consulted during field visit, March 1984. (See GRBS Working Document No. 54, Health Situation in the Republic of Guinea, by Evelyne Laurin.)

b) Includes hospital with 72 beds; 7 health centers with 31 beds, 2 neighborhood dispensaries each with one bed, an immigration center with one bed. Does not include a leprosy center with 2 beds.

University of Michigan, Gambia River Basin Studies, 1985.

3.3.7. Primary Health Care

In recent years there has been increasing recognition of the crucial role of primary health care in countries unable to extend the benefits of centralized medical care throughout their territories. The definition of the importance of primary health care culminated in the Alma-Ata Declaration of 1978, now accepted by WHO as a general guideline.

Far from being a stopgap measure, the primary health care (PHC) approach is intended to be a permanent feature of the country health service, in phase with the resources of the community but also collaborating with referral and specialist services.

Both Senegal and The Gambia have initiated PHC programs aimed at training village health workers (VHWs) to recognize and treat simple illnesses and to know when to refer more difficult cases to more highly skilled health workers. Such VHWs are usually selected by the community. Typically they are middle-aged or mature persons who have the confidence of the community and show some aptitude for receiving training in first aid and sanitation. Not infrequently the VHW is recruited from the ranks of the traditional health practitioner.

If the VHW is a man, his work is supplemented by selection of a local woman, usually the traditional midwife, to improve her skills by training as a traditional birth attendant (TBA). Her skills in delivering babies are utilized, and she receives additional training in maternal and child health care.

Problems in the process of resolution concern the following issues:

- literacy of the VHW and TBA;
- training of VHW and TBA;
- renumeration of VHW and TBA;
- restocking drug supplies at the village level;
- inadequacies of the national drug distribution systems.

- Senegal

In conformity with the spirit of the Alma-Ata Declaration and encouraged by the tutelage of WHO, the Ministry of Health of Senegal has declared itself committed to the goal of Health For All by the Year 2000. The Ministry hopes to achieve this goal in part by promoting a program of primary health care. The immediate objective is to create one health hut (case de santé) by the year 2000 in each village that does not now have a health post, and to realize 35 percent of this objective, that is 4,332 health huts by the year 1987.

The Cap-Vert region, which is completely urbanized, has adequate access to health care. The target group rather is, the rural population in the other seven regions. To date, the regions of Diourbel, Thiès, and Louga have no health huts but do have village pharmacies. In the remaining regions, including Casamance, Fleuve, Senegal Oriental and Sine-Saloum, which have 473 health huts, support has been received from USAID for the construction of facilities and for the training of VHWs and TBAs.

It is the philosophy of the Ministry of Health that the population must ultimately be responsible for its own state of health. The small portion of the national budget meted out to health (about 5 percent) is not enough to provide all needed services. The present plan is for the establishment of PHC units to be staffed, managed, maintained, and restocked with medicines by the villagers themselves.

Bakel Health Project. This project started in 1978 with a commitment of US$462,000 from USAID and $100,000 from Senegal. It consists of two components: (i) a primary health care program covering 23 villages; and (ii) an epidemiological study of water-borne diseases headed by Professor Samba Diallo of the University of Dakar. In the PHC part of the program, VHWs are being trained in first aid and sanitation, and the TBAs (matrones) are being trained in maternal and child health. Trainers included a contingent from WASH (Water and Sanitation for Health Project, Arlington, Virginia) who have taught basic sanitation, including construction of wells and latrines.

Sine-Saloum Health Project. This project commenced in 1978 with US$5 million from USAID to establish PHC posts (health huts or cases de santé) in the rural areas of the region. The operation resembles that of the Bakel project. The program was reevaluated and enlarged in 1980 with the additional allocation of US$8 million. Problems dealing with the supply and restocking of medicines by the village authorities have been tackled. Other problems centered around the capability of the VHW to read and write French: younger candidates who had this capability were often neither wanted nor respected by the villagers as their VHW. After dropping the reading requirement, more acceptable candidates have appeared and the attrition rate is lower. But problems of communication now devolve upon the next higher health authorities, usually the district nurse. There have also been problems in working out an acceptable system of remuneration for the services of the VHW. The costs are borne by the village, but there must be agreement as to whether the payments will be in the form of money, goods, or services. The remuneration of TBAs is not a problem as they are traditional figures in society which is accustomed to paying for their services.

At present, the training program for VHWs and TBAs lasts eight weeks. It is carried out in Kaolack and in nearby rural health centers.

- The Gambia

The PHC program is fairly new in The Gambia and the first group of trainees (termed community health workers, or CHWs) completed their training at Mansa Konko in 1981. CHWs are comprised of VHWs and TBAs. The VHW receives 10 weeks of training in first aid and sanitation, and is taught to dispense some drugs such as aspirin and chloroquine. Upon completion of his training he is provided with an initial (free) set of drugs, a spade and a wheelbarrow. He is expected to sell the drugs and to use the money so acquired to replace them, or the village authorities may purchase new drugs from the community health nurse (CHN). The TBA undergoes 10 weeks of training in midwifery, and maternal and child health. Upon completion of her training she is presented with a kit containing a supply of ergometrin and some instruments.

The CHWs are selected by their villages. The village development committee oversees their work and arranges for salary or other remuneration. The direct supervisor of the CHW is the CHN.

Since the Western Division is relatively well-served in terms of health care, it has been given low priority in the PHC program. Initial emphasis was on Lower River Division (LRD). By March 1982, all villages of LRD with a population of 400 or more which lacked a dispensary or subdispensary were provided with health care programs operated by trained CHWs. The program is still in its infancy. Progress has been rapid in MID and URD but figures were unavailable at the time of this writing.

- Guinea

The government of Guinea has acknowledged the following needs in the PHC field:

- the need to reorganize the health system towards the acceptance of PHC and the integration of health services;
- the need for continual promotion and development of training of the various categories of health manpower;
- the need for the promotion of family health, environmental health and health education;
- the need for adequate financial resources to support PHC units;
- the need for the adequate supervisory resources at central level to monitor and evaluate the PHC units.

Some steps have been taken towards the implementation of these goals. Senior Guinean health professionals have been trained in Togo. Regional health personnel are training village health agents to concentrate their efforts primarily in health education.

In 5 provinces 54 health professionals and paraprofessionals participated in training courses in primary health care. Reportedly 48 primary health care units had been established in 24 regions and 123 additional PHC units are to be operational by the end of 1984.

The introduction of a primary health care component into the secondary health training schools within the last year will provide new graduates the appropriate skills for implementing and supervising primary health care. A primary health care module of 15 hours theory and one month of practical training has been designed for the School of Medicine, but it has not been implemented yet. As of last year the practical theses of all medical students are on village health diagnosis and are conducted in the countryside.

To promote primary health care the government has adopted the following approaches:

- raising awareness in political and administrative authorities at the various levels of government political and administrative machinery;
- achieve adequate and continual motivation of the populations;
- progressive training of the health manpower needed for PHC, and specifically for the PHC units to be set up;
- decentralization of urban health workers towards rural areas;
- reorientation of teaching programs at the secondary health schools of Kankan and Labé, in order to meet PHC requirements;
- assignment of health personnel, upon leaving school, to health units in rural areas for a period of at least two years, before allowing them to work in the towns;
- reorientation of existing health manpower towards PHC;
- periodic coordination, supervision and evaluation of activities;

- strengthening of infrastructures at district health centers and support for PHC units.

3.3.8. Vaccines and the Cold Chain

- Senegal

The vaccines maintained in stock are supplied by foreign laboratories or by the Pasteur Institute. They include BCG, yellow fever, measles, DTCP, poliomyelitis (both oral and injectable), tetanus, rubella, cholera, and meningitis vaccines.

The cold chain operates as follows: vaccines are collected either at the Pasteur Institute or at Yoff Airport and taken in coolers to the Pharmacie Nationale d'Approvisionnement (PHARMAPRO). From this point they are distributed in coolers to the various regional sectors of the Service des Grandes Endémies (SGE). The eleven centers are located in Dakar, Bignona, Kolda, Diourbel, Podor, Saint-Louis, Louga, Tambacounda, Kédougou, Kaolack, and M'Bour. From these regional centers transportation is effected to the various health posts, always in coolers. The personnel who handle the vaccines have received special training.

SGE is the agency charged with the investigation and control of disease, including the immunization of the populace. Each SGE post is under the direction of the regional health officer (médecin-chef régional). The SGE conducts a continuing national program, the Programme Elargi de Vaccination, aimed at immunizing all children of preschool age.

Another health center which provides immunization of children and women of childbearing age is the Centre PMI (Protection Maternelle et Infantile). Vaccines, particularly against tetanus, are also stocked at health posts and maternities.

- The Gambia

Since 1979, extended program of immunization (EPI) activities have been integrated with those of the MCH sector which holds regular clinics for women and children around the country.

For purposes of administration, EPI has organized the country into three zones, each with populations of approximately 200,000 persons:

- Zone 1: Banjul, the Kombos, and the Western Division.
- Zone 2: the Lower River Division and the North Bank Division.

- Zone 3: MacCarthy Island Division and Upper River Division.

The commencement of activities in Zone 1 was May 1979; in Zone 2, September 1980; and in Zone 3, September 1981.

Vaccines are provided on a semiannual basis by UNICEF, except for the measles vaccine which is donated by USAID (through 1983). All EPI program vaccines are stored centrally in Banjul: the vaccines include BCG, DPT, poliomyelitis, measles, yellow fever and tetanus toxoid.

The cold chain begins when vaccines are picked up at Yundum Airport and are transported to the EPI Central Store at Medical Headquarters in Banjul. Vaccines are stored in electric freezers and kerosene-powered refrigerators. The EPI, in principal, delivers vaccines on a monthly basis to regional stores at Mansa Konko (provided with two electric refrigerators and one kerosene refrigerator), Bansang (two freezers and two refrigerators plus one kerosene refrigerator), and Basse (one deep-freeze and two refrigerators, all electric). Vaccines are transported in insulated cold boxes with ice packs.

Vaccines are transported from the regional stores in insulated carriers with ice packs, taken to subdispensaries and clinics, and unopened vaccine is returned to the regional center.

Problems have arisen because of the lack of vehicle fuel, the uncertainty of electricity, and criss-crossing of the channels of authority and communication. These problems are recognized and are being resolved. One encouraging report has come from Kaur, where a pilot study of a solar-powered refrigeration unit has given excellent results.

- Guinea

Immunizations and communicable disease case finding constitute the main activities of the mobile health services. Table 3.33. illustrates the vaccination coverage of the target population which includes individuals of the age group covered by specific vaccination within the regions in which the teams are active. These targets are subgroups of the countrywide long-term goal of the EPI program. Consumer demand and an active promotion campaign have brought tetanus and measles vaccinations to productive levels. The reliability of the production of case-finding activities by the mobile teams is questionable. For instance certain variations between the provinces do not reflect the epidemiology of some diseases or the population size.

TABLE 3.33.

VACCINATION COVERAGE IN 1982, REPUBLIC OF GUINEA

Vaccination	0-11 Months	12-35 Months[a]	Other Ages	Total[b]	Pregnant Women	% Vaccination Coverage at Last Evaluation[c]
B C G	2,574	2,998	7,690	61,680		17.62
D P T 1	7,567	5,959	3,812	99,829		30.35
D P T 2	3,612	1,416	780	43,121		13.10
D P T 3	2,804	686	275	19,344		5.88
POLIO 1	7,567	5,959	3,812	99,829		30.35
POLIO 2	3,612	1,416	780	43,121		13.10
POLIO 3	2,804	686	275	19,344		5.88
MEASLES	18,067	53,808	11,063	169,720		59.08
TETANUS 1			10,624	10,624	22,993	77.25
TETANUS 2			8,014	8,014	15,205	51.08

SOURCE: Ministry of Health. Report of the Expanded Program of Immunization. 1982.

NOTES: a) Our national EPI policy includes a target population of 0-3 years at the beginning. The age will be lowered in later years of the program.

b) Only the volume of vaccination given and the type of vaccine in the regions are indicated in most of the reports, which explains the disparity between the total vaccinations given and the age groups.

c) The figures show a percentage of the objective achieved, except for measles which shows that the target was exceeded by 17% due to an underestimation of the target population.

University of Michigan, Gambia River Basin Studies, 1985.

3.3.9. Drug Distribution

- Senegal

The national pharmacy (PHARMAPRO) is responsible for the distribution of drugs and medical supplies throughout the country. There are regional distribution centers in Saint-Louis, Kaolack, and Tambacounda. New supply centers have recently been created in Sine-Saloum with assistance from USAID. A decentralization of PHARMAPRO is planned in order to build up pharmacies in the regional centers.

PHARMAPRO receives its supplies principally from the Société Industrielle Pharmaceutique de l'Ouest Africain (SIPOA) in Dakar.

About 400 different products are available from PHARMAPRO, all destined for the health facilities, health huts, health posts, and health centers. Standard kits are supplied, consisting exclusively of medicines recommended by WHO.

It is noted that 75 percent of drug orders in Senegal are filled by PHARMAPRO.

- The Gambia

The central store is currently being managed by the CUSO. Since his arrival in 1981, the volunteer pharmacologist has revamped the ordering system for drugs and supplies, and has established a new system whereby the health centers and dispensaries issue orders for drug supplies and equipment every two months. Each facility is now expected to maintain established stock levels. Orders are submitted two weeks in advance of delivery. Distribution dates are assigned according to geographic location.

There is a standard order form containing 45 items which the central store attempts to fill from available stock. The main problem in shortages in central supply is due to delays in receiving overseas shipments. By the second quarter of 1983 only one of nine shipments ordered had arrived.

Distribution of drugs and supplies from the central store in Banjul is scheduled every two months. Delivery is easiest to the western region which is closest to Banjul since transport is easy to arrange. Service to the central and eastern regions require service by truck. The most distant parts of the country, 250-300 miles from Banjul, are visited

weekly or biweekly by a dresser/dispenser or MCH team who bring needed supplies with them.

- Guinea

PHARMAGUINEE is the state-owned organization responsible for the acquisition and distribution of pharmaceutical products, medical supplies and equipment in Guinea. Initially financed by the government, PHARMAGUINEE is reportedly self-financed now.

ENIPHARGUI (Enterprise Nationale de l'Industrie Pharmaceutique de Guinée) and importations are the only two sources of supply of PHARMAGUINEE. Thirty percent of importations are medical supplies. Under the technical guidance of MOH, the Ministry of Industries administers ENIPHARGUI. Forty-seven percent of PHARMAGUINEE's budget is spent on purchases from ENIPHARGUI, and the remaining fifty-three percent is spent on pharmaceuticals and equipment purchased overseas. ENIPHARGUI produces chloroquine and aspirin as well as some less commonly used medications. The MOH purchases 70 percent of the distribution of PHARMAGUINEE which includes primarily all the supplies and a proportion of the drugs. The 82 state pharmacies in the provinces, regional levels, and warehouses at the arrondissement level comprise 30 percent of PHARMAGUINEE's sales.

In principle no drugs can be purchased without a prescription. To cover operating expenses drugs are sold at higher prices than those charged to the MOH. Formerly PHARMAGUINEE used to transport and deliver the drugs to warehouses in the administrative provinces from which they were distributed to the regions. But now the regions must obtain their supplies directly from the national pharmacy in Conakry. From the scarcity of drugs observed in different health facilities during the mission, it can be assumed that the pharmaceutical system is inadequate.

3.4. Evaluation and Trends

3.4.1. Current Commitment to Health in the Gambia River Basin

The relative commitment of Member State governments to health may be declining. For example, the ratio of the Ministry of Health's budget to Senegal's national budget fell progressively from 9.3 percent in 1970-71

to 5.8 percent in 1980-81 (see Table 3.6.). A figure of 5-6 percent of the national budget now seems to be the extent that many governments in the world are willing to adopt for health expenditures, and Senegal is no exception. Related expenditures in The Gambia were not identified. The declining trend deserves scrutiny but any reversal of the trend seems unlikely in the absence of a major advance in the economic fortunes of the countries in question.

3.4.2. Significant Water-Associated Health Problems in the Gambia River Basin

Three major West African diseases transmitted by water could contribute to large-scale negative health impacts in the event of dam construction on the Gambia River: malaria, schistosomiasis, and onchocerciasis.

Malaria combined with poor nutrition now contributes to the unacceptable death rate of almost 450 per 1,000 children under five years in rural West Africa. While it is true that immunity of infection protects older groups so that malarial attacks are not very life-threatening, many of those who carry the parasite are not well and may have a heightened susceptibility to other diseases. Although some malaria control is practiced in urban areas, rural areas rarely, if ever, see organized control efforts (spraying for adult mosquitoes, larval mosquito source reduction, and chemoprophylaxis). Although the technology of local malaria control is well established, it is expensive and this, combined with logistic difficulties, probably limits application.

Schistosomiasis is insidious because the acute symptoms may be less distressing than those of other conditions and the long-term stress on health status may go unnoticed or be confused with unrelated problems. Control of schistosomiasis in the Member States is rarely spearheaded by governmental health authorities but is managed, if at all, by ad hoc research programs. Thus, independent investigators have been providing most of the relief from schistosomiasis in Senegal and The Gambia, in connection with the search for improved control methods. In Guinea no research is known.

Onchocerciasis or river blindness is frequently cited as a disease which will have its incidence reduced by river impoundment and the consequent destruction of blackfly breeding sites. In this connection it is important to look at the overall picture of blackfly breeding in the Gambia River Basin (Figure 3.3) in order to see how small a portion of the total blackfly breeding area in the Gambia River Basin will be destroyed by impoundment. This disease will continue to plague the area and, with the forced relocation of populations to new riverine sites, there may be local flare-ups. Currently, onchocerciasis control is not attempted by central health authorities in Senegal or Guinea. (The disease does not occur in The Gambia.) Since at present no medical solution to river blindness is available, control must be directed toward reduction of vector populations.

Networks of epidemiological and entomological evaluation, aquatic monitoring teams, logistic support for fixed-wing aircraft and helicopters, and supplies of insecticide are expensive and beyond the resources available to Member State governments. A logical step would be to join the international Onchocerciasis Control Programme (OCP), currently assisting seven countries of West Africa (Mali, Ivory Coast, Burkina Faso, Ghana, Togo, Benin, and Niger). Although a further scheme to include the Senegal River Basin area (which would also include the headwaters of the Gambia River) within the purview of OCP has been under consideration for several years, no final action has yet been taken.

3.4.3. Reporting Epidemiological Data in the Gambia River Basin

Currently, numerical information relating to the important water-borne diseases of the Gambia River Basin is fragmented and collection methods are not standardized. Since good planning must be based on adequately recording, compiling, analyzing, and publishing epidemiological statistics, it is highly desirable that statistical presentations be made uniform, at least among the Member States of OMVG. Spearheading an effort in this direction could become a task of a newly established health unit (HU) within the OMVG's Technical Staff. This health unit would, as a priority activity, establish close liaison with WHO and the three health ministries in the region.

3.4.4. Epidemics in the Gambia River Basin

Control programs aimed at specific medical problems are organized on an ad hoc basis within the countries of the Gambia River Basin in response to outstanding events. Examples would include the yellow fever outbreak in The Gambia in 1978-79 and the meningitis vaccination campaign in The Gambia in 1983-84. Given the invariable constraint of limited budget within health ministries, extraordinary events such as these will always have to be assisted by extraordinary funding sources. Although dam construction activities may be directly responsible for outbreaks of disease, it is highly unlikely that such responsiblity would be acknowledged unless the epidemic occurred within the construction camp. It is expected that the costs of coping with epidemics of disease will devolve upon the health ministry.

3.4.5. Summary

In summary, health authorities in the Member States recognize the presence of water-borne diseases in their areas of responsibility but are usually forced by fiscal constraints to limit interventions to treatment of identified cases while letting environmental control efforts go by the board. Preventive medicine now takes the form of MCH services, vaccination schedules, limited vector and pest control in urban centers and, in recent years, organized primary health care in larger villages.

An important role for OMVG, that of utilizing its new health unit to establish liaison with the health community in the Member States, becomes evident.

4. HEALTH IMPACTS OF PROPOSED DEVELOPMENT

4.1. Description of the Impact Matrix

The proposed development projects at the Balingho, Kekreti and Guinea dam sites will change the environment in ways likely to permit an increase in the numbers of disease vectors.

At the same time some of the components of change will have the opposite effect and will cause a decrease in numbers of vectors.

It is convenient to try separating the components of change into individual segments. Accordingly, Tables 4.1. through 4.12. show the changes that are anticipated: (i) during the construction phase of a West African dam; (ii) during the first five years (short-term); and (iii) after the first five years (long-term). Clearly the choice of components and their separation from each other is somewhat arbitrary.

The list of vectors represents the most important of the invertebrates endemic to the Gambia River Basin as reported by health authorities or documented in the literature.

The matrix is modelled on one proposed by the Joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control in the report of its third meeting held in Rome in September 1983.

The matrix utilizes rough qualitative projections (no change, increase, and decrease) for vector populations based on our current understanding of their requirements (such as still water, treetop breeding, saturated oxygen, sunlight, etc.) but in some cases these parameters are the subject of speculation. A more accurate assessment of one or more components would require quantitative treatment based on actual measurements. For example, a malacological survey would not only itemize the numbers of mollusks present but would include data on water temperature around the clock, chemical composition of the water, types of associated aquatic plants, water velocity (if any), and the presence and kinds of predators and parasites. Such studies are in general lacking in West Africa.

4.1.1. Construction Phase

4.1.1.1. <u>Emigration/immigration</u>. The movements of large numbers of persons (laborers and their families) to the construction sites will

TABLE 4.1. EFFECTS OF THE BALINGHO ANTISALINITY BARRAGE CONSTRUCTION PROJECT ON VECTOR POPULATIONS: CONSTRUCTION STAGE

0 = No change
– = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	G. palpalis	G. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Emigration/immigration of labor force + satellite population	0	+	+	+	0	0	+	0	+	0	Not applicable in The Gambia	–	0	0	0	0	0
2. Road construction; deforestation	0	0	0	0	–	–	0	–	–	–		–	0	0	0	0	0
3. Creation of borrow pits	0	+	+	0	0	0	+	0	0	0		0	+	+	+	0	0
4. Cessation of river current; marsh + pool seepage	0	0	+	0	0	0	+	0	0	0		0	+	+	+	+	+
5. Organic pollution	0	–	–	0	0	0	–	0	0	0		0	–	0	0	0	0
6. Introduction of new vectors	0	–	+	0	+	+	+	+	+	+		0	+	+	+	+	+
7. Establishment of aquatic plants	0	0	+	0	0	0	0	0	0	0		0	+	+	0	+	+
8. Canal construction for irrigation schemes	0	+	+	+	0	0	0	0	0	0		0	0	+	+	+	+
9. Interruption of bimonthly tidal action on mangroves	–	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	-1	+1	+5	+2	0	0	+3	0	+1	0	N.A.	-2	+3	+5	+4	+4	+4

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.2. EFFECTS OF THE KEKRETI DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: CONSTRUCTION STAGE

0 = No change
− = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	G. palpalis	G. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Emigration/immigration of labor force + satellite population	Not applicable in Senegal 0.	+	+	+	0	0	+	0	+	0	0	−	0	0	Probably not applicable in Senegal 0.	0	0
2. Road construction; deforestation		0	0	0	−	−	+	−	−	−	0	−	0	0		0	0
3. Creation of borrow pets		+	+	0	0	0	+	0	0	0	0	0	+	+		0	0
4. Cessation of river current; marsh + pool seepage		0	+	0	0	0	+	0	0	0	−	−	+	+		+	+
5. Organic pollution		−	−	0	0	0	−	0	0	0	−	−	0	+		+	0
6. Introduction of new vectors		0	+	0	+	+	+	+	+	+	0	+	0	−		−	−
7. Establishment of aquatic plants		0	+	0	0	0	0	0	0	0	0	0	+	+		+	+
8. Canal construction for irrigation schemes		+	+	+	0	0	0	0	0	0	−	0	0	+		+	+
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	−2	−5	+2	0	0	+4	0	+1	0	−3	−3	+3	+4	N.A.	+3	+2

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.3. EFFECTS OF THE KOGOU-FOULBE DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: CONSTRUCTION STAGE

0 = No change
– = Decrease in vector pop.
+ = Increase in vector pop.

	A. molas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	C. palpalis	C. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Emigration/immigration of labor force + satellite population	Not applicable in Middle Guinea	+	+	+	0	0	+	0	+	0	0	–	0	0	No evidence that this occurs in Fonta Djallon	0	Not known from Guinea
2. Road construction; deforestation		0	0	0	–	–	+	–	–	–	0	–	0	0		0	
3. Creation of borrow pits		+	+	0	0	0	+	0	0	0	0	0	+	+		+	
4. Cessation of river current; marsh + pool seepage		0	+	0	0	0	+	0	0	0	–	–	+	+		+	
5. Organic pollution		–	–	0	0	0	–	0	0	0	–	0	0	+		+	
6. Introduction of new vectors		–	+	0	+	+	+	+	+	+	0	+	0	–		–	
7. Establishment of aquatic plants		0	+	0	0	0	0	0	0	0	0	0	0	+		+	
8. Canal construction for irrigation schemes		0	+	0	0	0	+	0	0	0	0	0	0	0		+	
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	0	+5	+1	0	0	+5	0	+1	0	-2	-2	+2	+3	N.A.	+4	N.A.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.4. EFFECTS OF THE KOUYA AND KANKAKOURE DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: CONSTRUCTION STAGE

0 = No change
– = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/taylorii	G. palpalis	G. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Emigration/immigration of labor force + satellite population	Not applicable in Middle Guinea	+	+	+	0	0	+	0	+	0	0	–	0	0	Probably not applicable in Middle Guinea	0	Not known from Guinea
2. Road construction; deforestation		0	0	0	–	–	+	–	–	–	0	–	0	0		0	
3. Creation of borrow pits		+	+	0	0	0	+	0	0	0	0	0	+	+		+	
4. Cessation of river current; marsh + pool seepage		0	+	0	0	0	+	0	0	0	–	–	+	+		+	
5. Organic pollution		–	–	0	0	0	–	0	0	0	–	0	0	+		+	
6. Introduction of new vectors		–	+	0	+	+	+	+	+	+	0	+	0	–		–	
7. Establishment of aquatic plants		0	+	0	0	0	0	0	0	0	0	0	0	+		+	
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	0	+4	+1	0	0	+4	0	+1	0	-2	-2	+2	+3	N.A.	+3	N.A.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.5. EFFECTS OF THE BALINGHO ANTISALINITY BARRAGE CONSTRUCTION PROJECT ON VECTOR POPULATIONS: SHORT-TERM (< 5 years) OPERATIONAL STAGE

0 = No change
- = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	G. palpalis	G. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	B. senegalensis	Bu. globosus	Bu. guernei
1. Removal of tidal mixing upstream from barrage	-	0	0	0	0	0	0	0	0	0	Not applicable in The Gambia	0	0	0	0	0	0
2. Elimination of salinity gradient upstream	-	0	+	0	0	0	0	0	+	0		0	+	0	0	+	+
3. Increased surface area of water	0	0	+	0	0	0	+	0	0	0		0	+	+	0	+	+
4. Raised water table	0	+	0	+	0	0	+	0	-	-		-	+	+	+	+	+
5. Increased seepage + swamp formation	0	0	+	0	0	0	+	0	0	0		0	0	+	0	+	+
6. Irrigation scheme canals	0	0	+	0	0	0	+	0	0	0		0	0	+	0	+	+
7. Water characteristics: nutrients, microbe content, temperature, etc.	0	0	-	0	0	0	-	0	0	0		0	-	-	-	-	-
8. Enhancement of plant growth in river	0	0	+	0	0	0	+	0	0	0		0	+	+	+	+	+
9. Increased human wastes	0	0	-	0	0	0	-	0	0	0		0	-	+	0	+	0
10. Elimination of mangroves	-	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
11. Land clearing and trail building for power lines	0	+	0	+	-	-	0	-	-	-		-	0	0	0	0	0
12. Influx of population and associated activities	0	+	0	+	0	0	+	0	-	-		-	+	+	+	+	+
13. Changes in numbers and kinds of livestock	+	+	+	+	+	+	+	+	+	+		+	-	+	+	+	+
14. Changes in traditional farming practices	-	+	+	+	+	+	+	+	0	0		+	+	+	+	+	+
15. Changes in wildlife habitat and abundance of mammals and birds	-	0	+	0	+	+	+	+	+	+		+	0	0	0	0	0
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	-4	+5	+6	+5	+2	+2	+7	+2	0	-1	N.A.	0	+3	+8	+4	+9	+8

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.6. EFFECTS OF THE KEKRETI DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: SHORT-TERM (< 5 years) OPERATIONAL STAGE

0 = No change
- = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	C. palpalis	C. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Increased surface area of water	Not applicable in Senegal Oriental	0	+	0	0	0	+	0	0	0	-	0	+	+	Not applicable in Senegal Oriental	+	+
2. Raised water table		+	0	0	0	0	+	0	-	-	0	-	+	+		+	+
3. Vegetation submergence		0	+	0	-	-	+	-	-	0	-	0	0	+		+	+
4. Increased seepage; swamps		0	+	0	0	0	+	0	0	0	0	0	0	+		+	+
5. Beginning erosion in area of dam		0	0	0	0	0	0	0	0	0	+	0	0	-		-	-
6. Spillway; downstream irrigation canals		0	-	0	0	0	-	0	-	-	+	-	-	-		-	-
7. Water characteristics: nutrients, H_2S; microbe content; temperature; wind + waves		0	-	0	0	0	-	0	0	0	-	0	-	-		-	-
8. Enhancement of plant growth; emerging aquatic macroflora		0	+	0	0	0	-	0	0	0	-	0	0	+		+	+
9. Land clearing; road building		0	0	0	-	-	0	-	-	-	0	0	0	0		0	0
10. Emerging terrestrial vegetation; reforestation		+	+	+	+	+	+	+	+	+	0	+	+	+		+	+
11. Emerging terrestrial fauna; rodents; birds		+	+	+	+	+	+	+	+	+	+	+	-	+		+	+
12. Influx of human population + associated activities; increased human wastes		+	+	+	0	0	+	0	-	-	0	-	+	+		+	+
13. Changes in numbers and kinds of livestock		+	+	+	+	+	+	+	+	+	0	+	-	+		+	+
14. Changes in traditional farming practices		+	+	+	+	+	+	+	0	0	0	+	+	+		+	+
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	+6	+7	+5	+2	+2	+6	+2	-2	-1	-1	+1	+1	+7	N.A.	+7	+7

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.7. EFFECTS OF THE KOGOU-FOULBE DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: SHORT-TERM (< 5 years) OPERATIONAL STAGE

0 = No change
- = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/taylori	G. palpalis	G. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Increased surface area of water	Not applicable in Middle Guinea	0	+	0	0	0	+	0	0	0	-	0	+	+	Probably not applicable in Middle Guinea	+	Not known from Guinea
2. Raised water table		+	0	0	0	0	+	0	-	-	0	-	+	+		+	
3. Vegetation submergence		0	+	0	-	-	+	-	-	0	-	0	0	+		+	
4. Increased seepage; swamps		0	+	0	0	0	+	0	0	0	0	0	0	+		+	
5. Beginning erosion in area of dam		0	0	0	0	0	0	0	0	0	+	0	0	-		-	
6. Spillway; downstream irrigation canals		0	-	0	0	0	-	0	-	-	+	-	-	-		-	
7. Water characteristics: nutrients, H_2S; microbe content; temperature; wind + waves		0	-	0	0	0	-	0	0	0	-	0	-	-		-	
8. Enhancement of plant growth; emerging aquatic macroflora		0	+	0	0	0	-	0	0	0	-	0	0	+		+	
9. Land clearing; road building		0	0	0	-	-	0	-	-	-	0	0	0	0		0	
10. Emerging terrestrial vegetation; reforestation		+	+	+	+	+	+	+	+	+	0	+	+	+		+	
11. Emerging terrestrial fauna; rodents; birds		+	+	+	+	+	+	+	+	+	+	+	-	+		+	
12. Influx of human population + associated activities; increased human wastes		+	+	+	0	0	+	0	-	-	0	-	+	+		+	
13. Changes in numbers and kinds of livestock		+	+	+	+	+	+	+	+	+	0	+	-	+		+	
14. Changes in traditional farming practices		+	+	+	+	+	+	+	0	0	0	+	+	+		+	
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	+6	+7	+5	+2	+2	+6	+2	-2	-1	-1	+1	+1	+7	N.A.	+7	N.A.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.8. EFFECTS OF THE KOUYA AND KANKAKOURE DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: SHORT-TERM (< 5 years) OPERATIONAL STAGE

0 = No change
- = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	C. palpalis	C. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Increased surface area of water	Not applicable in Middle Guinea	0	+	0	0	0	+	0	0	0	-	0	+	+	Probably not applicable in Middle Guinea	+	Not known from Guinea
2. Raised water table		+	0	0	0	0	+	0	-	-	0	-	+	+		+	
3. Vegetation submergence		0	+	0	-	-	+	-	-	0	-	0	0	+		+	
4. Increased seepage; swamps		0	+	0	0	0	+	0	0	0	0	0	0	+		+	
5. Beginning erosion in area of dam		0	0	0	0	0	0	0	0	0	+	0	0	-		-	
6. Spillway; downstream irrigation canals		0	-	0	0	0	-	0	-	-	+	-	-	-		-	
7. Water characteristics: nutrients, H_2S; microbe content; temperature; wind + waves		0	-	0	0	0	-	0	0	0	-	0	-			-	
8. Enhancement of plant growth; emerging aquatic macroflora		0	+	0	0	0	-	0	0	0	-	0	0	+		+	
9. Land clearing; road building		0	0	0	-	-	0	-	-	-	0	0	0	0		0	
10. Emerging terrestrial vegetation; reforestation		+	+	+	+	+	+	+	+	+	0	+	+	+		+	
11. Emerging terrestrial fauna; rodents; birds		+	+	+	+	+	+	+	+	+	+	+	-	+		+	
12. Influx of human population + associated activities; increased human wastes		+	+	+	0	0	+	0	-	-	0	-	+	+		+	
13. Changes in numbers and kinds of livestock		+	+	+	+	+	+	+	+	+	0	+	-	+		+	
14. Changes in traditional farming practices		+	+	+	+	+	+	+	0	0	0	+	+	+		+	
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	+6	+7	+5	+2	+2	+6	+2	-2	-1	-1	+1	+1	+7	N.A.	+7	N.A.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.9. EFFECTS OF THE BALINGHO ANTISALINITY BARRAGE CONSTRUCTION PROJECT ON VECTOR POPULATIONS: LONG-TERM (> 5 years) OPERATIONAL STAGE

0 = No change
– = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	G. palpalis	G. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Fresh water; absence of flow at edges; high water (1.5 + G.D.) upstream	–	0	+	0	0	0	+	0	+	0	Not applicable in The Gambia	0	+	+	0	+	+
2. Shallow shore; mud; reeds + sedges	–	0	+	0	0	0	+	0	0	0		0	+	+	+	+	+
3. Erosion patterns become permanent; swamps form	0	0	+	0	0	0	+	0	+	0		0	0	0	0	+	+
4. Aquatic micro- + macro-fauna in equilibrium	0	0	+	0	0	0	+	0	0	0		0	+	+	0	+	+
5. Terrestrial natural vegetation grows up along shore	0	0	+	0	+	+	–	+	+	0		+	0	0	0	0	0
6. Proximal + distant perennial irrigation; new farms, crops	0	+	0	0	+	0	+	0	0	0		+	0	0	0	0	0
7. Balance achieved between vertebrate + invertebrate aquatic fauna	0	0	–	0	0	0	–	0	0	0		+	0	0	0	0	0
8. Terrestrial fauna changes; rodents, birds, livestock	+	0	+	+	+	+	+	+	+	+		+	0	0	0	0	0
9. Human settlements; intense water contact; pollution	–	+	+	+				–	–	–		0	+	+	0	+	+
10. Deforestation	–	0	0	0	–	–	0	–	–	–		–	0	0	0	0	0
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	–3	+2	+6	+2	+2	+1	+4	0	+2	–1	N.A.	+3	+4	+4	+1	+5	+5

University of Michigan, Gambia River Basin Studies. 1985.

TABLE 4.10. EFFECTS OF THE KEKRETI DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: LONG-TERM (> 5 years) OPERATIONAL STAGE

0 = No change
- = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	C. palpalis	C. morsitans	S. damnosum	Ph. duboscqi	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Filled reservoir; slow water flow; high water over long distances upstream	Not applicable in Senegal Oriental	0	+	0	0	0	+	0	+	0	-	0	+	+	Probably not applicable in Senegal Oriental	+	+
2. Turbulent water downstream from spillway		0	-	0	0	0	-	0	0	0	+	0	-	-		-	-
3. Formation of foreshore; shallows + mud bottom		0	+	0	0	0	+	0	0	0	0	0	+	+		+	+
4. New topography; steady state established on shore; permanent swamps		0	+	0	0	0	+	0	0	0	-	-	0	0		+	+
5. Aquatic flora reaches equilibrium		0	+	0	0	0	+	0	0	0	0	0	0	+		+	+
6. Terrestrial vegetation dense near shore; reforestation		0	+	0	+	+	-	+	+	0	0	0	0	0		0	0
7. Perennial irrigation downstream; cash crops		+	0	+	+	0	+	0	0	0	0	+	0	0		0	0
8. Aquatic fauna reach equilibrium		0	+	0	0	0	+	0	0	0	0	0	+	+		+	+
9. Terrestrial fauna develops; domestic animals, livestock, rodents, birds		0	+	+	+	+	+	+	+	+	0	+	0	0		0	0
10. Fishery development in reservoir		0	0	0	0	0	0	0	0	0	0	0	-	-		-	-
11. Human settlements; intense water contact; pollution		+	+	+	0	0	+	0	0	0	0	0	+	+		+	+
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	+2	+7	+3	+3	+2	+6	+2	+3	+1	-1	+1	+2	+3	N.A.	+4	+4

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.11. EFFECTS OF THE FOUTA-FOULBE DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: LONG-TERM (5 years) OPERATIONAL STAGE

0 = No change
− = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	G. palpalis	G. morsitans	S. damnosum	Ph. dubosqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Filled reservoir; slow water flow; high water over long distances upstream	Not applicable in Middle Guinea	0	+	0	0	0	+	0	+	0	−	0	+	+	Probably not applicable in Middle Guinea	+	Not known from Guinea
2. Turbulent water downstream from spillway		0	−	0	0	0	−	0	0	0	+	0	−	−		−	
3. Formation of foreshore; shallows + mud bottom		0	+	0	0	0	+	0	0	0	0	0	+	+		+	
4. New topography; steady state established on shore; permanent swamps		0	+	0	0	0	+	0	0	0	−	−	0	0		+	
5. Aquatic flora reaches equilibrium		0	+	0	0	0	+	0	0	0	0	0	0	+		+	
6. Terrestrial vegetation dense near shore; reforestation		0	+	0	+	+	−	+	+	0	0	0	0	0		0	
7. Perennial irrigation downstream; cash crops		+	0	+	+	0	+	0	0	0	0	+	0	0		0	
8. Aquatic fauna reach equilibrium		0	+	0	0	0	+	0	0	0	0	0	+	+		+	
9. Terrestrial fauna develops; domestic animals, livestock, rodents, birds		0	+	+	+	+	+	+	+	+	0	+	0	0		0	
10. Fishery development in reservoir		0	0	0	0	0	0	0	0	0	0	0	−	−		−	
11. Human settlements; intense water contact; pollution		+	+	+	0	0	+	0	0	0	0	0	+	+		+	
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	+2	+7	+3	+3	+2	+6	+2	+3	+1	−1	+1	+2	+3	N.A.	+4	N.A.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 4.12. EFFECTS OF THE KOUYA AND KANKAKOURE DAM CONSTRUCTION PROJECT ON VECTOR POPULATIONS: LONG-TERM (> 5 years) OPERATIONAL STAGE

0 = No change
- = Decrease in vector pop.
+ = Increase in vector pop.

	A. melas	A. gambiae	A. funestus	Ae. aegypti	Ae. africanus	Ae. luteocephalus	Ae. vittatus	Ae. furcifer/tayl.	C. palpalis	C. morsitans	S. damnosum	Ph. duboscqui	Cyclops spp.	B. pfeifferi	Bu. senegalensis	Bu. globosus	Bu. guernei
1. Filled reservoir; slow water flow; high water over long distances upstream		0	+	0	0	0	+	0	+	0	-	0	+	+		+	
2. Turbulent water downstream from spillway		0	-	0	0	0	-	0	0	0	+	0	-	-		-	
3. Formation of foreshore; shallows + mud bottom		0	+	0	0	0	+	0	0	0	0	0	+	+		+	
4. New topography; steady state established on shore; permanent swamps		0	+	0	0	0	+	0	0	0	-	-	0	0		+	
5. Aquatic flora reaches equilibrium		0	+	0	0	0	+	0	0	0	0	0	0	+		+	
6. Terrestrial vegetation dense near shore; reforestation		0	+	0	+	+	-	+	+	0	0	0	0	0		0	
7. Aquatic fauna reaches equilibrium		0	+	0	0	0	+	0	0	0	0	0	+	+		+	
8. Terrestrial fauna develops; domestic animals, livestock, rodents, birds		0	+	+	+	+	+	+	+	+	0	+	0	0		0	
9. Fishery development in reservoir		0	0	0	0	0	0	0	0	0	0	0	-	-		-	
10. Human settlements; intense water contact; pollution		+	+	+	0	0	+	0	0	0	0	0	+	+		+	
	Malaria	Chikungunya Malaria Filariasis	Malaria	Dengue Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Yellow Fever	Trypanosomiasis	Trypanosomiasis	Onchocerciasis	Leishmaniasis	Dracontiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis	Schistosomiasis
Probable Outcome	N.A.	+1	+7	+2	+2	+2	+5	+2	+3	+1	-1	0	+2	+3	N.A.	+4	N.A.

University of Michigan, Gambia River Basin Studies, 1985.

entail creation of breeding sites for the domestic mosquitoes, notably Anopheles gambiae and Aedes aegypti. There will be improved conditions for the robust open-water breeders such as A. funestus and Ae. vittatus. Tree-breeders such as Ae. africanus, Ae. luteocephalus, and Ae. furcifer/taylori will not be affected. Human activities may favor riverine tsetse fly breeding and riverside congregations of people will certainly offer tsetse flies new food opportunities. The destruction of wild rodent burrows in the vicinity of construction sites and camps may have an adverse effect on Phlebotomus sandfly populations.

4.1.1.2. Road construction/deforestation. This will adversely affect tree-breeding mosquitoes and tsetse flies. Some sandfly breeding sites may be destroyed.

4.1.1.3. Borrow pits. Bulldozers create pits which, if unattended, will become ponds. Opportunist mosquitoes such as A. funestus and to some extent, A. gambiae, will make use of them. If they persist, snails such as Biomphalaria pfeifferi and Bulinus globosus will breed in them. They will support heavy populations of tropical copepods (Thermocyclops sp.).

4.1.1.4. Cessation of river current; marsh and poll seepage. This will encourage free-water mosquitoes (Anopheles funestus and Aedes vittatus). Conditions will be good for copepods and pond snails.

4.1.1.5. Organic pollution. This will presumably be somewhat localized but will have a deleterious effect on breeding of A. gambiae, A. funestus and Ae. vittatus, as well as copepods, if the pollutants are concentrated.

4.1.1.6. Introduction of new vectors. Almost all of the subject vectors are expected to benefit from the possible introduction of new strains to newly created habitats.

4.1.1.7. Establishment of aquatic plants. This will benefit primarily the aquatic pulmonate snails, such as Bulinus truncatus guernei, which occurs in close association with hornwort (Ceratophyllum demersum) and Biomphalaria pfeifferi which is often found on floating weeds.

4.1.1.8. Canal construction. Irrigation canals are traditionally connected with improved breeding of some mosquitoes (A. gambiae, A. funestus, Ae. aegypti) and are notorious for harboring pulmonate snails.

4.1.1.9. Interruption of bimonthly tidal action on mangroves. This component is characteristic only of the Balingho salt-exclusion barrage. The replacement of salt tidal flats in the areas of *Avicennia* mangroves will eventuate in local extinction of the saltwater breeding *A. melas*.

4.1.2. Short-term (less than 5 years) Operational Stage

4.1.2.1. Removal of tidal mixing upstream from barrage. This component applies only to the Balingho barrage. The effect will be to eliminate saltwater breeding *A. melas* from former tide-influenced mud flats.

4.1.2.2. Elimination of salinity gradient. Referring only to the Balingho barrage, this component will favor production of certain river-breeding mosquitoes (*A. funestus*), and copepods, and might mean the difference necessary to encourage marginal populations of snails such as *B. globosus* and *B. guernei*. There is a possibility that the lack of salt could render some riverine lands more attractive to tsetse breeding.

4.1.2.3. Increased surface area of water. This will encourage increased populations of lake-dwelling organisms such as *A. funestus*, *Ae. vittatus* and the pulmonate snails. At the same time, blackfly breeding will be reduced or eliminated.

4.1.2.4. Raised water table. While this component may favor certain of the pulmonate snails as well as *A. gambiae* and *Ae. vittatus* under certain conditions, it will probably have a deleterious effect on breeding of riverine tsetse flies, by rendering unusable certain breeding sites near the water's edge. Sandfly breeding may also be interrupted by flooding of rodent burrows.

4.1.2.5. Vegetation submergence. Inundation of forests will discourage breeding of tree-dwelling mosquitoes. On the other hand, submerged woody vegetation will provide added substrate for growth of algae, thus increasing food supply of pulmonate snails.

4.1.2.6. Increased seepage and formation of permanent swamps. This component will represent an important increase in habitat for certain snails and mosquitoes. However, the advantage will probably be only marginal as far as snails are concerned.

4.1.2.7. Beginning of erosion in the area of the dam. Assuming that this component is not corrected by design elements, the effect could be

deleterious to some snail habitats but might enhance breeding of blackflies by creating suitable (even if temporary) habitats.

4.1.2.8. Spillway activity and flushing action on irrigation canals downstream. An uncontrolled spillway will create many breeding sites for blackflies and the benefit of reducing breeding sites by inundation above the dam site may be offset by enhanced breeding below the dam site. On the other hand, the vigorous flushing action of spillway releases would be expected to injure populations of mosquitoes and snails.

4.1.2.9. Water characteristics. In the event that the water quality in an impoundment is influenced by nutrients contained in runoffs from adjacent agricultural lands, or by silt load or decay of submerged vegetation, lake-breeding mosquitoes and snails may show an initial population enhancement that will be reversed as the impoundment progresses toward a state of eutrophication.

4.1.2.10. Enhancement of plant growth. Impoundment with its consequent reduction of flow velocity will encourage growth of aquatic macrophytes, some of which are utilized as substrates by the pulmonate snails while at the same time shelter larvae of lake-breeding mosquitoes.

4.1.2.11. Land clearing and road building. This component is a necessary adjunct of the construction activities and, in the Gambia River Basin, will assume great importance in view of the relatively poor state of access roads in existence. Cutting down trees will negatively impact populations of tree-breeding mosquitoes and may also render some present tsetse breeding sites unusable.

4.1.2.12. Emerging terrestrial vegetation and reforestation. In the short run, enhanced growth of vegetation at the edge of the water will encourage increased production of almost all the subject vectors.

4.1.2.13. Emerging terrestrial fauna, rodents, and birds. Increases in populations of small mammals and birds, for whatever reason, ought to be accompanied by a corresponding increase in the invertebrates which depend on them for food. Indirectly, these increases will favor the growth of aquatic snails by virtue of the vertebrate contribution of waste products to the trophic cycle and subsequent utilization of these by plant microorganisms which, in turn, are utilized by the snails.

4.1.2.14. Influx of human population with its associated activities. In the short run, the population is expected to increase at focal points

along the edge of any impoundment. All kinds of human activities seem to encourage domestic mosquitoes except those designed to combat mosquitoes. With regard to snails, uncontrolled deposition of human wastes in waters adjacent to habitations may provide a congenial habitat for certain aquatic snails (B. globosus has sometimes been termed a "garbage snail"). Conversely, some tsetse and sandfly breeding sites will be destroyed or altered beyond the capacity of the vectors to utilize them.

4.1.2.15. Changes in numbers and kinds of livestock. Heightened human activity near impoundments is bound to be reflected in increased numbers of livestock (cattle, sheep, goats and possibly, in non-Islamic communities, pigs). This will benefit their opportunistic ectoparasites (see section 4.1.2.13.).

4.1.2.16. Changes in traditional farming practices. The new emphasis on irrigation agriculture will create added niches for mosquitoes and snails in the form of lead-in canals, irrigation channels and holding ponds.

4.1.3. Long-term (More than 5 Years) Operational Stage

4.1.3.1. Establishment of a freshwater habitat. With regard to the Balingho barrage, the absence of flow and the regularization of the water level (at about 1.5 m above Gambia Datum) will have the effect of creating a very long lake out of the present river. Such a lake will have many pondlike areas along its course which will encourage breeding of pond snails and mosquitoes as well as water fleas.

4.1.3.2. Shallow shore with mud, sedges, and reeds. This is another consequence of the establishment of pondlike conditions along the shoreline. Such conditions may not favor breeding of riverine tsetses but may encourage mud-dwellers such as B. senegalensis.

4.1.3.3. Erosion patterns become permanent; swamps form. In the long run, depressions in the floodplain will become swamps. They will no longer have a seasonal character but will permit breeding of suitable vectors on a perennial basis.

4.1.3.4. Filled reservoir. The Kekreti dam and the Guinea dams will eventuate in impoundments long distances upstream, creating new aquatic habitats of great extent. A. funestus and Ae. vittatus will take

advantage of this situation. It is thought that Bulinus senegalensis will be unable to utilize the new lakes, and blackfly breeding sites above the dam will cease to exist.

4.1.3.5. Turbulence downstream from spillway. New blackfly breeding sites will be created downstream from unregulated spillways.

4.1.3.6. Aquatic microfauna and macrofauna in equilibrium. After five years the patterns of ecological succession will have become stable. The effects of any naturally established biological controls will have become evident (mollusk-eating fish, bacteria pathogenic for mosquito larvae, etc.), and vector populations in the impoundment will demonstrate permanent levels of population density.

4.1.3.7. Terrestrial vegetation grows up along shore. In the long run trees that had been drowned by rising water or by salt exclusion (for example, red mangroves) will be replaced by new growth. Since many tropical trees demonstrate rapid growth rates, it is expected that arboreal mosquito niches will have been replaced at the water's edge after five years. But at the same time it may be noted that the new shoreline shade may deny habitat to sun-loving mosquitoes such as Ae. vittatus.

4.1.3.8. Perennial irrigation downstream. Irrigation agriculture is one of the principal benefits anticipated from river development schemes. After five years, it is expected that permanent patterns of new land use will have become established. Changes will have occurred in soil humidity, favoring breeding of many mosquito species and possibly sandflies.

4.1.3.9. Aquatic fauna and flora reach equilibrium. The productivity of the impoundments for aquatic snails, copepods and open-water mosquitoes will have become established after five years. Certain species which were present in only marginal numbers before the changes occurred may increase fairly rapidly, but eventually the population numbers will flatten out.

4.1.3.10. Fishery development in reservoirs. Certain fish species feed on snails and will probably exert a degree of pressure on mollusk populations. These include the catfishes (Chrysichthys furcatus and C. nigrodigitatus) feeding on the bottom and Tilapia spp. feeding in the water column. (See Aquatic Ecology and Gambia River Basin Development.)

4.1.3.11. Terrestrial fauna develops. In addition to anticipated increases in the size of local livestock herds, competition for habitat sites will have been generated by inundation and reduction of available land area. After five years it is expected that a degree of equilibrium will have been reached and that most of the mosquitoes will benefit from the change.

4.1.3.12. Human settlements. The localization of new settlements will have taken place. It is expected that many of these will be close to the new lakes. Heightened levels of human water contact plus the inevitable pollution will encourage and support mosquito and snail populations.

4.2. Impacts of Water Management on Diseases Associated with Water

4.2.1. Water-borne and Water-washed Diseases

The frequency of the diseases listed in sections 3.1.1. and 3.1.2. may be reduced by the provision of either more abundant or more accessible water. These diseases are not proposed as life-threatening but they contribute significantly to the load of daily misery.

There is no quick answer to the question, "what is an adequate volume of water for hygienic purposes?" A few liters may seem insufficient and a few hundred, more than adequate. A start must be made somewhere and the logical consequence of impounding the Gambia River, namely, the perennial availability of very large quantities of water, ought to lead eventually to a decision to make some of this water available for domestic purposes.

It has been stated that water use will not be optimal for health unless water is piped to the home (Feachem, McGarry and Mara, 1977). However, it must be recognized that piped supplies have not been contemplated as yet in the context of overall development planning. But it is noted that very large amounts of freshwater would be required by the construction proposed at the Balingho site, water volumes not available unless piped from upriver. Is it possible that the provision of such piped supplies for construction purposes might serve as the nucleus of a broader system of piped supplies for domestic purposes in contiguous rural areas?

The alternative to piped supplies is the digging of more wells in the community, thus reducing the need for long trips to bring back minimal supplies.

The availability of groundwater and the fragility of the aquifer must be studied. The present wells in the Farafenni area tend to go dry at the end of the dry season, particularly in drought years, thus permitting the risk of saltwater intrusion into the aquifer resulting in the spoiling of the well for indeterminate periods into the future.

4.2.2. Water-based Diseases

4.2.2.1. Guinea worm. Guinea worm disease (dracontiasis or dracunculosis) is a seasonal disease with peak transmission occurring during the dry season in areas where people depend on surface water for drinking purposes.

Although guinea worm has not occurred in epidemics in West Africa, conditions of impoundment could permit this. In Nigeria, although guinea worm transmission had been recorded at low intensity in dispensary locations on the eastern side of the Kainji Lake area, the disease occurred in epidemic proportion following the formation of Kainji Lake in 1968. A prevalence of 31 percent (which was higher than rates reported elsewhere in Nigeria) was recorded in five villages on the east shore. The ponds and surface waters resulting from the vertical movement of the Kainji Lake's level on the estuaries of tributary streams and rivers were readily available to farmers on their way to their farms and to traders on their way to the markets. Indeed, the people affected most were farmers and traders. Women and children were less exposed.

A similar outbreak or outbreaks should be anticipated in connection with the Kekreti dam in Senegal and the Guinea dams. The Nigerian transmitter is the water flea, *Thermocyclops nigerianus*, a ubiquitous species that has also been reported from the Gambia River (see Aquatic Ecology and Gambia River Basin Development).

4.2.2.2. Schistosomiasis.

- The Gambia

Schistosomiasis haematobia: MAJOR IMPACT. At present, transmission is limited to seasonal laterite pools, away from the river, in the Upper River and MacCarthy Island divisions, and there is no transmission in the

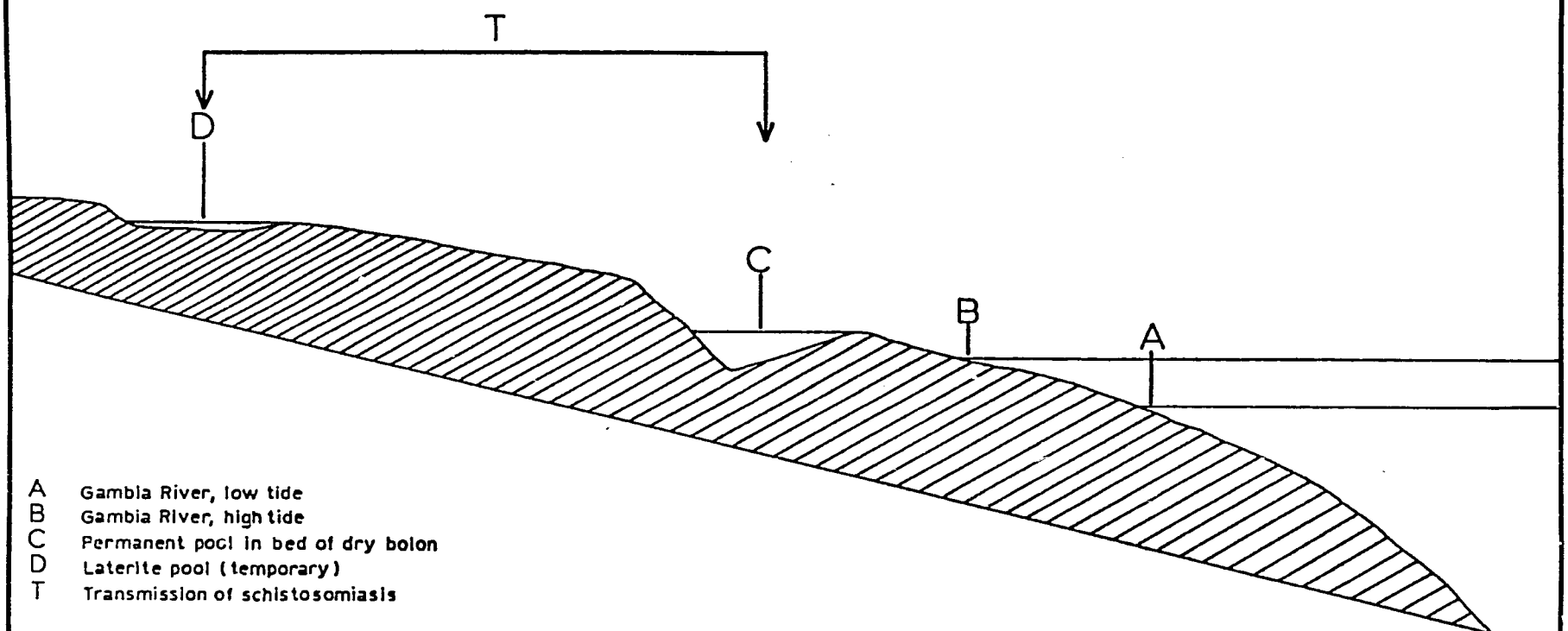
Gambia River (see Figures 4.1. through 4.3.). But the snail, Bulinus truncatus guernei, is now known to inhabit the Gambia River near Sapu (MID). It is recalled that a similar snail, B. truncatus rohlfsi, which was virtually unknown in the Volta River prior to construction of the Akosombo Dam, eventually became the principal transmitter of urinary schistosomiasis in Lake Volta when conditions of impoundment favored its development. It is realized that conditions in the Gambia River after closure of the Balingho barrage will not necessarily imitate those in Lake Volta. Nevertheless, certain parameters will be met: the reduction of salinity to a very low figure, the removal of tidal or daily vertical movement of the water, and the establishment of many localities of pondlike conditions along the length of the river. These conditions will certainly allow B. truncatus guernei to proliferate. When this occurs in proximity to human settlements or regular human water contact points, the elements of the life cycle of the parasite will be brought together, and a new kind of transmission for The Gambia will come into existence.

The present agricultural schemes, at Sapu, and in the Jahaly Pacharr area, seem to be associated with a minimal amount of transmission of urinary schistosomiasis mediated (apparently) by B. globosus/jousseaumei (see Figure 4.4.). There is every reason to believe that this small incidence will also increase, with increased participation by people and intensified cultivation.

It is not expected that the Balingho barrage will impact on the present pattern of transmission in The Gambia since this is unconnected with the river.

Schistosomiasis mansoni: MAJOR IMPACT. Although there is very little intestinal schistosomiasis in The Gambia today, the elements of the life cycle are all in place in The Gambia, now held in check apparently by the annual disappearance of suitable surface water and possibly by the inability of the snails to withstand elevated temperatures. The Gambia River is not now particularly suitable for Biomphalaria snails but this would change quickly with construction of the barrage and the consequent changes in the river. At present it is believed that under conditions imposed by the saltwater extrusion barrage, many suitable niches for Biomphalaria snails would emerge.

Figure 4.1. Schematic drawing of a cross-section of The Gambia, through MacCarthy Island Division, from the southern border (left) to the river (right). The drawing illustrates how the present transmission pattern of urinary schistosomiasis is unaffected by events connected with the river.



University of Michigan, Gambia River Basin Studies, 1985.

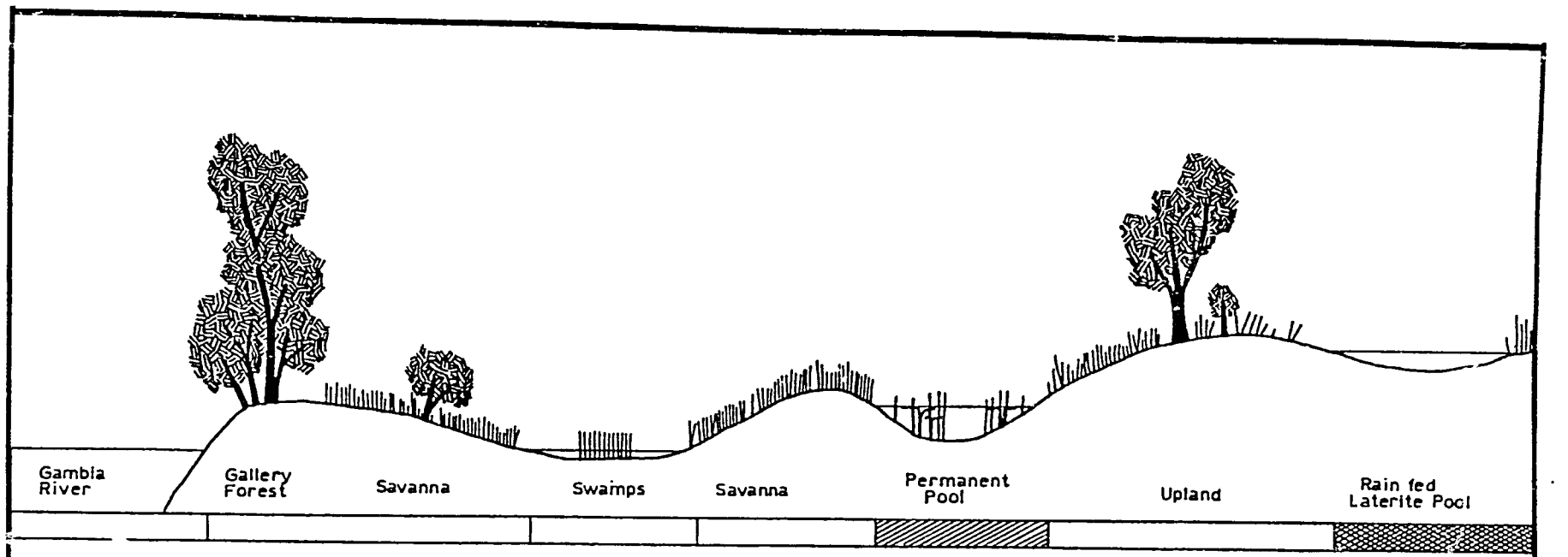


Figure 4.2. Distribution of Bulinus senegalensis in The Gambia before and after construction of an anti salinity barrage at Balingho. The cross section is hypothetical, through the eastern sector of the country (MacCarthy Island Division and Upper River Division).

University of Michigan, Gambia River Basin Studies, 1985.

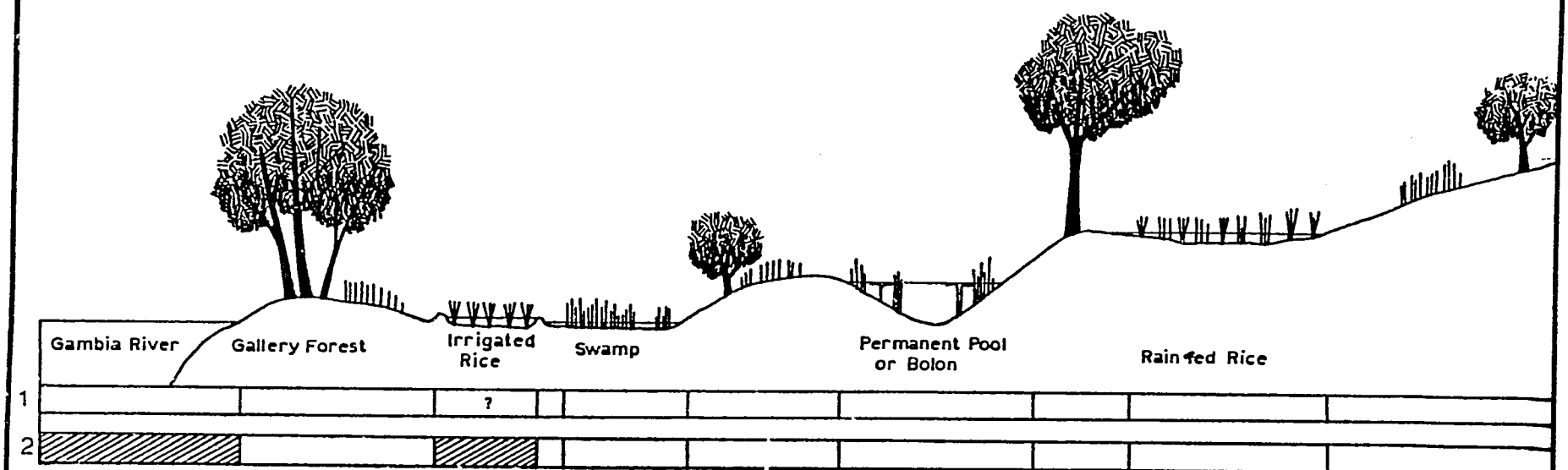


Figure 4.3. Distribution of *Bulinus truncatus quernei* in The Gambia before (1) and after (2) construction of an anti salinity barrage at Balingho. The cross-section is hypothetical through MacCarthy Island Division.

University of Michigan, Gambia River Basin Studies, 1985.

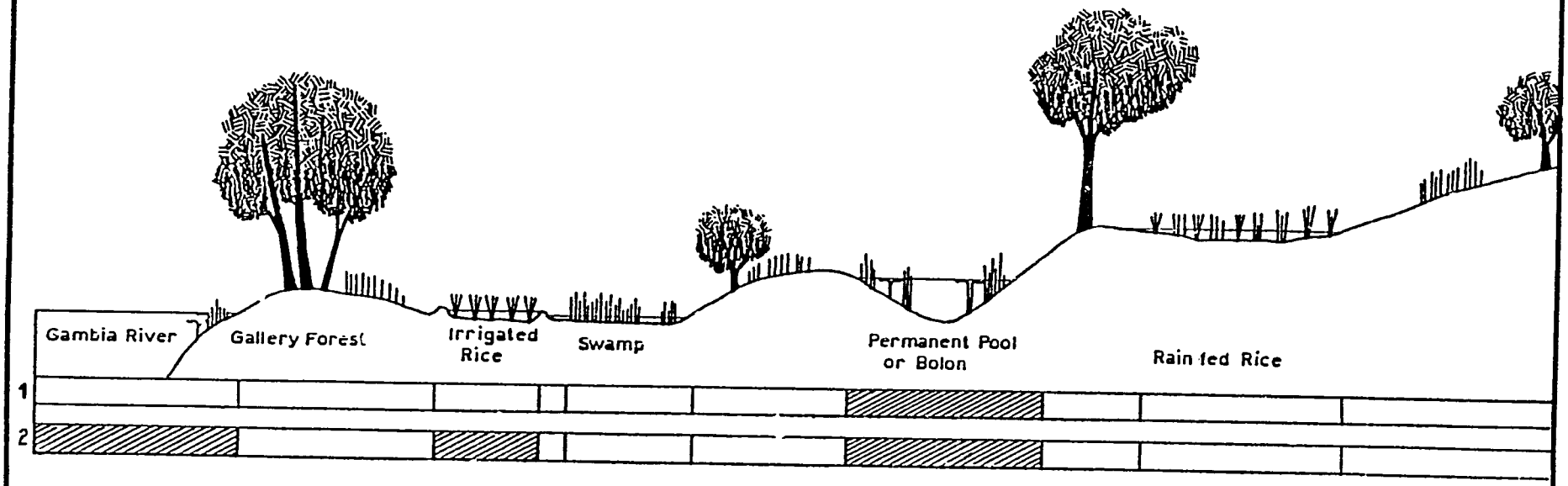


Figure 4.4. Distribution of Bulinus globosus/B. lousseaumei in The Gambia before (1) and after (2) construction of an anti salinity barrage at Balingho. The cross-section is hypothetical through MacCarthy Island Division.

University of Michigan, Gambia River Basin Studies, 1985.

- Senegal

Schistosomiasis haematobia: MAJOR IMPACT. Currently, transmission is seasonal, occurring in ponds and wash areas where water contact tends to be prolonged. Transmission is severely limited by the availability of surface water, a fact which seems to have acted as a brake on spread in the past. The transmitting snail is principally Bulinus truncatus guernei, a species which cannot withstand desiccation and is restricted to the few permanent-water sites in southeast Senegal. Large populations are probably reestablished after each rainy season, thus limiting the time of transmission to the few months between commencement of the rains, with growth of the new snail population, and the ensuing dry season. This species is well-adapted to irrigation schemes and reservoirs.

With the construction of the Kekreti Dam and the creation of a large impounded lake behind it, many small niches will come into existence that will be exempt from the annual drying cycle. If such collections of snails happen to be in proximity to human population centers, the conditions will be met for perennial transmission of urinary schistosomiasis. Since the dynamics of transmission is subject to the laws of mass action, it is confidently predicted that transmission will increase as components of transmission are strengthened. Both parasite and snail are apparently established in population settlements near the Gambia River and along the road between Salemata and Kedougou. The missing component, which now limits spreading, is the paucity of surface water.

Schistosomiasis mansoni: MAJOR IMPACT. At present this is one of the least prevalent of infectious diseases in southeastern Senegal. However, there are pockets of infection in school children in Salemata and Kedougou. The hypothesis that the transmitting snail, Biomphalaria pfeifferi, would be encountered in the area was substantiated by field searches conducted during the present project (Schneider and Malek, 1984). This snail favors permanent waters that are clear and oxygen-rich, with little movement or current. Biomphalaria requires slightly higher ambient temperatures than does Bulinus. It is expected that the newly established Kekreti Lake will be stocked with suitable food plants (emergent Nymphaea sp. and submergent Ceratophyllum sp.)

along its margins. Wherever fishing villages develop at the edge of the water, transmission will become perennial.

- Guinea

Both urinary and intestinal schistosomiasis are reported from Koundara and it is expected that the construction of the Kogou Fouibe Dam will have a MAJOR IMPACT on the transmission of both forms. The host snail for the urinary form is B. globosus. The water in the river may be unsuitable for this snail because of its extremely low ion content and it is predicted that schistosome-bearing snails will never do well in the Koulountou River or in the impoundment. They will, instead, flourish in downstream irrigation schemes. With increased human population and water contact throughout the year, both forms of schistosomiasis should show an increase in incidence.

At the Kouya and Kankakoure damsites, there will be a QUESTIONABLE IMPACT. The water of the Gambia River and its principal tributaries in this area seems to be unsuitable for the schistosomiasis snails. The dams are scheduled for hydroelectric output only and no irrigation schemes are planned. The area seems relatively unpopulated at present. If vector snails do somehow manage to benefit from the impoundment and thrive, they will probably be very localized and seldom in contact with people.

However, the threat cannot be ignored completely, as both forms of schistosomiasis have been reported from the Fouta Djallon.

4.2.3. Water-related Diseases

4.2.3.1. Malaria. There is a well-known paradox in dealing with holoendemic malaria in Africa: successful traditional malaria control may weaken rather than strengthen a community's group resistance.

In much of the Gambia River Basin, where malaria transmission can continue throughout the greater part of the year and spleen rates in children can rise above 75 percent, malaria victims acquire and maintain an effective immunity that modifies the severity of each attack while at the same time, allow small numbers of parasites to circulate in the blood and to infect new mosquitoes. (This immune state is called premunition; it depends on the infected human host being daily challenged with multiple infected mosquito bites and is species-specific and indeed,

probably strain-specific: a worker coming from a distance may find that his immunity vis-à-vis malaria strains in his area of origin may not protect him from severe attacks caused by new local strains.)

As a result of premunition, adult Africans in holoendemic areas suffer modified malarial attacks that often amount to little more than a severe headache and a fever. Indeed, such victims are apt to ask for aspirin before asking for an antimalarial.

(A corollary is, of course, that immune Africans who leave the holoendemic area for prolonged periods, for example, to study in Europe or the United States, may lose their immunity and upon reintroduction to their former locations, may suffer unwontedly severe attacks before malaria immunity is reestablished.)

The existence of community premunition should not imply that malaria poses no problem in an African community. The immune state is acquired slowly so that infants and young children may suffer severely. The combination of malnutrition and early malaria is probably as responsible as anything else for the high death rates (thought to reach 450 per 1,000 in some areas) in children under the age of five.

Aggressive traditional malaria control by means of drugs might rid a holoendemic community of its malaria but would also deprive the people of their immunity, leaving the way open for reinvasion if concomitant control efforts aimed at vectors were relaxed. The ensuing primary-type malaria attacks in the now nonimmune community could create medical havoc.

Vaccination is one answer. The development of an effective malaria vaccine seems to be a fast-approaching goal. Indeed, USAID-sponsored field trials of test sporazoite vaccines may be tested in West Africa within two years. It is understood that The Gambia will probably participate in such trials although a timetable has not yet been established. However, it is premature to include vaccines in the thinking about malaria control at this time.

Considering the demands of premunition status, it might prove wiser to limit group prophylaxis in holoendemic communities to the age group under five who have not yet developed, or need more time to develop, immunity.

Decisions regarding either local or country-wide malaria control will remain the responsibility of the country health authorities. Obviously

clinical disease will be treated on a case by case basis. Construction contractors should be expected to include vector control as part of the environmental sanitation efforts that will accompany establishment of a "company town" or workers' camp.

- The Gambia: MAJOR IMPACT

Currently, transmission of malaria along the Gambia River from the estuary to Kaur, including Balingho, is effected by the domestic breeder Anopheles gambiae, assisted by the saltwater breeder A. melas. A. funestus, although occasionally recovered in collections in this area, cannot now be considered a major transmitter. Most villages between Balingho and the area where saltwater influence terminates and white mangrove stands peter out (between Dankunku Island and Kaur) are positioned 2 to 5 kilometers away from the river. A. melas breed on the salt flats yet regularly fly the short distances to villages in search of human blood meals (Giglioli, 1964). (See Figure 4.5.) The anticipated chain of events as a result of construction of a saltwater barrage at Balingho may be stated as follows: replacement of a periodic saltwater tidal movement (with bimonthly spring tides) with a freshwater environment stabilized at 1.3 to 1.7 m + G.D., will kill the mangroves and, at the same time, eradicate the restricted breeding sites of melas, which will disappear from these areas. Establishment of a freshwater habitat extending some 60 kilometers upriver from Balingho will alter the ecological balance and provide numerous niches for funestus which will become dominant. Funestus with its long flight range, its preference for feeding on man, its willingness to invade houses and bite in them, will become a major transmitter of malaria and possibly filariasis in the Balingho area; its numbers will be enhanced by the cessation of the daily tidal fluctuations in river level which now apparently inhibit mosquito breeding in the river above the salt tongue. It is thought to be a more efficient vector of malaria than melas. In summary, an indirect effect of construction of the Balingho barrage is expected to be replacement of a less efficient malaria vector (melas) with a more efficient one (funestus). Once this change has occurred it is difficult to conceive of any mitigating actions that might reverse the situation other than increased vigilance in local mosquito control programs in villages.

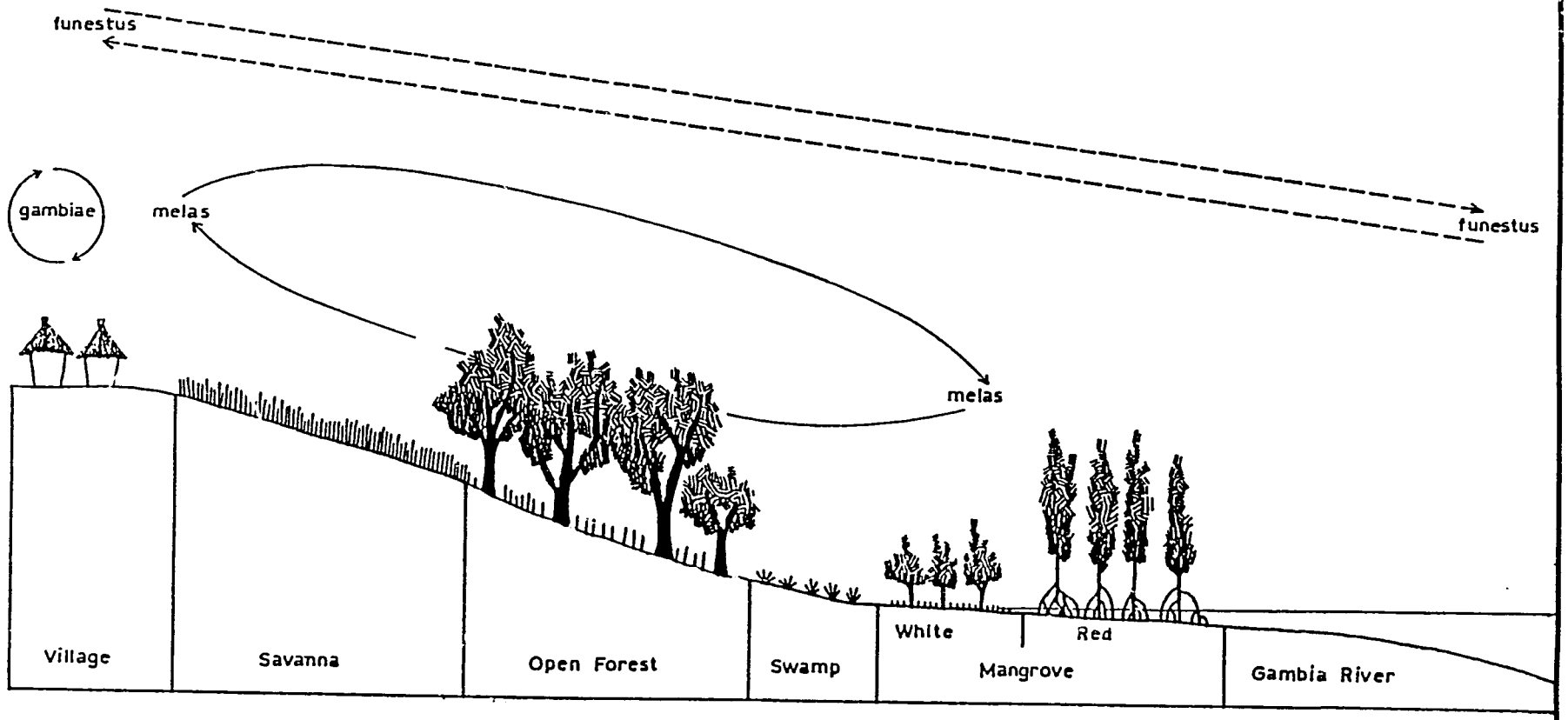


Figure 4.5. Flight paths of A. melas (from Avicennia swamps) and A. gambiae (domestic breeders) in a hypothetical cross-section of Lower River Division, The Gambia. Actual mosquito movements indicated with solid lines. Theoretical movement of A. funestus after construction of anti salinity barrage at Balingho indicated by dotted lines.

University of Michigan, Gambia River Basin Studies, 1985.

- Senegal: MAJOR IMPACT

It is thought that funestus breeding is held in check in Senegal Oriental by the dry season. Yet, even during a prolonged dry season, many small focal collections of water persist in the region which now offer important breeding places for funestus. The establishment of a perennial supply of surface water of great extent and complicated shoreline will change the transmission pattern in the area; instead of replacing gambiae for a few months at the end of the rainy season as now happens, gambiae and funestus will both be present on a year-round basis. The result will be increased transmission of malaria in the affected human population.

- Guinea: MAJOR IMPACT

The observations made for Senegal apply equally to Guinea. Differences in enhanced mosquito production will be related to local differences in surface water availability. Tidal influences do not figure in the thinking, but funestus production along the shoreline of impounded lakes will increase, subject only to the control exerted by periodic draw down.

4.2.3.2. Other mosquito-borne diseases. Bancroftian filariasis is transmitted by Anopheles gambiae and A. funestus as well as by the ubiquitous Culex pipiens. The comments in section 4.2.3.1. apply to filariasis as well as malaria. Under current conditions, the public health importance of filariasis in the Gambia River Basin seems to be relatively low. Firm predictions of enhanced transmission under impoundment conditions are probably to be avoided.

Yellow fever and dengue exist sporadically in the Gambia River Basin. Vaccination programs against yellow fever suffer from poor logistics and become activated only in the face of epidemics. There is no known protection against dengue. Both diseases are transmitted in towns by the domestic Aedes aegypti, which breeds in small water collections but not in the Gambia River. If epidemics of yellow fever do occur as a consequence of dam construction and river impoundment, they will be the result of inattention to the rules of domestic mosquito control and will occur in construction worker camps. For this to happen, the wild virus must be introduced to the town mosquitoes by a human host who will have acquired a chance infection in the countryside, where the

sylvatic virus is maintained by a monkey-mosquito-monkey cycle, associated with gallery forests and plantations. Outbreaks would be thus only indirectly associated with the Gambia River but directly associated with dam construction.

4.2.3.3. Onchocerciasis. Some degree of control over the ravages of river blindness should constitute one of the rare positive health impacts of dam construction in West African blackfly territory. Since Simulium flies require shallow, flowing, highly oxygenated water for breeding, removal of this type of habitat exerts a permanent check on blackfly numbers and thus on Onchocerca transmission.

Two things, however, must be remembered. First, blackflies breed in the outflow of dams, thus transmission in spillway vicinities may be enhanced locally rather than reduced. Second, the very large number of feeder streams which flow into the new impoundment may continue to harbor blackflies and if these are in proximity to human habitations or work sites, local transmission may be seen to continue long after the main riverine breeding sites have disappeared.

- The Gambia

The Gambia River is 494 kilometers long from the estuary to the Senegal border but the land slopes only about 5 centimeters per kilometer in this stretch, and tidal mixing rather than inclined flow is probably responsible for perceived water movements in the river during the dry season and part of the rainy season. These conditions are not suitable for Simulium breeding, and neither blackflies nor river blindness have been reported from The Gambia.

- Senegal

The dam at Kekreti will impound the Gambia River for a distance of some 65 kilometers, almost to Mako, and will also destroy the beds of two major tributaries, the Tiokoye and the Diarha, so that the resulting lake will have a combined length of approximately 150 kilometers. Blackfly breeding will vanish wherever the lake is established, although the spillway area might create a new breeding site.

A glance at the map (Figure 3.3) shows that the area to be inundated will comprise but a small fraction of the total geographic area suitable for blackfly breeding in Sénégal Oriental. Impounding a small section of the very extensive breeding range will benefit only those who live

adjacent to the inundation areas. Since it is presumed that these people will be invited to move to other parts of Sénégal Oriental (where there is still a good likelihood of encountering blackflies), it may be seen that the image of a positive health impact on onchocerciasis must be considerably modified.

- Guinea

The Kogou Foulbe dam will impound a 40-kilometer stretch of the Koulountou River near its headwaters in the Fouta Djallon. Blackfly breeding will disappear above the dam site but, in the absence of concerted control efforts, intense breeding will continue below the dam site where most of the people live. The Koundara area is identified (see Figure 3.3) as a zone of hyperendemic onchocerciasis; transmission downstream will not be modified by dam construction upriver.

There is no report of blackfly breeding in the Liti River from its headwaters to its confluence with the Gambia River but it must be assumed that this indicates a failure of investigators to search this river, one of the most inaccessible of the entire Fouta Djallon. The Kankakoure dam will inundate about 20 kilometers of the Liti, and it must be guessed that this will affect many good blackfly breeding sites during the rainy season.

The Kouya dam will control blackfly breeding for a distance of about 25 kilometers upstream.

It is noted again that the total distance of sections of impounded river in this portion of the Gambia River Basin comprises but a small proportion of the total drainage area in which breeding has been reported. Certainly, destruction of Simulium breeding sites should constitute a health benefit but since these sites occur in relatively unpopulated sections of the country at present, it is difficult to assess the impact of this benefit in advance of the fact.

4.2.3.4. Trypanosomiasis.

- The Gambia

Sleeping sickness was occurring in epidemic form in The Gambia as recently as the 1950s. At present it has subsided to a state of fluctuating but declining endemicity. Only sporadic cases are reported, sometimes originating outside the country. Nevertheless, the disease has not vanished from The Gambia and the vector situation is not stable.

The most likely source of future trouble from this disease will be the tendency for G. palpalis to take advantage of man-made disturbances, a trend that may be developing in The Gambia (MacLennon, 1979).

In general, when palpalis infestation remains sylvatic in terms of habitat and food supply, flies feed only occasionally on man who is the usual source of the human trypanosome, Trypanosoma brucei gambiense. With flies dispersed in the countryside, the chances of the full human-to-human cycle materializing are reduced. But when natural habitat is removed, flies may become tied to areas of human influence and get into the habit of feeding repeatedly on man who frequents artificial habitats to bathe, to fish, to farm, etc.

- Senegal

Reported cases of sleeping sickness are now very rare in Senegal and it is believed that most of the country is free of this infection (200). A few small pockets of infestation, however, may persist, constituting a source of parasites. The few cases of illness are always in persons who frequent riverbanks (shepherds, charcoal burners, women searching for firewood).

In view of the persistence of human parasites, in spite of their rarity and dispersion, the possibility exists for a resurgence of sleeping sickness in areas where tsetse-human contacts are frequent. Such localities will become more numerous with the creation of the Kekreti Lake. New roads will be built in fly country, many crossing streams. New villages will be built, accompanied by local deforestation. Clearings in forests are often utilized by tsetse flies as "hunting grounds."

All things considered, it is believed that environmental perturbations in the Kekreti region in association with dam construction activities, will permit a resurgence of sleeping sickness. Contributing factors will include population movements, the absence of mass prophylaxis, lapses in uncovering new cases, and the possibility of an animal reservoir for human parasites (for example, in pigs). It is not possible, however, to state with any assurance that this resurgence will take on major proportions, since sleeping sickness has been shown to be declining in West Africa over the last ten years.

- Guinea

In the absence of recent data, it would seem logical to cite the observations made previously for Senegal as probably applying equally to the Fouta Djallon area of Guinea.

4.2.3.5. Leishmaniasis. Little is known about the ecology of visceral leishmaniasis (VL) in West Africa. The absence of VL in Senegal, despite the prevalence of canine visceral leishmaniasis, has often been noted (Zahar, 1981). The infection in dogs probably involves an unidentified wild reservoir with the dog as a domestic reservoir. The transmitting sandfly is unknown. It is believed that transmission of the canine disease to man must be exceptional if it occurs at all (Zahar, 1981). Rare cases of VL occur in The Gambia. It has never been seen in Guinea (Zahar, 1981).

Cutaneous leishmaniasis (CL) in Senegal is well established. The disease is benign. Victims are aware of the eventual spontaneous cure of the infection and often do not seek medical help for it. New cases of CL have been appearing in The Gambia and it has been suggested that these might herald further outbreaks (Conteh and Desjeux, 1983). CL infection may exist in Guinea but remains undiagnosed due to the lack of laboratory services in the country (Zahar, 1981).

The available data do not permit a clear picture of the ecology of CL but certain elements are understood. Transmission to humans is associated with fluctuations in rodent reservoir populations and by seasonal increases in numbers of sandflies. These changes are in turn affected by bioclimatic conditions. Usually the months preceding the rainy season in sub-Sahelian regions of West Africa are characterized by increased temperature and humidity in the microclimates harboring the sandflies. The result is a net increase in vector numbers so that transmission of CL tends to be seasonal: 70 to 80 percent of CL cases in Senegal appear during the rainy season (Zahar, 1981).

It would appear that broad environmental changes leading to perennially heightened humidity in microclimates could eventuate in year-round transmission of CL in the area of the Gambia River Basin. With regard to VL, however, such a prediction would be based on guesswork and not facts.

4.3. Systematic Impacts

It is now widely known that economic development activities mediated through the introduction of radical changes of man-environment relationships may also disrupt disease patterns, creating new areas of prevalence, new foci and often, serious outbreaks of disease. Water management schemes such as those proposed for the Gambia River Basin are particularly likely to set off a series of ecosystem disturbances involving parasitic and other infectious disease transmission cycles. The literature is now replete with accounts of dramatic increases in water-related diseases such as malaria and schistosomiasis in Africa and elsewhere in the tropical world (cf. section 4.2).

From the health standpoint, human reaction to developmental changes may be viewed systematically in terms of (i) traditional migration; (ii) local population increases during construction phase; and (iii) requirements for resettlement.

4.3.1. Migration

In the area of impact of the proposed developments in the Gambia River Basin, seasonal transhumance still occurs. Pastoral nomads follow flocks to new grazing grounds in a pattern dictated by the seasons and the availability of green pasture. Nomad populations are typically small and dispersed. The implications for human disease transmission are accordingly also small.

Migration of rural people to urban areas is a more sizeable problem that exists today and will be exacerbated by installation of large development programs in areas which are now essentially rural or unpopulated. The proposed development projects will establish work camps to service the laborers, and it is the uniform experience of other similar projects in Africa that such work camps become transformed into permanent villages and even towns. The concentrated presence of a large number of salaried workers and their families acts as the initial attractant.

Satellite camps and squatter settlements eventually add to the environmental stress imposed by the population influx. Infectious disease transmission is governed by a sort of epidemiological "law of

mass action;" the larger the population of susceptible hosts, the greater the chance for tranfer of the infectious agent.

It is widely recognized that urban life is associated with an increased risk of certain kinds of disease. In this connection, the World Health Organization has developed a number of studies of rural-urban migration, including one in Senegal which might well serve as a paradigm for West Africa. The Senegal Collaborative Study was carried out from 1970 to 1973 by WHO, the University of Dakar, and ORSTOM, with the technical assistance of the Ministry of Public Health and Social Affairs in Senegal. The object of the study was to assess the effects of urban migration on the health of a sample of Serer migrants from the rural district of Niakhar, 100 km southeast of Dakar.

The urban sample was compared to a sample of rural population of Niakhar from three points of view: (i) the sociodemographic situation; (ii) physical and mental health; and (iii) adaptation to immediate environment.

4.3.1.1. Sociodemographic situation. The distribution by age group, sex, and marital status showed that the urban population tended to be younger than the rural population and included twice as many single females. Traditional religious practices remained important in the rural area but decreased in significance in Dakar among the urban migrants. The educational level, as measured by school attendance and number of years spent in school, was much higher among urban than among rural dwellers; it was also markedly higher among adult males than females. Urban acculturation produced differences in diet, food consumption, clothing and housing.

4.3.1.2. Physical and mental health. The way in which rural and urban dwellers perceived and dealt with health problems did not differ greatly. However, while males migrating to the city continued to trust both folk and modern therapy, females tended to believe more in modern medicine when living in Dakar.

Three areas of medical concern were studied in particular: (i) precursors of coronary heart disease (CHD); (ii) anemia; and (iii) infectious diseases.

(i) Little difference was observed between rural and urban populations for most of the precursors of CHD measured except

that urban dwellers had higher levels of cholesterol and the males smoked more cigarettes.

(ii) Anemia was more common in the rural area in both sexes.

(iii) Malaria, intestinal parasites, and pulmonary tuberculosis were more prevalent in the rural sample. Schistosomiasis was quite common in both the urban and rural samples.

4.3.1.3. Adaptation to the environment. It appeared that the group comprising single young women had more difficulty than either single or married men adapting to urban life.

The Senegal Collaborative Study illustrates the fact that urbanization in Africa is a "push" rather than a "pull" phenomenon, the majority of migrants escaping from the poverty of rural living rather than being pulled in by the availability of employment. The urban development that may be expected as a consequence of the establishment of work centers for the Gambia River development dams will differ from the regular flow of rural dwellers to the cities only in that the availability of employment for the men will be greater. At first there will indeed by a "pull" phenomenon. This will cease with completion of the work, but the work town, if it remains, will continue to attract people to it after the job opportunities end. There will be increased unemployment and, as a consequence, higher crime rates, less education, and probably lower community health status.

4.3.2. Construction Phase

The working conditions created by the establishment of a dam construction authority in any of the Member States will necessitate the importation of labor. As job opportunities become advertised, unskilled labor will stream to the construction site from within the country as well as from neighboring regions, including Mali, Guinea-Bissau, and Mauritania. Needless to say, Senegal, The Gambia and Guinea will supply labor to each other.

The increase in local density of the population and the invasion of essentially sylvatic ecosystems will exacerbate the health problems cited elsewhere in this report (see section 4.2). Unless there is careful planning, initial living conditions will be up to the transplanted

individuals. There will be crowding with its inevitable high incidence of respiratory conditions and tuberculosis. The Balingho and Kekreti dam sites are in a region of meningitis epidemics which seasonally thrive in situations of population congestion. In the case of the Balingho area, there is already a scarcity of water for house use. Combined with absence of sanitary facilities, this will cause an increased frequency of enteritis, poliomyelitis, amebiasis, and bacillary dysentery. The possibilities for seeing a cholera epidemic would seem good. The massive arrival of immigrants will cause housing problems, and increases in rents and food costs. The fringe population not directly employed by the construction authorities will undergo employment instability as well as unemployment. The predominance of single men in the labor population will encourage prostitution and consequently high incidences of venereal diseases.

4.3.3. Resettlement

The resettlement of large populations in the path of advancing waters has always been a bête noire of governments, largely because the activity is apt to be badly managed, and many economic and health consequences tend to be unanticipated.

The size of the population to be affected may be grossly underestimated. In the case of the Akosombo Dam that created Lake Volta, the original estimate of population to be resettled was 50,000 but the final figure was 80,000. The original cost estimate for this was £ 4 million but the final expenditure was £ 13 million. On the other hand, the immigrants who can expect profit from the aquatic resources of the new lake are now estimated at over 80,000 and their fishing villages, uncomplicated by many health regulations, are thriving along the banks of the lake (Waddy, 1975).

A somewhat different story came out of the resettlement at Kainji Dam in Nigeria. There was plenty of land available close to the old villages, among people of the same ethnic groups and with well-established market systems already well-known to the displaced communities. The population density of the country, both east and west of the southern half of the dam, was extremely low and in fact, a 3,000

square-mile game reserve was established to the west without the need to resettle a single village. Around the northern half of the lake the population density was about 20 per square kilometer. The largest town to require resettlement was Bussa, with 3,000 inhabitants. New Bussa was built to service the dam labor force and became the resettlement area; it was only 50 kilometers from the old town. In spite of the fact that resettlement at Kainji was relatively simplified, many mistakes were made including a complete neglect of sanitation in the new villages, ineffective well-digging, and failure to build new roads. The complete inaccessibility of the new villages hampered many activities.

In the Gambia River Basin, resettlement in The Gambia does not appear to be considered, and in Senegal the population density around the Kekreti area appears to be relatively low. Nevertheless, at Kekreti, the best bottom land will, as usual, disappear under the lake and it is not immediately obvious where the people so displaced will go.

On the Zambezi River the effort to resettle 22,000 Batonka pastoralists away from the developing Kariba Lake and back to certain ancestral homelands involved considerable preparatory work, including the following:

- Construction of 962 miles of new permanent access roads, together with the cutting of hundreds of miles of tracks for vehicle service routes;
- Construction of 20 dams and sinking 233 borehole wells in the new settlement areas;
- Provision of motor transport for the people, their possessions, their grain and their livestock;
- Construction of a hospital and a chain of clinics in the new areas;
- Supply of reserve grain stores amounting to seven bags of maize per family, to provide food pending the reaping of the first crops in the new areas;
- Building a new administrative station strategically placed at the edge of what was to become the new lake, to oversee water transport for communications along the lake shore;
- Initiation of an intensive tsetse fly control program by airborne application of insecticide, in order to render resettlement areas habitable by people and cattle;

- Removal of trees and bush from large tracts of future lake basin in order to facilitate eventual establishment of a fishing industry in the lake utilizing gill nets.

All of this was accomplished with minimal human casualties.

Regretfully, the attempt to move the Northern Rhodesian Tonga was less peaceful, one tribal group resisting a detachment of police with spears, resulting in a number of predictable casualties.

5. MITIGATION AND MANAGEMENT

5.1. Current In-country Responsibilities

The three Member States deal in a basically similar fashion with provision of health services to the population. The pattern of services is based on (i) tradition (read, colonial practice); (ii) public demand (mostly in the case of catastrophic events such as highly visible epidemics of yellow fever or meningitis); and (iii) budgetary constraint.

All Member States maintain a health infrastructure comprised of professionals and paraprofessionals. All provide treatment of clinical disease on an individual basis if the individual is able to get to a treatment center. Preventive medicine is provided by maternal and child health (MCH) clinics, immunization programs scheduled systematically in terms of time and demography (at least on paper), and organized insect and rat control services in the large urban centers. The concept of primary health care, promoted at the Alma-Ata Conference of 1978 and now supported by the World Health Organization, is accepted by all Member States, although the degree of implementation of the concept varies from country to country.

The ratio of budgeted health expenditures to the national budgets appears to be from 3 to 7 percent in the Member States. Most of it is subsumed by treatment of clinical disease, personnel salaries, and maintenance of physical plants. The budgets seem to be always inadequate and certainly lack the elasticity that would permit in-country control of natural disasters such as epidemics. Faced with such crises the health authorities must have recourse to international aid or to the private, voluntary sector. The Gambia's yellow fever (YF) epidemic of 1978-1979, which produced 8,400 YF cases and 1,600 deaths, was the occasion for delivering 546,000 vaccinations with 17D vaccine, representing coverage of approximately 95.5 percent of the estimated 1978 population. Management of this catastrophe was clearly beyond the resources of the Gambian government. The Gambia's Ministry of Health was eventually assisted on this occasion by the Center for Disease Control (USA), USAID (USA), ORSTOM (Senegal), the Medical Research Council Laboratories (The

Gambia), the Medical Research Establishment (Great Britain), and the Virus Research Laboratory (Nigeria).

As indicated elsewhere, the proposed development activities of the OMVG in the Gambia River Basin will probably promote heightened transmission of certain water-related diseases. Under present conditions of budgetary allocation, the several governments will probably be unable to respond in a timely fashion to the health needs that will result. Moreover, it is quite likely that they will be unable to react even given sufficient time to prepare, since the percentage of the national budget at present subsumed by the health establishment appears to be fixed. If 3 to 7 percent of GNP does indeed represent the extent of the social commitment to health, new health challenges created by development projects may remain unaddressed by the ministries. This is admittedly speculative, but points up the need for early liaison and planning sessions between representatives of OMVG and those of the countries' health delivery infrastructure. Such meetings would define the health role and responsibilities of OMVG in the context of the extensive ecological disruptions that will accompany river resource development.

5.2. Mitigation Measures

An array of interventions is presently available in water-borne disease control. In this report, the criterion for identifying them must be a history of dependable performance assessment under field conditions.

The nature of an intervention depends on the etiological agent and its life cycle which vary considerably from parasite to parasite although all those treated herein are water-related. Certain broad-scale interventions affect transmission of many infections and thus should receive priority attention from planners; the categories include principally environmental sanitation, the installation of safe water supplies, and health education. Other measures, including chemoprophylaxis and vector control, are specific and must be tailored to the epidemiological characteristics of the infection.

There is considerable experience with control programs for malaria, schistosomiasis and onchocerciasis. Chemotherapeutic interventions exist for many of the subject parasites. Yellow fever yields to mass

vaccination. The water-borne and water-washed diseases often recede before the advent of improved standards of living, notably improved water supplies and sanitation.

The most vexing of the water-related health problems facing authorities in the Gambia River Basin is onchocerciasis in Senegal and Guinea. No widely acceptable drug is yet available for this infection and control is still dependant on attempts to eradicate the vector blackflies.

Table 5.1. compares the relative importance, in highly subjective terms, of the methods generally available for the management of the diseases listed in section 3.1.

5.2.1. Water Supply Improvements

The following discussion is based on Feachem, McGarry and Mara (1977).

In most, if not all, low-income communities in hot climates, water-related infections are major causes of morbidity and mortality. A selection of the most outstanding of these diseases is the basis for the discussion in section 3.1 of this report. These disease problems will respond to improvements in water quantity, quality, availability and reliability. The cost to the community of the burden of these diseases comprises part of the savings envisaged by making water supply improvements (see below).

Recent statistics prepared by the World Health Organization depict the rural population of 91 developing countries at the end of 1970 comprising 72 percent of the total. Importantly, 86 percent of this rural population were judged to be without "reasonable access to safe water." In Africa, the number and percentage of people lacking such access were, respectively, 136 million and 89 percent. It is assumed that the last figure is applicable to the general condition in the Member States and the Gambia River Basin.

These figures indicate a problem. The solution to the problem lies in efficient and rational resource allocation and planning for water supply developments. All of the developments proposed for the Gambia River Basin lie in rural, relatively undeveloped areas. Resource allocation and planning would therefore appear to devolve primarily on the development planners and, specifically, on the construction

TABLE 5.1.

RELATIVE IMPORTANCE OF GENERAL METHODS AVAILABLE FOR THE MANAGEMENT OF THE MAJOR DISEASES ASSOCIATED WITH WATER AND DISCUSSED IN THIS REPORT

	Vaccination	Water Supply	Sanitation	Drug Prophylaxis	Vector Control	Health Education
Cholera	++	++++	++++	-	-	++++
Typhoid	++++	++	++++	-	-	++++
Bacillary dysentery	-	++++	++++	-	-	++++
Amebiasis	-	++	++++	-	-	++++
Poliomyelitis	++++	++++	++++	-	-	++++
Scabies	-	++	+++	-	-	+
Ringworm	-	+++	+++	-	-	++
Trachoma	-	++	+++	-	++	+
Yaws	-	++	++++	+(?)[a]	-	++
Guinea Worm	-	++++	++++	-	++	++++
Schistosomiasis	-	++++	++++	+(?)[b]	+++	++++
Malaria	-	+++	-	++++	++++	++++
Yellow Fever	++++	+++	-	-	++++	++++
Dengue	-	+++	-	-	++++	++++
Onchocerciasis	-	++++	-	-	+++	++++
Filariasis	-	++	-	++++	++++	++
Hookworm	-	+	++++	-	-	++++

NOTES: Graded on a subjective scale where: ++++ = Most important; +++ = Highly important; ++ = Very important; + = Important; - = Not important.

a) Possibility that the widespread use of penicillin for other infections has resulted in a certain amount of control of yaws.

b) Drug prophylaxis of schistosomiasis is proposed but still essentially experimental.

University of Michigan, Gambia River Basin Studies, 1985.

contractors who will be expected to provide suitable living and working conditions for the laborers. Such resources will include not only the water supply but also the financial and human resources needed to design, implement and maintain a water supply program. The goals and prerequisite conditions for such a program are summarized in Table 5.2. The list attempts to be chronological: immediate benefits are identified first and the presumably, longest term benefits last.

In general, the fundamental aim of water supply improvements for low-income communities, as well as newly developed supplies intended to serve construction camps, should be to reduce the cost of water to the consumer. Such cost includes: (i) any cash payment made to the water authority, to the standpipe owner, to the water-carrier or vendor, etc.; (ii) the value of the time and energy expended in collecting water wherever the individual lacks water supplied to the dwelling; (iii) the cost of sickness related to the use of polluted water, to the use of insufficient water or to diseases acquired in the course of collecting water.

5.2.1.1. Anticipated water supply problem at Balingho. Although the above discussion is aimed primarily at the provision of potable, safe water for domestic use, it is noted that the mechanics of construction, particularly the manufacture of vast quantities of cement, will create a priority demand for freshwater in large volumes. In Senegal and Guinea it is feasible to utilize river water for this purpose but the river at the Balingho site in The Gambia contains seawater.

During the initiation of construction activity on the Balingho barrage, the population in the nearby villages will increase beyond the support capacity of the present services. Farafenni, which is currently experiencing shortages of water, is also expanding so rapidly that it will be difficult to cope with new water demands. This is also true of Beretto, Bambatenda, Yellitenda and Genoi, Pakalinding, and Mansa Konko. The working borehole wells in Mansa Konko currently supply the government quarters and the health center with piped water. Yellitenda receives some of this supply. But Bambatenda, on the opposite side of the river, does not enjoy the same facilities: on the right bank (where construction site service quarters will presumably be located) all water supplies are obtained from either concrete-lined or traditional wells,

TABLE 5.2.

WATER SUPPLY IMPROVEMENTS IN RURAL COMMUNITIES:
GOALS, POTENTIAL BENEFITS, AND COMPLEMENTARY INPUTS

Goals	Benefits	Complementary Inputs or Prerequisite Conditions
Immediate	Improve water: quality quantity availability	Active community participation and support; competent design; adequate facilities for operation and maintenance; appropriate technology utilized.
Stage I.	Save time Save energy Improved health	New supply used in preference to old; New supply closer to dwellings than old; Water use pattern changed to take advantage of improved quantity, availability and reliability; Hygiene changed to utilize improved supply; Other environmental health measures taken; Supply must not create new health hazards (e.g., mosquito sites).
Stage II.	Labor release Crop innovation Crop improvement Animal husbandry innovation and improvement	Good advice and extension services must be provided by government personnel concerned with agriculture, animal husbandry, cooperatives, marketing, education, credit, etc.
Stage III.	Higher cash incomes Increased and more reliable subsistence Improved health Increased leisure	Water supply development must be just a single component of an integrated rural development program which has the active support of the local community.

University of Michigan, Gambia River Basin Studies, 1985.

which have a tendency to go dry in drought years. At Bambatenda a brisk business is done by water vendors who either cross on the ferry from Yellitenda or fetch water from Beretto or Farafenni.

Sinking many new borehole wells may exhaust the already fragile acquifer and lead to extensive seawater intrusion. If this occurs it can be reversed only by recharging with rainwater, which is likely to be a prolonged process in view of the recent scarcity of rains in this region.

5.2.2. Mass Chemotherapy

Individual case management of specific diseases is the responsibility of the attending physician and has no place in the present discussion.

Mass chemotherapy, however, can be a major weapon in combating certain infections if the drugs are nontoxic (except against the parasite) and free of distressing side effects. Table 5.3. lists the 19 water-associated diseases which are targets for discussion in this report and identifies the drug of choice. Also listed is a comment on the utility of employing mass chemotherapy in the control of the disease.

The use of chloroquine in the prophylaxis of malaria is highly effective and widely used throughout the malarious world. A serious problem, however, is the fairly rapid evolution of drug-resistant strains of parasite, particularly drug-resistant Plasmodium falciparum. These strains have now appeared in East Africa and have extended westward as far as Ivory Coast. It is expected that drug-resistance may appear in Senegal and The Gambia in the very near future, at which time the utility of chloroquine as a prophylactic will vanish and recourse will be had to other drugs which may not serve so well in the program of mass prophylaxis. Chloroquine may be entrusted to the hands of the village health worker in the primary health care programs.

With regard to schistosomiasis, metrifonate has been used in pilot studies. It has the advantage of being relatively cheap to purchase. A disadvantage is that the procedure involves three doses with 20-day intervals separating the doses. In smaller communities with effective social control there would seem to be a definite place for metrifonate on a mass basis. Since it does not protect against reinfection, repeated doses will always be required in order to measure a "permanent" effect on the community.

TABLE 5.3.

UTILITY OF MASS CHEMOPROPHYLAXIS FOR THE DISEASES LISTED IN SECTION 3.1 OF THIS REPORT

Disease	Drug of Choice	Is Use of Mass Chemotherapy Warranted
Cholera	Broad-spectrum antibiotics	No
Typhoid	Chloramphenicol	No
Shigellosis	Sulfonamides; tetracycline	No
Amebiasis	Metronidazole + Diodoquine	No
Poliomyelitis	None	No
Scabies	Benzyl benzoate	No
Ringworm	Undecenoic acid	No
Trachoma	Sulfonamides + antibiotics	No
Yaws	Penicillin	(a)
Guinea Worm	Metronidazole	No
Schistosomiasis	Metrifonate; Praziquantel	(b)
Malaria	Chloroquine	Yes
Yellow Fever	None	No
Dengue	None	No
Onchocerciasis	Diethylcarbamazine[c]	Yes[c]
Filariasis	Diethylcarbamazine[c]	Yes[c]
Trypanosomiasis	Pentamidine	Yes
Leishmaniasis	Pentavalent antimony	No
Hookworm disease	Levamisole; Thiabendazole; Mebendazole	No

NOTES: a) The widespread use of penicillin for a large array of diseases is thought to have had an unintentional effect on the incidence of yaws in Africa.

b) The use of mass chemotherapy of urinary schistosomiasis must be considered as still experimental; metrifonate does not protect against reinfection.

c) Success with diethylcarbamazine in mass chemotherapy depends upon obtaining good cooperation from the population.

University of Michigan, Gambia River Basin Studies, 1985.

Mass pentamidine prophylaxis has been used effectively on a very wide scale for the control of trypanosomiasis gambiense especially in the former French colonies, although it is now acknowledged that it cannot by itself eradicate the disease. It may be of greatest use in special situations, such as the protection of organized labor forces where a risk of infection exists.

Diethylcarbamazine has been employed against a variety of filariases, including Bancroftian filariasis and onchocerciasis. The effect of the drug is to destroy the circulating microfilaria and thus remove the individual as a source of infection to mosquitoes. Success with diethylcarbamazine in mass chemotherapy depends upon obtaining good cooperation from the population, which may be difficult in large communities. The entire population must be treated since it is usually impractical to determine all the microfilaria carriers at once. Since the side effects may be severe (anaphylactic reactions and itching) word-of-mouth warnings may keep a significant number of people out of reach of the program. It is important to note that the OCP has abandoned efforts to utilize diethylcarbamazine as a central tool of its control program in Africa.

5.2.3. Vector Control

The control of disease transmitters depends largely on alterations in the environmental and/or the use of pesticides. The water-based and water-related diseases (see sections 3.1.3 and 3.1.4) are carried by invertebrates (insects, snails and water fleas) that are susceptible of attack.

The specific vectors/transmitters include:

- The snails of schistosomiasis.
- The mosquitoes of malaria and filariasis.
- The mosquitoes of yellow fever and dengue.
- The blackflies of onchocerciasis.
- The tsetse flies of trypanosomiasis.
- The sandflies of leishmaniasis.
- The water fleas of dracunculosis.

5.2.3.1. Snails. Control is effected by poisoning with molluscicides and by bioenvironmental methods.

At present the molluscicide of choice is niclosamide (Bayluscide[R], Mollutox[R]). When used focally and periodically its practical cost/effectiveness has been widely established and can be very satisfactory. Rapid interruption of transmission can be obtained. Application equipment is usually simple and cheap. Application methods do not require special skills. Water-use patterns of the community dictate application sites but community participation in application programs is not essential and safety margins for man and domestic animals are wide.

Bioenvironmental methods may prove useful in specific localities but have not been universally applied. They include biological control and physical methods. (Genetic control methods do not apply to snail intermediate hosts in Africa.)

Biological control of snails is in its infancy. No particular method can be recommended for use in the Gambia River Basin, but many predators, parasites and competitors of aquatic gastropods have been described and research on their effectiveness under field conditions in the Gambia River Basin should be encouraged; of particular interest would be studies on predation by ducks and competition by introduced competitor snails.

Physical methods of snail control may often appear to be more environmentally acceptable than molluscicide application. Such methods may include increasing flow velocity in rice field feeder channels, putting such channels underground, fluctuating water level in rice fields, and eliminating ancillary habitats by draining, filling, or vegetation clearance.

5.2.3.2. Anopheline mosquitoes. Mosquitoes may be attacked in the larval or the adult stages. Larvae may be destroyed by intermittent drying of domestic water containers, larviciding appropriate water surfaces, intermittent drying, sluicing, and biological methods. Destruction of adult mosquitoes involves use of space spraying, and residual insecticide spraying. Source reduction (i.e., destruction of breeding habitats) may involve filling, small-scale drainage and other forms of water management.

Larvae are killed by applications of chemicals to the water so as to produce a continuous film on the surface which interferes with larval respiration or poisons it outright. The list includes mineral oils;

Paris green, chlorinated hydrocarbons (DDT, HCH, dieldrin); organophosphorus compounds (malathion, fenthion, dichlorvos, temephos); and carbamates (carbaryl, propoxur, landrin). The last three groups supply the bases for aerosol formulation or aerial powders utilized against adult mosquitoes.

Bancroftian filariasis is usually transmitted by the same species of mosquitoes that transmit malaria, and control measures aimed at the mosquitoes will reduce the incidence of filariasis.

5.2.3.3. Aedes mosquitoes. The mosquitoes that transmit yellow fever and dengue in urban settings are domestic breeders and can be attacked by the methods used against domestic-breeding anophelines. Sylvatic, tree-breeding Aedes, the transmitters of sylvatic yellow fever, have been attacked by aerial spraying, after target sites of suitably limited area have been identified, but this approach is probably not cost-effective.

5.2.3.4. Blackflies. Antivector operations directed by the OCP are in general directed against the larvae of Simulium using insecticides which are accompanied by no intolerable risks. The product in general use is temephos (Abate), but where resistance to this compound has developed a second organophosphorus product, chlorphoxime, has been used. Separately, an agent of biological control has been employed where resistance to both chemicals has developed. This is the bacterium, Bacillus thuringiensis, serotype H-14. It is ecologically attractive, being quite innocuous for mammals and nontargeted aquatic fauna, but is twice as expensive as temephos and, depending on location, can be six times as expensive. Moreover, use of H-14 is incompatible with very elevated stream velocities such as occur during floods.

Antilarval agents are disbursed in pulverised form from low-flying aircraft. This is necessary because of the inaccessibility of many larval sites by road in relatively undeveloped territory.

5.2.3.5. Tsetse flies. Rupture of the man/tsetse contact can be done by destroying tsetse breeding habitat, removing its food supply, or killing adults with insecticides. Alternatively, methods that have apparently been effective in the past without proper documentation include removing man from the environment or by large-scale alteration of

the environment. In the past the method most resorted to has been forcible translocation of populations by colonial authorities.

Human trypanosomiasis does not now seem to be a problem in the Gambia River Basin. Control methods, if a decision is made that they are desirable, can be either chemical or biological. The main chemical control depends on aerial application of insecticides to resting-site vegetation. Dieldrin requires only a single application. Other products such as endosulfan or decamethrin require two or more applications for adequate control. Biological control methods include vegetation associates which are the flies' habitats; bush clearing is effective but must be maintained with vigilance in African areas. Other methods, including use of predators or parasites, or release of sterile male flies, have yet to reach a point where they are widely applied in practice. The sterile male technique is likely to be most effective, if put to the test, to eradicate the dangerous low-density residual populations of tsetse that may survive insecticide applications.

5.2.3.6. Sandflies. Sandflies are very susceptible to insecticides of all types and these can be applied to known resting or breeding sites. The use of personal repellants such as dimethyl phthalate is warranted. House-spraying is of course ineffective if the sandflies in question prove to be exophilic.

5.2.3.7. Water fleas. Prevention is merely a question of protecting drinking water from pollution by guinea worm patients. Cyclops are killed by raising the temperature of the water in which they live by a few degrees. The addition of a trace of potash (potassium carbonate or potassium hydroxide) to the water is equally effective. Wells may be treated every two weeks with bleach (sodium hypochlorite).

5.2.4. Health Education

This subject is generally considered to be "difficult" in the sense that demonstrable proof of the effectiveness of health education in order to justify the cost is not easy to acquire. At the same time it may be "safe" since community education is a frequent goal of development programs and the health component may require minimal justification.

In rural Africa, where literacy levels are low, the term health education refers to influencing the community decision making process as

it is brought to bear on health matters. Extensive use is made of visual aids such as flannelgraphs, photograph boards, and even cinematic techniques. In this sense the French word animation, with the connotation of both stimulation and inspiration, should be substituted for education.

The techniques of rural animation are specialized. In the health sphere, close liaison is obviously required with health authorities. Yet the cost burden of animation rurale is likely to fall on the Ministry of Education rather than on the Ministry of Health.

To the extent that animation rurale utilizes health expertise yet is predicated upon community comprehension and cooperation, the participation of the primary health care worker may figure importantly in the overall picture.

5.3. Management Schemes

The present report identifies certain diseases that will accompany proposed dam construction in the Gambia River Basin. Foremost among them in terms of importance are schistosomiasis and malaria in all Member States and onchocerciasis in Senegal and Guinea. Management strategies for dealing with these entities have been developed in other countries. The following section treats the management of these diseases largely from a systems viewpoint. It is to be noted that priorities differ from country to country. The elements of a management scheme will be tailored to the specific locale.

Discussion of the management of the other diseases cited in the present report is not exhaustive and is discussed in Section 5.2. The diseases are seldom candidates for control campaigns except under epidemic conditions. Water-borne and water-washed diseases (Sections 3.1.1 and 3.1.2) will recede or disappear nonspecifically with improvements in environmental sanitation and personal hygiene. In the absence of such measures the diseases in question are dealt with on an individual basis. Some among them, such as cholera, typhoid and poliomyelitis, will succumb specifically to mass immunization.

Anti-vector strategies effective in malaria control are also useful in combating the mosquito-borne viruses (yellow fever and dengue) and Bancroftian filariasis.

Sleeping sickness and the human leishmaniases are not current problems in the Gambia River Basin and there are no current strategies for their control. Thus specific mitigative measures cannot be cited here. For the record, however, it may be helpful to note that elements of any management scheme will necessarily include vector control (Section 5.2.3.5) and individual or mass chemotherapy and/or prophylaxis (Section 5.2.2).

5.3.1. Schistosomiasis

Schistosomiasis management comprises four components:

- Chemotherapy.
- Snail control.
- Sanitation and water supply.
- Education (animation rurale).

The decision to utilize any or all of these components in a management scheme requires consideration of the pattern of transmission, the kinds of snails involved in local transmission, the magnitude of the affected human population, and the logistic feasibility, all of which bring to bear on the cost-effectiveness of the scheme. It should be noted that management schemes employing more than one or all of these components would seem to have a better chance of measurable success than use of only one component. It is also imperative to take into consideration the degree of commitment of the established health delivery system toward the goals of the scheme since it is unlikely that any large-scale control project, which must be viewed as long-term, can maintain momentum without the support and cooperation of the government and the official medical establishment.

5.3.1.1. The Gambia. At the present the principal source of transmission in The Gambia occurs well away from the river in seasonal ponds on the laterite plateau, in URD and MID. Transmission is seasonal; the infecting water sources drying up with the advancing dry season. Construction projects proposed for the river are not expected to affect the established pattern of transmission; thus this disease remains the responsibility of the country health authorities and should not devolve upon the OMVG because of its activities.

However, two potential schistosomiasis problems in this region will result from planned developments and thus will entail OMVG

responsibility. The first involves the Jahaly Pacharr swamp development scheme; the second is the possible spread of schistosomiasis mansoni in and near the main river after construction of the Balingho barrage.

Inhabitants of the Jahaly Pacharr scheme area are engaged in groundnut cultivation and subsistence agriculture. Most population centers ar located on the main highwa. The fields are essentially rain-fed and under current conditions only a small amount of water from the river is applied to a few hectares of rice paddy in the immediate neighborhood of the former CDC project as improved by the Chinese team in the 1970s. Wells provide most of the water for domestic purposes. The population seems to be stable with little immigration or out-migration. Nutrition and literacy levels are low.

- Jahaly Pacharr irrigation scheme

The Balingho barrage is expected to permit addition of about 24,000 hectares of farmland along the river in areas now inundated by seawater tides. Further, a major increase in the size of irrigated rice holdings up-river will be developed, the rationale for the development of the Jahaly and Pacharr swamps. These swamps are located about six kilometers from each other on the left (south) bank of the Gambia River in MacCarthy Island Division. The Agricultural Station at Sapu is situated between the two swamps.

The Jahaly swamp (with an area of about 1,230 ha) is intersected by creeks fed by the river. Leftover works of the failed Colonial Development Corporation include flood protection dikes, a sluice gate in the Jahaly bolon, and improvements on the main creeks. The gate in the bolon still eliminates the tidal effect. In the dry season only the larger creeks and some low-lying land are flooded. In the rainy season much of the swamp is inundated but flood protection still functions in the vicinity of the old Colonial Development Corporation scheme. Upland runoff thus is now drained via the Sare Samba Sumalem swamp.

The Pacharr swamp (about 1,190 ha) still has about 10 percent of its area covered by forest. There are small pumping schemes serving an area of about 80 ha situated near the river on both sides of the Pacharr bolon. Flood protection works were never installed here and water enters the swamp during high tide. Drainage is prevented because the creeks have not been improved.

Tidal water is fresh at this level. Among snails collected in the vicinity of the Colonial Development Corporation works in the Jahaly area were two potential transmitters of urinary schistosomiasis, Bulinus globosus and B. truncatus guernei. It is expected that both species will be able to flourish in irrigation schemes in greater numbers than now seem to barely exist.

Table 5.4. lists the kinds of human activities and points of man/snail contact in irrigation projects that may require attention. Table 5.5. lists the physical measures that are available for reducing the prevalence and incidence of schistosomiasis. A major assumption is that there will be a local increase in population accompanying the augmented Jahaly Pacharr scheme.

- The Gambia River as a habitat for schistosome snails

At the present time the Gambia River is not a suitable habitat for the snails of intestinal schistosomiasis. The snails of urinary schistosomiasis are to be found in it but in extremely small numbers, and associated with the mouths of bolons and creeks which are blocked by vegetation.

The conditions imposed by the Balingho barrage will permit the development of pondlike conditions along the river such as now exist in some of the larger bolons. The snail, Biomphalaria pfeifferi, is already established in the Simoto bolon, east of Basse. There is a good possibility that the development will permit the extension of this snail to the river wherever flow is reduced and water plants can grow up.

Such an eventuality would constitute the basis for a greatly increased incidence of intestinal schistosomiasis among the people residing beside and using the river. This kind of development has occurred in other countries, such as Ghana and Nigeria, although the impoundment conditions were not comparable to those expected in the Gambia River.

The spread of Bulinus globosus and B. t. guernei is easier to predict. The genus Bulinus is characterized by its robust nature. The species in question are able to utilize a greater range than Biomphalaria of physical limits, such as depth, speed of current, and relative oxygenation of the water. They will colonize the river.

TABLE 5.4.

HUMAN ACTIVITIES AND POINTS OF HUMAN/SNAIL CONTACT IN IRRIGATION PROJECTS

Human Activity	Human Snail Contact Points
Irrigation of fields	Standing water in fields
	Manipulating siphons from secondary (field) laterals
Maintenance of irrigation system	All canals and drains
Washing; personal, laundry, dishes[a]	Laterals (secondary), drains, rivers, sidepools
Recreation	Sidepools, rivers, canals, main lateral
Obtaining (fetching) water	Laterals (secondary), drains, rivers, sidepools
Drinking water	Laterals (secondary), drains, rivers, sidepools
Residuals disposal:	
Personal	Fields, drains, laterals (main and secondary), river
Garbage	Drains, laterals (main and secondary), river
Livestock management	Floodplain of river, sidepools, ponds, swamps

SOURCE: Rosenfield and Bower. "Management Strategies for Mitigating Adverse Health Impacts of Water Resources Development Projects," Progress in Water Technology, 11 (1/2): 285-301, 1979.

NOTE: a) If domestic water is separately supplied, there could be less of a problem for disease transmission.

University of Michigan, Gambia River Basin Studies, 1985

TABLE 5.5.

CLASSIFICATION OF PHYSICAL MEASURES FOR REDUCING THE PREVALENCE OF SCHISTOSOMIASIS

I. Reducing Human Contact with Snails

A. Reducing snail habitats snail habitats and/or snail populations

1. Mollusciciding

a. all habitats
b. focal (treating only habitats which are known transmission sites, e.g., which human contact occurs)

2. Constructing mechanical screening at diversion point to prevent entry of snails into irrigation system

3. Lining of main canal

4. Draining standing water in fields and from main canal and laterals

5. Vegetation/silt removal from main canal, laterals, drains

6. Introducing predator or competitor species

7. Piped transport of water to secondary laterals

8. Increasing efficiency of irrigation

B. Modifying human activities

1. Provision of domestic water supplies by standpipes in courtyards

2. Provision of laundries

3. Provision of showers

4. Provision of swimming pools

5. Protection[a] of water recreation sites

6. Location of canals and drains away from existing settlements

7. Provision of boots for irrigators and irrigation system maintenance workers

8. Provision of latrines and garbage disposal sites in closer proximity to villages than canal, laterals, drains

9. Protection[a] of animal grazing areas

II. Medically Treating Population with Drugs (Chemotherapy)

A. All infected population

B. Specific segments of the population (i.e., heaviest egg passers, 0 to 14 year olds)

SOURCE: Rosenfield and Bower. "Management Strategies for Mitigating Adverse Health Impacts of Water Resources Development Projects," Progress in Water Technology, 11 (1/2): 285-301, 1979.

NOTE: a) Protection in this context means physically restricting access to or egress from the area, such as by fencing.

University of Michigan, Gambia River Basin Studies, 1985.

Management of this situation, should it arise, will be problematical but measures are available (see section 5.3.1.4.). In general terms, such management will exact its greatest toll in costs for professional personnel not now available to work in the rural areas that will be most affected by the changes.

5.3.1.2. Senegal. Transmission occurs in seasonal ponds and slow streams. Man-made sites include rice fields and, to a limited extent, small impoundments. Proper management must address the problem of locating transmission sites before other measures can be brought into play. As in The Gambia, transmission is seasonal and focal. Construction of the Kekreti Dam will create an ecological situation resembling that produced in Lake Volta and Lake Kainji. Conditions will exist for an explosion in numbers of snails, particularly in juxtaposition to human settlements. It is predicted that *Bulinus truncatus guernei* will become the principal pest. *B. globosus* would also be a candidate for this position, but the experience in Lake Volta was at variance with the prediction (*B. globosus*, widely expected to become a serious health menace, remained localized whereas *B. truncatus rohlfsi*, barely recognized in the area before the impoundment, assumed the proportions of the major transmitter). *Biomphalaria pfeifferi* can be found, although rare, even during the most severe of dry seasons in Senegal Oriental. Its numbers are probably controlled at present by the annual droughts and the elevated temperatures. Although not as robust as *Bulinus* it is confidently expected that conditions favorable to it will come into existence in the Kekreti Lake.

The management of schistosomiasis in Lake Volta has been a vexing and unsatisfactory business. After a decade of research efforts by the World Health Organization, originally backstopped and eventually inherited by the country health ministry, the problem still persists. It is now agreed that snail control along the entire Lake Volta shoreline is impossible but that focal control of cercarial transmission at water contract sites may be promising.

Assuming that a parallel event occurs in the Kekreti Lake, a similar response would be indicated. Management would have to be by means of focal snail control and by chemotherapy of all infected persons. Consideration would have to be given to investment and maintenance costs

for trained operators, engineers, and physicians, in addition to local workers. Using the experience in Lake Volta as a paradigm, control would be necessary because the disease would be highly visible and people would complain about it, but at the same time it is expected that costs might be restrained if the problem were identified and acknowledged at an early stage in the life of the project.

5.3.1.3. Guinea. Although intestinal schistosomiasis is widespread in upper Guinea, there are few data on its occurrence in middle Guinea in the region of the Gambia River Basin. It is believed that impoundment of the Koulountou River in connection with the Kogou-Foulbe Dam might permit an increase in the populations of some snails in surrounding areas, since these would be expected to benefit from the perennial availability of water in the impoundment and the possible accompanying irrigation schemes. It should be noted, however, that the water is relatively free of the cations necessary for building shell and that the mollusk fauna of the Koulountou River seems to be relatively depauperate.

In the event that mitigation measures are required for a schistosomiasis problem generated by the impoundment of the Koulountou, recourse must be had to the list of physical and chemical measures identified in Table 5.5.

It is believed that schistosomiasis could be an unlikely consequence of impoundment of the Gambia River at the Kouya and Kankakoure sites in view of the low human population density in the region and the apparent unsuitability of the water for mollusks.

5.3.1.4. Management procedures for schistosomiasis. Table 5.6. illustrates possible sets of physical measures to reduce schistosomiasis prevalence in a water resource development area. Stress is on irrigation schemes. The sets include measures which are tried and true as well as some which have been rarely tried. The qualitative estimates of cost and effectiveness derive from past projects in other areas of Africa.

Schistosomiasis management will require input from external agencies as well as national health delivery structure and local communities. All should be involved in project planning. National as well as external donor agencies will probably provide project financing and any construction or installation necessary (piped water, cement linings for canals, etc.). If the local community authorities are excused from

TABLE 5.6.

SELECTED SETS OF PHYSICAL MEASURES FOR REDUCING PREVALENCE OF SCHISTOSOMIASIS: QUALITATIVE MANAGEMENT REQUIREMENTS, COSTS, AND EFFECTIVENESS

	Physical Measures Used	Management Requirements	Costs	Effectiveness in Reducing Schistosomiasis
Set I	No physical measures explicitly for schistosomiasis.	None	None	None
Set II	Mollusciciding all sites.	Trained operators, local workers	Low investment, high maintenance costs	Low
Set III	Chemotherapy for all sites.	Doctors, local workers	Low investment, high maintenance costs	High short-term; low long-term
Set IV	Chemotherapy for all infected persons; mechanical screening at diversion point; drainage facilities; vegetation and silt removal; improved irrigation efficiency.	Doctors, engineers, local workers	Medium investment, medium maintenance costs	Medium
Set V	Focal mollusciciding; provision of domestic water supplies; protection of water recreation sites; provision of boots for irrigators and irrigation system maintenance workers; chemotherapy for specific segment of infected population.	Trained operators, engineers, doctors, local workers	Medium investment, medium maintenance costs	Medium

University of Michigan, Gambia River Basin Studies, 1985.

Table 5.6. (con't.)

	Physical Measures Used	Management Requirements	Costs	Effectiveness in Reducing Schistosomiasis
Set VI	Mollusciciding all sites; mechanical screening at diversion point; drainage; vegetation/silt removal; provision of domestic water supplies, laundries, and showers; provision of latrines and garbage disposal sites; targeted chemotherapy.	Doctors, engineers, trained operators, local workers, health educators	High investment high maintenance costs	High

SOURCE: Rosenfield and Bower. "Management Strategies for Mitigating Adverse Health Impacts of Water Resources Development Projects," Progress in Water Technology, 11 (1/2): 285-301, 1979.

University of Michigan, Gambia River Basin Studies, 1985.

financial considerations at this level, they will be closely involved with the national authorities in the operation of an antisnail campaign, maintenance of the achieved sanitated state, and cooperation of age groups targeted for chemotherapy. Project monitoring would be a responsibility of the national authorities (see Table 5.7.).

5.3.2. Malaria

Malaria control relies on chemotherapy and vector control. Technology permits a choice of interventions in each category. The World Health Organization has identified four levels of malaria control intervention, designed to accommodate the full range of gradations of national commitment to control malaria. Each level is designed to yield the maximum level of protection against the burden of malaria, using all currently available human and material resources. The levels have been termed the "Tactical Variants" (Bruce-Chwatt, 1980; USAID, 1982).

Tactical Variant I has as its goal to reduce and prevent mortality due to malaria by chemotherapy. This variant will be used in areas with a high prevalence of malaria, severe clinical illness and high death rates, low socioeconomic status, and limited experience in the administration of malaria programs. This level of activity is expected to be most generally applicable in Africa south of the Sahara, including the areas of the Member States proposed for dam construction.

Tactical Variant II has as its goal to reduce and prevent both mortality and morbidity by chemoprophylaxis as well as treatment.

Tactical Variant III, in addition to reducing mortality and morbidity, seeks to reduce the prevalence of malaria by interfering with man/vector contacts.

Tactical Variant IV has as its goal the achievement of countrywide malaria control.

- Planning Principles:

  i) Chemotherapy: The principles for achieving reduction in malaria-related mortality in the Member States are:

  - To work with and strengthen the existing health delivery infrastructure in each country.

  - To work to extend primary health care (PHC) delivery to populations with demonstrated excess mortality.

TABLE 5.7.

IMPLEMENTATION INCENTIVES IN RELATION TO PROJECT ELEMENTS AND LEVELS OF AGENCIES INVOLVED IN SCHISTOSOMIASIS MANAGEMENT PROGRAMS

	External Agencies	National Agencies	Local Communities
Project planning	Provision of technical assistance; development of guidelines for analysis of impacts and of schistosomiasis management strategies	Promulgation of requirements for impact analysis and of guidelines for such analysis	Integral participation in project planning
Project financing; construction and installation	Specification by financing agency that financing is contingent upon: (1) explicit analyses be made of impacts on schistosomiasis; (2) local individuals who will be responsible for project O&M, including schistosomiasis management, be integrally involved in project planning; and (3) schistosomiasis management strategy by incorporated	Financing of potable water supply, laundry, waste disposal facilities	
Project construction/ installation		Provision of construction inspection by health authorities	

University of Michigan, Gambia River Basin Studies, 1985.

Table 5.7. con't.

	External Agencies	National Agencies	Local Communities
Project operation and maintenance		Provision of training to local individuals in O&M of irrigation system, including schistosomiasis management Provision of continuing health education program for target population Provision of free chemotherapy Provision of free molluscicide Payment of bonus for performance, i.e., based on snail population, degree of removal of vegetation/silt from canals	Prohibition by local ordinance of disposal of wastes in canals, laterals, river; prohibiting water recreation in canals, laterals, drains (as long as alternative provided) Continuation of program of persuasion by local power structure to induce compliance
Project monitoring		Provision of survey teams: (1) before and after mollusciciding (2) for random inspection of irrigation system maintenance (3) for random inspection of irrigation activity, e.g., to check on wearing of boots	

SOURCE: Rosenfield and Bower. "Management Strategies for Mitigating Adverse Health Impacts of Water Resources Development Projects," Progress in Water Technology, 11 (1/2): 285-301, 1979.

University of Michigan, Gambia River Basin Studies, 1985.

- To provide the most cost-effective intervention(s) to achieve the objective.
- To provide for ongoing assessment of logistics and outcomes (mortality rate in the target populations) in order to provide a basis for evaluation of the intervention.

- ii) Chemoprophylaxis: Morbidity reduction (part of Tactical Variant II) may be extended through the PHC system to carefully defined groups such as children aged 0-4 or pregnant women whose composition is centrally determined. A PHC system with an effective outreach is necessary.

- iii) Vector Control: All vector control measures may be employed at one point or another within a country but it would be rare and probably undesirable to utilize all of them at a single location. Vector control operations should be considered when the prevalence of malaria infection and incidence of morbidity and mortality are high in an area where it is politically or economically necessary to reduce the disease burden on the entire affected population, such as in a dam construction labor campsite. Major considerations in arriving at a decision to undertake vector control include:

  - Malaria prevalence, seasonal variations, area infected.
  - Vector species and breeding sites.
  - Vector density and number of infective bites.
  - Vector habits, including biting and resting patterns.
  - Susceptibility of vectors to insecticides.
  - Density, mobility and behavior of human population.
  - Type of housing and relation to breeding sites.
  - Cost of alternative interventions.
  - Availability of structures, personnel, funding, and management systems for implementation.

Serious consideration of insecticides requires specialized technical advice from the early planning stages of the construction project.

- Costs

Cost effectiveness of vector control depends on the method employed and the characteristics of the locality. In urban areas of Africa the

malaria prevalence may be low; source reduction or larvicidal attacks are practical and cost-effective. In rural areas of Africa where malaria is holoendemic, the only practicable method of effective vector control may be a program of residual spraying; this, however, will depend on the type of housing, as there is little to be gained by applying residual insecticides to mud walls.

Costs of chemotherapeutic approaches to management of malaria include not only drug costs but also the cost of ocean freight, storage, and transportation. If the program is privately financed, instead of being a government-supported program, there will be import duties.

There will be several manpower components of any control program, and all manpower costs must be identified and included in the initial cost proposal. Where malaria treatment is provided by PHC workers, the proportion of the cost of those workers' salaries which will be attributable to malaria should be decided in advance. A method of factoring in malaria control will depend on the methods used for compensating the PHC worker, i.e., whether by salary, community-sponsored donations of goods, or donated labor.

5.3.3. Onchocerciasis

One of the largest endemic areas of onchocerciasis in the world occurs in West Africa. The Volta River Basin, incorporating parts of Benin, Ghana, Ivory Coast, Mali, Niger, Togo, and all of Burkina Faso, has been the area of the Onchocerciasis Control Program (OCP) since 1975. Control is carried out by attacking the blackfly vector. Because many Simulium breeding sites are inaccessible by land, insecticide application is made by aircraft. Fixed-wing planes are used over large, open rivers; narrow, twisting waterways are reached by helicopter. The insecticide selected by OCP is the biodegradable Abate (temephos) which is highly effective against blackfly larvae, and of very low toxicity for man and nontargeted animals and plants. Follow-up epidemiological evaluation measures changes in incidence, prevalence and intensity of infection, and visual acuity in selected villages. Results in the Volta River Basin already show a reduced incidence of blindness associated with a reduction in transmission.

However, the sanitated area tends to be reinfested by new blackflies moving into the basin from the west. Countries which contribute to the

reinfestation include Mali, Senegal, and Guinea. These countries made an official appeal to WHO in 1977 to have the area of OCP operations extended westward, the so-called Senegambia Project. Later, the governments of Guinea-Bissau and Sierra Leone asked to be included in this project. An initial study was carried out by WHO (1979-1981) to improve knowledge of onchocerciasis in these countries and to develop from there a basic strategy for a new control effort. If implemented, the Senegambia Project will block the reinvasion of the Volta River Basin at the same time that it controls the disease in Senegal, Guinea and Mali.

However, as of this writing, the Senegambia Project, now well past the initial planning stage, has not been implemented.

The strategy of blackfly control is imposed by the present unavailability of a suitable drug for mass chemoprophylaxis.

An overall strategy proposed by the Senegambia Project envisions:

- Treatment programs directed toward individuals who risk blindness.
- Rehabilitation of the blind.
- Involvement of the primary health care system in <u>animation rurale</u>.

The first item is the only one in this list that is strictly international in its organization and management.

6. ECONOMIC IMPLICATIONS

6.1. Introduction

The economic implications of the health effects of river basin development arise from the changes that development will bring about in the environment and the population movements it will induce. The environment will be changed by impounding water behind dams, by irrigation schemes and by changing water flows from spillways. These changes will affect disease-vector habitats, thus the incidence of infectious diseases in the area populations. Construction activities associated with basin development plus new economic opportunities arising from development will concentrate populations in new areas, with concomitant health implications.

The costs or benefits of the health impacts of these environmental changes and population movements should be charged against or credited to the benefits of the Gambia River Basin development. This chapter identifies the costs and benefits that should be charged against or credited to basin development, estimates what some of the costs or benefits are, and suggests a strategy for mitigative measures.

6.2. Methodology for Evaluation of Economic Effects

The costs and benefits of the health impacts due to basin development should, in principle, be measured as the monetary values of the changes in health of the affected populations. However, satisfactory methods to place monetary values on all of the costs of poor health (notably, the pure utility losses of poor health and death, and productivity costs) have not been developed. Hence, a secondary method is used to approximate these costs and benefits: the costs of measures taken to mitigate the negative health consequences of basin development.

This analysis takes the narrow view that basin development should only be responsible (both economically and practically) for the incremental costs imposed by population movements. Where, for example, development causes a health problem that would ordinarily be treated by distributing a drug to the affected population through the primary health

care (PHC) system, the development should be charged only for the total cost of the drug plus any special training necessary for handlers, not for the creation of additional PHC centers. Where the development causes population displacements to areas not served by the existing PHC network, the cost of new construction would be charged against the development, but not the cost of staffing and supplying of the new PFC centers. These costs would continue to be a part of the responsibility of the national government.

In addition, the individual basin development activities (barrage construction at Balingho, dam construction at Kekreti and at three sites in Guinea, and irrigation development in MID in The Gambia) are separable and health costs of each will be presented separately, so that each may be analyzed economically as an individual development intervention.

Finally, for the economic accounting of benefits and costs, it is not necessary for the proposed health interventions to be actually undertaken. If they are undertaken, the public health impacted by the development of the basin will become stabilized or will improve. If they are not undertaken, the public health will certainly deteriorate. The economic value of that deterioration is approximated by the unspent cost of the proposed mitigating measures. In either case there will be an economic cost for health which is approximated by the costs of the mitigating measures. The cost can be assumed by special funding measures originating with national governments, OMVG, or special donors. But when the mitigative measures are not undertaken, the health costs of the basin development will be borne directly by the populations themselves.

6.3. Integrating Strategy of Mitigative Measures

A strategy for public health in the basin is presented here which assumes that some entity (national governments, OMVG, or donors) will fund mitigative measures for the health effects of basin development. As noted above, economic costs of the health effects of the basin development will arise whether or not the mitigative measures are funded. Financial savings will accrue to funding agencies if they do not undertake the measures, but costs will be passed on to the populations which will go unprotected from the health effects of basin development.

Hence, all of the costs presented in this strategy should be charged against the economic benefits of the development activities, regardless of whether they are actually undertaken.

The strategy presented here has been designed to integrate health costs that should be charged against the development, to identify the magnitude of those costs, and to suggest how the mitigative measures might be organized. Costs were estimated using the best available data. The proposed organization of mitigative measures corresponds to both the economic and practical assignment of responsibility for costs between basin development and the national governments, and among basin development interventions.

In the description of the strategy, summary costs of mitigative measures have been presented by intervention. In some cases, deficient information made accurate estimation of costs impossible. In all cases, however, the methods used for calculation of costs, whether complete or not, have been presented in further detail, so that calculations may be completed whenever additional information is obtained, or recalculation may be done whenever improved data are availabale. The objective was to give order of magnitude estimates rather than precise figures for these costs.

The only health benefit that is expected to arise from the development is a reduction in onchocerciasis transmission upstream from Senegal and Guinea dams. Since the effort to control onchocerciasis in the basin area is not yet in place, the financial gain from an avoided mitigative measure is zero. However, the cost of any future attempt to control onchocerciasis would be slightly reduced; for simplicity, this benefit will be omitted.

6.3.1. Assumptions

The strategy is based on the following assumptions about the health effects of the development activities:

- Only three major health problems are likely to arise from the environmental changes brought about by basin development, namely, malaria, schistosomiasis, and onchocerciasis. Specific mitigative measures need only be considered for these three problems, but the strategy should provide for the possibility of mitigative measures for the other effects (mentioned elsewhere in this report) which might arise.

- There will be no major in-migration to the area because of the basin development, beyond the construction and service populations (see Rural Development in the Gambia River Basin).

6.3.2. Strategy

NOTE: The assignment of mitigative measures to OMVG, national governments, and irrigation authorities in this strategy is made only in the form of recommendations. The recommended assignments represent what are felt to be the best arrangements from practical and economic points of view. Whether measures are actually undertaken by the recommended entities or by others will have little impact on the magnitudes of the costs calculated.

6.3.2.1. Health unit. The OMVG should establish a health unit (HU) to oversee health problems created by construction, service, and displaced populations and to assist administratively with the problems created for the current residents of the basin. The duties of the health unit would include:

- Identification for new health costs incurred by the displaced populations and, in particular, the need for new wells for drinking water and new primary health care (PHC) physical infrastructure.

Kekreti	wells and clinics cost	$58,883
Balingho	wells and clinics cost	83,325
3Gs (3 Guinea dams)	see coefficients	

- Assisting national Ministries of Health (MOHs) in public education (animation rurale) programs regarding area populations affected by malaria, schistosomiasis, and onchocerciasis.

  Kekreti, Balingho, and 3Gs: $120,000 (one time) and $150,000 annually.

- Training (if necessary) of national MOH personnel in care and prevention of malaria (PHC personnel) and schistosomiasis in the basin area.

Kekreti	$1,800 (one time)
Balingho	4,800 (one time)
3Gs	no data

- Arranging for payment (possibly through donors) for extra antimalarial and antischistosomal drugs, and focal mollusciciding needed.

Kekreti

antimalarials annual cost	$7,185
antischistosomiasis drugs annual cost	3,170
mollusciciding annual cost	11,175

Balingho

antimalarials annual cost	$57,598
antischistosomiasis drugs annual cost	25,164
mollusciciding annual cost	11,175

3Gs

no data

- Monitoring the possible development of and being prepared for the treatment of any of the other disease problems (e.g., trypanosomiasis) that might arise because of the basin development.

Annual cost $50,000

6.3.2.2. Construction contractors. The construction contractor should screen construction and service populations for: health problems; control of malaria (spraying dwellings, source reduction, chemoprophylaxis, and chemotherapy) and schistosomiasis (chemoprophylaxis of 5-14 year olds) in these populations.

Kekreti

screening cost (once)	$55,000
malaria spraying, chemoprophylaxis, and chemotherapy annual cost	2,930
malaria source reduction annual cost	5,000
schistosomiasis chemoprophylaxis annual cost	198
personnel annual cost	8,128

Balingho

screening cost (once)	$31,250
malaria spraying, chemoprophylaxis, and chemotherapy annual cost	3,335
malaria source reduction annual cost	5,000
schistosomiasis chemoprophylaxis annual cost	225
personnel annual cost	8,560

3Gs

screening cost (once)	$77,500
malaria spraying,chemoprophylaxis, and chemotherapy annual cost	4,129
malaria source reduction annual cost	5,000
schistosomiasis chemoprophylaxis annual cost	279
personnel annual cost	9,408

6.3.2.3. Health care systems. The MOHs should add antimalarial and antischistosome elements to their delivery packages for national health care systems in the basin areas. The national MOHs should establish a liaison with OMVG to pursue questions relating to training of personnel, financing of drug needs, and development of public education (animation rurale).

6.3.2.4. Irrigation health units. An Irrigation Health Unit (IHU) should be set up in The Gambia to handle the problems of schistosomiasis in the irrigated areas. It would: molluscicide the irrigation canals; treat cases of schistosomiasis as necessary; monitor schistosomiasis control in irrigated areas; and (possibly) alter the design of the irrigation system to minimize the threat of schistosomiasis.

Cost (per 1,000 ha)

antischistosomiasis drugs annual cost	$ 564
molluscicidiing annual cost	2,500

Cost (per 5,000 ha)

monitoring annual cost	$5,850

6.3.2.5. Onchocerciasis. Onchocerciasis should not be dealt with except within the framework of the proposed Senegambia extension of the Onchocerciasis Control Program (OCP), except for warning resettling populations away from endemic onchocerciasis areas. The latter should be done by the HU and the national MOHs as a part of the public education program. Ad hoc action on onchocerciasis in the basin would be ineffective and costly in the absence of a wider regional approach such as provided by the OCP.

6.4. Timestreams of Costs

The timestreams of costs of these mitigative health measures (outlined in the strategies) are summarized in Tables 6.1. through 6.5.

Table 6.1. (Timestream 1) shows the basin-wide costs of the mitigative measures, i.e. those that cannot be assigned to a specific development activity. Year 0 cost for public education is the cost of one year of expatriate assistance to set up public education programs in

the three countries of the basin. The recurrent cost beginning in year 1 is the cost of operating the OMVG Health Unit.

Table 6.2. (Timestream 2) and Table 6.3. (Timestream 3) assume that construction of the dam at Kekreti and the barrage at Balingho will each last five years. Populations used in year 0 are based on L.G. Colvin's estimates for 1985. Population growth in the two areas is assumed to be 3.0 percent per year.

Table 6.4. (Timestream 4) shows only costs of mitigative measures for the construction population. Data are not currently available to complete costs for other populations.

Table 6.5. (Timestream 5) is based on the projected "fast" and "slow" rates of irrigation development shown in the LRDC report.

Tables 6.6. through 6.13. provide further data on the methods for calculation of health costs.

TABLE 6.1.

OVERALL BASIN DEVELOPMENT HEALTH COSTS (Timestream 1)

Year	OMVG Health Unit	Public Education	Total
0	$ 0	$120,000	$120,000
1	50,000	0	50,000
2	50,000	0	50,000
3	50,000	0	50,000
4	50,000	0	50,000
5	50,000	0	50,000
6	50,000	0	50,000
7	50,000	0	50,000
8	50,000	0	50,000

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.2.

KEKRETI DAM CONSTRUCTION (Timestream 2)

Year	Construction Population[a]	Other Population[b]	Total
0	55,000	60,683	115,683
1	16,257	72,161	88,418
2	16,257	72,490	88,747
3	16,257	72,830	89,087
4	16,257	73,179	89,436
5	16,257	73,539	89,796
6	0	73,910	73,910
7	0	74,292	74,292
8	0	74,686	74,686

NOTES: (a) Initial screening cost for construction and service populations. Malaria and schistosomiasis protection for construction and service populations.

(b) Replacement of physical health and sanitation infrastructure for displaced population. Public education (animation rurale) of original population. Malaria and schistosomiasis protection for original population. Year 0 population = 1985 estimate; 3.0% annual growth.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.3.

BALINGHO BARRAGE CONSTRUCTION (Timestream 3)

Year	Construction Population[a]	Other Population[b]	Total
0	31,250	83,325	114,575
1	17,120	148,977	166,097
2	17,120	151,611	168,731
3	17,120	154,324	171,444
4	17,120	157,119	174,239
5	17,120	159,997	177,117
6	0	162,962	162,962
7	0	166,015	166,015
8	0	169,161	169,161

NOTES: (a) Initial screening cost for construction and service populations. Malaria and schistosomiasis protection for construction and service populations.

(b) Replacement of physical health and sanitation infrastructure for displaced population. Public education (animation rurale) of original population. Malaria and schistosomiasis protection for original population. Year 0 population = 1985 estimate; 3.0% annual growth.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.4.

3 GUINEA DAMS' CONSTRUCTION (Timestream 4)

Year	Construction Population[a]	Other Population[b]	Total
0	77,500	n/a	n/a
1	18,186	n/a	n/a
2	18,186	n/a	n/a
3	18,186	n/a	n/a
4	18,186	n/a	n/a
5	18,186	n/a	n/a
6	0	n/a	n/a
7	0	n/a	n/a
8	0	n/a	n/a

NOTES: (a) Initial screening cost for construction and service populations. Malaria and schistosomiasis protection for construction and service populations.
(b) Data not available; same formulas as for Kekreti and Balingho may be used.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.5.

IRRIGATION DEVELOPMENT (Timestream 5)

	Fast Rate[a]			Slow Rate[a]		
Year	Irrigation Health Unit	Schisto-somiasis Cost	Total	Irrigation Health Unit	Schisto-somiasis Cost	Total
1995	$ 5,850	$ 2,756	$ 8,606	$ 5,850	$ 1,838	$ 7,688
2000	11,700	15,619	27,319	5,850	6,431	12,281
2005	11,700	28,788	40,488	5,850	14,088	19,938
2010	17,550	42.650	59,200	11,700	21,744	33,444
2015	23,400	54,819	78,219	11,700	29,400	41,100
2020	29,250	67,681	96,931	17,550	37,056	54,606
2025	35,100	78,094	113,194	17,550	44,713	62,263

NOTE: (a) Rates from LRDC Report, Table 4.1.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.6.

PHYSICAL HEALTH AND SANITARY INFRASTRUCTURE RECONSTRUCTION

	Population Displaced[a]	Wells[b]	Cost[c]	Health Centers[d]	Cost[e]	Total Cost
Kekreti	10,600	21	46,662	11	12,221	58,883
Balingho	15,000	30	66,660	15	16,665	83,325
3Gs	n/a	n/a	n/a	n/a	n/a	n/a

NOTES: (a) All to be resettled in Kekreti and Balingho. Source: UM GRBS Rural Development in the Gambia River Basin report.
(b) 1 well per 500 people resettled.
(c) $2,222 per well. Source: AHT and HH, Ltd., Main Report.
(d) 1 health center per 1,000 people resettled.
(e) $1,111 per health center. Source: AHT and HHL, Main Report.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.7.

MALARIA AND SCHISTOSOMIASIS CONTROL AND SCREENING COSTS FOR CONSTRUCTION POPULATION

	Construction Population[a]	Service Population[b]	One-Time Screening Cost[c]	Malaria Control Cost[d,e]	Schisto-somiasis Control Cost[f]	Personnel Cost	Total Annual Cost
Kekreti	2,000	200	$55,000	$7,930	$198	$8,128	$16,257
Balingho	2,500	500	31,250	8,335	225	8,560	17,120
3Gs	2,800	300	77,500	9,129	279	9,408	18,816

NOTES:

(a) Source: L.G. Colvin

(b) Source: L.G. Colvin. Use high estimate of Balingho service population.

(c) $25 per person screened. Balingho to use local labor, so no screening of dependents or service population.

(d) $.071 chemotherapy per person in Kekreti and Guinea areas:

	% population	annual fevers	dose
0-12 years	37.8	3	2 x 150 mg.
13+ years	62.2	1	4 x 150 mg.

cost/150 mg: $0.015 (1982).

$.133 chemoprophylaxis per person in Kekreti and Guinea areas:

	% population	treatment freq.	dose
pregnant women	4.0*	1 x per week	300 mg.
0-5 years	18.0	1 x per week	75 mg.

*assumes women 15-44 years = 22% pop., CBR = 48, 10% preg. wastage.

cost/150 mg: $0.015 (1982).

$.071 chemotherapy per person in Balingho area:

	% population	annual fevers	dose
0-12 years	38.1	3	2 x 150 mg.
13+ years	61.9	1	4 x 150 mg.

cost/150 mg: $0.015 (1982).

$.135 chemoprophylaxis per person in Balingho area:

	% population	treatment freq.	dose
pregnant women	4.0*	1 x per wk.	300 mg.
0-5 years	18.5	1 x per wk.	75 mg.

*assumes women 15-44 yrs = 22% pop., CBR = 48, 10% preg. wastage.

cost/150mg: $0.015 (1982).

$1.128 spraying cost per person all sites:
cost of 50% tech. prod. wettable powder malathion: $2.50/kg. (1982).
sprayer cost: $100 (1982).
nozzle tips cost: $1.25 (1982).
application: 2 gm tech. prod./sq. m.
house surface: 250 ssq. m.
frequency: 2 x/yr.
density of pop.: 5 persons/house.

(e) $5,000 annual source reduction cost all sites.

(f) $.09 annual cost of schistosomiasis chemoprophylaxis/person/yr:
dose: 3 tablets metrifonate.
frequency: 3 x /yr.
cost of metrifonate: $0.01/tablet (1984).
the sum of malaria and schistosomiasis control costs = personnel costs.

SOURCES: Population structures: L.G. Colvin; control costs: USAID, Manual on Malaria Control in Primary Health Care in Africa, Washington, DC, 1982.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.8.

PUBLIC EDUCATION (Animation Rurale) COSTS

	One-Time Technical Assistance Cost[a]	Annual Cost[b]
Basin	$120,000	$ 0
The Gambia	0	50,000
Senegal	0	50,000
Guinea	0	50,000

NOTES: (a) One technical advisor to establish a public education (animation rurale) program in each country.

(b) Assumes economy of scale in operating three programs versus cost of $100,000 for a single program.

SOURCE: D.R. Foote, et. al., "Findings from the First Year Evaluation of the Mass Media and Health Practiced Project in The Gambia, Institute for Communication Research, Stanford University, December, 1983.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.9.

TRAINING OF NATIONAL MOH PERSONNEL IN MALARIA AND SCHISTOSOMIASIS CONTROL

	Health Centers in Area[a]	One-Time Cost of Training[b]
Kekreti	40	$4,800
Balingho	15	1,800
3Gs	n/a	n/a

NOTES: (a) 22 health facilities in MID.
18 health facilities in URD.
15 of 46 health centers in Senegal Oriental assumed in affected area.
n/a health centers in affected area of Guinea.
(b) 3 persons trained per health center.
$40 cost per person trained.

SOURCE: "Health Statistics 1981, Medical and Health Department, Health Statistics Unit, Banjul.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.10.

COST OF ANTIMALARIAL AND ANTISCHISTOSOMIASIS DRUGS AND MOLLUSCICIDING

	Population[a]	Antimalarials Cost[b]	Antischistosomiasis Drugs[c]	Number of Sites[d]	Mollusciciding Cost[e]
Kekreti	$ 35,220	$ 7,185	$ 3,170	75	$11,175
Balingho	279,600	57,598	25,164	75	11,175
3Gs	n/a	n/a	n/a	n/a	n/a

NOTES: (a) 6,000 sq. km. area around Kekreti
5.87 people/sq. km in Senegal Oriental (1985), L.G. Colvin.
155,100 people in MID (1985), L.G. Colvin.
124,500 people in URD (1985), L.G. Colvin.
N/A people in Guinea area.

(b) $.204 per person/yr. in Kekreti and Guinea areas; see Appendix 1b.
$.206 per person/yr. in Balingho area; see Appendix 1b.

(c) $.09 per person/yr. in all areas; see Appendix 1b.
50 schistosomiasis foci MID.
25 schistosomiasis foci URD.
75 schistosomiasis foci Guinea area.

(e) $149 annual cost of mollusciciding/site/yr., G. Barnish, "Evaluation of Chemotherapy in the control of Schistosoma mansoni in the Marquis Valley, Saint Lucia, II. Biological results," Am. J. Trop. Med. and Hyg., 31, 1982.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.11.

MONITORING OF DISEASE PROBLEMS IN THE BASIN

Item	Unit Cost	Annual Cost
Personnel		
Physician	$10,000	$10,000
Parasitologist	10,000	10,000
2 Lab Techs.	3,000	6,000
2 Drivers	1,500	3,000
2 Sec/Typist	1,000	2,000
2 Messengers	1,000	2,000
Equipment and Supplies		
2 4WD+parts[a]	$20,000	4,000
lab equipment[a]	20,000	2,000
lab supplies	1,000	1,000
office supplies	500	500
Rent		3,500
POL[b]		6,000
Total Annual Cost		$50,000

NOTES: (a) 5 yr. life for vehicles; 10 year life for lab equip.
(b) 15,000 km x $.020/km. x 2 vehicles.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.12.

IRRIGATION HEALTH UNIT

Costs per 1000 ha irrigation:

Treatment cost:

7.5 labor units per 2.0 ha irrigated rice.[a]
1.67 persons per labor unit.[a]
6,263 persons per 1000 ha.
$.09 cost of treatment per person per year
$564 treatment cost per 1000 ha.

Mollusciciding Cost:

$2.50 cost (1981) of treatment with Bayluscide per ha per year.[b]
$2,500 mollusciciding cost per 1000 ha.

Total Cost per 1000 ha:

$3,064

NOTES: (a) LRDC report, Table 4.1.
(b) A.C. Evans, "Schistosomiasis control in Southeast Zimbabwe," Am. J. Trop. Med. and Hyg., 32, 1983.

University of Michigan, Gambia River Basin Studies, 1985.

TABLE 6.13.

HEALTH UNIT COST PER 5,000 HA IRRIGATION

Item	Unit Cost	Annual Cost
Personnel		
Lab Tech.	$3,000	$3,000
Equipment and Supplies		
motorcycle[a]	1,500	500
lab equipment[a]	3,000	300
lab supplies	250	250
office supplies	100	100
Rent		1,200
POL[b]	500	
Total Annual Costs/5,000 ha		$5,850

NOTES: (a) 3 yr. life for motorcycle; 10 yr. life for lab equip.
(b) 5,000 km at $0.10 per km.

University of Michigan, Gambia River Basin Studies, 1985.

7. RECOMMENDATIONS

The following recommendations are based on certain assumptions: that the construction of dams on the Gambia River, with all that this will entail in terms of irreversible environmental changes, will take place; that OMVG will want to exert leadership in focussing on attendant health problems; and that national budgets as well as some development project funds will be devoted to preventing new disease outbreaks, controlling endemic conditions and possibly elevating the level of social commitment in each member state country with regard to health improvement.

- It is recommended that the technical staff of OMVG be augmented by employing a health specialist and assisting him, a surveillance supervisor.

It is clear that the decisions about where and when to build a tropical river dam must be based on the convenience of geographic, geological, technical, economic, and demographic concerns. Preoccupations with public health are important aspects of these concerns, since the purpose of building a dam is to promote social progress as well as to enable an increase of wealth to the society.

While it is realized that the tasks and responsibilities of the engineers are complex and difficult, and that they must be allowed freedom from as many extraneous considerations as possible, the role of the health professional may usefully take shape very early in the planning of a dam. Initially he must be prepared to exert influence during the stage of constructing a master plan, so as to assure medical security for the workers and other staff in place on the work site.

Subsequent to the departure of the construction contractors, country health authorities will be left with the responsibility for taking charge of new requirements for etiological, epidemiological and prophylactic surveillance of the country.

During the developmental and discussion stages of the dam building plan, it is desirable that health authorities be represented on any consultative committee that may be formed to assist project direction, on a footing equal with geologists, economists, agronomists, and ecologists.

Health needs could be most readily met by having a health unit added to the OMVG technical staff, manned by a health specialist who would be assisted by a surveillance supervisor.

The functions of the health unit should include:

i) Forming an initial liaison with the health authorities (e.g., Ministry of Health or its equivalent) with a view to sharing information and assisting in decision making;

ii) Preparing the necessary justification and dimension for such health interventions as are deemed needful by project managers, and presenting and explaining these matters to local health authorities;

iii) Establishing additional contacts with government entities responsible for social services tangential to health, such as veterinary extension services (e.g., Ministry of Agriculture), or water supply (e.g., Ministry of Rural Development);

iv) Planning, coordinating, and analyzing a nutritional surveillance system such as recommended in this report (see Appendix I.).

- It is recommended that a long-term program of health surveillance be mounted in each of the member state countries.

The data provided in the present report represent summaries gleaned from the literature. In many cases the sources consulted were not current and in most cases, information was incomplete.

However, sound planning requires access to sound data. In the course of the present survey the need for a well-organized, long-term health study in the field, in each of the member states, became apparent. The performance requirements will be different in each country, so such surveys should be mounted country by country, to obviate problems of logistics, supplies, political realities, and financial transactions. Standardized reporting methods should be adopted.

Examples of such surveys that have been successfully mounted in the past include the epidemiological studies captained by Dr. A. Buck in Chad, Peru, and Afghanistan. If such complete studies could be designed and performed in the member state countries of the Gambia River Basin, they would assist OMVG by establishing a sounder numerical basis for the magnitude of needed health interventions, as well as a more reasonable approximation of costs than is conveyed (perhaps) in the present report.

Such surveys would be long-term in concept (minimum of two years, in order to take into account the vagaries of the West African drought on water-associated infections) and expensive. If the need for such surveys

is accepted, OMVG should be in a good position to spearhead the organization, management, leadership, and funding. By utilizing the health unit of the OMVG technical staff as an intermediary between funding agencies and scientific staff, a large degree of standardization of reported data could be achieved.

- It is recommended that OMVG prepare a position paper outlining the dimensions of its proposed interventions in the field of public health, which will serve as a guideline to dam construction planners and contractors as well as to host country health authorities.

The quality and extent of medical services that might be required to resolve the most serious health problems affecting the member states cannot be provided out of current revenues.

It is predicted that dam construction will cause a deterioration in an already low state of national health. An influx of development money will probably be viewed by host governments as an opportunity to start up control programs and health services that would otherwise remain only recommendations in health sector reports To the degree that the health interests of OMVG and host country coincide, national authorities will understandably be willing to defer to OMVG which will initially control the funds.

However, the health interests of OMVG are more restricted than those of the host country, which they parallel as they supplement. The dam constructors will be working with a contract that requires them to provide health services to employees and staff. The host country will also benefit from vector control programs and immunizations and, after the work is finished, will inherit permanent installations such as hospital buildings and clinics. They will not, of course, become automatically enabled to staff and finance these new installations, unless those responsible for the country's health engage in considerable preliminary budget planning in advance of termination of construction and departure of the contractors.

It is the purpose of this recommendation to point out that there could be room for misunderstanding and eventually substantial disagreement unless the dimensions of OMVG's health interests are defined early, their intents formulated and coordinated with country health authorities, and the ultimate source of medical and health authority in each country pinpointed.

- It is recommended that a regional workshop in vector identification be organized within the framework of the health unit of the OMVG technical staff, possibly under the sponsorship of USAID.

The public health segment of the GRBS was essentially a one-man literature survey involving minimal fieldwork. Consequently, opportunities for counterpart participation, as requested by OMVG and offered by other teams through the UM/USAID/OMVG Host Country counterpart Training Program, were not readily apparent.

It was believed, however, that some level of technical input was desirable, given the proposed involvement of OMVG technical staff personnel in the health areas. In early 1983 a proposal was advanced under Task 2 ("Supplemental Field Research") of the Work Plan (Working Document No. 4) to organize and present a training course for member state technicians that would involve francophone technicians in recognition and identification of the important water-borne disease vectors of the upper basin.

The work plan proposal (page 94) was singled out for approval in the minutes of the May 1983 meeting of the OMVG Ad Hoc Work Plan Review Committee. At this time it was proposed to make use of the upcoming "window" on the weather that would be available during the early dry season of November 1983 through January 1984.

During the period between May and November, the approval of some of the involved health authorities was secured and some of the participants were even provisionally designated (from Guinea), but the matter of funding for the project was not resolved and consequently, the workshop did not take place. There were no funds in the GRBS budget available for diversion to this project nor was it clear that the health budgets of the member states were prepared to become involved in defraying the cost. It is nevertheless a highly desirable project and should still be pursued even though the GRBS project is now ended.

An outline of the proposal, defining the dimensions of the coursework and attempting to guess at the cost, is presented in Appendix II.

- It is recommended that consideration be given to establishing a health information retrieval system for the OMVG Technical Staff and others.

The present report was based, for the most part, on literature obtained from library centers in Banjul and Dakar. Source documents were

photocopied as they were uncovered. The resulting collection of bibliographic references makes up the bulk of the citations listed in the Bibliography.

Although the participation of the GRBS has now ended, the health interests of OMVG will continue to develop.

It is hoped that the new headquarters of OMVG will provide space and technical services for accessing and classifying the health-related documents that were collected during the course of this work and which remain the property of OMVG.

- A suggestion has been made that the OMVG laboratory to be established might serve in health monitoring work and possibly vector studies. For this the laboratory would have to be re-equipped. As presently conceived, it is geared only for carrying out studies in water analysis and riverine ecology. Its equipment, from the University of Michigan project, is not suitable for health work with the possible exception of the dissecting microscope. It is not recommended that the laboratory be asked to assist in health monitoring before considerable attention could be given to identifying and purchasing new equipment, a task that would have to be consigned to the person or persons eventually asked to do the work.

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APPENDIX I.

A FOOD AND NUTRITION SURVEILLANCE SYSTEM FOR THE GAMBIA RIVER BASIN

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DEFINITION OF KEY TERMS

Surveillance — An ongoing process to monitor that gains in income and/or food output are reaching the most nutritionally needy population. It evaluates progress and allows for early warning of unforeseen negative impacts in order to make any necessary revisions in management, inputs, activities and outputs.

Survey — Consists of a baseline and of an end of project survey which allow for a critical examination of the project design, its results and its effectiveness.

ABBREVIATIONS

DANAS	Division de l'Alimentation et de la Nutrition Appliquée au Sénégal
RNA	Regional Nutrition Agent of DANAS
CRS	Catholic Relief Service
PPMU	Planning, Programming and Monitoring Unit of the Ministry of Agriculture, The Gambia
MEPID	Ministry of Economic Planning and Industrial Development, The Gambia
MLGL	Ministry of Local Governments and Lands, The Gambia
CDA	Community Development Assistant of the MLGL
PPNS	Programme de Protection Nutritionelle et de Santé, Senegal (similar to CRS in The Gambia)
ORANA	Organisme de Recherches sur l'Alimentation et la Nutrition Africaines

I. OBJECTIVES

OBJECTIVES OF THIS REPORT

At the request of CRED, the consultant stayed in Gambia for four weeks starting March 19, 1984. Her work is to be part of the CRED/University of Michigan assessment of environmental impact for the Gambia River Basin Studies (GRBS), which assumes that the dams of Kekreti and Balingho will be built.

The terms of reference given to the consultant were stated as follows:

> To develop a methodological approach to monitoring the nutritional status of the population in the Senegambia portion of the Gambia River Basin. The primary target population will be those affected by the transition from rainfed to irrigated agriculture in the Basin. The approach to be developed will incorporate nutrition surveys and evaluations of nutritional status. The Gambia River Basin Development Organisation (OMVG) will be expected to conduct the monitoring effort after the GRBS has been completed.

The consultant has therefore critically examined the possible food and nutrition impacts of this project by an extensive literature review and contacts with concerned organizations in Banjul (see list of persons contacted in Annex A). Among the proposed mitigating measures, the consultant has described the one concerning surveillance of food availability and nutritional status in a detailed and operational manner.

OMVG can use the present food and nutrition surveillance proposal which only requires updating before it is implemented.

OMVG can also use this report in order to justify funding of a health unit. Surveillance and baseline information for evaluation should be started before the construction of the dams. OMVG should be the coordinating body for planning and for integrating the activities of the three states. To perform that role will require a health unit staffed by at least one public health expert and one surveillance supervisor; then, depending on the allocation of responsibilities among all participating organizations, if needed, the OMVG health unit can be expanded to undertake the surveillance itself.

OMVG OBJECTIVES

It is known that "inadequate nutrition is the most basic and difficult health problem amongst the inhabitants of the Gambia River Basin especially among children in rural areas" (UNDP, 1977:11). Thus, the governments of Senegal, The Gambia and Guinea have decided to assess the feasibility of harnessing the waters of the Gambia river by building two dams with the following objectives (UNDP, 1977):

Balingho dam: for salinity control;
to ensure fresh water upstream;
to provide fresh water storage for irrigation or domestic use.

Kekreti dam: to provide water for irrigation schemes;
to regulate the river water levels;
to generate electricity.

The overall goal of the Gambia River Basin Development Project can be assumed to be increasing food production and incomes to improve the level of living of the population in the Basin. The second national development plan food strategy for The Gambia also acknowledged that "a pressing objective would be to increase the low seasonal energy intakes of young children and pregnant and lactating women for their current 60-70% of requirements to at least 80-90%" (The Gambia, Food Strategy Report, Parts II & III, 1981). However, the formulation of quantitative objectives for the whole Basin cannot be done until baseline data are available, otherwise unrealistic objectives might be set, unnecessary ones included, and vital ones omitted.

The following food strategy outlined by The Gambia (The Gambia, 1981) can be used as a guideline for the whole Basin and should be given serious consideration by OMVG in planning its interventions:

> In general terms the long-term strategy for the improvement of nutrition must be the improvement in rural incomes such that families have the capacity to produce sufficient cereals and to buy those foods which supply those nutrients which cannot be home produced or could be bought more efficiently. In this context it is important to note again the sexual division of labour and income-earning work in the family in The Gambia; it is necessary to increase the incomes of women such that they can provide extra food to themselves and their children in addition

to that provided by the husband. In such circumstances that impact of education will be much more effective if the women have the capacity to procure nutritious foods. In addition to increasing food production and cash incomes, the availability of food in local markets should be increased which will meet the demand from those who are not self-sufficient. The long-term strategy should also include provision for seasonal factors, especially food shortages before harvest, and for deficiencies caused by occasional droughts. At the present time, there is insufficient information available to make a distinction between different target groups (geographical, ethnic or income) in the country on the basis of their nutritional deficiencies. Pregnant and lactating women and young children may well be an "at risk" group in all parts of the country, although the nutritional deficiencies of these groups cannot be entirely removed by increasing agricultural production or by altering its balance.

In the short run, attention should be paid to increasing production of cereals and groundnuts, by means of adaptive research, input, supply and improved marketing. Facilities for the improved processing of millets and sorghum should be introduced. The continued attention to improving groundnut production, e.g., by more adequate fertilizer application, should lead to nutritional improvements as the information on dietary patterns indicates. The improvement of millet and sorghum production might be attractive to producers if coupled with an improved marketing system.

Increases in the returns to women's work (by special extension, credit and input supply efforts) through improvement of the productivity of their crops, and a reduction in their dependence on heavy work (e.g., by partial mechanization of their tasks in fields, post harvest processing, swamp rehabilitation) will help to improve their nutritional status; it would be just as effective to reduce womens' energy expenditure as to increase their intakes.

These improvements in women's well-being would benefit their children as well in terms of providing more time for their emotional development and better nutrition in the form of, for example, oils for soups. The expansion of marketing and production facilities for grains would have some impact on the seasonal hunger problem and in this context the further development of a shorter duration cereal such as white maize might reduce the seasonal hunger gap.

A monitoring system whereby nutrition problems and programme impacts are detected might be considered. For different functions, monitoring systems exist already in several agencies: (i) food production levels by District Commissioners and the Ministry of Local Government for food aid purposes; (ii)

nutritional status of programme participants in CRS projects; and (iii) immunization levels by the Expanded Programme for Immunization in the Ministry of Health. These all might form the basis for an effective evaluation system, and indeed also for a direct input into the planning process.

Fish are important in the Gambian diet but the industry is delicately poised with regard to supply and demand and the marketing of fish inland and any strategy for increased consumption should be approached with care, drawing on past lessons. These include the introduction of a price policy and of expensive technology for processing. The small-scale approach to fish drying and smoking should be continued, together with the training programme to increase employment for Gambians in the fishing industry (The Gambia, Food Strategy Report, 1981).

II. SITUATION

SUMMARY OF MAIN PROBLEMS

The principal nutritional deficiency symptoms found in the Senegambian population are: low growth rate in children due to low energy intake combined with a high prevalence of gastroenteritis, malaria and parasitic diseases; anemia; and goiter.

The Gambian infant mortality rate in 1982 of 160 deaths per 1,000 live births (The Gambia, 1982:40) reflects the importance of the diseases mentioned above. Tembo (1979) attributes the fact that 50 percent of the children die before 5 years of age to malaria, diarrhea, malnutrition and respiratory diseases.

The unequal distribution of resources is reflected in the urban/rural gap: in 1972, the infant mortality rate was of 217 deaths per 1,000 live births nationally, but it was of 342/1000 in rural areas (Elmer, 1983).

ENERGY DEFICIENCY

> A review of evidence on the state of nutrition in The Gambia indicates that energy intake is just adequate on a per capita basis, although some deficits may occur for all groups in the wet season, after a poor crop season, or in isolated pockets of the country. At other times pregnant and lactating women and infants may have deficient energy intake. Protein intake appears to be satisfactory (primarily due to groundnuts augmenting the basic cereals), although young children and women may suffer deficiencies (The Gambia, Food Strategy Report Part I, 1981:27).

When considering aggregate (national) figures, calorie and protein requirements seem to be fulfilled: 105 percent of calorie requirements and 150 percent of protein requirements in The Gambia. In Senegal (Diourbel, Casamance and Kedougou), ORANA showed per capita energy intakes to be 99%, 87% and 78% of need, respectively, and for protein intakes 169%, 137% and 114% (The Gambia, Food Strategy Report Part I, 1981:21). These figures hide seasonal differences as the next section will explain.

In 1981, the World Bank (World Bank, 1981), was of the opinion that "without food exports, the food produced in The Gambia would be more than enough to feed its entire population normally."

The exported food consists mainly of groundnuts, fish and palm kernels. But even if food supply were sufficient on a national basis, the effective demand for food would still pose problems due to inequalities in purchasing power, in accessibility to food supplies and other socioeconomic factors. In addition, the presence of infections and parasites lower the absorption of food intake thereby influencing nutritional status. A typical example of a socioeconomic factor is that of the high water content of weaning food which is often blamed for the low energy intake in children, but this would not be a problem if it were not accompanied by the lack of time of mothers to cook several meals per day for children.

Some workers found that "hazardous access, lack of shade and poor environmental conditions make it impossible for women to bring their children with them to the rice fields. The health and nutritional condition of children under five is by no means improved when mothers are absent from home for sometimes 10 hours at a stretch. To expect rice farmers to spend more time and effort on rice cultivation will only accentuate this problem," (Phillips et. al., 1982:57). The following table illustrates the sudden increase in demand for work during the Navet season (July-October):

Although the problem of high water content in food for children should be addressed, education programs geared at increasing feeding frequency should also be planned with the time-factor of women in mind. The following comment summarizes the issue by showing the awareness by parents of the need for frequent feedings, but lack of time and of education or means to prepare nourishing meals:

> Most parents are aware of the need to frequently feed their children. Where porridge is cooked for breakfast it is common for a special bowl to be set aside for the youngest toddlers to eat at will throughout the day (Phillips, 1982:117).

TABLE 1

FAMILY LABOR

	Peanuts	Millet
I. NOR	70.5	260.0
II. TIORON	2,237.5	1,740.0
III. NAVET	6,424.5	7,331.0
IV. LOLLY	2,311.5	1,112.0
	11,044.0	10,443.0

SOURCE: CRED. Consumption Effects of Agricultural Policies: Cameroon and Senegal. Ann Arbor: CRED/University of Michigan, 1982. p. 190.

University of Michigan, Gambia River Basin Studies, 1985.

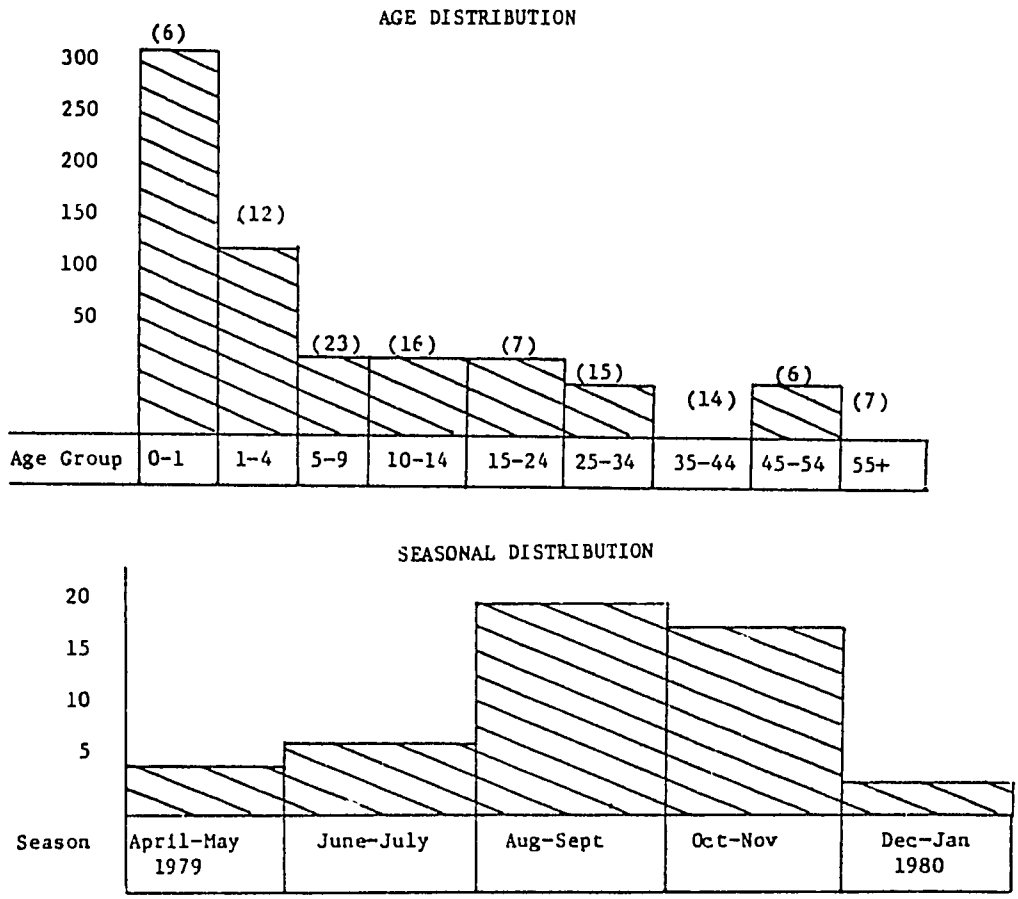
SEASONALITY

The effective demand as well as the supply of food are very low during the preharvest season (the "période de soudure"), when food stores from last year's supply are empty, and the morbidity increases due to the rains (see Figure 1).

The World Bank (1981:93) reported the MRC's finding that intakes of calories in Keneba were 20-24 percent less during the hungry season (July-September) than during the rest of the year. This problem of seasonality occurs throughout Africa; the OMVS already pointed out in their environmental impact assessment (GFCC, 1981:VI-26) that "the marked seasonality of food supply is reflected in the fluctuation of caloric intake. The highest caloric intake, from January through March, is nearly adequate (97 percent of requirements) and after that, caloric intake falls consistently through October when intake meets only 75 percent of the requirements."

FIGURE 1.

AGE DISTRIBUTION AND SEASONAL VARIATION IN COMPLAINTS OF DIARRHOEAL DISEASE



SOURCE: Phillips, Coles, and Seaman. Village Food Systems in West Africa. London: International African Institute. 1982:245.

NOTES: Figures in parentheses indicate total numbers in each group, as well as the rate of complaint of diarrhoea in different age groups and in different seasons of the year. Each attack of diarrhoea represents, so far as is possible, a single discrete attack of illness. Some of the attacks may represent relapses of a single continuous infection. Attacks of dysentry i.e., with mucus and blood, were very rare; these thus have not been distinguished from diarrhoea. The high prevalence of diarrhoea in children is expected as is the greater incidence of diarrhoeal disease during the rainy season.

WATER CONTAMINATION

Water is given to young children almost from birth. Counts of 10^3 of fecal coliforms per 100 ml were common in the rainy season in the wells of Keneba. Within one to five days of the first rainfall, contamination had increased 10 to 100 fold with counts of 5 x 10^5 per 100 ml recorded (Rowland, 1979).

These findings are confirmed by Barrell (1980) who reported that "village well water in Keneba was heavily contaminated; counts of fecal coliforms often exceeded 10^4/100 ml." Undoubtedly, the high prevalence of gastroenteritis in children is related to poor environmental sanitation, in which water contamination plays a large part.

Cole (197[illegible]) found that the average child had gastroenteritis 13.1 percent of the time, and malaria only 1.0 percent of the time. Gastroenteritis and malaria occurring when energy intake is low percipitate the deterioration of nutritional status. The MRC (Rowland, 1977) investigated "the relationship between the prevalence of nine different categories of diseases and growth to determine the quantitative contribution of the diseases to the growth faltering observed. There was a highly significant negative relationship between gastroenteritis and both weight gain and height gain. The only other disease category having a similar relationship was malaria, but in this instance only with weight gain."

OTHER PROBLEMS

Deficiency-induced anaemia (deficiencies in iron, folate and riboflavin) is prevalent and this may lead to miscarriages and even maternal and infant mortality at childbirth. Poor nutritional status among children is seen despite relatively favourable aggregate food availability and this appears to be caused by infections interacting with poor intake at certain times of the year (The Gambia, Food Strategy Report, Part I. 1981:27).

Intake data on vitamins and minerals showed that in Keneba (study by MRC), where the study is limited to pregnant and lactating women and infants, vitamin A, riboflavin and folate are deficient year-round and vitamin C deficient in the wet season. In the Senegal studies (by ORANA), riboflavin, folate and zinc are all deficient. The effect of prolonged

deficiencies of riboflavin is not well understood at the moment; lack of folate, on the other hand is known to contribute to anemia (The Gambia, Food Strategy Report, Part I. 1981:23).

Measles is a well-known child killer in Africa because of the interaction of infection and poor nutritional status. Immunization is a mitigating measure, and in The Gambia coverage is improving (see Table 2). The efficacy of the vaccine depends on the good cold chain and according to the Gambian Medical and Health Department (The Gambia, 1981:22), there is a lack of proper temperature monitoring. This is also the case in parts of Senegal.

RECAPITULATION ON THE MALNOURISHED: WHO, WHEN AND WHY?

Who?

Because of the nature of the work that will be undertaken by the OMVG program, the at-risk segments of the population can be identified as follows:

TABLE 2

IMMUNIZATION COVERAGE IN THE GAMBIA, 1979 & 1982
(Number Represents Percent of Target Population)

Antigen	1979	1982
DPT 1	71	91
DPT 3	40	80
Polio 1	35	89
Polio 3	6	69
Measles	42	71

SOURCE: The Gambia. Gambia MCH-EPI Evaluation, November 15-26, 1981. Banjul: 1982. p. 3.

University of Michigan, Gambia River Basin Studies, 1985.

- population groups to be resettled.
- population groups directly affected by the transition from rainfed to irrigated agriculture.
- population groups that will migrate to the GRB.

Within each of these groups, the already at-risk groups are:

- children under five years of age.
- pregnant and lactating women (World Bank, 1981).

This classification will be used when monitoring and/or evaluating the food consumption and nutritional status of the population in the Basin.

When?

The "période de soudure" precipitates the precarious balance that exists into acute malnutrition, increased morbidity and mortality. Since any other major change, in weather or population movements for example, could also make the balance tilt the OMVG needs to make sure that the changes its program will bring about will not be detrimental to the Gambia River Basin populations. Implementation of the proposed mitigating measures and setting up a surveillance system in case an unforeseen event happens, should prevent any negative impact.

Why?

The inequality in access to resources between rural and urban areas is exemplified in the following table:

TABLE 3

PERCENTAGE OF POPULATION HAVING ACCESS TO SAFE WATER (1973)
(in percentage)

Gambia	Banjul	Kombo St. Mary	Brikama	Mansa Konko	Kerewan	Georgetown	Basse
11.5	99.7	47.1	7.0	1.0	1.1	4.7	0.4

SOURCE: The World Bank. The Gambia: Basic Needs in The Gambia. Washington, D.C.: December 1981.

University of Michigan, Gambia River Basin Studies, 1985.

In general, poor nutrition is associated with poverty and also with change (J. Leonard); this is why the supply-oriented approach (i.e., increased agricultural production) must be corrected by emphasizing the importance of effective demand (access to food via income, roads, etc.), and social rather than technical solutions need to be sought. It is for

example as important to spread the benefits of a program as to generate them. Moreover, in order to improve nutritional status, a proper environmental sanitation program and an excellent vaccination coverage are necessary complements to any project aiming at increasing food supply and effective demand for food.

III. POSSIBLE IMPACTS OF THE OMVG PROGRAM ON FOOD & NUTRITION

RELATIONSHIPS BETWEEN FOOD PRODUCTION, CONSUMPTION & NUTRITIONAL STATUS

Figure 2 shows the many variables that can influence each of the elements of the food system. This is why increased food production does not necessarily translate into increased consumption or better nutritional status.

In Senegal, CRED (1982) found that "although food consumption was highly correlated with total income over a broad range of values, anthropometric measurements failed to highlight the same relationship." In Cali, Colombia, Bertrand et. al., showed that nutritional status was more related to environmental conditions in the neighborhood than to the family food intake, thus suggesting a more direct relationship between socioeconomic, environmental factors and nutritional status than between food intake and nutritional status. CRED also mentions the ORANA finding by Ndiaye et. al., (1982:169) that no correlation has been established between income and anthropometrically estimated nutritional status in rural Africa.

Figure 3 by Josserand (1984:29) who was involved in the CRED study in Senegal, shows the interfering variable to be accounted for before any inference can be made on the relationship between agricultural policy and nutritional status.

POSSIBLE IMPACTS ON FOOD SUPPLY

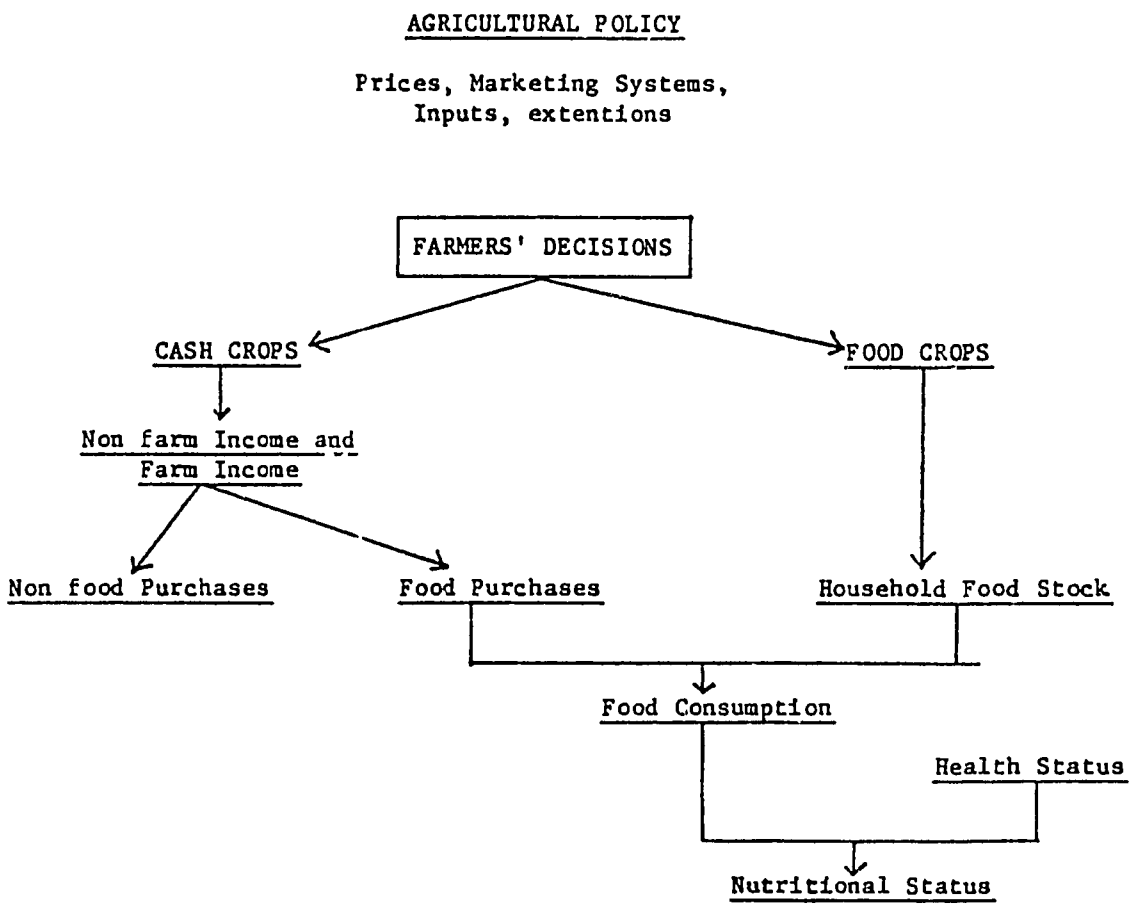
Food Supply

This will be affected differently at each phase of the OMVG program. During dam impoundment, resettled populations will need to be provided with food for about one year until their new land is cleared and productive. The AHT report recommends the adequate provision of 250 kg of cereal per person (AHT, 1983).

Although limited, the experience of the Jahaly Pacharr smallholder rice project should be sought when planning for food aid. Prior to

FIGURE 2.

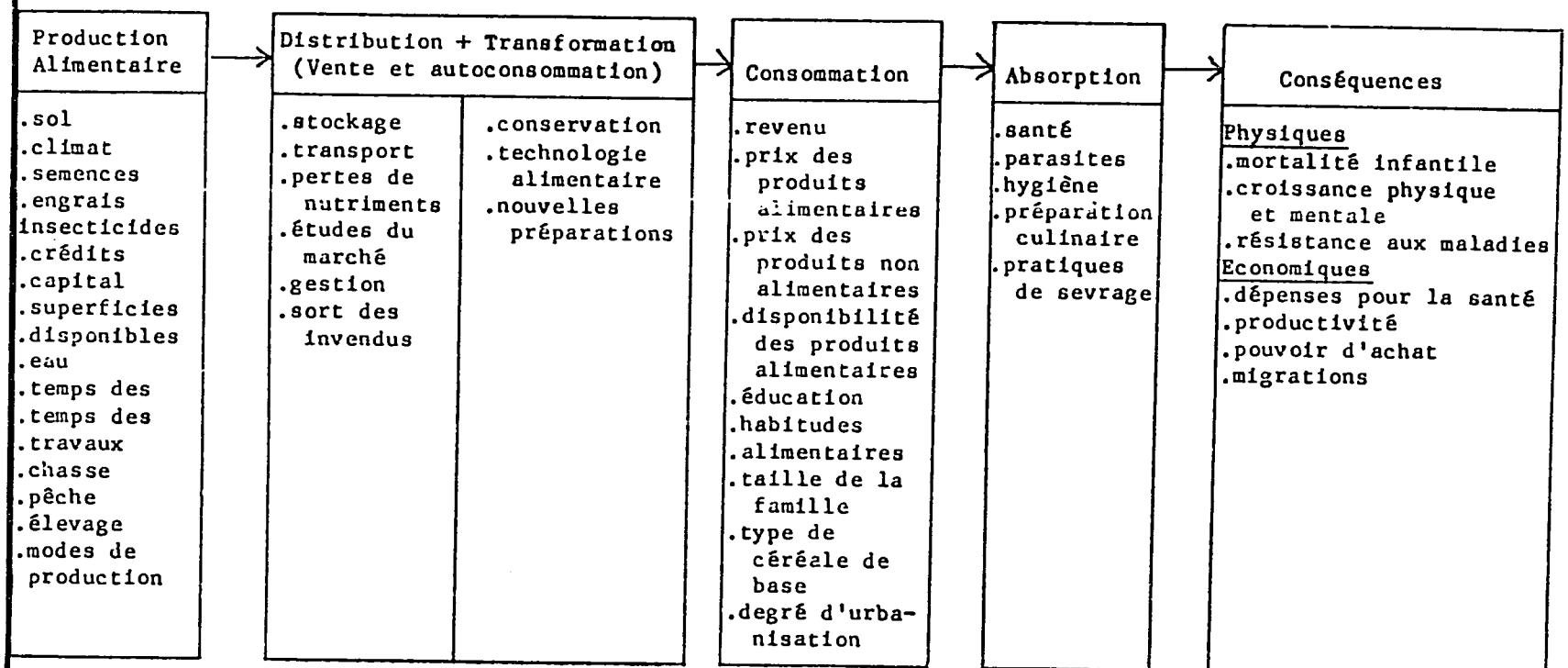
CONCEPTUAL CHAIN LINKING AGRICULTURAL POLICY
WITH NUTRITIONAL STATUS



University of Michigan, Gambia River Basin Studies, 1985.

FIGURE 3.

LE SYSTEME ALIMENTAIRE



La liste des facteurs influençant chaque étape du système n'est que partielle. Le but de cette systématisation est d'identifier les raisons du décalage entre production et consommation.

University of Michigan, Gambia River Basin Studies, 1985.

displacement of populations a careful account of the surface of land owned by each compound, family and individual will help in allocation of food aid. Prior to resettlement, areas that will be resettled should be provided with: i) boreholes; ii) reserve stores of grain; and iii) appropriate medical facilities.

There are two impacts affected during the irrigation schemes. First, during rainfed/irrigated compound holdings, irrigation will take place without fundamental changes in the existing farming system and the social setup. Rainfed cultivation, animal husbandry, swamp rice growing will be maintained and irrigated crop production will come in as a new production system (UNDP, 1977). Secondly, during irrigated compound holdings and irrigated mechanized farms, the switch to irrigated agriculture should only improve the production by providing the assurance of at least one crop per year.

The loss of cultivated land area during the construction of the irrigation schemes will require the constitution of cereal reserves to compensate for the loss of grain production during the conversion period.

Traditional Foods

These will probably be replaced by nontraditional foods. This is a pattern experienced in any urbanizing population and is due to the mixing of different ethnic and national groups as well as to better access. The following changes have been observed in an experimental unit near Koungheul in Senegal, where a small garden project was introduced (Marek, 1981): oil replaces peanut butter in preparing sauces; rice or maize replaces millet (although this depends on the amount of millet produced by the family); almost unknown to the rural population, bread replaces traditional breakfasts; coffee and tea consumption increase; fresh meat consumption increases with income; wild fruit and leaves are replaced by home-grown or market-bought vegetables and spices (although the drought, which decreased the number of trees, might also be responsible for this change); the more monetarized communities who have the means of getting to a market place will eat a larger variety of dishes and ingredients.

Rice versus peanuts? Considering that rice is an increasingly important item in the diet of the Senegambian population, demand for it

will increase and it is possible that the emphasis on rice growing in the Basin will lead to a reallocation of inputs from peanuts or other noncereal crop to rice. It is expected (Goode et. al., 1979) that "the successful implementation of this major project will cause a shift of power towards the rice farmer and away from the groundnut producer."

> To produce more rice will mean that more time and effort will have to be devoted to its cultivation. Without full mechanization of production EITHER the women who presently grow rice will have to work harder than before to the detriment of children's care and domestic duties OR their menfolk will have to devote their time and efforts to growing this crop. Unfortunately men cannot farm the swamps and the uplands simultaneously. (Transplanting of rice for example conflicts with early millet harvesting while rainfed rice must be harvested when groundnuts require most crop protection.) If men work on rice, upland cereal and groundnut production is almost inevitably going to suffer (Phillips, 1982:138).

The loss of peanut crops for rice crops combined with the urbanization process of replacing peanut butter by oil can only be detrimental to food intake since it means the loss of a good source of proteins. "Groundnuts are a key element in the economy, providing not only a valuable contribution to the local diet but the cash income and foreign exchange with which to purchase inputs and imported foods such as rice and, directly and indirectly, to sustain the service sectors and infrastructure of the economy. Plans to increase the production of food crops such as coos and rice (essentially an import substitution measure) should not be at the expense of groundnut production," (The Gambia, Food Strategy Report, Parts II & III, 1981).

Rice versus millet? The Diourbel study (Josserand, 1984) showed that among nonrice producers, "the village with the highest total income bought and consumed the least amount of rice, while the poorest village consumed both the lowest total amount of grain (millet plus rice) and the highest proportion of rice in total grain." The author attributes this to the fact that "millet is the traditional food, and is more nourishing than rice." The qualities of both grains have to be recalled here: "although millet stores very well on the whole or split panicle, it does not keep so well in grain form, and does not keep at all once it has been

ground. This requires that each day's supply be pounded or otherwise processed. Rice, on the contrary, is not grown in the area, and is less nourishing, but it keeps well in grain form and does not require long and taxing processing before it is cooked" (Josserand, 1984). The introduction of millet mills would help women greatly, especially since the milled flour is dry (as opposed to home-pounded flour which is wet), and it can keep at least one month as compared to a few days for wet flour. Although rice is lower in iron and protein than sorghum or millet, the advantages of one cereal over another cannot be weighed without looking at the overall diet; the diversity of the diet often compensates for the low content of one or two nutrients in one ingredient. Other considerations such as ease and cost of production are equally as important since they affect supply by farmers and marketers as well as demand by households.

In conclusion, it can be expected that rice consumption will increase in relation to other cereals. However, the following warning should be kept in mind by agricultural policymakers:

> Efforts need to be intensified to encourage production of low cost rice wherever possible, e.g., through greater utilization of land already available for irrigated production or with partial water control as in the case of swamp rice. Locally-produced rice is already sold at subsidized prices. However, unless unit costs are reduced by more efficient production, including higher cropping intensities, enabling economic charges to be made for water so as to cover recurrent costs of pumping and maintenance and replacement of equipment, increased rice production will exacerbate the country's difficult financial position and slow down overall economic growth (The Gambia, Food Strategy Report, Parts II & III, 1981).

Meat and fish. The loss of grazing land and its hypothetical replacement by rice straw might bring problems with livestock, thereby directly influencing milk and meat consumption in the area.

> In the Campleman report (FAO, 1977), it was estimated that the current level of fish consumption was about 24 kg/cap/year, ranging between 45 kg in the urban sector and 19 kg in the rural sector. In the riverine villages of Sankwia and Bureng, surveyed by the International African Institute, fish (smoked, dried, and fresh) contributed between 12 and 25 percent of the protein intake, depending on the season. Average per capita intake of fish was 15.5 kg per year. In upland villages fresh

> fish was not consumed in any significant quantity, but dried fish was present in two meals in every five throughout the year (The Gambia, Food Strategy Report, Part I, 1981:85).

According to the UM GRBS River Resources team (communication, Marion Var Maren), it is possible that migrating fish species and those requiring fast running water will disappear in the lake following impoundment, and predator fish species will be relatively less abundant downstream from the dam. However, above the Kekreti Dam, an increase in fish can be expected. Gannett Flemming (1981), estimated that in the Senegal River, the decrease in fish stocks in the estuary and the decrease in reproduction sites in the flooding plain will decrease the availability of fish.

Période de soudure. The période de soudure is characterised by the decreased diversity of food available between June and September, before harvest, when nutritional status deteriorates (see Annex B for an example of food availability throughout the year).

Irrigated agriculture should eliminate this difficult period since there will be no more reliance on rains. This might constitute the most influential impact of the project on food intake and possibly nutritional status.

The impact expected of such a change would mean a reduction in mortality rates of children below 5 years of age. It could also mean an increased work efficiency in adults since the période de soudure corresponds to the sowing, weeding and harvesting periods.

POSSIBLE IMPACTS ON FOOD CONSUMPTION

An often neglected aspect of food consumption, and one which affects children in particular, is the time-factor of women:

> One reason often given, both in The Gambia and Senegal, in part, explanation of the trend away from the consumption of millet and sorghum (coos) at home is the scarcity of milling machines, whether hand or pedal-operated or mechanically powered. Purchased rice, on the other hand, arrives in milled form and needs only boiling. Pounding is reported to be the most disliked form of work by many rural women. In Senegal, UNICEF is undertaking a program of providing and maintaining coos mills in rural communes. As far as rice is concerned, in

The Gambia, women commonly pay, often in kind, the equivalent of 10% of the value of rice to have it milled at local mills owned by local entrepreneurs (The Gambia, Food Strategy Report, Parts II & III, 1981).

Day-to-day work involving water, fuel fetching, processing, working in the fields, sale of goods and the preparation of several meals a day, leaves little time to women for special caring of children. Often a young girl is left in charge of caring for smaller children, under the supervision of an elder lady. It cannot be expected of women to become more educated, to wash, feed their children more often, to boil the water, to do more chores, unless effort is made to alleviate their work load and free some of their time.

The impact of the project should also be evaluated in this aspect by looking at the amount of time women spend in different activities, which activities have disappeared, which new ones were introduced.

According to the UM GRBS Wildlife/Vegetation team (communication, Dario Rodriguez), the time needed to obtain cooking fuel (wood) will not be increased since small trees that regenerate rapidly are now and will be used for fuel (Combretum, Acacia, Cassia and Pterocarpus species). In addition, if done, the clearing of land for the lake impoundment and for irrigated schemes will provide a stock of wood for the transition period. A soil management program similar to the Woodlots Project of the Gambian Department of Forestry, could be established around population centers and would provide fast regenerating wood along with edible legumes (used to regenerate soil nitrogen).

The increased production of rice, traditionally a woman's crop, might put more pressure on women's time due to field preparation, although it is also expected that men will participate more and more in rice cultivation.

The time needed to obtain water along with the availability of clean water are aspects of the program which will also have repercussions on food intake as well as on nutritional status.

The OMVG will have the responsibility to plan for the regular and sufficient supply of food to the population in the Gambia River Basin through the coordination of the production and marketing systems. OMVG must also coordinate the water development, forestry and appropriate

technology programs in order for those to be on schedule for the planned irrigated schemes and resettlements.

POSSIBLE IMPACTS ON HEALTH STATUS

So far we have considered only the influence of food consumption on nutritional status. The other factor influencing nutritional status is health status.

Concerning the resettlement phase of the program, "one of the major lacks associated with man-made lakes is the absence of baseline studies of disease and nutritional health among the relocatees before their removal...though it is not possible to document...there is good reason to expect that the transition period is associated with a higher death rate and with an increased incidence of disease. Factors supporting this interpretation include higher population densities in relocation areas, nutritional stress caused by inadequate food supplies, inadequate domestic water supplies and changes in the nature and incidence of disease" (Thayer, 1975:458).

IV. POSSIBLE MITIGATING MEASURES

In this chapter, we will be concerned mainly with mitigating measures that will influence food intake by affecting food availability, income and time availability, and those that will influence nutritional status by affecting environmental sanitation and health status.

AGRICULTURAL PLANNING

The OMVG's agricultural planners will need to evaluate the food requirements of the population in the Gambia River Basin based on population projections and food requirements; this information is available in Annex E. After the definitive Gambia River Basin development project is decided upon, the information of Annex E only requires updating and a multiplication operation to be used for planning purposes. Based on food requirements of the population, the planners will then adjust the food balance sheets (which include local production and imports-exports) to make sure that requirements of the local population are met.

This exercise will have to be undertaken each year and will serve as a guide for production targets.

Let me also repeat here that attention to maintaining the cultivation of peanuts for home consumption should be addressed carefully because "peanuts are rich in vitamins, minerals, energy and protein of which they provide lysine, a limiting amino acid in both millet and rice" (CRED, 1982:123).

INCOME

According to CRED (1982:170), "agricultural policies influencing rural incomes are, in the short-term, more likely to have an impact on the nutritional status of adults, while more structural changes (e.g., variety of foods grown by the family, education, access to health care) are more likely to influence the nutritional status of children." However, the relationship between income and caloric intake was obvious

in the CRED's study and "better-off families ate significantly more calories than their less successful neighbors" (CRED, 1982:229).

Increased food production and diversification in production should be the aims of the irrigation schemes if the objective of increasing rural incomes is to be achieved.

A food marketing system needs to be put in place to take full advantage of increased food production. Attention should be paid to the adequate distribution of revenues (via pricing, credits, etc.) in order to favor the poorest groups first. "All government programs and projects, including those financed by aid donors, should be examined with a view to maximizing the direct benefits to small farmers and the rural poor and minimizing bureaucratic expenditures" (The Gambia, Food Strategy Report, Parts II & III, 1981:55).

In the development of fish resources for a food strategy in The Gambia, the following factors have already been identified as important (The Gambia, Food Strategy Report, Part I, 1981:89):

i) the availability of purchasing power in the rural communities, especially among the undernourished, to buy fresh, or even dried, fish;

ii) the extent to which technology in the form of refrigeration or simple ice plants and transport can improve the availability of processed and fresh fish in rural areas without raising its cost (at storage facilities where fishermen can preserve their catch);

iii) the potential of the industry for employment; could manufacture of equipment (boats, nets, etc.) for inland fishing be encouraged, drawing on the considerable expertise in the Department and a current ITIS consultancy on boat building? The development of the river for fishing should be considered as an important means of trade with Senegal, Guinea and Mali, with revenue for The Gambia.

TECHNOLOGY

In the previous chapters the following problems have been identified:

- lack of clean drinking and cooking water;
- lack of time for women to properly improve their family's environment;

The mitigating measures are known:

- appropriate technology to harness sun energy for fuel, or increase cooking stove efficiency;
- provision of piped water or more wells;
- introduction of coos mills (with renewable energy, if possible) to ease the chore of pounding, a task that women in Koumbidia, Senegal, considered to be the hardest chore (Marek, 1981).

Of course, such measures need to be carefully studied for acceptability before any one is introduced.

Mention has already been made of introducing wood plots near heavily populated areas.

A health education program should parallel any new technology project, and especially water development projects.

FOOD AID

Food aid is acceptable only as a temporary measure helping the populations go through:

- resettlements;
- the transition phase from rainfed to irrigated agriculture (where currently cultivated lands are being modified).

Food aid should be provided until the new fields are productive. Planning for food aid should be undertaken by OMVG with the WFP and CRS.

HEALTH CARE

An improved Primary Health Care (PHC) system will affect nutritional status by improving health status via surveillance of children and referral for those needing care, provision of ORT techniques to children with diarrhoea and improvement in vaccination coverage.

Although the health care system of The Gambia and Senegal have improved greatly, they are now understaffed and undersupplied. Annex F lists some of the organizations involved in improving health and nutritional status. The OMVG Health Unit (to be created), should work in

close collaboration with these institutions and help them justify the intensification of efforts to be made in the Gambia River Basin. This planning task should be undertaken as soon as the decision of building the dams is taken. Thus, the Senegal Oriental Region will become a priority area for the Ministry of Health in Dakar.

SURVEILLANCE OF FOOD AVAILABILITY AND NUTRITIONAL STATUS

There can be no assurance that resultant gains in income and/or food output are reaching the most nutritionally needy population groups. To monitor this, the OMVG has to set up a surveillance system.

Surveillance of the food availability and nutritional status, if linked to a proper action program, can help evaluate progress and allow for early warning of any unforeseen negative impact. It will also assist any necessary revisions in management, inputs, activities and outputs.

An evaluation is also necessary in order to allow, after the project is completed, a critical examination of the design itself, of results and of effectiveness. An evaluation requires baseline end of project surveys.

OMVG'S TASKS IN IMPLEMENTING MITIGATING MEASURES

The OMVG should realize that it will have primary responsibility for planning and coordinating the mitigating measures identified. The aim should be that OMVG's activities will be eventually taken over by institutions in each nation. The early integration of OMVG's activities is therefore essential.

Annex F shows a partial list of agencies involved in activities related to the proposed mitigating measures. This list needs to be kept up-to-date and it can be used by OMVG's Health Unit when planning.

The OMVG's Health Unit should be composed of a Health Planner and of a Surveillance Supervisor; they will:

i) participate in the agricultural planning of the Gambia River Basin (see section on agricultural planning), by estimating the future population, taking into account migrations. Needs can then be calculated on a per capita basis (see Annex E for example). These targets can then be

monitored year by year by examining production, imports, exports and population growth. Results of the food availability and nutritional status surveillance system will also be used for agricultural planning by analyzing trends;

ii) provide the Ministries/Department of Health with the justifications for directing their priorities to the Gambia River Basin (see section on health care);

iii) plan and supervise the distribution of food aid (see section on food aid) for resettled populations and during the transition from rainfed to irrigated agriculture (with CRS, WFP and PPNS in Senegal);

iv) provide the Ministries of Rural Development with the justifications for directing the water supply priority to the Gambia River Basin. In parallel, funding could be sought directly by OMVG for an intensified effort of providing piped water and wells to particularly affected (resettled) villages;

v) provide the Ministries of Rural Development and other concerned agencies with the justifications for implementing programs aimed at lessening the chores of rural women (see section on technology);

vi) plan and coordinate or implement a food availability and nutritional status surveillance system. The next chapter of this report deals specifically with this recommendation. It will need to be readjusted and completed, once decisions on who will the project affect are taken.

OMVG can make great use of Food Strategy Report (The Gambia, 1981), which has excellent policy objectives as well as precise strategies for food and nutrition; it also contains a useful summary of programmes and projects for 1981-86.

V. METHODOLOGY FOR A FOOD AVAILABILITY & NUTRITIONAL STATUS SYSTEM USING EXISTING DATA SOURCES

INTRODUCTION

The food availability and nutritional status surveillance system is intended to provide the OMVG with a data base that will enable timely and effective responses to changing conditions within the GRB.

The following system has been proposed with the idea of using existing data collection sources, merging them and analyzing them centrally, at OMVG, so that trends can be quickly identified and action sought. This approach has the advantage of being cost-efficient and it increases the institutional collaboration between the ministries concerned and OMVG.

The implementation of the proposed system requires a full-time surveillance supervisor at OMVG to supervise data collection, to collect data forms, to review them, to enter data into a microcomputer, to analyze it and to generate periodic reports for the needs of OMVG.

In case the use of existing data sources is found not to be feasible, because of the cessation of activities in one or several of these systems, the OMVG will have to implement the surveillance system itself or contract with an agency to do it. This alternative is described in the next chapter, but its requirements in resources are much higher than those of the system proposed in this chapter, and the consultant recommends that it should not be sought until all possibilities of using the existing system have failed.

The fact that the Gambian Department of Health has requested WHO to send a consultant to design a nutrition surveillance system by blending the existing sources of information (Infant Welfare Card and CRS) shows the commitment of the government to use existing resources in an effort at efficiency.

The surveillance system's objectives are:

- to make any necessary revisions in management, inputs and activities, according to the analysis of trends;

- to detect and respond to important changes that need immediate action (via an emergency fund? enough flexibility in management to quickly reorient action? ...).

In addition to these objectives, a practical surveillance system should be cost-efficient: the minimum amount of data should provide the maximum of information.

> Since the translation of project benefits into a measurable change in nutritional status indicators is often a long process, the improvement of food consumption levels will be a more acceptable shorter-term indicator of progress (FAO, 1982).

It is proposed here that both kinds of data be obtained in addition to food availability at the market level:

- data on food availability: from market surveys;
- data of food consumption: from household surveys;
- data on nutritional status: from household surveys and from CRS returns (Catholic Relief Service).

In order for data to be translated into useful information that can be used to generate action, Figure 4 on the flow of information is recommended.

TYPE OF DATA NEEDED

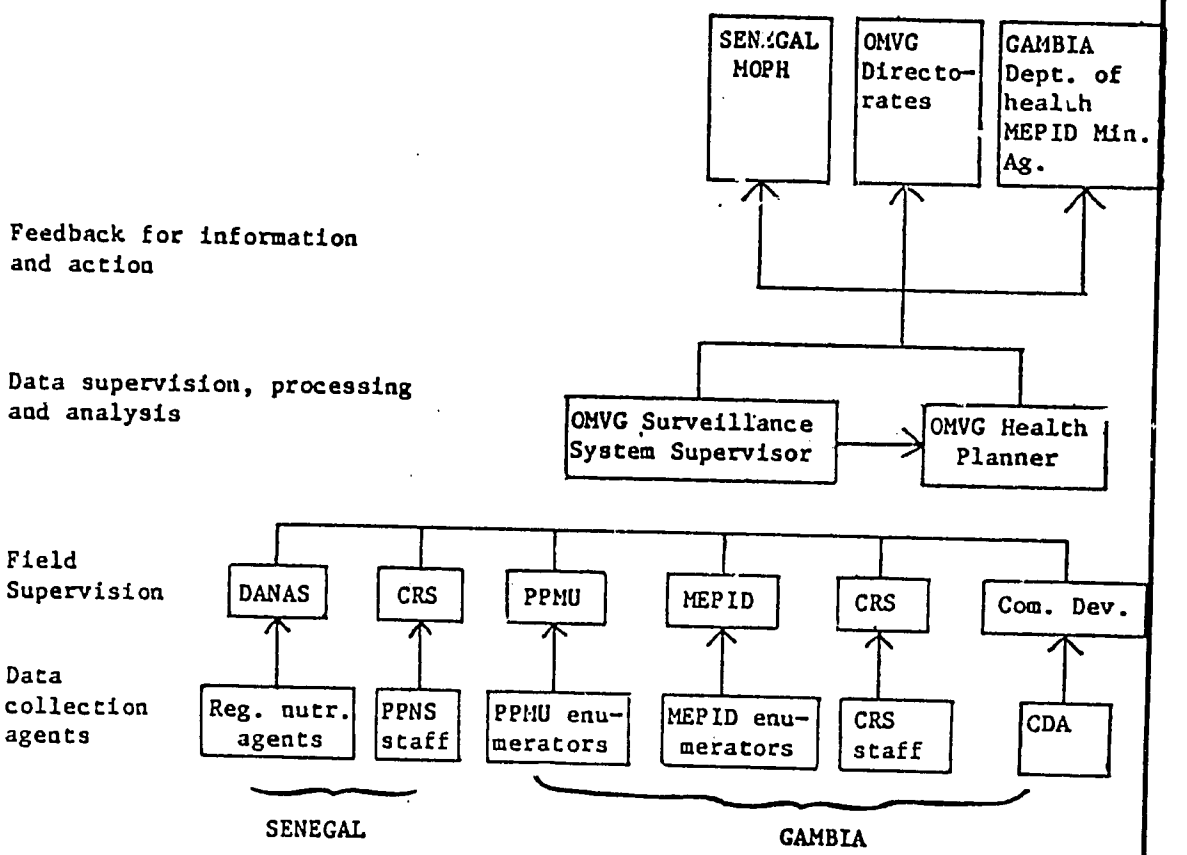
It is assumed that the monitoring of agricultural production will be carried out by the OMVG and this concern is not addressed here.

Food Availability

Food availability is expected to increase if the OMVG's objectives are met. Food availability can be assessed by food balance sheets (where the amount of locally produced food is added to imported food, exported food is subtracted, and the total is divided by the population concerned). This method gives a very crude measure of the food supply but is an excellent planning tool, highly recommended for OMVG's agricultural planning. The proposed method of market study provides a more realistic picture than the food balance sheet. It will allow OMVG to find out what is available at different periods of the year and

FIGURE 4.

DIAGRAM ON THE FLOW OF INFORMATION FOR A FOOD AVAILABILITY & NUTRITION STATUS SURVEILLANCE SYSTEM IN THE GAMBIA RIVER BASIN



University of Michigan, Gambia River Basin Studies, 1985.

monitor changes that will occur. Marked differences between market availability and household consumption can then be investigated (prices too high? lack of transport? etc.).

The market questionnaire consists of a list of all food items that can be found in the market. The enumerator simply does two rounds of the market, walking, ticking the items on the questionnaire that are available on the market stands.

Food Consumption

The objective here is to know how food supplies are distributed among the different segments of the population. We are especially concerned with the following groups:

- population groups to be displaced/resettled;
- population groups to be directly affected by the transition from rainfed to irrigated agriculture.

The questionnaire requires that an enumerator be present during meal preparation and records the kind of ingredients going into the cooking pot.

Nutritional Status

The objective here is to identify as much of the current malnutrition (wasting) as possible.

As the Table 4 shows, weight for height would be the most appropriate indicator to use because it indicates acute undernutrition (wasting); however this indicator is not currently collected. Weight for age is the indicator now being collected by the existing surveillance systems.

Phillips (1982) measured both the weight for age and weight for height on a sample of 369 children below 10 years of age in The Gambia. He found that "on the basis of weight for age, between 3 and 4 percent of children would be classified as severely malnourished compared with just under 2 percent using the weight for height ratio." This supports the use of weight for age since for our objective, it is more important to pick up slightly more cases than exist than to underestimate the proportions of the problem (i.e., high sensitivity which means that the probability is high that a person with the condition will be classified as having the condition).

TABLE 4

RATING OF THE DIFFERENT INDICATORS BY ABILITY TO FULFILL CRITERIA

Criterion	Weight for Age	Height for Age	Weight for Height	Arm Circumference
1. Population Group				
• To serve as an overall indicator of malnutrition	4	2	3	3
• To identify current malnutrition (wasting)	3	1	4	3
• To identify a maximum of malnourished children	4	2	2	3
2. Instruments				
• cost	2	3	1	4
• portability	3	2	2	4
3. Difficulty in Taking Measure	3	2	1	3
4. Time to Take Measure	3	3	2	3
5. Reliability (low error)	3	3	2	2
6. Sensitivity to Change over a Short Time Period	4	1	4	3
7. Resistance to Measure by Families	3	3	3	4
8. Age Preference	0-6 years, but best 3 years	0-6 years, but best 2 years	0-6 years, but best 2 years	approx. 1-4 years
9. Other			age independent	age independent; system adaptable for nonliterate workers

SOURCE: Growth Monitoring of Preschool Children, Series 1, Nbr. 3, Oct. 1981. (exact reference lost).

NOTE: Each indicator has been rated on a scale of 0-4:
0 = not appropriate
1 = poor performance
2 = moderate performance
3 = good performance
4 = excellent performance

University of Michigan, Gambia River Basin Studies, 1985.

Weight for age is a good basic indicator, combining acute and chronic malnutrition. Two disadvantages of this indicator are first, that it will classify as malnourished a child who is recovering but who was malnourished, and second, it also relies on age data which are sometimes subject to error. Its advantages are that it is sensitive to small changes (although many variables influence small fluctuations in weight), its measure is objective and repeatable, weighing is relatively easy for inexperienced field workers to manage, although it does require a literate worker, and finally the measure is not very time-consuming.

Another easily collected indicator of current malnutrition is the mid-arm circumference (MAC): it is an indicator of severe current malnutrition, whether or not stunting is present. It has several advantages: measurement is taken with an inexpensive and portable arm tape; it is quick to use; it does not require exact age data. Its disadvantages are that it will only identify children with severe malnutrition; variability is high on measurement. Field workers need practice taking the measurement to do it accurately. Finding the upper mid-arm and placing the tape around the arm without compressing the tissue are difficult.

Environmental data: the source of water used for home consumption, its distance from the kitchen area, are good indicators of well-being by providing an indirect measure of the availability of water. The presence of latrines could also be checked by the enumerator to evaluate the level of sanitation within the household.

An open-ended "comments" question will be asked in case anything of importance to the family has not been covered by the questionnaire. The enumerator also keeps a diary for whatever additional comments he feels appropriate, if he knows of something important that has happened in communities other than the ones he surveys.

TIMING OF DATA COLLECTION

Considering that differences in food availability, food consumption and nutritional status are known to vary most between the *période de soudure* (July-August) and postharvest (Nov. and on), under nonchange

conditions it would be recommended to collect data for these two periods. However, since major changes are expected to take place in the Gambia River Basin, it is proposed that data be collected and analyzed quarterly, following the four main agricultural seasons as shown in the Table 5 (see Annex C for the rice calendar).

The OMVG officials responsible for agriculture and those responsible for the present surveillance system will meet at the beginning of each new year to agree on the surveillance periods to be used in order to ensure that they both use the same periods.

The surveillance system should be implemented at least one year before any major work in the Gambia River Basin is undertaken. It will permit comparison between seasons, before, during and after changes occur.

TABLE 5

TIMING OF MAJOR AGRICULTURAL ACTIVITIES BY CROP

Season	Month	Peanuts	Millet
NOR	February March April	Gleaning Gleaning Field manuring, clearing	Collecting millet stalks Manuring, clearing
THIORON	May June	Shelling for seed, clearing Shelling for seed, clearing	Clearing Sowing
NAVET	July August September October	Shelling, sowing 1st weeding 2nd weeding 3rd weeding Lifting	Sowing 1st weeding 2nd weeding 3rd weeding Harvest
LOLLY	November December January	Stacking & threshing transport Winnowing Threshing/winnowing	Transport Grain storage

SOURCE: CRED, Consumption Effects of Agricultural Policies: Cameroon and Senegal, CRED, University of Michigan, Ann Arbor, 1982. p. 189.

University of Michigan, Gambia River Basin Studies, 1985.

DATA COLLECTION INSTRUMENTS AND AGENTS

The map (Annex H), shows the different centres in which data are already being collected by existing organizations in The Gambia. It also highlights the areas identified as most suitable for irrigated rice farming.

Table 6 summarizes this section and Annex D shows the data collection instruments used and proposed.

The population strata in which the surveillance system is interested are defined as follows:

stratum 1 rural population to be displaced from the Kekreti impoundment area.

stratum 2 rural population directly affected by the irregation scheme (living within three kilometers of the scheme).

stratum 3 rural population not directly affected by the irrigation scheme (living more than 20 km by road from a scheme).

stratum 4 population living in urban areas.

Stratum 1 is dealt with in the section on Senegal while the other three strata are being addressed in the following paragraphs since they concern The Gambia.

Data on Food Availability

The Central Statistic Department of the Ministry of Economic Planning and Industrial Development (MEPID) send their four enumerators from Banjul each month to visit six market centres and fill out form no. 1, Annex D. There is one field supervisor at MEPID. The results are analyzed at the Central Statistics Department and compiled in the Yearly National Accounts Report. Data on retail prices come out every month as an appendix to the Yearly Report.

Unfortunately, as the map indicates, this collection system is only carried out on stratum 4. However, the agents could include strata 2 and 3 by stopping in smaller market centres along their way.

TABLE 6

SUMMARY TABLE ON DISTRIBUTION OF TASKS (PER QUARTER) AMONG DATA COLLECTION AGENTS TO COVER THE SAMPLE SIZE NEEDED FOR EACH INDICATOR

Indicator	Stratum	Data Collection Agent	# of Units Covered by Agent	Total # of Units Covered	# Covered Stratum
Food Availability	1	1 DANAS Regional Nutrition Agent (RNA)	4 markets	4 markets	4
	2	4 MEPID enumerators	1 market each	4 markets	4
	3	4 MEPID enumerators	1 market each	4 markets	4
	4	4 MEPID enumerators	1 market each	4 markets	4
				16 markets	
Food Consumption	1	1 DANAS RNA	10 households	10 households	100
		9 health post nurses	10 hh. each	90 households	
	2	5 PPMU enumerators	10 hh. each	50 households	100
		5 CDA enumerators	10 hh. each	50 households	
	3	5 PPMU enumerators	10 hh. each	50 households	100
		5 CDA enumerators	10 hh. each	50 households	
	4	10 CDA enumerators	10 hh. each	50 households	100
				400 households	
Weight for Age and MAC	1	1 DANAS RNA	10 hh. each[a]	30 children	
		9 health post nurses	10 hh. each	270 children	
	2	5 PPMU enumerators	10 hh. each	150 children	300
		5 CDA enumerators	10 hh. each	150 children	
	3	5 PPMU enumerators	10 hh. each	150 children	300
		5 CDA enumerators	10 hh. each	150 children	
	4	10 CDA enumerators	10 hh. each	150 children	300
				1,200 children	
Weight for Age (from CRS returns)		4 CRS centres per stratum		16 centres	

NOTE: (a) 3 children per household will be surveyed.

University of Michigan, Gambia River Basin Studies, 1985.

Data on Food Consumption

Because village health workers (VHWs) are often illiterate, they cannot be used for data collection. The Community Health Nurse (CHN) who supervises VHWs are already too busy to be relied upon for additional work (communication, Mrs. Mboge, MCH Director).

The 120 Community Development Assistants (CDAs) from the Directorate of Community Development, Ministry of Local Government and Land (MLGL), who live in villages throughout The Gambia could be used to provide the necessary data. The selected CDAs would visit compounds chosen at random within their villages (see next section on sampling procedures). This would require that the CDA plan to visit the compound during lunch preparation time and that he spend about one hour per compound to fill out form no. 3 (see Annex D).

There are also 7 PPMU enumerators living permanently in villages of stratum 2, and 22 in villages of stratum 3. They survey compounds monthly for crop yields, input requirements, etc. They could be asked to visit randomly chosen compounds in their villages to fill our form no. 3.

Data on Nutritional Status

From the Catholic Relief Service (CRS): there are 86 CRS centers (see location on map) where data on about 33,000 children and their mothers are collected monthly. CRS services involve weight for age surveillance of children under 5 years of age, nutrition education and distribution of food supplements. The monthly records are summarized by CRS/Banjul on form no. 4, Annex D, showing the number and percentage of children below the 60th and 80th percentiles of the Harvard standard.

There are 3 CRS centres located within stratum 2, 2 in stratum 4 and the rest are located mainly in stratum 3.

OMVG could easily gather form no. 5 of Annex D each month from CRS/Banjul, and enter the data on microcomputer.

However, the ideal is to collect nutritional status data on children of compounds where data on food consumption is collected. This possibility is outlined below.

From the health service system: The Infant Welfare Card (form no. 6, Annex D), is filled out by the health personnel at health centres but is

kept by the mother; only the vaccination data are reported by the MCH staff on their own register in order to fill out the MCH Monthly Return (form no. 7, Annex D), which is sent to Medical Statistics in Banjul.

Although a form could be designed to collect the weight for age data by the MCH centres, it does not seem worthwhile considering the workload at the MCH centre and the fact that the CRS centres already collect this kind of information (i.e., there might be duplication of cases).

However, if the CDAs were asked to collect food consumption information, they could also easily take the mid-arm circumference (MAC) of the children in the compounds they visit on form no. 3-bis, Annex D). MAC has the advantage of being quick, easy and requires no cumbersome tools (see the rating of MAC compared to other indicators in Table 7).

The CDA could also ask to see the Infant Welfare Card (90% of the children have this card), and he could report on form no. 3-bis the last weight for age indicated on the card (form no. 6, Annex D).

From the PPMU enumerators: They would collect MAC and weight for age information on children of compounds visited for food consumption data in the same manner as the CHN (see above).

Data Collection in Senegal

The area to be flooded behind the Kekreti dam is located in Senegal, but no information is yet available on the irrigation schemes to be developed there. We are therefore mainly concerned here with population stratum 1, although parts of the Sine-Saloum region are included in the Gambia River Basin area where population from strata 2 and 4 live.

When the decision of where the irrigated perimeters to be developed in Senegal Oriental is taken, population from stratum 1 will be identified for Senegal, and it will be chosen in the same way stratum 1 in The Gambia was.

The Plan of Action for the Division of Food and Applied Nutrition (DANAS, p. 9) gives the responsibility of weight for age surveillance to either the village health worker or the health post nurse. In Senegal Oriental, there are 43 operating government health posts and 99 health huts operated by VHWs (MSP, 1982). Distribution of medical facilities in the Basin area still needs to be determined by mapping. The Plan of Action suggests that the Primary Health Care (PHC) workers will be

supervised by a regional nutrition agent who will also be carrying out the following:

- market studies;
- nutritional status surveillance;
- sociological surveys.

DANAS's priority areas are: Sine-Saloum, Casamance, and Senegal Oriental. DANAS activities also include supervision of the CRS centres, known there as PPNS (Programme de Protection Nutritionelle et de Santé). There are 31 operating PPNS centres (MSP, 1982:41) and they collect weight for age data on children under 5 years of age. PPNS data could be collected the same way The Gambia's CRS data will be collected.

OMVG could require that Senegal Oriental be made the priority region in assigning a Regional Nutrition Agent (RNA). Such an agent would be given the responsibility for surveillance of the displaced population.

Monitoring should start one full year before displacement occurs to allow for comparisons between seasons from one year to the next.

SAMPLING PROCEDURE

The catchment area of the Gambia River Basin encompasses 77,850 km^2 of which 77% lies in Senegal, 14 percent in The Gambia and 9 percent in Guinea. However, 85% of the irrigated schemes will be located in the MacCarthy Island Division of The Gambia which includes the local government areas of Kuntaur and Georgetown (see the map in Annex G), and the rest will be located in the Upper River Division. Table 7 indicates the number of households in each local governments area of Gambia.

The survey universe is composed of the entire population of the Gambia River Basin which totals about 1,015,168 people (the five administrative divisions of Gambia contained 1690,096 persons in 1983, and Senegal Oriental contained 325,072 people in 1980).

Our primary concern is to monitor the food availability and nutritional status among population groups that will change their cultivation methods, but population groups not directly concerned by the irrigation schemes will also be affected due to changes in production, development of infrastructures, marketing policies, etc.

Stratification (Step 1)

For our purpose of the Basin population will be divided into the following four strata:

Stratum 1 population groups to be displaced and resettled (in the Kekreti impoundment area);

Stratum 2 rural population directly affected by the transition from rainfed to irrigated agriculture (living within 3 kms by road of an irrigated scheme);

Stratum 3 rural population not directly affected by the irrigation scheme (living more than 20 kms from an irrigated scheme);

Stratum 4 urban population.

TABLE 7

DISTRIBUTION OF THE GAMBIA'S TOTAL POPULATION BY LOCAL GOVERNMENT AREA (1983) CENSUS

Local Government Area	Population in Households	Population in Institutions	Total Population	Percentage of Total Population
Banjul	42,638	1,896	44,536	6.4
Kombo St. Mary	102,022	836	102,858	14.8
Brikama	137,705	799	138,504	19.9
Mansakonko	55,216	404	55,620	8.0
Kerewan	111,236	175	111,411	16.0
Kuntaur	58,420	410	58,830	8.5
Georgetown	70,304	907	71,211	10.2
Basse	112,555	361	112,916	16.2
The Gambia	690,096	5,790	695,886	100.0

SOURCE: Central Statistics Department. 1983 Census. The Gambia Preliminary Results. Banjul, 1984.

NOTE: The population in institutions refers to persons enumerated on census night (i.e., 15th April, 1983) in hotels, ships, hospitals, prisons, and outdoor sleepers, etc.

University of Michigan, Gambia River Basin Studies, 1985.

Once the 1983 census of Gambia is published, the location of the Gambia River Basin population will be divided into these strata (by village) by using the map in Annex G.

Selection of urban areas: Basse, Bansang, Kaur and Mansakonko are four urban areas (Stratum 4) which are covered by MFPID agents. These 4 cities, along with Georgetown, can constitute the urban sample. Within each city, 2 areas will be chosen to represent the most at-risk groups: the poorest and the one which receives the most of the recent immigrants. Five households will be chosen at random within these two communities for collection of data on food consumption and nutritional status.

Determination of sample size (Step 2)

In order to make sure that our sample is not too small, we will borrow the methodology used to calculate the sample size to test the effect of supplementary feeding programs (see procedures for calculation in Annex H). The sample size (n) needed for weight for age data, at significance level = 0.05 and with power of 0.95 (the power of a test is the estimate of the likelihood that a net effect will be observed if it exists) is 176, and for mid-arm circumference, n = 263.

Our units are the number of children on which anthropometric measurements will be taken.

It can safely be assumed that the standard deviation of our population will be smaller than the one used for the above calculations which is based on strict field trial. Therefore, 263 is maximum sample size for each stratum. For ease, we will round it off to 300. Refer to Table 6 to see the number of field agents needed to collect data on this sample size.

Random selection of sampling units (Step 3)

The list of villages where there are PPMU and CNA agent will be drawn up for each stratum. Then villages will be chosen at random from this list (see Table 6 which shows that 6 villages are needed in each stratum).

Then, the next part of this step is to be carried out in the field by the surveillance system supervisor and the enumerators. In each sampled village, the first compound is selected at random, then the agent

proceeds to adjacent households until 10 households are chosen, or until 30 children age 6 months to 71 months are available from the households, whichever comes first.

Selection of markets for data on food availability: the MEPID will decide on the most practical additional markets to be surveyed by their agents in each stratum (4 markets per stratum).

Once the data collection units have been chosen no change can be made on the list. Should a community or market disappear (it might happen!), the system supervisor will select a replacement unit for the field agent.

In Senegal: Stratum 1 (in Senegal Oriental) and Strata 2 and 3 (in Sine-Saloum) will be surveyed by the DANAS agents and the health post nurses following the same sampling procedure as outlined above.

Table 6 shows how the sample is divided among strata (equal sample size for each stratum) and the workload of the field collection agents each quarter.

TASKS OF PERSONNEL AT EACH LEVEL OF THE SURVEILLANCE SYSTEM

The following represents the minimum personnel necessary to implement the surveillance system:

Level	In Gambia	In Senegal
OMVG	1 surveillance system supervisor 1 health planner	
Field Supervisors	1 from MEPID 1 from PPMU 1 from MLGL 1 from CRS	1 RNA from DANAS
Field Agents	4 MEPID enumerators 10 PPMU enumerators 20 CDA enumerators 16 CRS centres staff	1 DANAS RNA 9 health post nurses

University of Michigan, Gambia River Basin Studies, 1985.

Surveillance System Supervisor

The system supervisor (refer to Figure 4) will be responsible for the successful operation of the surveillance system. Any important decision concerning the operation and modification of the system or the duties of the field agents should be mutually shared by the system supervisor and the field supervisors.

The system supervisor should be able to understand the principles underlying the design of the system, and have the technical skills necessary to make any changes in both the data collection and microcomputer areas.

The following responsibilities are those of the system supervisor:

i) briefing the field supervisors on the OMVG surveillance system so that data collection responsibilities can be delegated to data collection agents;

ii) identify the data collection agents in each stratum;

iii) training and refresher courses (when found necessary) for data collection agents, in collaboration with the field supervisors;

iv) supervision of data collection agents, in collaboration with field supervisors. The system supervisor should anticipate being on the road several days a month;

v) reviewing the raw data as they arrive to detect obvious errors or omissions;

vi) entry of the data into the computer;

vii) data analysis and production of such charts, tables, graphs and periodic reports for the needs of OMVG;

viii) the computer equipment used for the surveillance system.

The supervisor should have a principal voice in determining which other persons will be permitted to use that equipment and he should ensure that such persons are adequately familiar with the equipment.

The qualifications necessary for this position are:

- a Master of Public Health degree in biostatistics or epidemiology;

- at least 5 years experience in conducting surveys in Africa;
- excellent coordination capabilities;
- fluent French and English;
- at least two years experience in the use of computers for data entry and analysis. Experience in the writing of computer programs, in any language, is highly desirable.

Field Supervisors

These personnel are already employed by the different agencies under consideration. They will be mainly responsible for:

i) training of field agents, in coordination with the system supervisor;

ii) supervision of data collection agents, in collaboration with the system supervisor;

iii) collection of data from field agents and making these data available to the system supervisor on time.

Field Agents

Field agents staying in the chosen villages will be identified. In stratum 4 (urban), the agents staying in the village closest to the chosen urban centres will be sent to the centre for data collection if no other agent is available in the urban centre.

Each enumerator (or field agent) will:

i) visit 10 households (see Table 7) to collect data on food consumption (by filling out form no. 3, Annex D) and on anthropometrics (by filling out form no. 3, Annex 4).

ii) keep a diary for recording any events occurring in their area and for which space is not provided on the questionnaires;

iii) send their filled questionnaires to their respective field supervisors on a regular basis.

The field agents will be given a schedule drawn by the field supervisor and the system supervisor to ensure that each source of information is visited on time.

The field agents must be able to speak the languages spoken in the communities to which they will be assigned. They must understand the

TABLE 8 (Dummy Table)

FREQUENCY OF FOOD CONSUMED IN DIFFERENT SEASONS 1979/90
(All figures expressed as percentage frequencies)

Food Item	March		July		September		December	
	S	B	S	B	S	B	S	B
Rice (grain or flour)	78	84	83	88	72	92	92	71
Coos (grain or flour)	13	22	17	20	28	16	11	29
Groundnuts or pasts	33	21	38	59	42	32	46	36
Fish (dried or smoked)	34	41	53	50	40	56	43	41
Tomato paste	35	32	40	32	33	36	38	23
Onions	30	21	21	17	16	14	27	24
Fresh leaves	4	2	15	13	25	14	5	8
Baobab leaf flour	7	13	9	2	5	0	6	12
Locust bean rolls	4	1	6	0	11	2	7	2
Fresh fish	16	8	6	7	7	16	18	13
Meat/chicken	8	9	6	9	11	0	7	4
Oil (g/nut or palm)	19	8	9	7	11	12	18	13
Cassava root	12	0	0	0	2	0	4	1
Sugar	30	32	19	30	26	28	22	35
Sour/fresh milk	11	13	8	17	7	30	10	24
Baobab fruit	0	0	0	0	5	2	0	0
Fresh vegetables	3	7	6	0	21	2	11	17
Number of Meals Sampled	117	120	53	54	56	30	136	119
Fresh breakfast	63	52	36	30	41	20	20	36
Leftover b/fast	22	33	18	40	27	30	57	48
No breakfast	15	14	45	30	32	50	22	17
Lunch	100	100	100	100	100	100	100	100
Fresh supper	100	100	100	100	100	100	100	100
Leftover supper	0	0	0	0	0	0	0	0
Total Days Sampled	41	42	22	20	22	20	49	42

SOURCE: Phillips Denzil, Coles Anne and Seaman John. Village Food Systems in West Africa. International African Institute, London, 1982.

University of Michigan, Gambia River Basin Studies, 1985.

goals and principles underlying the surveillance system sufficiently well to appropriately collect the necessary information.

DATA ANALYSIS AND USE OF INFORMATION

The system supervisor is responsible for data processing, analysis and for the quarterly report which should be produced two weeks after the end of each quarter, at the latest.

Data will be analyzed using a statistical package for the social sciences (SPSS), or equivalent for the microcomputer.

Dummy Tables 8 and 9 are examples of frequency tables that can appear in the quarterly report; an analysis of variance can be carried out to compare several population means (4 means per year) and T-tests to compare two population means (the one from the same season last year to the one this year).

In The Gambia, the Department of Health, Epidemiology Unit, after revising the health information system, has decided "that all surveillance data should funnel through the Regional Health Teams to Medical Statistics where they would be processed and distributed, as needed, to other offices and as feedback" (Sonneman, 1983:5).

OMVG can also run regression analyses trying to correlate data from their surveillance system and data on morbidity and mortality statistics from Medical Statistics; the same can be done with agricultural statistics (with average yield for the major crops in each stratum, for example).

USE OF INFORMATION

A monitoring system loses its meaning if it is not linked to an action program. OMVG will need to conceive a system (concerning distribution of inputs, marketing, etc.) flexible enough to be quickly reoriented if necessary. Another source of quick action would be the creation of an emergency fund which could be used for sudden needs (food aid, education campaigns, repairs, etc.).

Regular information meetings with the different development organizations concerned will be organized to coordinate and reorient actions according to trends observed by OMVG.

TABLE 9 (Dummy Table)

ORIGIN OF STAPLE FOOD BY STRATUM
RICE (%)

Stratum	Bought	Home Grown	Given	Other
1	85	9	6	0
2				
3				
4				

University of Michigan, Gambia River Basin Studies, 1985.

ORGANIZATION OF THE SURVEILANCE SYSTEM

Training

Enumerators can be trained in about 4 days (this includes the two days of trial study in the field). The Community Development Center in Mansakonko can be used for that purpose. The field trial study will be carried out in and around Mansakonko in order to: check that the enumerators understand what is asked of them; and check the forms for comprehension and translation.

Informing the Populations

The population in villages to be monitored need to be informed in order to obtain their cooperation. The confidentiality of the information to be obtained must be stressed.

Data Collection

Each enumerator should keep a surveillance diary to record information on food and nutrition as well as on various events that are not recorded on the questionnaires. Each questionnaire or form should be carefully checked by the field and system supervisors when they come around each quarter to see the enumerators. Filled forms are checked for inconsistencies, errors or incompleteness. At this stage, it is still possible to visit the respondent again to check statements and to make corrections.

COSTS

The cost for a surveillance system using existing data collection agents would be as follows:

	Approximate 1984 Cost (in US$)*
Investment Costs	
1 microcomputer with printer	2,000
computer programs	1,000
1 vehicle for the field	16,000
1 vehicle for the city	6,000
1 copy machine	800
1 generator	1,200
Subtotal	27,000
Yearly Recurrent Costs	
salary & benefits for:	
a health planner	125,000
a surveillance system supervisor	125,000
fuel for field trips	3,000
fuel for generator	1,200
vehicle maintenance	2,200
computer maintenance	500
office supplies (at 5/day)	2,000
enumerators allowance (at 2 dalasis/ night; for 4 nights/month each)	900
Subtotal	259,800
Training (in Mansakonko)	
room & board for 5 days for 56 people (at 25 dalasis/person/day)	7,000
petrol for field pre-test 50 km	50
Subtotal	7,050
Grand Total (for first year of operator)	$293,850

NOTE: *rate: US $1 = 3.30 Dalasis

University of Michigan, Gambia River Basin Studies, 1985.

VI. METHODOLOGY FOR A SURVEILLANCE TO BE IMPLEMENTED FULLY BY OMVG

INTRODUCTION

As an alternative, in case the above mentioned agents are not yet assigned, or are found to be unable to carry out the surveillance outlined above, the OMVG will be responsible for providing monitoring data. Under this approach, the same kind of data as mentioned in the previous chapter can be collected.

The food and nutrition surveillance could easily be linked to other surveillance systems (health, environment, etc.) in order to increase efficiency and to use the same enumerators for different tasks. OMVG could therefore set up its own monitoring unit.

Still another approach would involve a contractor undertaking the surveillance for OMVG. An agency such as the MRC in The Gambia might become involved.

Whatever approach is taken, the food and nutrition surveillance system requires the following full-time personnel:

- 1 health planner
- 1 surveillance system supervisor
- 2 market enumerators (for 16 market visits/quarter)
- 14 food and nutrition enumerators (each enumerator stays 3 days/village to visit 6 households; the collection process takes 3 weeks per quarter);
- 3 field agent supervisors.

COSTS

The same samplying procedure, enumeration units and division of work load as outlined in the previous chapter can be followed.

	Approximate 1984 cost (in US$)*
Investment Costs	
1 microcomputer with printer	2,000
computer programs	1,000
1 vehicle for the field	16,000
1 vehicle for the city	6,000
1 copy machine	800
1 generator	1,200
1 mimeograph machine	500
20 motorbicycles	12,000
20 backpacks	200
20 survey supplies (pencils, watch, etc.)	200
at least one more room at OMVG for meeting with enumerators	-
Subtotal	39,900
Yearly Recurrent Costs	
salary & benefits, travel, etc., for:	
a health planner	125,000
a surveillance system supervisor	125,000
salary & benefits for 19 full-time agents (includes field allowance) @ 43.20 dalasis/person/year	14,812
fuel for about 20 enumerators (@ 3 dalasis/liter) 60 liter/enumerator	1,000
fuel for generator	1,200
fuel for field trips	3,000
vehicle maintenance (10% of cost)	2,200
microcomputer maintenance	500
motorbicycles maintenance	1,500
office supplies	2,000
Subtotal	276,212
Training (in Mansakonko)	
room & board for 5 days for 21 people (@ 25 dalasis/person/day)	2,625
petrol for field pre-test (@ 3 dalasis/liter) 150 km	150
Subtotal	2,775
Grand Total (for first year of operator)	$318,887

NOTE: *rate: US $1 = 3.50 Dalasis.

University of Michigan, Gambia River Basin Studies, 1985.

VII. EVALUATION OF THE IMPACT OF THE OMVG PROGRAM ON FOOD AVAILABILITY AND NUTRITIONAL STATUS

For causality to be established, the best study design is that of a control case. However, because finding a control group for the OMVG program (a group not affected at all by the OMVG program) is impossible, the stratification of the Gambia River Basin population in four strata is the best way to approximate this desired design.

The evaluation differs from the surveillance system. The evaluation consists of two surveys, one to be carried out before the OMVG program is started and one after the program has been implemented. The objective of the evaluation is to critically examine the results of the OMVG program, while the surveillance system is part of the possible mitigating measures of the program (see the objectives of the surveillance system mentioned earlier.

The results of the proposed surveillance system can also be used in evaluating the impact of the program, by examining changes that occurred within each population stratum. But the opportunity presented in The Gambia by the FAO/WHO survey makes it possible to study factors that could not be studied by a surveillance system: changes in morbidity, nutrient intakes, weight for age, the role distribution among family members, etc.

THE FAO/WHO PROPOSAL FOR A FOOD & NUTRITION SURVEY IN THE GAMBIA

The Government of The Gambia has already expressed the desire to undertake a national food and nutrition survey to be implemented in 1984. Such a survey (designed by I.S. Dema and J.V. Kreysler, August 1983) should serve as baseline study for the OMVG impact evaluation. OMVG will therefore need to make provisions for a second survey to be undertaken after its program, or certain phases of it, have been implemented. The OMVG's health planner should identify a time at which the second survey needs to be undertaken (but not less than 5 years after each phase to be evaluated is completed). The OMVG can use the cost of the FAO/WHO survey to budget the second survey.

The following comments apply directly to the Project Proposal written by Dema and Kreysler:

- Before it is implemented, the FAO/WHO survey should be approved by ORANA (Organisme de Recherche sur l'Alimentation et la Nutrition pour l'Afrique) in Dakar, since this organization has a long experience of surveys in the region, has good data analysis capabilities and is compiling a data bank on food and nutrition for West Africa (contact Mr. A.M. Ndiaye, the director, or Dr. S. Chevassus-Agnes, tel: 22-58-92).
- The OMVG should be represented in the Interministerial Steering Committee responsible for the survey in order to start an institutional memory at OMVG on food and nutrition, and to ensure that OMVG's priorities are covered.
- The Department of Statistics of the Ministry of Economic Planning and Industrial Development should be represented in the above-mentioned Committee since it is responsible for monitoring the availability and prices of food throughout The Gambia (see the comments taken from the Food Strategy Report in Annex F, section b, of this report).
- The two enumeration areas proposed by Dema and Kreysler are rural and urban. The rural enumeration area should be further broken down into the strata used for the present surveillance system for OMVG which is as follows:

  Stratum 1 population to be displaced from the Kekreti impoundment area;

  Stratum 2 rural population directly affected by the irrigation schemes (living within 3 km of the scheme);

  Stratum 3 rural population not directly affected by the irrigation scheme (living more than 20 km of the scheme);

  Stratum 4 population living in urban areas.

- The FAO/WHO survey should cover strata 2, 3 and 4 (stratum 1 occurs only in Senegal).

- In the Nutrition Survey Form (Appendix II), since the presence of an Infant Welfare Card is checked for each child, why not record the last weight for age written on that card by the MCH staff? This approach is recommended in the present surveillance system because it provides one more easily obtained piece of data on anthropometry.

- In Appendix IV, "Dietary Survey Techniques", under Section E, not enough emphasis is put on the careful weighing of ingredients that go into the cooking pot. I also did not see any mention on the weighing of the staple food (only weighing of soup ingredients is mentioned).

- In the Dietary Survey Form, question 1, on procurement of food and appliances, could be combined with question 2.b, on the cooking of food, by using the questionnaire on food consumption of the present report (see form no. 3, Annex D); I could not find the form on the weighing of food in my copy of the Dema-Kreysler report, but form no. 3, Annex D of the present report could also be used for this purpose by adding one more column for weights in the first table of the form.

- The role of the PPMU enumerators is not well-defined in the proposal.

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ANNEXES

ANNEX A

LIST OF PERSONS CONTACTED
(March-April 1984)

Date	Name of Person	Organization	Subject of Discussion
3/16	Dr. Chevassus-Agnes	ORSTOM/ORANA Dakar	Data for Gambia & Senegal.
3/26	Mr. John Schwager	UNDP Deputy Resident Representative	UNDP programs & plans for financing mitigating measures.
	Ms. Antoline	World Food Program Officer/UNDP	The WFP in Gambia. Data sources.
3/27	Ms. Leslie Snyder/ Dr. Peter Spain	USAID's Mass Media/ ORT project. Dept. of Health	Data sources. ORT program and its evaluation.
	Dr. Taylor Nigel	Nutritionist/Dept. of Health	Data sources. Nutritional status of population. Surveillance programs.
3/29	Ms. Mariatou Faal	Planning, Programming & Monitoring Unit (PPMU) Min. of Agriculture	Food consumption & nutritional status survey and surveillance.
3/30	Mr. Yaha Diallo	Assistant Statistician PPMU/Min. of Agriculture	Data collection procedures & data analysis of PPMU's surveillance system.
4/9	Mr. Yaha Diallo		Feedback on proposed surveillance system.
4/3	Mrs. Ndiaye/Mr. Faaty/ Mr. Sarr	Catholic Relief Service Food & Nutrition supervisor/CRS F&N assistants	Nutritional status surveillance system; data collection procedures & data analysis.
4/4	Mr. Robert Couturier	Chief of Party, Land Reclamation & Development Consultants (LR DC)	Identification of area to be irrigated.
4/4	Mr. Alieu Ndow	Acting Director for Statistics/Min. of Economic Planning &	Market-food availability surveillance system. Feedback on proposed
4/9	Mr. Alieu Ndow	Industrial Devlpmt.	surveillance system methodology.
4/4	Mr. Ismail Ndiaye	Assistant to MCH Director/Min. of Health	Infant Welfare Card/field agents.

ANNEX A. (con't.)

Date	Name of Person	Organization	Subject of Discussion
4/5	Dr. Andy Bradley	Medical geographer/ MRC-Farafenni	Morbidity & Mortality Distribution. Field agents
4/7	Mr. Mark Lawrence	Nutritionist/MRC-Keneba	Feedback on proposed surveillance methodology.
4/9	Mr. Thierry Loutte Mr. Victor Bahoum	PPMU/Min. of Agric. Director, PPMU	" " " "
4/2	Mr. Bai Bojang	Director, Community Development/Min. of Local Govts. & Lands MCH Director	Availability of field agents. Feedback on proposed surveillance system availability of field agents.

Persons contacted within the CRED/University of Michigan Team:

- Dr. Curt Schneider, Public Health Team Leader
- Dr. Karl Lagler, Chief of Party
- Dr. Bill Derman, Socioeconomic Team Leader
- Mr. Leonard Malczynski, Socioeconomics
- Ms. Marion Van Maren, Fisheries
- Mr. Dario Rodriguez, Forestry
- Dr. Marty Makinen, Health Economist

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ANNEX B

LE CALENDRIFR DE LA DISPONIBILITE DES LEGUMES ET DES FRUITS

Fruits ou Legumes	Jan	Fev	Mars	Avril	Mai	Juin	Juillet	Aug	Sept	Oct	Nov	Dec
banane	X	X	X	X	X	X	X	X	X	X	X	X
ananas	X	X	X	X	X							X
papaye	X	X	X	X	X							X
mangue				X	X	X	X					
pain de singe	X	X	X	X							X	X
orange	X	X	X								X	X
citron	X	X	X	X	X	X	X	X	X	X	X	X
pamplemousse	X	X	X								X	X
pomme d'acajou				X	X							
pastèque	X	X	X	X						X	X	X
mandarine	X	X									X	X
goyave	X	X	X									X
nère							X	X	X			
bissap (fleure)				X	X	X						
oignon	X	X	X	X	X	X	X	X	X	X	X	X
aubergine amer.	X	X	X	X								X
tomate	X	X	X	X	X							
pomme de terre	X	X	X	X	X					X	X	X
piment	X	X	X	X	X				X	X	X	X
salade	X	X	X	X	X						X	X
choux	X	X	X	X	X							
aubergine	X	X	X	X	X	L'HIVERNAGE				X	X	X
carrotte	X	X	X	X	X							
navet	X	X	X	X							X	X
haricot vert	X	X	X	X						X	X	X
niébé (seche)	X	X	X									X
courge	X	X	X	X						X	X	X
gombo	X	X	X	X	X	X	X	X	X	X	X	X
bissap (feuille)	X	X	X	X	X	X	X	X	X	X	X	X
céleri			X	X								
poivron	X	X	X	X							X	X
concombre								X	X	X	X	X
radis	X	X	X	X						X	X	X
persil	X	X	X	X	X							
menthe		X	X	X								
Nombre total de fruits et legumes disponibles	28	29	29	28	18	7	7	7	8	13	20	25

SOURCE: Peace Corps, Senegal (exact reference lost, but refers to a market in Casamance).

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ANNEX C

RICE FARMING SCHEDULE

1.		Selection and cleaning of seed.	Early June
2.	A	Clearing of nursery beds (kuyfo) - burning and cutting of grasses.	End June
	B	Clearing of upland rice fields (tintikan mano) - if any are to be cultivated.	End June/ Early July
3.	A	Broadcasting seeds/applying fertiliser into nursery beds.	End June/ Early July
	B	Broadcasting/drilling seeds into upland rice fields (if any cultivated).	
4.		Clearing of other banto faroos (preference for those fields where medium duration varieties are to be broadcast directly). -- involves cutting and burning of grasses, hoeing and ploughing.	Early July
5.	A	Broadcasting seed/applying fertiliser onto banto faroos.	Early/mid July
	B	Early weeding of nursery beds.	
6.		Clearing of mangrove swamp fields (mang kito faroo) cutting back mangroves, pulling out swamp grasses, hoeing and ploughing.	Mid July
7.		Clearing of leo kono faroos - cutting and stacking tall grasses - hoeing.	Mid July
8.		Weeding of nursery beds and upland fields (tintikan faroos) - if any grown.	July
9.		Second clearance/weeding of banto faroos for which seedlings are to be transplanted includes minor hoeing and stacking of weeds.	Mid August
10.		Pulling up seedlings, transporting and transplanting them into banto faroos.	Mid/late August
11.		Second clearance/weeding/stacking of mang kito and leo faroos (swamp rice) in preparation for transplanting.	Mid August

ANNEX C. (con't.)

12.	A	Uprooting seedlings, transporting and transplanting them into (1) leo faroos (2) mang kito faroos.	Late Sept. early Oct.
	B	Bird/pig and monkey scaring.	
13.		Harvesting of early rice (mani juno) - if any grown.	Late Sept./ early Oct.
14.	A	Bird, pig and monkey scaring other banto faroo.	Mid October
	B	Harvesting of banto faroo rice as it ripens, transporting harvested rice home.	Mid November
15.		Bird/pig and monkey scaring in baa faroos	December
16.		Harvesting amd tranporting of leo rice and manc kito rice from baa faroos.	Early/late January

SOURCE: Phillips, D., Coles, A. and Seaman, J. Village Food Systems in West Africa. International African Institute, London. 1982.

University of Michigan, Gambia River Basin Studies, 1985.

ANNEX D

Form #1	Wholesale Price Collection. Central Statistics Department. Ministry of Economic Planning & Industrial Development
Form #2	Omitted
Form #3	Questionnaire on Food Consumption and Anthropometry
Form #4	CRS Monthly Master Chart
Form #5	CRS Monthly Report from the Master Chart
Form #6	MCH, Child Welfare Card
Form #7	MCH Monthly Return

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ANNEX D, Form 1

CENTRAL STATISTICS DEPARTMENT
MINISTRY OF ECONOMIC PLANNING AND INDUSTRIAL DEVELOPMENT
WHOLESALE PRICE COLLECTION

NAME OF MARKET _____ DIVISION _____ DATE _____

	LOCAL UNIT	WEIGHT OF LOCAL UNIT			PRICE PER UNIT		
		W1	W2	W3	P1	P2	P3
CEREALS AND PULSES							
1. Rice (local)							
2. Miller							
3. Sanjo							
4. Suno							
5. Kinto							
6. Basso							
7. Maize							
8. Dry beans							
FRUITS							
9. Orances							
10. Mango							
11. Lime							
12. Banana							
13. Paw-paw							
14. Guava							
VEGETABLES							
15. Tomato							
16. Bitter tomato							
17. Garden eggs							
18. Okra							
19. Pumpkin							
20. Cabbage							
21. Lettuce							
22. Green leaves-suriel leaves (Bisap)							

ANNEX D, Form 1 (con't.)

NAME OF MARKET _____ DIVISION _____ DATE _____

	LOCAL UNIT	WEIGHT OF LOCAL UNIT			PRICE PER UNIT		
		W1	W2	W3	P1	P2	P3
23. Green leaves-Kren-kren							
24. Pepper							
ROOT CROPS							
25. Sweet potatoes							
26. Cassava							
27. Onions							
LIVESTOCK							
28. Cattle (live animals)	Number						
29. Sheep							
30. Goat							
31. Fow (local)							
32. Pig (domestic)							
FISH AND CRUSTACEA							
33. Bonga (fresh)							
34. Bonga (tonon)							
35. Ladyfish (tonon)							
36. Barracudas (sedda) fresh							
37. Barracudas (smoked)							
38. Oyster							
FORESTRY PRODUCTS							
39. Palm Oil							
40. Palm wine							
41. Firewood							
42. Charcoal							
43.							
44.							
45.							

ANNEX D, Form 3

QUESTIONNAIRE FOR FOOD CONSUMPTION & NUTRITIONAL STATUS SURVEILLANCE IN THE GAMBIA RIVER BASIN (needs to be coded)

Date: _____
month date year

Time: _____

Name of enumerator: _____

City/Village/Quarter: _____

Name of compound head: _____

Name of person interviewed: _____

BREAKFAST

Is breakfast composed of:

- leftovers from the previous night? yes _____ no _____
  if yes, name of dish: _____

INGREDIENTS	ORIGIN

- a new preparation: yes _____ no _____
  if yes, name of dish: _____

INGREDIENTS	ORIGIN

- other? (specify): _____

OTHER MEALS OR "SNACKS" THAN BREAKFAST, LUNCH AND DINNER

Name of dish	Ingredients	Origin	Who ate?	When

ANNEX D, Form 3 (con't.)

Name of dish being prepared: _____

To be eaten: at noon _____ in evening _____

Frequency of preparation of this dish:

_____ times/week

_____ times/month

INGREDIENTS	ORIGIN (bought? given? wild leaves? home grown? other? specify)

Are any special guest sharing the meal? Yes _____ No _____

Of the above listed ingredients, are certain ingredients difficult to get at certain times of the year? Yes _____ No _____

if yes, which ones?	Why?	Replaced by what

Is any other dish than the one mentioned above eaten for lunch? Yes _____

No _____ . If yes, name of the dish: _____

If yes, where did it come from? gift _____ leftover _____

Comments: _____

What are the other dishes eaten for lunch by the family these days?

ANNEX D, Form 3 (con't.)

Name of Dish	Frequency eaten/week/month

What are the other dishes eaten for dinner by the family these days?

Name of Dish	Frequency eaten/week/month

Is any special food prepared for children? Yes _____ No _____

If yes, name of preparation: _____

INGREDIENTS:	ORIGIN:

Age of children who eat it (in months)	Is child still breastfed? (Y/N)	Does child also eat adult food? (Y/N)

Comments: _____

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ANNEX D, Form 3-bis

QUESTIONNAIRE FOR THE SURVEILLANCE
OF NUTRITIONAL STATUS
(to be used with Annex D, Form 3)

Child's name: _____

Child's age: _____

Date of birth: _____

MAC: _____ red: _____ yellow: _____ blue: _____

Infant Welfare Card: _____ Weight: _____

Month: _____ Year: _____

Child's name: _____

Child's age: _____

Date of birth: _____

MAC: _____ red: _____ yellow: _____ blue: _____

Infant Welfare Card: _____ Weight: _____

Month: _____ Year: _____

Child's name: _____

Child's age: _____

Date of birth: _____

MAC: _____ red: _____ yellow: _____ blue: _____

Infant Welfare Card: _____ Weight: _____

Month: _____ Year: _____

Comments: _____

University of Michigan, Gambia River Basin Studies, 1985.

MASTER CHART

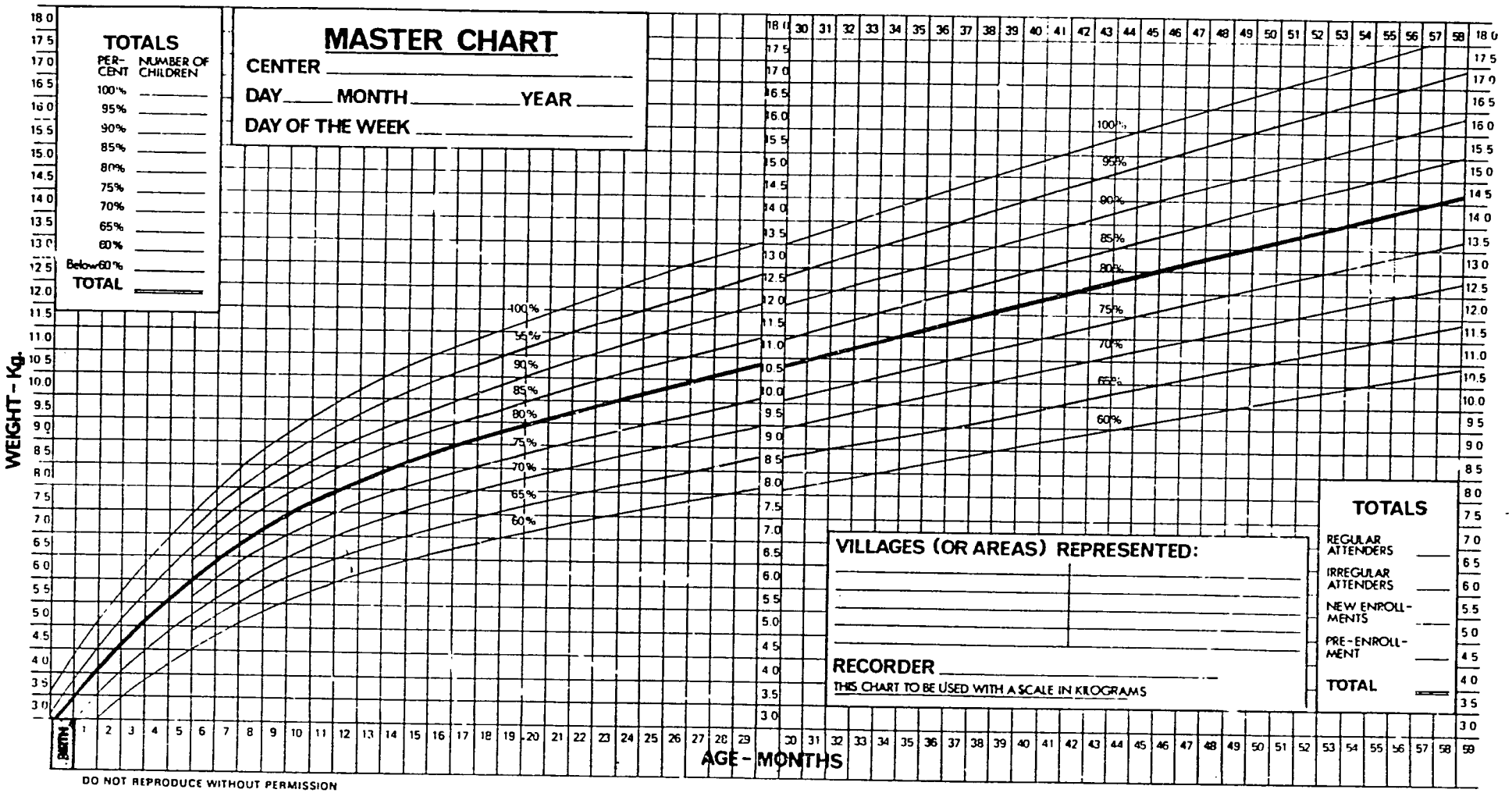
CENTER _____

DAY ____ MONTH _____ YEAR ____

DAY OF THE WEEK _____

TOTALS

PER-CENT	NUMBER OF CHILDREN
100%	
95%	
90%	
85%	
80%	
75%	
70%	
65%	
60%	
Below 60%	
TOTAL	



VILLAGES (OR AREAS) REPRESENTED:

_____

_____

_____

_____

RECORDER _____

THIS CHART TO BE USED WITH A SCALE IN KILOGRAMS

TOTALS

REGULAR ATTENDERS	
IRREGULAR ATTENDERS	
NEW ENROLL-MENTS	
PRE-ENROLL-MENT	
TOTAL	

DO NOT REPRODUCE WITHOUT PERMISSION

PUBLISHED BY DR C. CAPONE BOX 48932 NAIROBI

Annex D , Form 4

MONTHLY REPORT

FROM THE MASTER CHART

COUNTRY: _____ (District)

MONTH: _____

Centers	No. of children at percent of harvards standard										Total Children Graphed	New Children Reg.	Mean	S.D.	# 80%	% 80%	Comments
	100	95	90	85	80	75	70	65	60	below 60							

University of Michigan, Gambia River Basin Studies, 1985.

Annex D, Form 5

ANNEX D Form #6

IMMUNIZATION RECORD

Anti-Tuberculosis Immunization (B.C.G.)

Date of B.C.G. Immunization.....

(B.C.G. can be given immediately after birth)

Date of Recognizing B.C.G. SCAR

Poliomyelitis Immunization

Date of First Polio.....
(at the age of two months or later)

Date of Second Polio.....
(one month after first dose)

Date of Third Polio.....

Booster.....

Whooping Cough, Tetanus and Diphtheria Immunization

Date of First Injection.....
(at the age of 2 months or later)

Date of Second Injection.....
(one month after first injection)

Date of Third Injection.....

Booster.....

Measles Immunization

Date.....

(at the age of 9 months or later)

Yellow Fever Immunization

Date of Injection

(at the age of 9 months or later)

PERSONAL HISTORY

Welfare Centre	Child's No.
Child's Name	Sex
Father's Name	
Mother's Name	

Date of Birth

Place of Delivery

Home | Health Facility

Date First Seen

Address/Name of Village and Compound

Brothers and Sisters

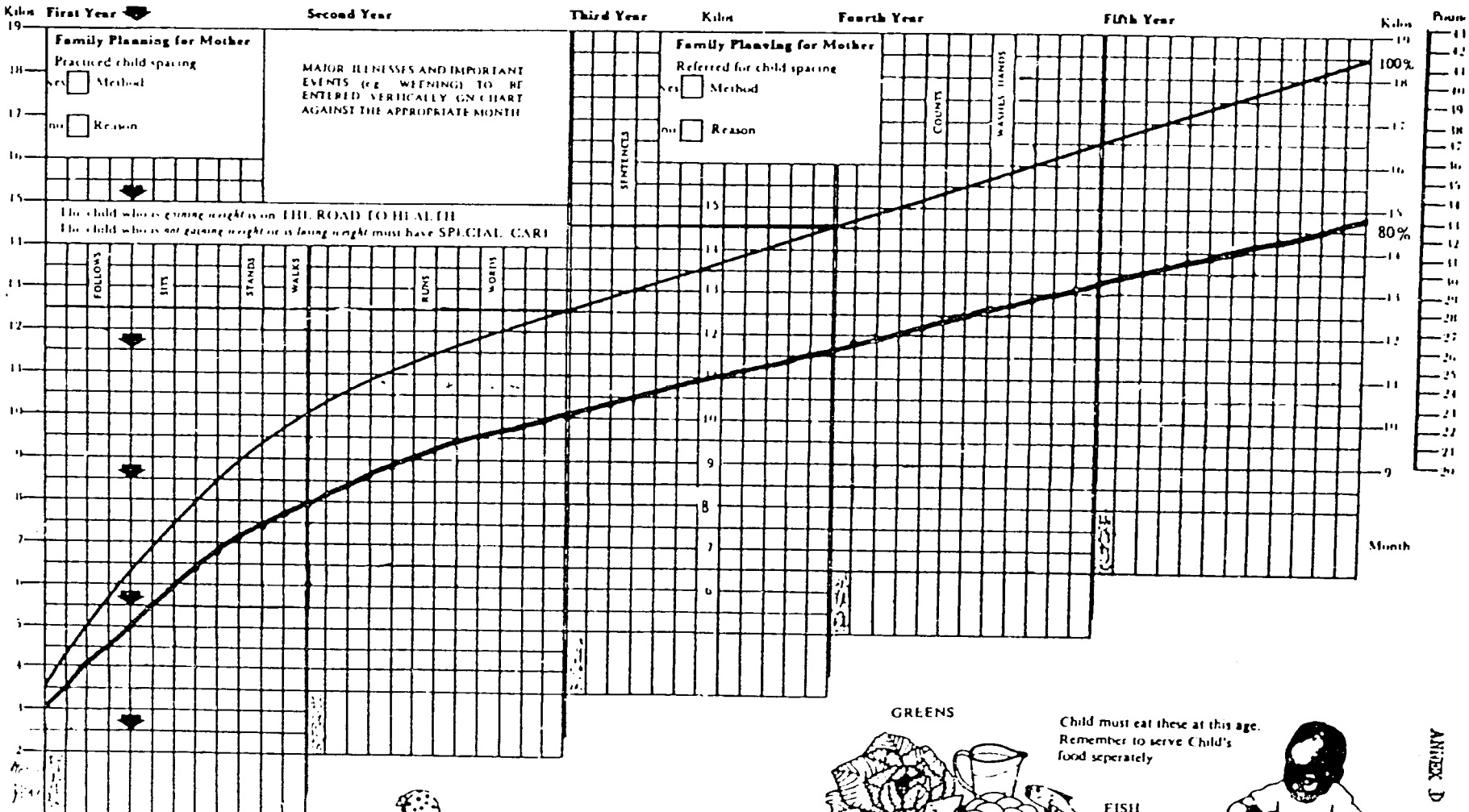
Year of Birth	Sex	Remarks

Annex D Form 6

CHILD WELFARE VISITS

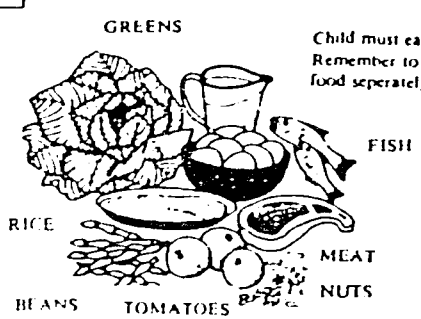
Date	Treatment Centre	Complaint, treatment, referral	Investigations	Initials

CHILD'S HEALTH AND WEIGHT RECORD OVER FIRST FIVE YEARS.



Breast is Best

Now Baby can be spoon fed with freshly made Pap at the age of 4 months



Child must eat these at this age. Remember to serve Child's food seperately

ANNEX D Form #6

ANNEX D, Form 7

MCH MONTHLY RETURN

MCH TEAM _____ MONTH _____ 19____

INFANT WELFARE CLINICS

Vaccinations given:

ECG	_____	
DET 1	_____	
DET 2	_____	_____
DET 3	_____	
DET B	_____	
Polio 1	_____	
Polio 2	_____	_____
Polio 3	_____	
Polio B	_____	
Measles	_____	
Y. fever	_____	

Number of 'at risk' children weighted _____

Number of home visits made _____

Number of referrals _____

Date submitted: _____

SIGNATURE:

Date received RHT _____

Date received MCH _____

ANTENATAL CLINICS

Vaccinations given:

TT1	_____	
TT2	_____	_____
TT3/B	_____	

Deliveries:

At the centre
- Live _____
- Stillbirths _____

Outside the centre
- Live _____
- Stillbirths _____

Number of referrals _____

VACCINE INVENTORY

Vaccine	Balance at 1st of month	Received during month	Balance at end of month
BCG	_____doses	_____doses	_____doses
DPT	_____doses	_____doses	_____doses
Polio	_____doses	_____doses	_____doses
Measles	_____doses	_____doses	_____doses
Y. fever	_____doses	_____doses	_____doses
Tet. Tox.	_____doses	_____doses	_____doses

COLD CHAIN

Number of days temperature was recorded _____

Number of days temperature exceeded 10°C. _____

KEROSENE: Gallons in drum at end of month ___gal.

CLINICS SCHEDULED

Place	Dates*	Attendances IWC Old	IWC New	ANC Old	ANC New	Comments

*Circle date if clinic not held and explain reason under "Comments".

ANNEX E, Form A

PROTEIN REQUIREMENTS, MALES AND FEMALES, THE GAMBIA, 1980

Age Group (years)	Population Size (thousands)		Body Weight (kg)	Per kg body wt	Total Ideal Protein	Adjusted For Chemical Store Pattern of 70%	Total adjusted Protein (thousand gm)	
0-4	108		10.0	1.36	13.6	19.4	2095.2	
5-9	86		24.7	0.94	23.2	33.1	2846.6	
Males								
10-14	36		36.0	0.76	27.4	39.1	1406.6	
15-19	31		45.2	0.60	27.1	38.7	1199.7	
Females								
10-14	36		36.0	0.70	25.2	36.0	1296.0	
15-19	31	P: 3.1	48.1	0.55	26.4	37.7	1168.7	P: 40.3
		L: 4.6						L:110.4
Adult Male	134		57.3	0.57	32.7	46.7	6257.8	
Adult Female	141	P: 9.6	51.6	0.52	26.8	38.3	5400.3	P:124.8
		L:14.4						L:345.8
							21671.9	621.3
						37.0	22293.0	

SOURCE: The Gambia, Food Strategy Report, Part I: Review of Food & Nutrition in the first National Development Plan. March 1981.

NOTE: Assumed that 10% of women age 15-44 are in latter half of pregnancy and 15% are in first six months of lactation. According to the recommendations 13 gm and 24 gm of adjusted protein respectively have been included to cover the extra protein needs of pregnancy and lactation.

University of Michigan, Gambia River Basin Studies, 1985.

ANNEX E, Form B

ENERGY REQUIREMENTS OF MALES, THE GAMBIA, 1980

Age Group (years)	Population Size (thousands)	Body Weight (kg)	Energy per kg	Requirements Per Capita	(Kcal) Total (millions)
0-4	54	10.0	101	1010	54.540
5-9	43	24.7	78	2184	93.912
10-14	36	36.0	64	2304	82.944
15-19	31	45.2	46	2392	74.152
20-29	48	55.8	46	2667	123.216
30-49	57	58.9	45	2651	151.107
50+	29	57.1	39	2227	46.583
	298			2163	644.454

TABLE 2

ENERGY REQUIREMENTS FOR FEMALES, THE GAMBIA, 1980

Age Group (years)	Population Size (thousands)	Body Weight (kg)	Energy per kg	Requirements Per Capita	(Kcal) Total (millions)	
0-4	54	10.0	101	1010	54.540	
5-9	43	21.5	78	1677	72.211	
10-14	36	36.0	56	2016	72.576	
15-19	31 P: 6.2 L:12.4	48.1	43	2107	65.317	P: 1.754 L: 6.820
20-29	49 P: 9.8 L:19.6	53.0	40	2120	103.880	P: 2.773 L:10.788
30-49	58 P: 9.4 L:18.8	51.1	39	1993	115.594	P: 2.660 L:10.340
50+	34	50.1	34	1720	58.480	
	305				542.598	35.127
				1894	577.725	
				2027	1.222.179	

SOURCE: Ibidem as previous table.

NOTE: Total Males and Females 603.

University of Michigan, Gambia River Basin Studies, 1985.

ANNEX E, Form C

ALIMENTS DE BASE: RELATION ENTRE LA PRODUCTION ET LES BESOISS NUTRITIONNELS

Aliments de Base	Rendement/hecatre (tonne) (brute)[3]		Rendement/hecatre (tonne) (nette)[3]		Valeur nutritive de grains préparés (100 g cru)		Rendement/hectare en besoins nutritionnel annuels pour une famille moyenne[4]		Surface necessaire pour satisfaire 85% des besoins nutritionnels[4] annuels pour une famille moyenne (hectares)	
	T[1]	A[2]	T	A	Proteines	Calories	Proteines	Calories	Proteines	Calories
Riz	.7	(2.5)	.38	(1.34)	7.0	363	29 (102)	35 (126)	2.93 (.83)	2.43 (.67)
Mil	.5	(1.8)	.43	(1.55)	9.3	387	44 (157)	43 (155)	1.93 (.54)	1.98 (.55)
Sorgho	.5	(1.8)	.43	(1.55)	9.6	375	45 (162)	42 (150)	1.89 (.53)	2.02 (.57)
Mais	1.0	(4.0)	.84	(3.37)	9.3	353	85 (342)	77 (307)	1.0 (.25)	1.10 (.28)
Ble	2.3	(3.5)	1.46	(2.24)	10.6	364	169 (259)	137 (211)	.50 (.33)	.62 (.40)
Manioc	.5	(12)	1.69	(10.06)	1.1	337	200 (121)	247 (876)	4.25 (.70)	.58 (.10)

SOURCE: Communication by Malon Duffy, USAID, 1983.

NOTES: 1- le rendement moyen par methodes de culture traditionnelles.

2- le rendement atteint par methodes de culture ameliorées.

3- nette = déduction faite des besoins en semences, des pertes en stockage, des pertes de la transformation.

4- me famille moyenne = 5 personnes dont 2 adultes jeunes, 2 enfants, et une adult agée.

University of Michigan, Gambia River Basin Studies, 1985.

ANNEX F, Section A

TABLE 1

SUMMARY OF PROGRAMS AND POLICIES OF INSTITUTIONS IN THE GAMBIA THAT WILL BECOME INVOLVED IN THE OMVG PROGRAM

Institutions	Programs or Policies
Central Health Institutions	
Ministry of Helath, Labour, and Social Welfare	1. Improving the management capability of the ministry, with particular reference to the drug-distribution system.
Health Centers	2. Improving health planning. 3. Immunization campaign.
Village-Level Health and Nutrition Institutions (MHNC)	
Supplementary nutrition, day-care, and maternal and child health care center administered by village nutrition workers	4. Supplemental feeding of pregnant and lactating women. 5. Supplemental feeding of infants and small children. 6. Day-care center for infants and small children.
Village health workers	7. Antenatal and maternal care. 8. Provision of simple curative health care and a village stock of drugs.
Village-level education in health, nutrition, and family planning	9. Iron-deficiency program. 10. Education in health, nutrition, hygiene, and family planning.
Local Government Inspectorate	11. Provision of clearn surroundings by means of sewage disposal. 12. Village water supply.
Ministry of Agriculture and Natural Resources	
Rural Development Project	13. Lessening the agricultural work loads of women. 14. Improving the storage of food grains.
Research services	15. Developing early varieties of food grains.
General Surveillance (PPMU)	16. Increasing rural production. 17. Monitoring crop yields, infants and needs of farmers.
Gambia Produce Marketing Board (GPMB)	18. Changing marketing policies with respect to the system of payments.

SOURCE: The World Bank, The Gambia: Basic Needs in The Gambia, Washington, D.C., December 1981. p. 26.

NOTE: See next page for addendum by consultant.

ANNEX F, Section A/TABLE 1 (con't.)

Institutions	Programs or Policies
Department of Water Resources	1. Digging of cement lining wells in rural areas. UNDP provides financing, logistical inputs & training; villagers provide food, lodging & water for well workers (priority area is South Bank, GTZ and Saudi financing take care of North Bank).
World Food Programme/UNDP	1. School feeding program for rural children (fed once a day). 2. Emergency operations for seasonal hunger periods. 3. Food for work at Jahally Pachar irrigation scheme.
Department of Community Development	1. Development of wood-stove design to increase burning efficiency; development of briquettes made of groundnut shells.
Department of Health	1. Mass Media/Oral Rehydration Therapy project; implemented by VHWs and staff from rural health structures.
Ministry of Local Government	1. Distribution of food aid.
Ministry of Economic Planning and Industrial Development/Dept. of Statistics	1. Monitoring of availability and prices of food in market places.
UNDP experimental projects	1. Photo-voltaic pumping station. 2. Wind mill.

University of Michigan, Gambia River Basin Studies, 1985.

ANNEX F, Section A

TABLE 2

PARTIAL LIST OF INSTITUTIONS AND THEIR PROGRAMS THAT WILL BECOME INVOLVED IN THE OMVG PROGRAM IN SENEGAL

Institutions	Programs or Policies
Ministry of Public Health	1. Improving the statistical system for health monitoring. 2. Improvement of the drug distribution system. 3. Expanded program of immunization. 4. Extension of coverage by PHC. 5. MCH.
DANAS (Division de l'alimentation et de la nutrition au Sénégal)	1. Program of Nutritional & Health Protection (PPNS): - food distribution; now provides supplements to an average of 307 children and 230 mothers by PPNS centre. - nutritional status monitoring. 2. Food consumption monitoring.
Ministry of Rural Development	1. Water supply. 2. Lessening the work load of women. 3. Coordination of agricultural policies and interventions.
Ministry of Agriculture	1. Improvement of food grain storage. 2. Extension services.
Regional Development Agencies (RDAs)	1. Agricultural extension.
ORANA (Organisme de Recherches sur l'Alimentation et la Nutrition Africaines)	1. Data bank. 2. Implementation of food and nutrition surveys.

University of Michigan, Gambia River Basin Studies, 1985.

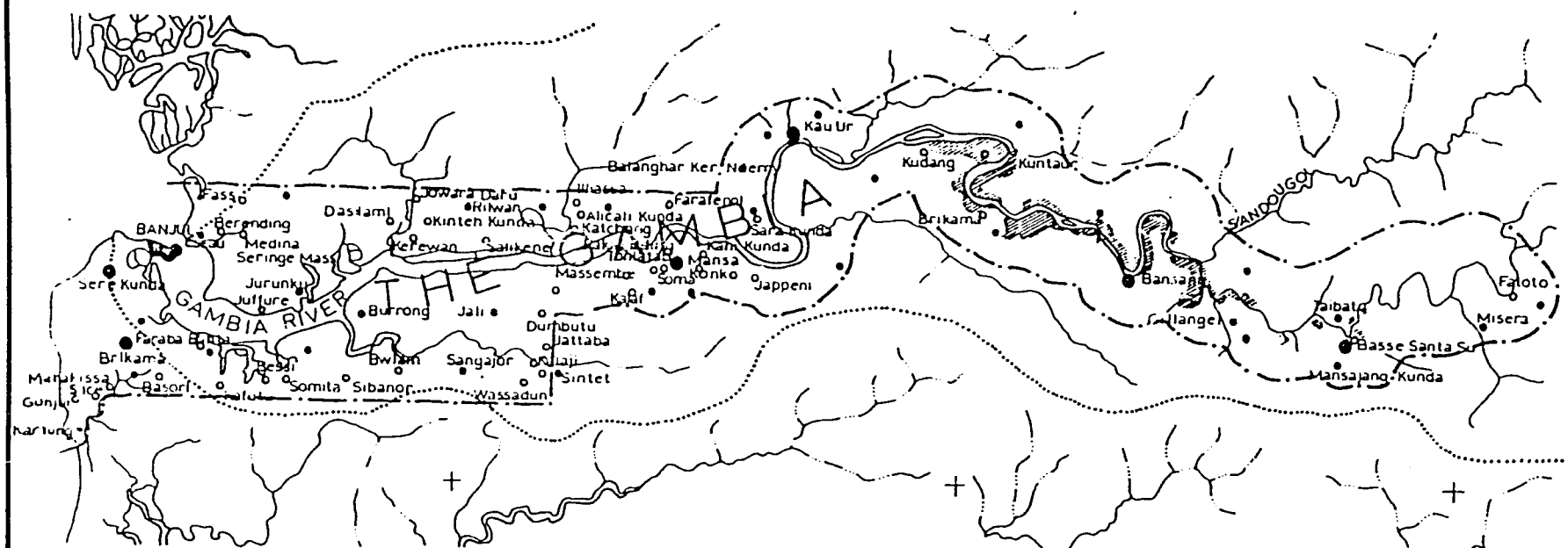
ANNEX F, Section B

In that it exercises control on behalf of the Cabinet for intersectoral allocation of resources and the coordination of national planning, MEPID clearly has an essential part to play in ensuring increased food production, food security and improved nutrition. When it comes to sectoral and microplanning, programming and the management of implementation, however, the lead Ministry is MANR since all depends on increasing production and productivity in the field. Yet, without the full collaboration of other Ministries such as Health, Education and Works and, of direct significance for agricultural production, marketing and input supply, the new Ministry of Water Resources & the Environment and the enlarged Ministry of Local Government, along with parastatals such as the GPMB and the GCDB, progress will be inhibited.

It is important, however, that progress on food and nutrition matters is reviewed regularly -- preferably at six-monthly intervals but at least once a year -- and we believe it would be appropriate for the Agricultural Sector Committee to convene for this purpose specifically to deal with food and nutrition and, in doing so, to co-opt representatives from all the other relevant Ministries and agencies. A brief record of the conclusions and recommendations of these special meetings on Food and Nutrition could well be tabled for the information of Parliament and, subject to any directives from the National Development Council, passed on to executive Ministries and parastatals for follow-up action.

It would, we believe, be appropriate for Ministries and other bodies with a special responsibility for some aspect of food and nutrition, to use the special meetings of the Agricultural Sector Committee to ensure that these aspects are brought to the fore and regularly reviewed. As part of our brief, we prepared a review on nutrition in The Gambia which was widely distributed before being discussed by the Steering Committee (a revised version now being included in Part I of this report) and it would be appropriate for the Ministry of Health in collaboration with MANR to update this periodically.

SOURCE: The Gambia, Food Strategy Report, Parts II & III: Major Constraints and Strategy Options. Summary of Programmes and Projects for FYP II. March 1981. p. 175.



- o Catholic Relief Service (CRS) Centers
- • Villages where a HPMU enumerator (Planning, Programming and Monitoring Unit of the Ministry of Agriculture) stays in permanence
- ● Centers where the enumerators of the Ministry of Economic Planning conduct market surveys.
- ▨ Area included in the 30,000 hectares particularly favourable for irrigated rice cultivation (it is anticipated that by 2025, 77% of those will be irrigated) (Source: LRDC, 1984).

ANNEX G. Map of The Gambia with the Distribution of Data Collection Agents for the Proposed Surveillance System

University of Michigan, Gambia River Basin Studies, 1985.

ANNEX H

MEAN INDICATOR RESPONSE TO SUPPLEMENTARY FEEDING

Field Trials

Type of Malnutrition	Type of Analysis	Indicator	Age	Duration of Suppl.	% Suppl. Diet	Deficit rel. to std.	Response to Suppl.	Pooled SD	Responsiveness = 1/1 (Respon/SD)^2
PEM	Suppl. vs. Control	Attained: Wt.	36 mo.	36 mo.	17%-Cal. 36%-Pro.	4.5 kg. (Denver)	0.9 kg.	1.3 kg.	0.24
		Ht.	"	"	"		2.3 cm.	3.9 cm.	0.17
		Arm Circum.	"	"	"		0.35 cm.	0.9 cm.	0.08

Ref: Maretorell, et al. 1980. Nutr. Rep. Int. 21:219-230.

The procedure for estimating sample size for comparison of independent samples utilizes the relation:

$$n = \frac{K^2\ 2s^2}{d^2} = \frac{K^2}{1/2(d/s)^2} = \frac{K^2}{f^2 \times \text{Responsiveness}}$$

for weight-for-age: $n = \frac{(13)^2(13)^2}{0.25} = 176$

for M.A.C.: $n = \frac{(13)^2(0.08)^2}{0.9} = 263$

- where s is an estimate of the standard deviation of the variable under consideration (see Table I.9).
- d is the difference to be detected; this should be a fraction (f) of the responses shown in Table I.9, below which one is indifferent to whether there is a response.
- K^2 is a multiplier value for different levels of significance and various associated powers in testing.

SOURCE: Mason, John; Habicht, Jean-Pierre; Tabataba, Hamid. Principles for Evaluation of On-going Programs. Cornell University, Working Paper Series No. 5, Ithaca, May 1982.

APPENDIX II

PROPOSED OMVG-SPONSORED SHORT COURSE IN VECTOR IDENTIFICATION

Name

"Regional Workshop in Vector Identification"

Purpose

To encourage effective communication between member states; to insure that member state development priorities and strategies in public health that pertain to waterborne disease control are reflected in future OMVG planning and coordinating processes; and to contribute toward building an institutional and technical capability within the OMVG for dealing with such interests.

Location

The home base for the course could be the Laboratory of Parasitology of the Service des Grandes Endémies, Tambacounda, Senegal Oriental. Field trips would be taken to populated areas of the upper Gambia River in the vicinities of Kédougou and Salémata, plus its tributaries.

Instruction

Instructors would be drawn from the staff of the Service des Grandes Endémies in Tambacounda. The GRBS public health team leader could participate on an ad hoc basis.

Language of instruction would be French.

Participants

The number of participants would probably be limited to six, to be proposed by the OMVG technical staff, the Service de Lutte Antiparasitaire (Senegal) and the Service National de Prévention (Guinea).

Schedule

The course should commence no earlier than November and no later than early or mid-January, because of constraints on collecting water-inhabiting organisms imposed by the advancing dry season.

Description of the Course

Four to six weeks would be spent in developing skills of field recognition of invertebrate disease vectors and transmitting agents in

areas of interest to OMVG development planning. Organisms to be studied would include mollusks, mosquitoes, tsetse flies, blackflies, and sandflies. Laboratory time would be devoted to learning morphological recognition characters. In the field, participants would become familiar with ecological niches and breeding site locations on the upper Gambia River, tributaries, and associated surface waters in areas that may be affected by the proposed Kekreti impoundment.

Costs

The following estimates are highly speculative but it is believed that the overall figure is correct to an order of magnitude.

o Personal Remuneration	
Students' food & lodging ($25/day x 42 days x 6 students)	$ 6,300
Teachers' stipend ($1,000 each x 2 teachers))	2,000
Students' per diem (5,000 CFA x 42 days x 6)	3,150
Teachers' per diem (5,000 CFA x 20 days x 2)	500
Total Personal Remuneration	$11,950
o Travel	
Airfares	
Dakar-Tambacounda (3RT)	1,200
Conakry-Dakar-Tambacounda (3RT)	240
Ground transport	100
Total Travel	$ 1,540
o Equipment	
Fuel[1] (assume 15 km/1; 3,000 km; petrol at 300 CFA/1)	150
Laboratory equipment (glassware, reagents, etc.)	500
Total Equipment	$ 650
TOTAL	$14,140

[1]One or two vehicles to be loaned by Service de Lutte Antiparasitaire or by USAID/Dakar.